CHAPTER-1

INTRODUCTION

1.1 SOIL EROSION

Soil erosion is a natural process that occurs when soil is displaced or removed from its original location by various agents such as water, wind, ice, or human activities. It's a significant environmental issue worldwide, with implications for agriculture, ecosystems, and infrastructure. The significance of soil erosion on water quality amplifies notably, especially through soil surface runoff. The production of sediment and soil erosion share a close correlation. Consequently, the most efficient approach to reducing sediment production involves stabilizing sediment source by managing erosion. Various conservation methods can be employed to mitigate erosion, but it's essential to grasp the factors influencing soil erosion initially. Soil erosion entails the detachment and transportation of soil particles from their original location due to the influence of water or wind. Therefore, the primary aim of erosion control is to minimize the impact of water or wind forces.

Soil erosion is made up of 3 stages:

Detachment: Detachment refers to the initial separation of soil particles from the ground surface. This detachment can occur due to the impact of raindrops, flowing water, wind, or other erosive forces. Rainfall can dislodge soil particles while flowing water can detach soil through processes like splash erosion, where raindrops splash soil particles onto nearby surfaces, and sheet erosion, where thin layers of soil are removed uniformly across a large area. Wind erosion can also detach soil particles by lifting and carrying them away as shown in (Fig 1.1)

Transport: Once soil particles are detached, they are transported by the erosive agent, such as water or wind. Water erosion can transport soil particles in suspension within the water, or as sediment rolling, sliding, or bouncing along the soil surface. The velocity and volume of water determine the distance and speed of soil particle transport. Similarly, wind erosion carries soil particles through saltation (bouncing), suspension, and surface creep, with particle transport influenced by wind speed, soil moisture, and particle size.

Deposition: Deposition occurs when the transported soil particles come to rest at a new location. This can happen when the erosive forces lose energy, such as when the water flow slows down or wind speed decreases. Deposition commonly occurs in areas where the erosive forces encounter obstacles, such as vegetation, rocks, or changes in slope, causing soil particles to settle out of suspension. Deposition contributes to the formation of sediment deposits, including riverbanks, floodplains, deltas, and dune

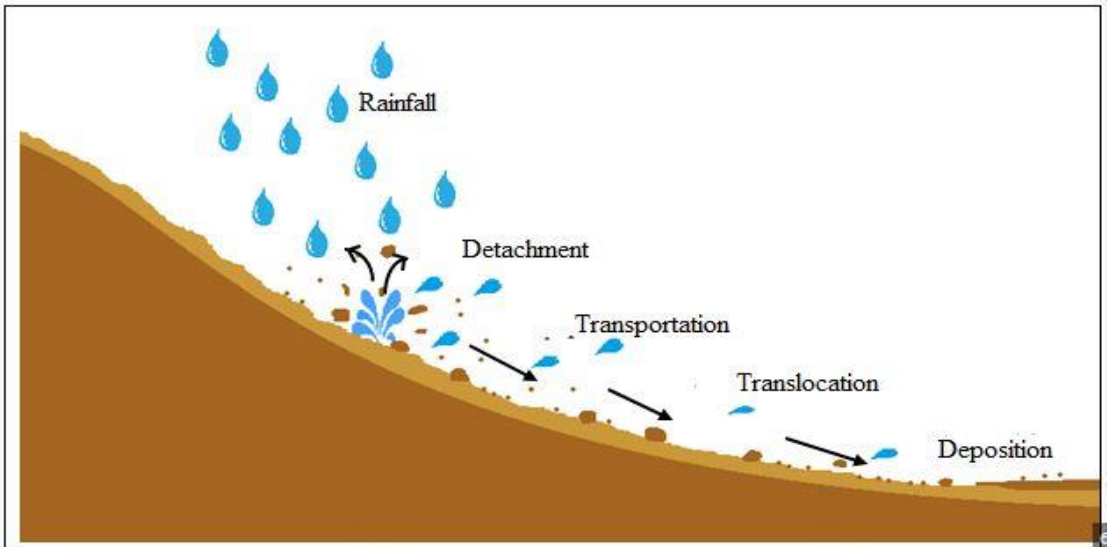


Fig 1.1 Soil erosion process

1.1.1 CAUSES OF SOIL EROSION

Soil erosion can be caused by various natural and human-induced factors, including:

- **Water Erosion**
  Rainfall: Intense or prolonged rainfall events can dislodge soil particles and initiate erosion.
  Runoff: Excess water running off the land surface can carry away soil particles, leading to erosion.

Flooding: Floodwaters can erode soil through their sheer force and volume, especially in areas with poor drainage or during extreme weather events.

- **Wind Erosion**

  Wind: Strong winds can lift and transport loose soil particles, causing erosion, particularly in arid and semi-arid regions with sparse vegetation cover.

  Deforestation: Removal of trees and other vegetation reduces the natural barrier against wind erosion, making soil more susceptible to being carried away by wind.

- **Human Activities**

  Deforestation: Clearing forests for agriculture, logging, or urban development exposes soil to erosion by removing the protective vegetation cover.

  Overgrazing**:** Excessive grazing by livestock can remove vegetation cover, trample soil, and compact the ground, making it more prone to erosion.

  Improper Land Management: Poor agricultural practices such as excessive tilling, monoculture farming, and improper irrigation can degrade soil structure and increase erosion rates.

  Construction: Land clearing for infrastructure development, such as roads, buildings, and mining operations, can disturb the soil and accelerate erosion.

  Mining: Excavation and removal of soil and rock layers disrupt natural landscapes and expose underlying soil to erosion.

- **Soil Characteristics**

  Soil Texture: Soil with high proportions of fine particles like clay and silt is more prone to erosion than sandy soils.

  Soil Structure: Compacted or poorly structured soils are more susceptible to erosion due to reduced permeability and stability.

Soil Moisture: Dry soils are more susceptible to wind erosion, while saturated soils are prone to water erosion.

- **Topography**

  Slope Gradient: Steep slopes accelerate water runoff, increasing the erosive power of water, whereas flat or gently sloping terrain allows water to infiltrate and reduces erosion.

  Terrain Features: Natural features such as valleys, gullies, and drainage patterns influence the direction and intensity of erosion processes.

1.1.2 EFFECTS OF SOIL EROSION

Soil erosion has a wide range of detrimental effects on the environment, economy, and society. Some of the key effects include:

- **Loss of Soil Fertility**: Erosion often removes the top layer of soil, which is rich in organic matter and nutrients essential for plant growth. This loss of fertile soil reduces agricultural productivity and can lead to decreased crop yields.

- **Decreased Agricultural Productivity**: Soil erosion can damage crops, disrupt root systems, and reduce the ability of soil to retain water and nutrients, resulting in lower agricultural yields. This can lead to food insecurity and economic losses for farmers and communities dependent on agriculture.

- **Water Pollution**: Sediments eroded from soil can be carried by runoff into water bodies such as rivers, lakes, and streams. This sedimentation can degrade water quality, increase turbidity, and harm aquatic ecosystems by smothering habitats, disrupting aquatic life cycles, and reducing oxygen levels.

- **Sedimentation of Waterways:** Excessive soil erosion contributes to sediment buildup in rivers, reservoirs, and other water bodies. This sedimentation reduces water storage capacity, increases the risk of flooding, and impairs navigation and recreational activities.

- **Loss of Biodiversity:** Soil erosion can degrade habitats, destroy vegetation, and disrupt ecosystems, leading to loss of biodiversity. This loss of plant and animal species can have cascading effects on ecosystem functions, such as pollination, nutrient cycling, and soil formation.

- **Infrastructure Damage**: Sediment-laden runoff from soil erosion can damage infrastructure such as roads, bridges, and buildings. Erosion-induced landslides and slope failures can pose safety hazards and require costly repairs and maintenance.

- **Degradation of Landscapes:** Soil erosion alters natural landscapes, leading to changes in landforms, loss of topsoil, and degradation of scenic beauty. This can impact tourism, recreation, and cultural heritage values associated with landscapes.

- **Climate Change**: Soil erosion releases stored carbon into the atmosphere, contributing to greenhouse gas emissions and climate change. Erosion can also disrupt carbon sequestration processes in soils, reducing their capacity to store carbon and mitigate climate change.

- **Economic Costs**: Soil erosion imposes significant economic costs on society, including loss of agricultural income, increased water treatment expenses, damage to infrastructure, and expenditures for erosion control measures. These costs can burden communities and governments, particularly in regions heavily affected by erosion.

1.1.3 PREVENTIONS OF SOIL EROSION

- **Afforestation**: Planting trees and establishing forests on degraded or vulnerable land helps stabilize soil, reduce water runoff, and prevent erosion by improving soil structure and increasing soil organic matter. Tree roots anchor soil, reducing the risk of erosion by water or wind.

- **Crop Rotation**: Rotating different crops in sequence helps maintain soil health and fertility, reduces soil erosion, and minimizes the buildup of pests and diseases. Different crops have varying root structures and nutrient requirements, which can improve soil structure and organic matter content.

- **Terrace Farming**: Building terraces or stepped platforms on steep slopes helps to create level areas for cultivation, reducing the erosive force of water runoff and preventing soil from being washed downhill. Terraces slow down water flow, allowing it to infiltrate into the soil and reducing erosion.

- **Shelter Belts (Windbreaks):** Planting rows of trees or shrubs perpendicular to prevailing wind directions helps reduce wind erosion by creating a barrier that deflects and slows down the wind. Shelter belts also protect crops, livestock, and soil from wind damage and help maintain microclimate conditions.

- **Embankments:** Constructing embankments or bunds along contours or waterways helps to control water runoff, reduce soil erosion, and prevent sedimentation. Embankments trap sediment, slow down water flow, and promote infiltration, protecting soil and water resources.

- **Applying Mulches:** Spreading organic or synthetic mulch materials such as straw, hay, wood chips, or plastic film on the soil surface helps to conserve soil moisture, suppress weed growth, and reduce erosion by shielding the soil from raindrop impact and surface runoff.

- **Matting:** Installing erosion control mats or blankets made of natural or synthetic materials helps stabilize soil on slopes, prevent surface erosion, and promote vegetation establishment. Mats provide temporary protection until vegetation roots become established, reducing erosion risk.

- **Bunding:** Building soil bunds or barriers along contours helps to slow down water runoff, reduce soil erosion, and retain soil moisture. Bunds trap sediment, prevent gully formation, and promote infiltration, enhancing soil fertility and resilience to erosion.

1.2 ARCGIS 10.8

ArcGIS version 10.8 is a powerful geographic information system (GIS) software developed by Esri, designed to help users create, manage, analyze, and visualize spatial data. With its intuitive interface and advanced tools, ArcGIS 10.8 enables users to make informed decisions and solve complex spatial problems across various industries and disciplines.

Mapping and Visualization in ArcGIS provides tools for creating high-quality maps and visualizations, allowing users to display spatial data in compelling and informative ways. Users can customize symbology, labels, and layouts to effectively communicate geographic information.

Spatial Analysis in ArcGIS offers a wide range of spatial analysis tools for exploring relationships, patterns, and trends in geographic data. Users can perform spatial queries, proximity analysis, statistical analysis, and more to gain insights into spatial phenomena.

Data Management in ArcGIS enables users to manage spatial data efficiently, including importing, exporting, editing, and organizing datasets.

Users can work with various data formats, including shapefiles, geodatabases, raster datasets, and web services.

Geoprocessing in ArcGIS includes a comprehensive suite of geoprocessing tools for performing spatial operations and analyses. These tools automate repetitive tasks, streamline workflows, and allow users to perform complex spatial analyses with ease.

Integration in ArcGIS integrates seamlessly with other Esri products and third-party applications, allowing users to leverage additional functionality and data sources. Integration with ArcGIS Online and ArcGIS Enterprise enables collaboration, data sharing, and access to cloud-based GIS resources.

Web Mapping in ArcGIS enables users to create interactive web maps and applications for sharing geographic information online. Users can publish maps to ArcGIS Online or ArcGIS Enterprise, allowing stakeholders to access and interact with maps using web browsers or mobile devices.

Spatial Data Science in ArcGIS includes tools and capabilities for conducting spatial data science workflows, such as spatial statistics, machine learning, and big data analysis. Users can apply advanced analytical techniques to extract meaningful insights from spatial data.

Customization and Extensibility in ArcGIS provides options for customizing and extending the software to meet specific requirements and workflows. Users can develop custom scripts, tools, and extensions using Python, Arc Objects, or the ArcGIS API for JavaScript.

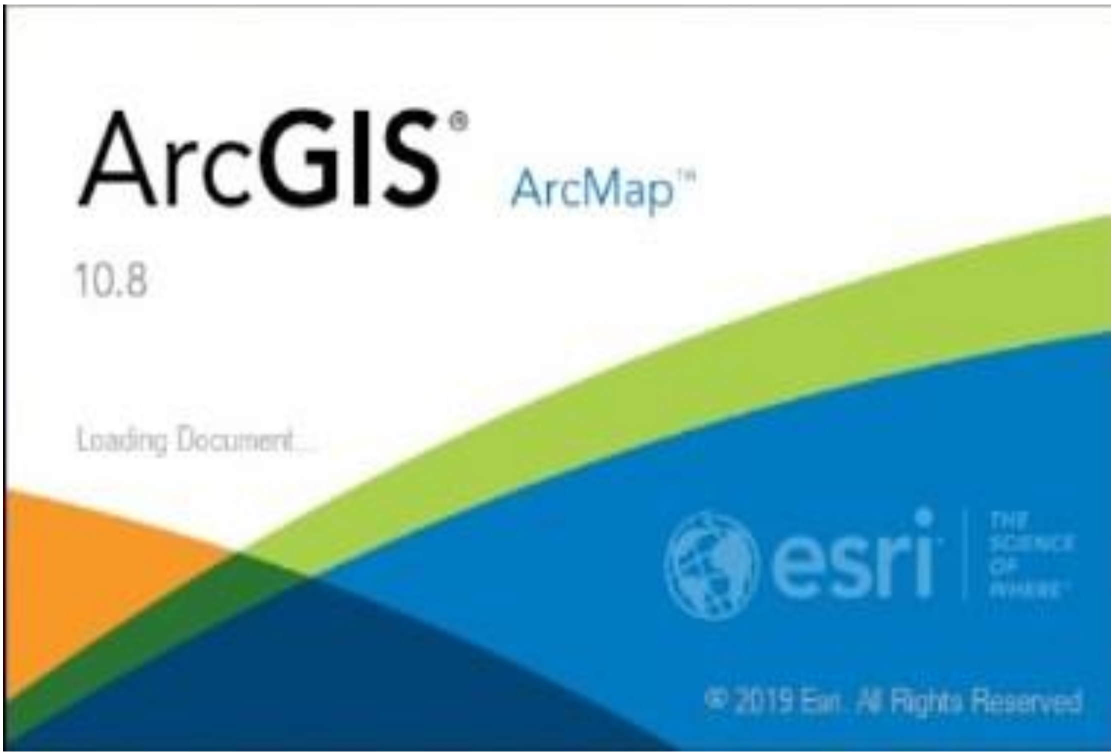


Fig 1.2 ArcGIS

1.2.1 APPLICATIONS OF ArcGIS

ArcGIS, a powerful Geographic Information System (GIS) software suite by Esri, has a wide range of applications across various industries. Some of the Applications are:

- **Urban planning:** ArcGIS helps urban planners visualize data like demographics, traffic patterns, and land use. This allows them to make informed decisions about zoning, infrastructure development, and resource allocation.

- **Environmental analysis:** Environmental scientists and analysts use ArcGIS to assess environmental risks, track wildlife migration patterns, and monitor pollution levels. They can create maps to show critical habitats, deforestation zones, or areas prone to natural disasters.

- **Archaeology:** Archaeologists use ArcGIS to map excavation sites, analyze spatial relationships between artifacts, and model past landscapes.

- **Real estate:** Real estate professionals use ArcGIS to identify potential property locations, assess property values, and understand the demographics of surrounding areas.

- **Marketing:** Marketing teams can leverage ArcGIS to analyze customer demographics, target specific audiences for advertising campaigns, and identify optimal locations for new stores.

- **Public health**: Public health officials can use ArcGIS to track the spread of diseases, identify areas with high vaccination rates, and allocate resources efficiently during emergencies.

- **Business logistics:** Businesses involved in logistics and transportation can use ArcGIS to optimize delivery routes, track shipments in real-time, and identify areas with high traffic congestion.

- **Natural resource management:** Forestry and wildlife management agencies use ArcGIS to monitor forest health, track timber harvests, and manage wildlife populations.

1.2.2 PRINCIPLES & WORKFLOW OF ARCGIS

ArcGIS may be a collection of software tools, but it operates on a foundation of key principles that shape its functionality and how you work with geographic information systems (GIS) in general. Let's break down these principles and the typical workflow involved.

Guiding Principles:

- All About Location**:** ArcGIS revolves around working with data that has a specific location. This data can be anything from addresses and property lines to variations in soil composition or weather patterns.

- Layering for Insights**:** Imagine a bunch of clear sheets stacked on one another, each holding a unique dataset. ArcGIS lets you layer these datasets to uncover connections and patterns between them.

- Adapting to Scale: No matter the size of your project, ArcGIS can handle your data. It can be used for anything from mapping a neighbourhood to analysing global trends.

- Geocoding for Integration**:** Assigning geographic coordinates (like latitude and longitude) to places that might not inherently have them allows ArcGIS to integrate various datasets with location references.

- A World of Shapes and Sizes**:** The Earth isn't flat, and maps need to consider this curvature. ArcGIS uses projections and coordinate systems to ensure your geographic data is depicted accurately

The ArcGIS Workflow:

- **Gathering the Geographic Goods:** This is where you collect the data you'll be working with. Data can come from a variety of sources, like government databases, aerial photos, GPS surveys, or even internal datasets within your organization.

- **Getting Squeaky Clean:** Raw data may require some cleaning, organization, and formatting to ensure it works seamlessly with ArcGIS. This might involve geocoding addresses or making sure all your data uses the same coordinate system.

- **Turning Data into Visual Stories:** ArcGIS provides a toolbox for creating maps and other visual representations of your data. You can choose from different map styles, symbols, and layouts to best convey your message.

- **Unveiling the Hidden Gems:** Beyond maps, ArcGIS allows you to perform spatial analysis. This involves using the geographic relationships within your data to uncover patterns, trends, and valuable insights. For example, you could analyze crime hotspots or identify areas with strong winds that are ideal for wind farms.

- **Sharing the Knowledge:** ArcGIS allows you to share your maps, data, and analysis results with colleagues and others involved in your project. This can be done through online platforms or by exporting reports and presentations.

These are general principles and processes. The specific tools you'll use within ArcGIS will depend on the goals of your project and the type of data you're working with.

1.2.3 Why ArcGIS

There are several compelling reasons why ArcGIS is a popular choice for working with geographic data (spatial data) across various industries:

- **Versatility:** ArcGIS offers a comprehensive set of tools for a wide range of tasks. You can create maps, analyze data, manage large datasets, and collaborate with others – all within the same software suite. This eliminates the need for multiple programs for different aspects of your workflow.

- **Industry-Specific Solutions:** ArcGIS isn't a one-size-fits-all solution. Esri offers various extensions and tools catering to specific needs in fields like urban planning, environmental analysis, or marketing. These specialized tools can significantly streamline your work.

- **Data Visualization:** ArcGIS excels at transforming complex spatial data into clear and visually appealing maps. This allows you to effectively communicate insights and patterns to both technical and non-technical audiences.

- **Data Management**: Working with large volumes of geographic data can be challenging. ArcGIS provides robust data management functionalities for organizing, storing, and retrieving data efficiently. This ensures your data is secure and readily accessible for analysis.

- **Collaboration:** ArcGIS facilitates seamless collaboration by allowing you to share maps, data, and insights with colleagues and stakeholders. This fosters better communication and decision-making within teams.

- **Established Player**: Esri, the developer of ArcGIS, is a well-established leader in the GIS field. They offer ongoing software updates, technical support, and a large user community for knowledge sharing. This ensures you have access to a reliable and constantly evolving platform.

Ultimately, the reasons to choose ArcGIS depend on your specific needs and priorities. However, its versatility, industry-specific options, robust data handling, and collaborative features make it a powerful tool for anyone working with location-based data.

1.3 USLE MODEL

` The Universal Soil Loss Equation (USLE) is a widely used model for estimating the average annual rate of soil erosion caused by sheet and rill erosion on agricultural lands. It's a valuable tool for understanding potential soil loss and developing conservation strategies.

Here's a breakdown of the USLE model:

Equation:

A = R * K * LS * C * P

Where:

- **A** is the estimated average annual soil loss (in tons per unit area per year)
- **R** is the rainfall erosivity factor, representing the erosive power of rainfall
- **K** is the soil erodibility factor, reflecting the inherent susceptibility of soil to erosion
- **LS** is the slope length and steepness factor, considering the influence of topography on erosion
- **C** is the cover-management factor, accounting for the effects of vegetation or land cover on reducing erosion
- **P** is the support practice factor, representing the impact of conservation practices on erosion control

Understanding the Factors:

- **R Factor (Rainfall Erosivity):** This factor considers the amount, intensity, and duration of rainfall in a region. Higher rainfall intensity and longer durations lead to higher R values, indicating greater erosive power.

- **K Factor (Soil Erodibility):** This factor depends on soil properties like texture, organic matter content, and structure. Soils with finer textures and less organic matter are generally more erodible and have higher K values.

- **LS Factor (Slope Length and Steepness):** Steeper slopes and longer slopes lead to greater erosion due to increased water velocity and flow accumulation. The LS factor is calculated based on the slope gradient and length.

- **C Factor (Cover-Management):** This factor reflects the ability of vegetation or land cover to protect the soil surface from raindrop impact and runoff. Crops with dense vegetation or permanent cover like forests have lower C factors, indicating less erosion.

- **P Factor (Support Practices):** This factor considers the effect of conservation practices like contour farming, terracing, or buffer strips in reducing erosion. Implementing these practices can significantly lower the P factor and overall soil loss.

Benefits of USLE:

- Provides a quantitative estimate of potential soil erosion
- Helps identify areas at high risk of erosion
- Allows for scenario building to evaluate the impact of different land management practices
- Supports the development of effective soil conservation plans

Limitations of USLE:

- Primarily applicable to sheet and rill erosion on agricultural lands
- Does not account for wind erosion or gully erosion
- Requires accurate data for each factor, which might not always be readily available

Overall, the USLE model is a valuable tool for land managers, conservationists, and policymakers in understanding soil erosion risks and implementing effective strategies to protect our valuable soil resources.

1.3.1 APPLICATIONS OF ARCGIS

The USLE model (Universal Soil Loss Equation) has a wide range of applications in various fields, particularly those concerned with soil conservation and land management. Here are some key applications:

- **Assessing Soil Erosion Risk:**
  The primary application of USLE is to estimate the average annual soil loss in a specific area. By calculating the individual factors (R, K, LS, C, and P)

applying the USLE formula, land managers can identify areas with high erosion potential represented in (Fig 1.4)

- **Prioritizing Conservation Efforts:**
  Based on the USLE-derived soil erosion risk map, conservation efforts can be prioritized. Areas with the highest erosion rates require immediate attention and implementation of appropriate conservation practices.

- **Evaluating Land Management Practices:**
  The USLE model allows for scenario building. Land managers can test the impact of different land use changes or conservation practices (like planting cover crops or building terraces) on potential soil loss. This helps choose the most effective strategies for reducing erosion.

- **Land-Use Planning and Policy Development:**
  USLE can inform land-use planning decisions. By identifying areas susceptible to erosion, planners can avoid development or promote practices that minimize soil loss in those areas. It can also support the development of soil conservation policies at the regional or national level.

- **Research and Education:**
  USLE plays a crucial role in research related to soil erosion. Scientists use it to understand the factors influencing erosion rates and evaluate the effectiveness of different conservation techniques.
  The model also serves as an educational tool for farmers, land managers, and policymakers, raising awareness about soil erosion and the importance of conservation practices.

Fig 1.3 Applications of ArcGIS

1.4 OBJECTIVES OF PRESENT STUDY

As mentioned above, Identification of Groundwater Potential Zone using Remote Sensing and GIS Technique. The specific aims of the present study are:

- To estimate the soil erosion
- To estimate the potential soil loss of the Cheyyeru River
- To identify erosion-prone areas

CHAPTER-2

LITERATURE REVIEW

2.1 GENERAL

- **Iradukunda et al., (2021).,** Human activities around Murera dam have increased sediment in the reservoir, reducing its water storage capacity by 14%. The study used special boats with GPS and sonar to map the reservoir's depth and sediment layers. Results show that sediment accumulates more in the southern part of the reservoir, with depths reaching up to 0.8 meters.

  This information is valuable for Kenyan policymakers as they develop strategies to manage sedimentation and protect the country's water resources. The study demonstrates the effectiveness of multifrequency acoustic systems for assessing sediment distribution in reservoirs.

- **Maqsoom. A et al., (2020).,** Soil erosion is a major threat in Chitral, particularly the southwest. The study used advanced techniques (RUSLE, GIS, and remote sensing) to map soil loss. Results show alarming rates of erosion, with some areas losing an average of 78 tons of soil per hectare each year! The most affected areas, including Asfik, Ispheru Arkari, Shoghar, Harchin, and Kalash, are highly susceptible due to factors like topography and soil type.

  This situation threatens land degradation and impacts local communities. The study's findings on sediment yield, erosion severity, and intensity can be used by planners and policymakers to take action. They can prioritize conservation efforts in high-risk areas and develop strategies to control erosion. The study highlights the value of this approach (RUSLE with GIS) for tackling soil erosion on a wider scale across Pakistan.

- **Boakye, E et al., (2020).,** This research investigated soil erosion in Ghana's Pra River Basin using advanced modeling (RUSLE, SEDD) combined with GIS mapping. The study reveals serious erosion issues, with estimations of annual soil loss exceeding 1 million tons and roughly 21% of the basin facing severe erosion. Farmlands, mining areas, and settlements are particularly susceptible. The model also predicts sediment yield averaging 2.7 tons per hectare annually.

These findings are valuable for resource management and planning. Prioritizing conservation efforts in severely eroded areas is crucial to reduce sediment entering rivers and streams, which can cause pollution. The study highlights the usefulness of this modeling approach (RUSLE, SEDD with GIS) for assessing soil erosion, especially in areas with limited data. An important point is the need for accurate soil data to ensure the model's effectiveness.

- **Huang, X et al., (2019).,** Floodplain vegetation in dry areas is vital for healthy ecosystems. However, building embankments along rivers disrupts the natural water flow, affecting this vegetation**.** This study proposes a new method to assess this impact. The method combines on-site water monitoring, satellite imagery analysis (NDVI), and geographic information systems (GIS).

  The researchers applied this approach to the Tarim River in China, where a recent embankment construction offered a perfect case study. They analyzed changes in groundwater levels, vegetation health (NDVI), and land use before and after the embankment.

- **Wynants, M et al., (2019).,** Historically, government policies aimed at increasing agricultural output have disrupted traditional land management practices in East Africa**.** This mismatch between top-down approaches and the region's dynamic environment led to problems like soil exhaustion and erosion. Additionally, these policies often marginalized local communities and their knowledge.

  As a result, many communities lack the resources and options to adapt to population growth and pressures on the land**.** This forces them to overuse natural resources, worsening the situation. Sustainable solutions require considering these historical and ongoing issues.

The key to success lies in supporting and building upon existing local knowledge and practices**.** Simply providing modern technologies won't solve the problem. Instead, we need to empower communities by integrating their expertise into regional and national plans. This collaborative approach, with strong local institutions connected to broader frameworks, can promote sustainable land management that safeguards soil health, food security, and livelihoods.

- **Zhao, F et al., (2018).,** This research investigates different methods for uncertainty analysis in hydrological modeling. The study uses a specific model (SWAT) and a case study in China's Jingchuan River Basin. The researchers compared three techniques (ParaSol, SUFI2, GLUE) to assess how well they capture uncertainties in model parameters.

  All three methods proved useful for identifying which parameters in the SWAT model are most influential for different flow rates (peak flow, average flow, low flow). However, they differed in their ability to analyze the overall uncertainty in model predictions.

  Parasol, while efficient at finding the most optimal parameter set, underestimated the uncertainty range. In contrast, SUFI2 and GLUE provided wider uncertainty ranges, indicating a more comprehensive analysis. When considering both effectiveness and efficiency, SUFI2 emerged as the superior method for uncertainty analysis in this case.

  This study provides valuable insights for hydrologists choosing uncertainty analysis methods, particularly those using the SWAT model.

- **Diwediga, B. et al., (2018).,** This study examined soil erosion in the Mo River basin of Togo. They used a modeling tool (LAMPT Mo) to track how soil erosion changed over time (1972-2014) and identify areas most susceptible to erosion. The study found that soil loss has been increasing over time and is exceeding sustainable levels, especially on steep slopes, poorly managed lands, and areas near rivers.

The research also investigated the effectiveness of different land management strategies. The results showed that implementing targeted soil conservation measures in erosion hotspots could significantly reduce soil loss, bringing it closer to acceptable levels. Overall, this study provides valuable insights for planning and implementing strategies to combat soil erosion in the Mo River basin.

- **Tadesse, L. et al., (2017**)., The study emphasizes the value of satellite data for monitoring the effectiveness of land management programs. The observed improvements in vegetation cover and reduced erosion suggest a positive impact of the program in the Yezat watershed. These findings can be valuable for developing future strategies to promote sustainable land use and livelihoods in the region.

- **Fagbohun, B et al., (2016**)., This study assessed soil erosion in Anambra, Nigeria, to identify areas needing conservation efforts. They used a Revised Universal Soil Loss Equation (RUSLE) model that considers factors like rainfall, soil type, slope, and vegetation cover.

  The results showed that a significant portion of the area (over 38%) experiences slight erosion (less than 10 tons per hectare per year). However, a concerning 22% of the land has severe erosion exceeding 235 tons per hectare per year.

- **Uddin, K et al., (2016**)., This study investigated soil erosion across the entire Koshi basin, a large Himalayan river basin. Traditionally, measuring erosion relies on field studies, which are impractical at this scale. Therefore, the researchers employed a new approach using remote sensing data and geographic information systems (GIS) to estimate soil erosion throughout the basin.

The study covered two decades (1990-2010) and revealed that the total annual soil erosion remained high at around 40 million tonnes. While the erosion risk stayed the same in most areas, it concerningly increased in over 9% of the basin. The study identified these areas with high and increasing erosion risk as top priorities for future conservation efforts.

This approach using remote sensing and GIS offers a valuable alternative to traditional field measurements for large-scale assessments. The information generated can be crucial for planning and prioritizing soil conservation strategies across the Koshi basin and potentially similar basins in the Himalayas.

- **Biswas, S.S et al., (2015).,** The study highlights the limitations of the traditional RUSLE method, particularly the absence of spatial data. The RUSLE with GIS approach offers a significant advantage by providing a detailed map of erosion risk across the basin, allowing for more targeted land management strategies.

  Both methods emphasize the importance of soil conservation practices like crop rotation and controlled grazing to reduce erosion, especially in plateau and fringe areas. These practices can help sustain the environment and reservoir longevity.

  An important caveat is that neither study included field data for calibration or validation, potentially affecting the accuracy of the results. Future studies that incorporate field measurements would provide even more reliable data for soil erosion assessment.

- **Sun, L et al., (2013**)., This study investigated the use of biochar derived from three waste materials (anaerobic digestion residue, palm bark, and eucalyptus) to remove methylene blue dye from water.

The biochars were all found to have a porous structure, and their effectiveness in dye removal varied. The biochar from anaerobic digestion residue (BC-R) showed the highest efficiency (almost 100% removal), followed by palm bark (BC-PB) and eucalyptus (BC-E).

Regardless of the biochar type, the removal process appeared to follow a specific pattern, suggesting a well-defined mechanism. The study also suggests that BC-R has the greatest potential for large-scale application due to its superior adsorption capacity.

Overall, the findings indicate that biochars derived from waste materials have promise for treating dye-contaminated water.

- **Prasannakumar, V et al., (2012**)., Researchers used a combination of RUSLE and GIS to assess soil erosion in a mountainous sub-watershed in Kerala, India. They found that areas with natural forest cover had the least erosion, while areas with human activity, especially on steep slopes, had the most erosion. This information can be used to create plans for managing the land and reducing soil erosion. While the current model is helpful, even more accurate predictions could be made with more detailed data on rainfall, soil, and other factors.

- **Panagos, P et al., (2012)**., Soil erosion modeling is often difficult because there isn't enough data on soil properties, especially a measure called the K-factor. This factor is important for understanding how easily soil erodes. Researchers used data from a large European soil survey to calculate the K-factor across the entire continent. This is a big improvement over previous methods, which relied on less detailed information. This new dataset should be a valuable resource for anyone studying soil erosion in Europe.

- **Bonilla, C. A et al., (2012)** Soil erosion by water is a serious problem in Central Chile, but predicting it has been difficult because scientists haven't had enough data on how easily different soils erode (called erodibility). This study used existing soil survey data to estimate erodibility for the first time across a large area of central Chile. They found that soil erodibility increased with the amount of silt in the soil and that soils high in silt were most susceptible to erosion. They also found that organic matter content wasn't a good predictor of erodibility. This information suggests that silt content is a good way to assess how susceptible soil is to erosion in this region, at least for preliminary assessments.

- **Tian, Y.C. et al., (2009).,** Researchers used satellite imagery and other data to assess the risk of soil erosion in the upper basin of Miyun Reservoir in 2003. They found that over 46% of the total area, or roughly 715,848 hectares, was susceptible to erosion. The majority of this area faced a slight or moderate erosion risk, with very little falling into the high-risk category. This suggests that while soil erosion is a concern in this region, it's mostly a low-to-moderate threat.

- **Dabral, P.P. et al., (2008**)., Scientists investigated soil erosion in the Dikrong River basin of India. They divided the basin into a grid and used a computer model to estimate how much soil was lost each year across the area. The model considered factors like rainfall, soil type, slope, vegetation cover, and land management practices. Their results showed that the average annual soil loss was 51 tons per hectare. While some areas had slight erosion, a significant portion of the basin (over 70%) fell into moderate to very severe erosion categories. This suggests that soil erosion is a serious problem in this region and that steps need to be taken to conserve the soil.

- **Hoyos, N et al., (2005**)., Scientists assessed soil erosion in a coffee-growing region of the Colombian Andes using a computer model. The model considered factors like rainfall, soil type, slope, vegetation cover, and land management practices. They found that during dry seasons, about 11% of the land faced a high risk of erosion (over 3.5 tons per hectare per season). This area increased to 28% during wet seasons. Areas with forest or shrub cover had lower erosion risk compared to those with coffee or pasture. Interestingly, the study suggests that converting coffee fields to pasture might actually decrease erosion risk.

This is likely because good management practices for pastures can significantly reduce erosion. Overall, the study highlights the importance of considering land cover and management practices when trying to conserve soil.

- **Fan, J.R et al., (2004)**., Scientists studied the Lizixi watershed in China to assess the effectiveness of soil conservation practices. They used satellite imagery and geographic information systems (GIS) to compare the land cover and erosion rates before and after conservation efforts were implemented. Their analysis showed a significant decrease in soil erosion (over 4%) and sediment carried by rivers (over 50%) following the conservation measures. This suggests that the soil conservation practices applied in the Lizixi watershed were successful in reducing soil erosion.

- **An et al., (2002**)., Researchers studied the effects of land-use changes on soil erosion in the Emilia-Romagna region of Italy. They used a computer model to estimate soil erosion across the entire region, dividing it into a grid of squares. The model considered factors like rainfall, soil type, slope, and land cover. Historical land-use data was also included to see how changes in land use over time have affected erosion rates. The study found that land-use changes have increased the vulnerability of the region's uplands to soil erosion in recent decades. This suggests that land-use planning and soil conservation practices are important for protecting the soil in this area.

- **Van Remortel, R.D et al., (2001**)., The USLE and RUSLE are models used to assess soil erosion. A previous computer program was designed to work with USLE on a large scale (geographic information systems). This paper describes changes made to that program so it can now be used with the RUSLE model. The changes involve updating the calculations and some assumptions about the slope of the land. The updated program seems to produce results that are consistent with the RUSLE guidelines, at least in the areas tested.

CHAPTER- 3

METHODOLOGY

3.1 DESCRIPTION OF THE STUDY AREA

Andhra Pradesh is bordered by the Palar River to the north and the Pennar River to the south represented in (Fig 3.2). The area predominantly consists of dune soils, characteristic of its landscape. Covering an area of 15,000 square kilometers, the Rajampet Cheyyeru River basin represents approximately 4.2% of the total land area of Andhra Pradesh. The primary land types include agriculture (60%), forest (30%), and urban areas (10%).

Rajampet Cheyyeru River basin experiences two distinct climate zones. The northern region falls under a semi-arid climate, with an average annual rainfall ranging from 600 to 800 mm. The southern parts experience a more humid tropical climate, with annual rainfall between 800 and 1000 mm.

The climate exhibits seasonal variations, characterized by dry and hot conditions from March to June, with temperatures soaring up to 40°C. The monsoon season, from July to September, brings heavy rainfall and cooler temperatures. From October to February, the area experiences a dry and cooler period, with temperatures averaging around 20°C.

Furthermore, there exists a rainfall gradient within the basin, with higher rainfall amounts recorded in the southern regions compared to the northern areas. Over the past decade, the average annual rainfall was recorded at 850 mm in the southern parts (Cheyyeru rainfall station) and 600 mm in the northern regions (Rajampet rainfall station).

Table 3.1 Population in Rajampet (Census 2011)

Population	**Males**	**Females**	**Households**
56,651	28,419	28,232	13,920

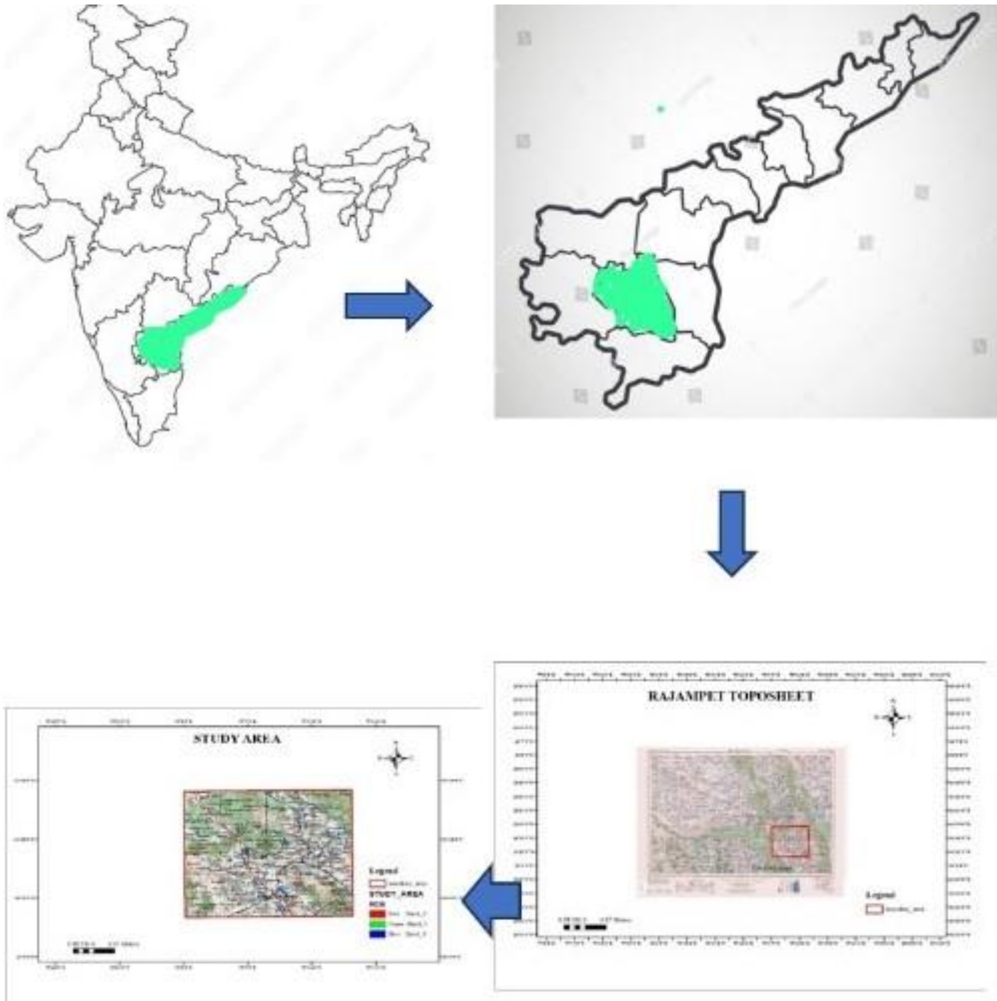


Fig 3.1 Study Area

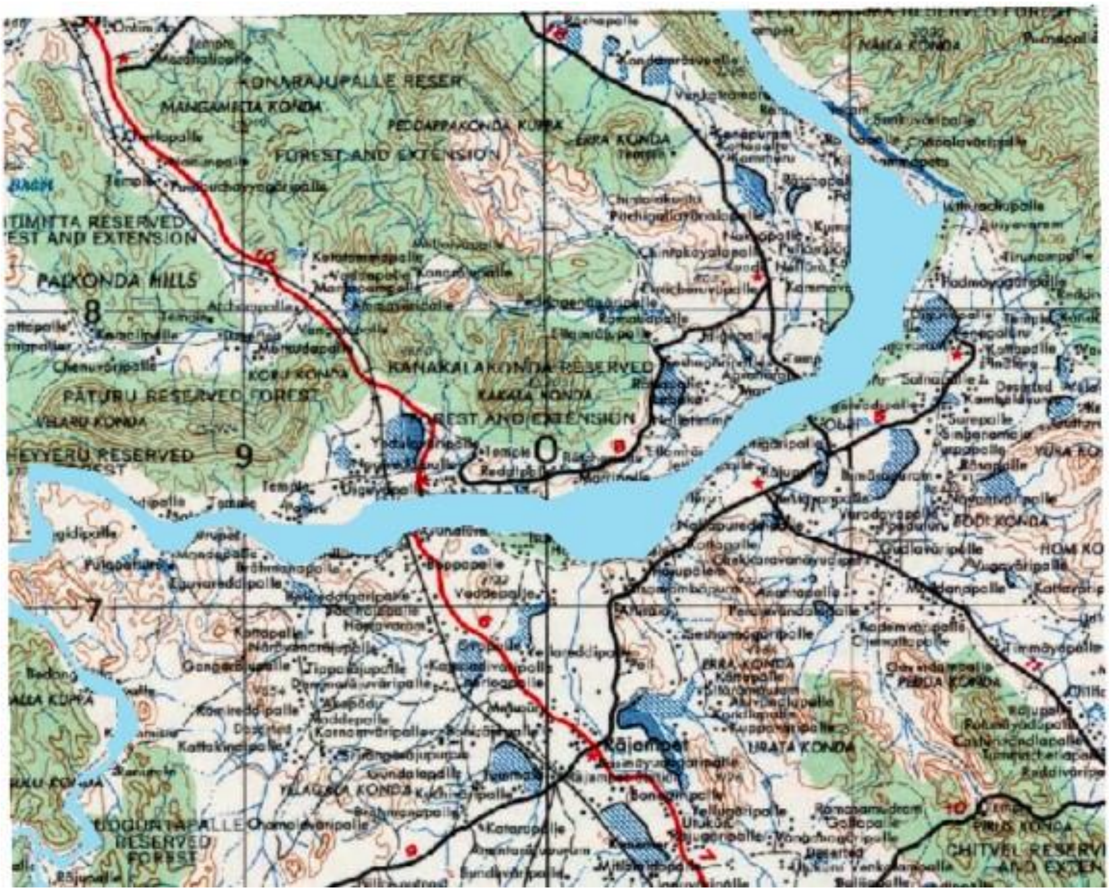


Fig 3.2 Extracted Study Area near Cheyyeru River

3.2 SOFTWARE USED

3.2.1 ArcGIS (10.8) software

ArcGIS, developed by Esri (Environmental Systems Research Institute), stands as a leading geographic information system (GIS) software utilized across diverse fields and industries. Renowned for its robust capabilities, ArcGIS enables users to effectively manage, analyze, visualize, and share spatial data. Its mapping and visualization tools facilitate the creation of comprehensive maps and visualizations, incorporating various data sources like satellite images and demographic data. Moreover, ArcGIS offers an extensive suite of spatial analysis tools, empowering users to derive insights and make informed decisions through tasks such as overlay analysis and proximity assessment. Data management functionalities within ArcGIS ensure efficient organization and manipulation of geographic datasets, supporting various formats and integration with databases.

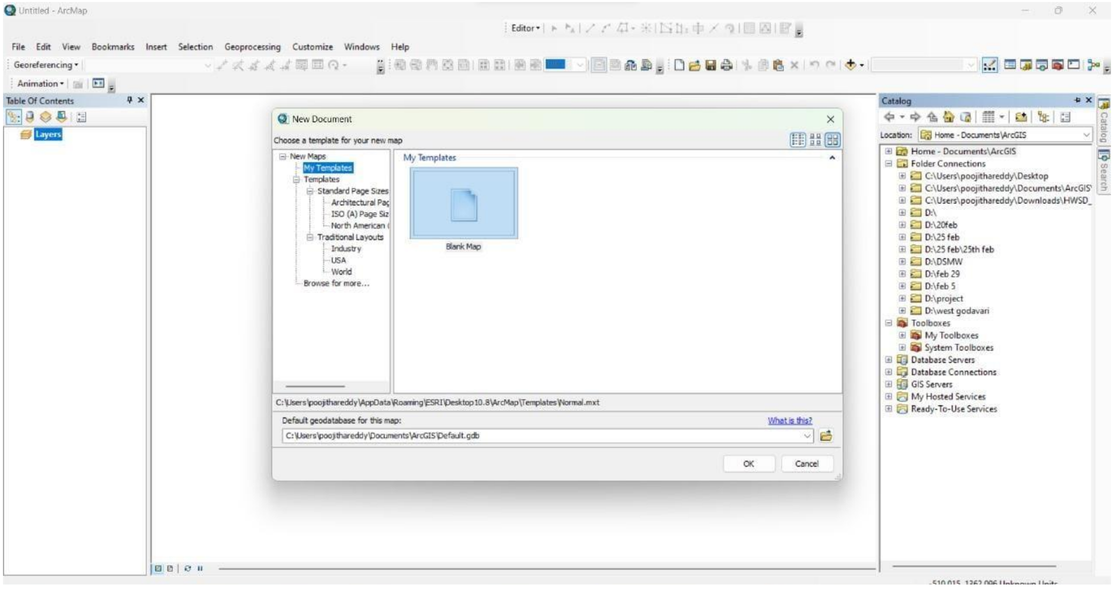


Fig 3.3 Interface of the ArcGIS 10.8

3.2.2 ArcGIS Toolbar

ArcGIS 10.8 streamlines your work with toolbars shown in (Fig3.4) which group shortcuts to common functions. Built-in toolbars like Standard (zooming, panning) and Data View (map layer management) are readily available. Need editing features? Activate the Edit toolbar for creating, modifying, and deleting spatial data. This can arrange the toolbars to suit your workflow perfectly. while ArcGIS 10.8 offers these functionalities, Esri recommends migrating to the more modern ArcGIS Pro for new projects.

- **3D Analyst Tools:** (Requires 3D Analyst extension) Work with 3D surfaces, allowing you to analyze terrain, create visibility maps, and perform other 3D-related tasks.
- **Analysis Tools**: Offer a wide range of functions for spatial analysis, including proximity analysis, hotspot identification, and overlay operations.

- **Cartography Tools**: Focus on creating visually appealing and informative maps. You can use these tools to add labels, change symbology, and create legends
- **Conversion Tools:** Facilitate the conversion of data from one format to another, ensuring compatibility with your project
- **Data Interoperability Tools:** Help you work with data from various sources, even if they use different formats or standards.
- **Data Management Tools**: Provide essential functions for organizing, manipulating, and maintaining your geospatial data.
- **Editing Tools:** This allows you to create, modify, and delete features in your map.
- **Geocoding Tools:** Assist with converting addresses or other location descriptions into spatial coordinates.
- **Geostatistical Analyst Tools:** (Requires Geostatistical Analyst extension) Offer specialized techniques for analyzing spatial patterns and relationships in your data.
- **Linear Referencing Tools:** Facilitate working with linear features, such as roads or pipelines, by enabling analysis based on distance or other measures along the feature.
- **Multidimensional Tools:** Manage and analyze data with multiple dimensions, such as time-series data.
- **Network Analyst Tools:** (Requires Network Analyst extension) Equip you with tools for analyzing transportation networks, finding optimal routes, and performing other network-related tasks.
- **Parcel Fabric Tools:** (Requires Parcel Fabric extension) Designed specifically for managing and analyzing land parcels.
- **Schematic Tools:** Help you create and maintain schematic diagrams that represent networks of features.
- **Server Tools:** Facilitate publishing maps and geospatial services on a server, allowing others to access and interact with your data.

- **Space-Time Pattern Mining Tools:** (Requires Space-Time Pattern Mining extension) Provide tools for analyzing spatiotemporal patterns, such as identifying disease outbreaks or crime hotspots.
- **Spatial Analyst Tools:** (Requires Spatial Analyst extension) Offer a comprehensive suite of tools for spatial analysis, including creating surface models, performing raster calculations, and conducting zonal statistics.
- **Tracking Analyst Tools:** (Requires Tracking Analyst extension) Enable you to analyze and visualize the movement of features over time.

The specific toolbars available depend on your ArcGIS license and extensions. This provides a starting point for understanding the vast capabilities of ArcGIS toolbars.

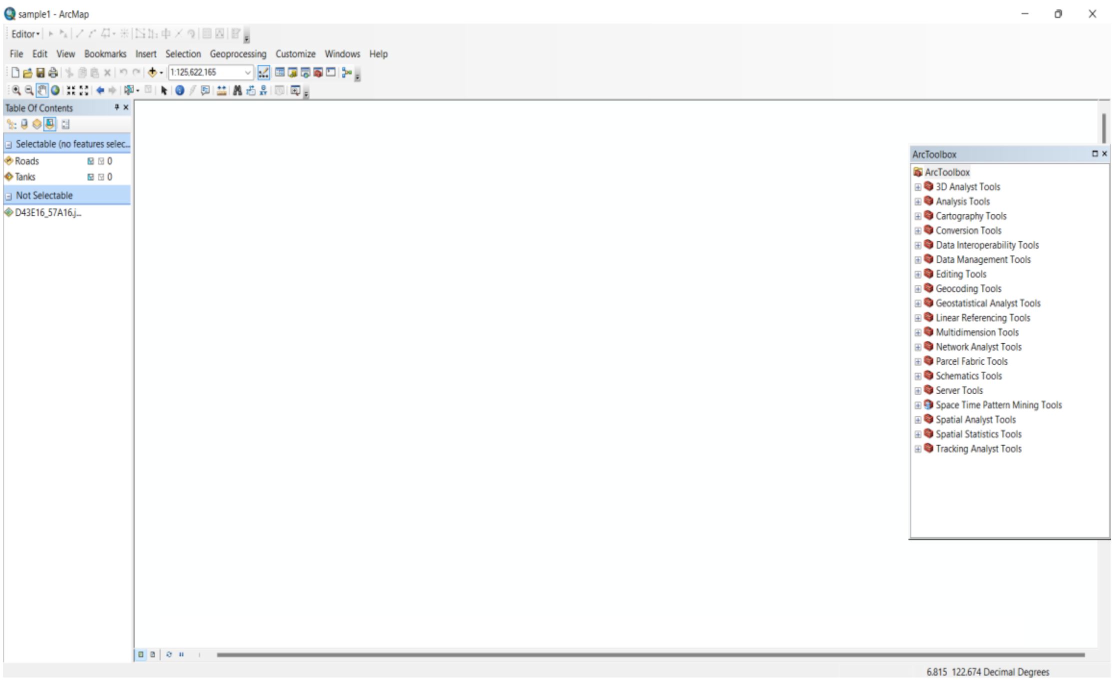


Fig 3.4 ArcGIS Toolbar

3.3 MAPPING OF SOIL EROSION

Mapping soil erosion risk near the Cheyyeru River using remote sensing and GIS offers valuable insights into land management practices. However, thorough validation through field observations and historical data is crucial to ensure the reliability of the results before using them for decision-making, such as implementing soil conservation strategies.

Data Gathering and Preparation:

- **Collect relevant datasets:**

Remote Sensing Data: High-resolution satellite imagery (e.g., Landsat, Sentinel-2) can reveal land cover types, vegetation density, and soil conditions.

Digital Elevation Model (DEM): This topographic data provides information on slope characteristics (length and steepness) which significantly influence erosion.

Soil Data: Soil maps or databases containing information on soil erodibility (K factor) are crucial.

Rainfall Data: Historical precipitation data helps estimate the erosivity factor (R) in the USLE.

- **Assigning Weights:**

Assign weights to each data layer based on its influence on soil erosion near the Cheyyeru River. Factors like slope and soil erodibility might hold more weight than vegetation density in some cases.

- **Overlay Analysis:**

Utilize ArcGIS or other GIS software to overlay the prepared datasets.

Employ spatial analysis tools to combine the weighted data layers, considering the USLE (Universal Soil Loss Equation) framework. This might involve reclassifying data and performing calculations.

- **Validation:**

Verification is essential to ensure the accuracy of the erosion risk map.

Field Observations: Assess potential erosion areas identified by the model through ground truthing (on-site observations).

Historical Erosion Data: If available, compare the model's predictions with historical records of erosion events near the Cheyyeru River.

3.4 GLOBAL RAINFALL EROSIVITY (R)

Rainfall erosivity plays a pivotal role across a spectrum of environmental and land management applications. Central to this role is its integration into soil erosion models such as the Universal Soil Loss Equation (USLE). Through ArcGIS's capabilities, rainfall erosivity data is incorporated into these models, aiding in the estimation of soil erosion rates and the identification of erosion-prone areas. By analyzing spatial patterns of rainfall erosivity, users can generate erosion risk maps, which serve as valuable tools for land managers and policymakers to prioritize conservation efforts and implement erosion control strategies. Moreover, rainfall erosivity data in ArcGIS informs land use planning by highlighting areas susceptible to erosion, facilitating sustainable land management decisions. Additionally, in water resource management, rainfall erosivity assessments aid in predicting sedimentation in water bodies, enabling proactive measures to safeguard water quality and ecosystem health. ArcGIS also supports climate change studies by analyzing historical erosivity patterns and simulating future scenarios, contributing to resilience planning and adaptation strategies. In essence, ArcGIS serves as a comprehensive platform for analyzing, visualizing, and integrating rainfall erosivity data, empowering users to address soil erosion challenges and promote sustainable land management practices.

- Source : https://esdac.jrc.ec.europa.eu/content/global- rainfall-erosivity

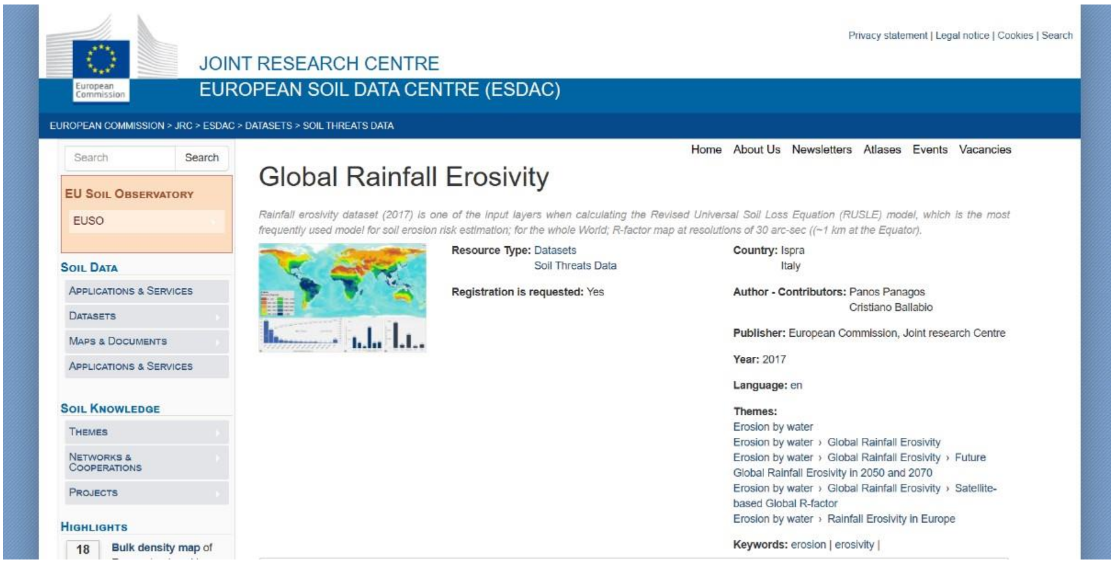


Fig 3.5 Interface of the Global Rainfall Erosivity Website

3.5 HWSD DATA(K)

The K-factor in soil erosion modeling reflects the soil type's susceptibility to erosion, sediment transportability, and the characteristics of runoff under specific rainfall conditions. In the context of ArcGIS, the process of incorporating the K-factor for soil erodibility assessment follows a systematic approach. Firstly, soil maps of the study region are acquired, typically sourced from reliable databases such as the FAO Digital Soil Map of the World Shapefile (DSMW) Shown in (Fig 3.6). Using ArcGIS software, the area of interest is delineated, and the soil data layer is clipped accordingly to focus solely on the study area. Next, K-factor values corresponding to different soil types are obtained from existing literature or soil databases.

Table 3.2 Estimating soil erodibility(K) based on soil texture and organic material content

Textural Class	Spanish Texture Class	Soil composition			Mean K (based on % organic material)		
		Sand	Silt	Clay	unknown	< 2%	≥ 2 %
Clay	Arcilloso	0-45	0-40	40-100	0.22	0.24	0.21
Sandy Clay	Arcilloso arenoso	45-65	0-20	35-55	0.2	0.2	0.2
Silty Clay	Arcilloso limoso	0-20	40-60	40-60	0.26	0.27	0.26
Sand	Arenoso	86-100	0-14	0-10	0.02	0.03	0.01
Sandy Loam	Franco arenoso	50-70	0-50	0-20	0.13	0.14	0.12
Clay Loam	Franco - arcilloso	20-45	15-52	27-40	0.3	0.33	0.28
Loam	Franco	23-52	28-50	7-27	0.3	0.34	0.26
Loamy Sand	Franco arenoso	70-86	0-30	0-15	0.04	0.05	0.04
Sandy Clay Loam	Franco arenso arcilloso	45-80	0-28	20-35	0.2	0.2	0.2
Silty Clay Loam	Franco limoso arcilloso	0-20	40-73	27-40	0.32	0.35	0.3
Silt	Limoso	0-20	88-100	0-12	0.38	0.41	0.37
Silty Loam	Franco limoso	20-50	74-88	0-27	0.38	0.41	0.37

OM = 1.7*OC

These values represent the erodibility of each soil type and serve as crucial parameters for soil erosion modeling. the soil maps and associated K-factor values are integrated into ArcGIS, where they are utilized to derive soil classes for the study area. This involves assigning appropriate K-factor values to each soil type based on the literature or empirical data Once the K-factor values are assigned to the soil classes, ArcGIS is used to analyze the data and generate a K-factor map for the study area. This map spatially represents the distribution of soil erodibility across the landscape, providing valuable insights into areas prone to erosion and aiding in the prioritization of erosion control measures.

Source: https://webarchive.iiasa.ac.at/Research/LUC/External-World-soil-database/HTML/)

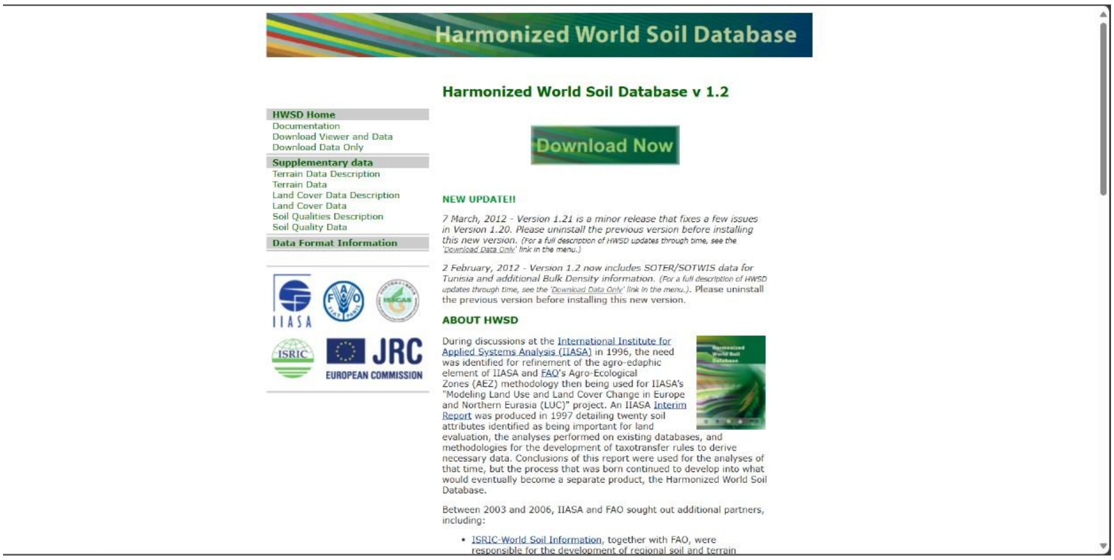


Fig 3.6 Interface of the HWSD website

3.6 SRTM DATA (LS)

ArcGIS proves to be a valuable tool for working with Digital Elevation Models (DEMs), which represent the Earth's surface as a grid of elevation values. DEM processing and analysis have raw elevation data (like LiDAR or stereo imagery), and ArcGIS's Spatial Analyst extension allows you to process and analyze it. This might involve tasks like filtering outliers, correcting for errors, or filling in missing data holes. Once prepared, you can use various tools to derive meaningful information from the DEM, such as slope, aspect, or flow direction - all crucial for understanding terrain characteristics. Utilizing Existing DEMs many government agencies or research institutions provide pre-processed DEMs for various regions. ArcGIS allows you to import these directly as raster layers. Once imported, you can perform similar analyses as mentioned earlier or use the DEM for visualization purposes, creating 3D terrain models or hillside maps to better understand the landscape.

- L = [(FA * cell size)/22.13]m (Moore and Wilson, 1992) where, FA is flow accumulation, cell size is the size of DEM and m ranges from 0.2-0.6.
- S= [(sin beta * 0.01745) / 0.09] ^ n where, ß is slope angle in percentage, n ranges from 1.0-1.3.

The computation of the Slope Length and Steepness (LS) factor, which is analogous to the topographic factor and relief factor in the Universal Soil Loss Equation (USLE) model, involves a series of essential steps in terrain analysis and hydrological modeling. The parameters associated with topography are derived from a Digital Elevation Model (DEM) dataset within ArcGIS. The DEM provides elevation information for each cell in the study area, allowing for the calculation of slope and aspect, which are fundamental components of the LS factor. The Flow Accumulation (FA) map is particularly crucial for LS-factor calculation. By calculating the flow direction with the DEM, the FA map determines the accumulation of flow for each cell based on the flow paths originating from surrounding cells. Areas with higher FA values indicate a higher potential for runoff and erosion. the LS factor is calculated as a combination of slope length and slope steepness effects. The slope length factor (L) accounts for the erosive impact of slope length, while the slope steepness factor (S) evaluates the effect of slope steepness on erosion. These factors are computed using appropriate algorithms within ArcGIS, incorporating information from the flow direction and flow accumulation maps.

Source: https://dwtkns.com/srtm30m

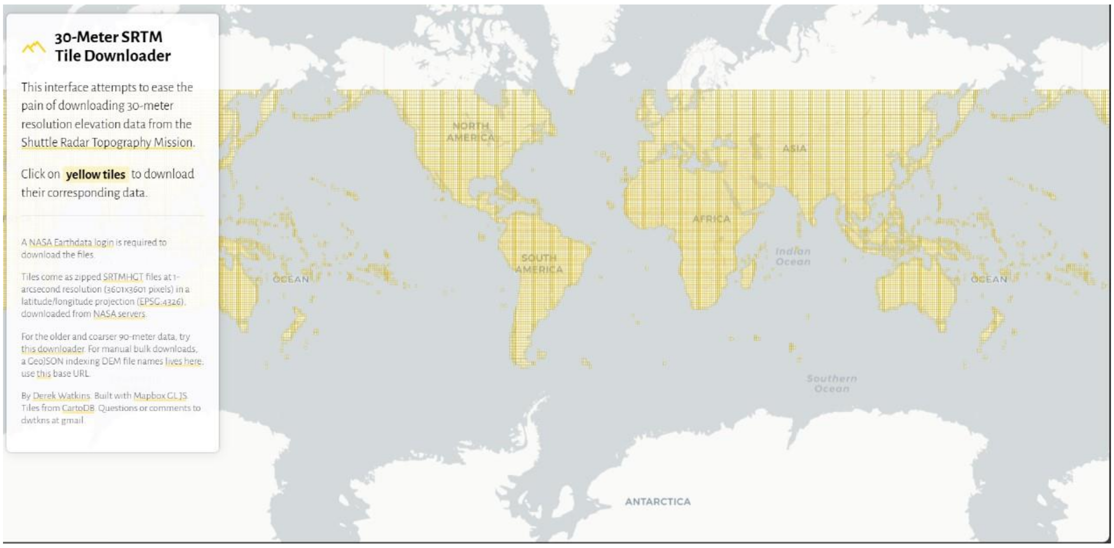


Fig 3.7 Interface of SRTM Data website

3.7 SENTINEL-2 LAND USE/LAND COVER DATA(C)

ArcGIS tackles soil erosion analysis through the USLE model, and a key factor within USLE is the C factor, representing land cover management's influence. Land Cover Obtain land cover data (raster layer) for your area, where each pixel signifies a specific land cover type (forest, cropland, etc.). Reclassify or Raster Calculator Utilize ArcGIS's reclassify tool or raster calculator. Based on your chosen method (land cover or NDVI), assign corresponding C factor values to each pixel in your respective raster layer. C factor map This output becomes your C factor map, a raster layer where each pixel represents the estimated C factor value for that location. With the C factor map and other USLE factors (rainfall erosivity, soil erodibility, slope, conservation practices), you can employ the USLE model within ArcGIS or specialized software to estimate potential soil erosion rates across your study area.

Source:https://www.arcgis.com/apps/instant/media/index.html?appid=fc92d38533d440078fl

Table 3.3 ESRI 2020 classes LULC map 10 classes

LULC class number	Class name	C value
1	Water	0
2	Trees	0.025
3	Grass	0.02
4	Flooded Vegetation	1
5	Crops	0.05
6	Shrubs	0.4
7	Built Area	1
8	Bare ground	1
9	Snow/Ice	0
10	Clouds	0

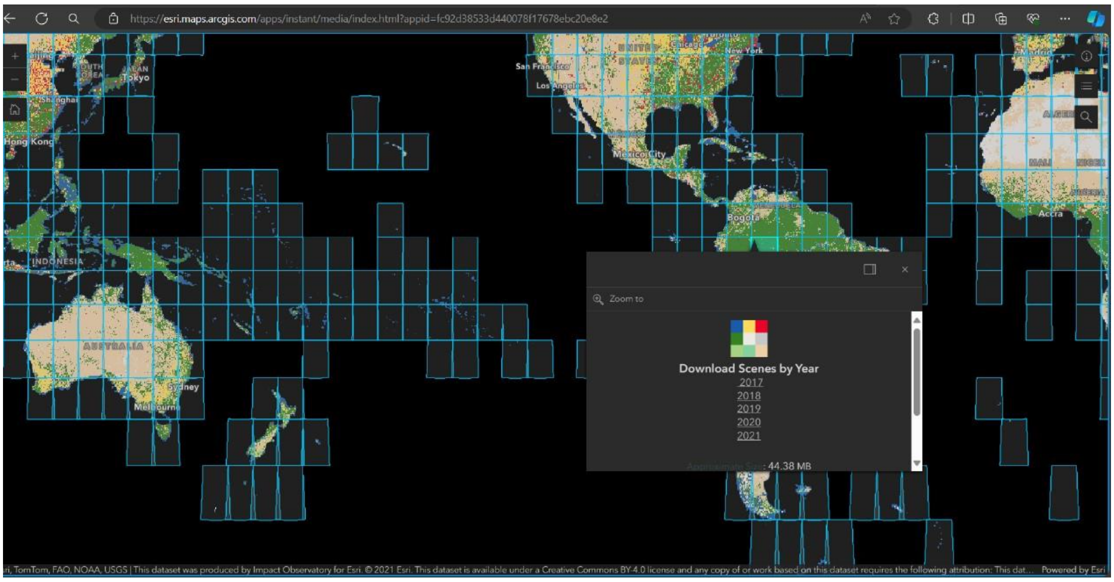


Fig 3.8 Interface of the Sentinel Website

3.8 SUPPORT PRACTICE FACTOR (P)

It signifies the impact of practices aimed at diminishing water runoff volume and velocity, consequently lowering erosion rates.

Values are obtained from literature based on the farmer's practices.

For easy interpretation, we can use 1, irrespective of land cover classes.

3.9 USGS EARTH EXPLORER

Free access to a variety of remote sensing data, including images from the Landsat, Dem, Sentinel, and other satellites, is provided using a device called USGS Earth Pioneer. USGS Earth Pioneer is an invaluable tool for scientists and application engineers in many environments to access remote sensing information for a variety of purposes, including land cover planning, natural observing, and disaster response.

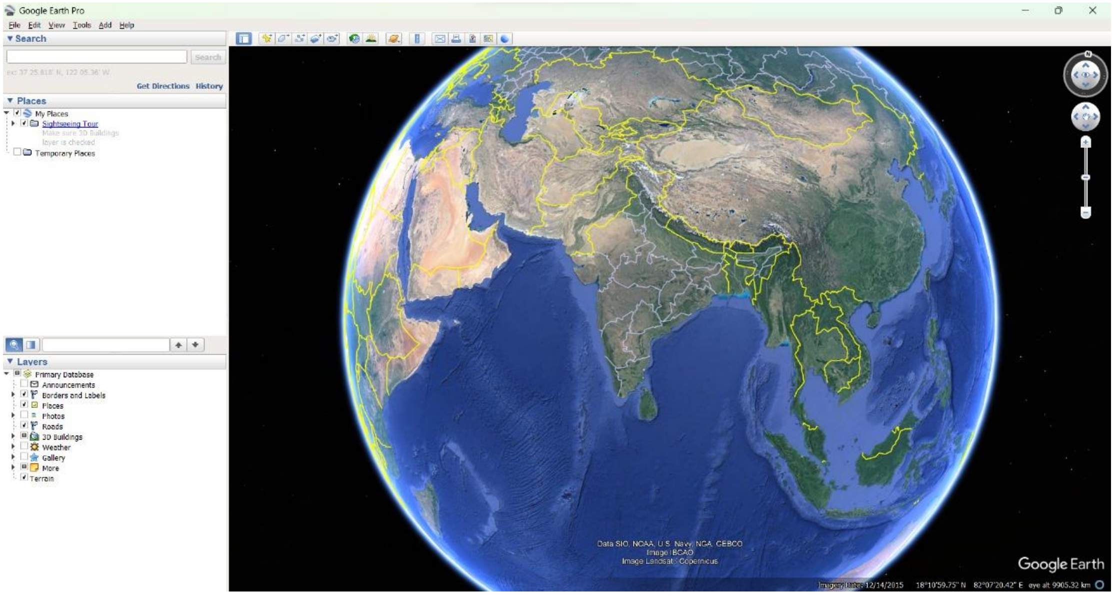


Fig 3.9 Interface of Google Earth pro

3.10 FLOWCHART OF METHODOLOGY

The methodology for implementing the Universal Soil Loss Equation (USLE) model within ArcGIS software involves a systematic series of steps aimed at assessing soil erosion risks and guiding land management decisions. Initially, spatial datasets including Digital Elevation Models (DEMs), soil data, land cover data, and rainfall data are acquired and pre-processed to ensure compatibility and reliability. Rainfall erosivity (R-factor) and soil erodibility (K-factor) are then determined using appropriate calculations based on rainfall and soil characteristics, respectively. Topographic factors (LS-factor) are derived by generating flow direction and accumulation maps from the DEM data and subsequently computing slope length (L) and steepness (S) effects. Concurrently, land cover (C-factor) and, if available, conservation practice (P-factor) factors are assigned based on land cover classifications and conservation practices. These factors are integrated into the USLE equation to calculate soil erosion estimates across the study area. Spatial analysis techniques within ArcGIS are then applied to visualize erosion patterns and identify vulnerable areas. Validation of the results may involve comparing estimated erosion rates with field observations or historical data.

Ultimately, the findings from the soil erosion assessment are used to inform land management strategies, conservation efforts, and policy-making processes.

The iterative nature of the methodology allows for continuous refinement and improvement, ensuring the accuracy and relevance of the soil erosion assessment over time. Through this comprehensive approach, ArcGIS serves as a powerful tool for evaluating soil erosion risks and promoting sustainable land use practices.

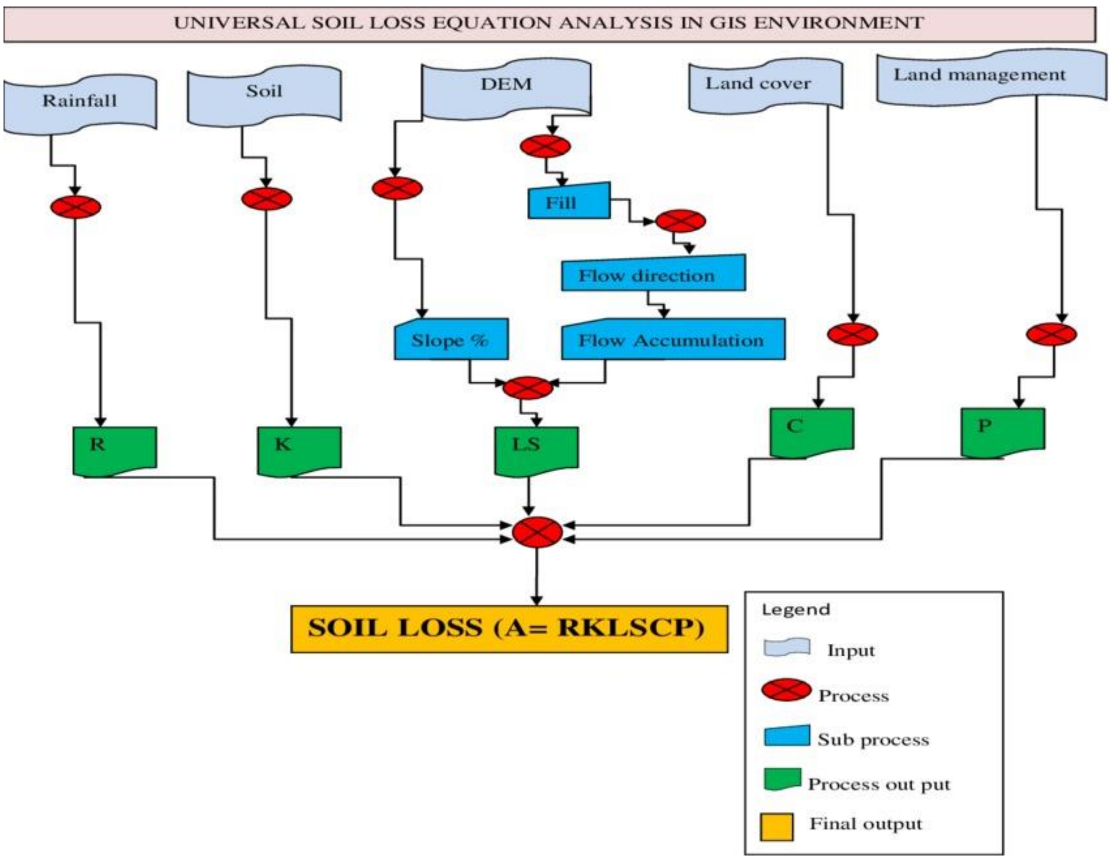


Fig. 3.10 Flowchart for the analysis of soil loss based on the USLE model.

Note:

DEM - Digital Elevation Model

LS - Slope length and Steepness

R - Rainfall Erosivity Factor

K - Soil Erodability Factor

LS - Slope length and Steepness Factor

C - LandCover Management Factor

P - Support Practice Factor

Table 3.4 Erosion classes as per Indian Standard References

SL.NO	EROSION CLASS	NUMERIC CLASS(T/HA/YEAR)
1	Slight	0-5
2	Moderate	5-10
3	High	10-15
4	Severe	15 -20
5	Very severe	20-40
6	Extremely severe	>40

CHAPTER – 4

RESULTS AND DISCUSSIONS

4.1 SOIL LOSS RATE ASSESSMENT

This study employed geographic information systems (GIS), and the USLE model to assess the severity and location of soil erosion across the studied area. Additionally, we calculated five factors influencing erosion risk: how much rain falls and its erosive power (R factor), how susceptible the soil is to erosion (K factor), the incline and length of slopes (LS factor), the way land cover is managed (C factor), and any soil conservation practices in place (P factor).

4.1.1 RAINFALL EROSIVITY (R-FACTOR)

We calculated a rainfall erosivity factor (R-factor) that varied significantly across the study area, ranging from 3613.55 to a very high 4157.17. On average, the rainfall erosivity was 3883.5 Represented in (Fig 4.2). As expected, the results showed higher rainfall erosivity in the southern part of the area. This factor considers both the amount and intensity of rainfall, with higher values indicating greater erosive power.

While a single R-value can't fully capture the variations in rainfall patterns across the study area, it remains an important factor for assessing soil erosion risks. This is especially true when considering future changes in land use, land cover, and climate. Factors like climate variations, how rainfall is distributed year-to-year, and rainfall intensity can all significantly impact erosivity.

- Rainfall erosivity is the kinetic energy of the raindrop's impact and the rate of associated runoff.
- Data source: Global Rainfall erosivity as shown in (Fig 4.1)
- Spatial coverage: World

Pixel size: 30 arc-seconds (~ 1 km at the equator)

Limitation: It can overestimate the soil erosion

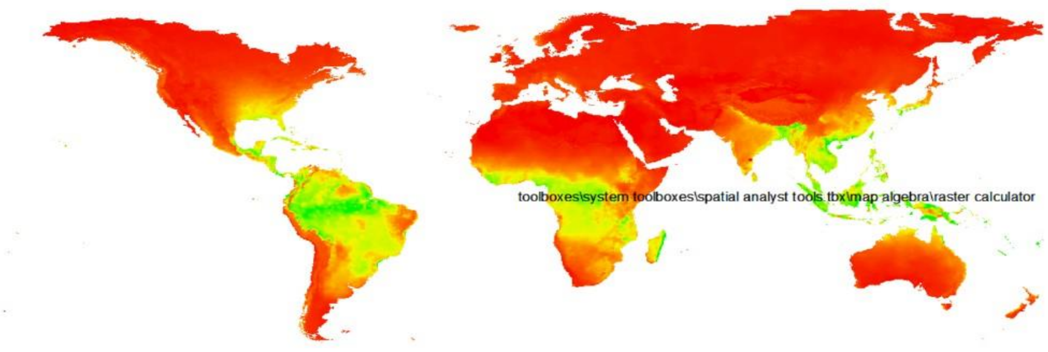


Fig 4.1 Rainfall Erosivity Data(Map)

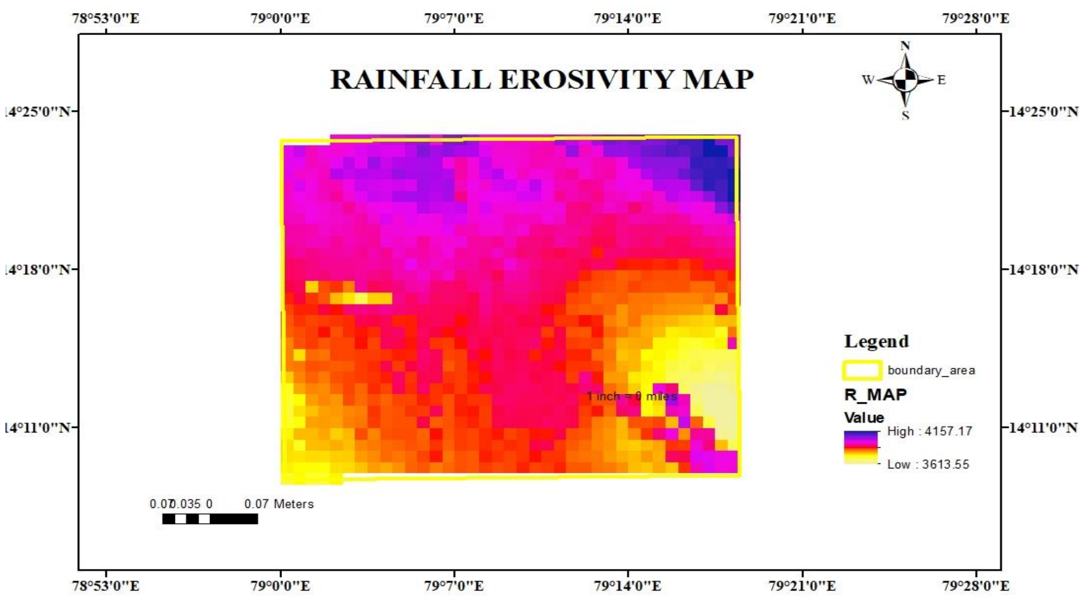


Fig 4.2 Distribution of Rainfall Erosivity(R-factor) For Study Area

4.1.2 SOIL ERODABILITY (K-FACTOR):

Soil erodibility (K-factor): The K-factor reflects how easily different soil types can be eroded by rain and runoff. It considers various soil properties, especially texture. Higher K-factor values indicate a soil that's more prone to erosion. In this study, the K-factor was calculated using a method developed by Wischmeier et al. (1971)

Another factor influencing the K-factor is how easily water can soak into the soil (penetration potential). The map of K-factor values for the study area shows that areas with higher K-factors (0.21 to 0.34 t ha h/ha MJ mm) are more susceptible to erosion, while areas with lower K-factors are less susceptible. This range indicates generally low to moderate erodibility for the soils in this area

- Soil erodibility represents the effect of soil properties and soil profile characteristics on soil loss.

Data source:

- Harmonized World Soil Database v 1.2 as shown in (Fig 4.3)
- Spatial coverage: World
- Pixel size: 30 arc-seconds (~1 km at the equator)
- Limitation: It can overestimate the soil erosion.

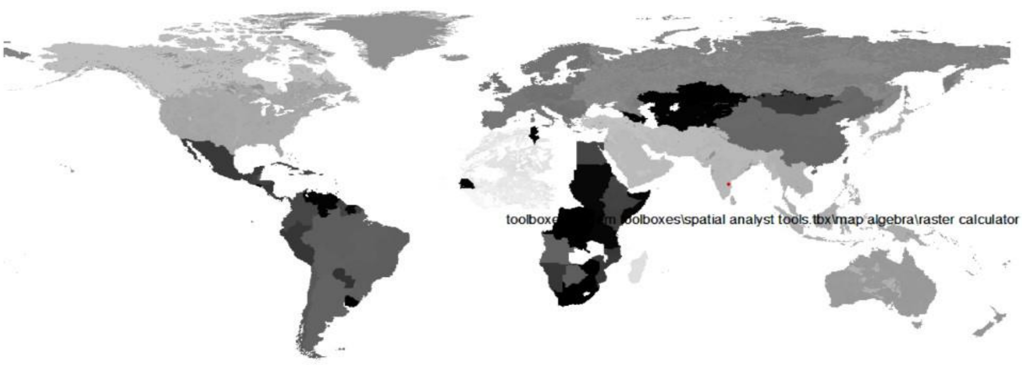


Fig 4.3 Soil Erodability Data (Map)

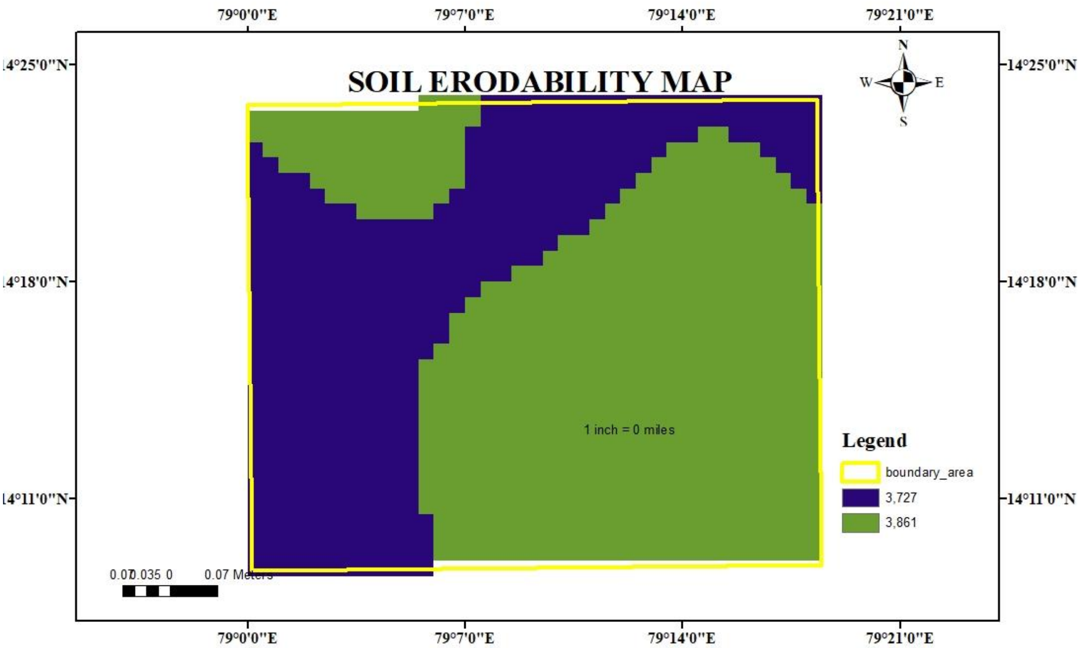


Fig 4.4 Soil Erodibility(K-factor) of Study Area

4.1.3 SLOPE LENGTH AND STEEPNESS(LS-FACTOR):

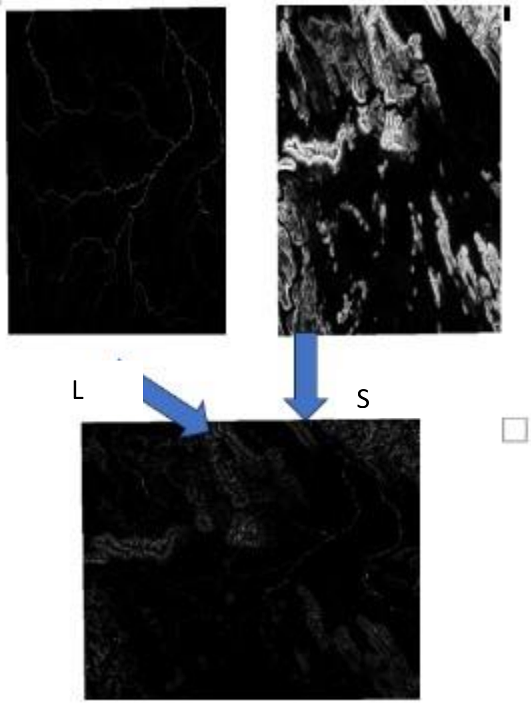
The LS factor, or slope length and steepness factor, assesses how a landscape's shape (topography) affects soil erosion. It essentially tells us how susceptible an area is to erosion based on its slopes. Steeper and longer slopes generally experience more erosion

To calculate the LS factor, scientists considered two key details: the amount of water accumulating in streams (river accumulation) and the steepness of the slopes (slope percentage).

- LS = (L * S)/100

  L – Slope length

  S - steepness



- LS = (L* S)/100

LS

Fig 4.5 LS -Factor

The analysis revealed that the central and southern regions have steeper slopes, as shown. These steeper slopes have a higher potential for runoff, and therefore, a higher rate of erosion. This erosion potential decreases as the slopes become gentler.

The LS factor itself ranged from 0 in the lower parts of the study area to a maximum of 23.1102 in the higher areas. Higher LS-factor values, concentrated in the central and eastern parts, indicate a greater risk of soil loss. This is because soil erosion increases as both slope length and steepness increase, with slope length having a more significant impact.

Overall, when examining all the factors that contribute to soil loss, the LS factor stands out as a major influence on the total amount of soil erosion in the area.

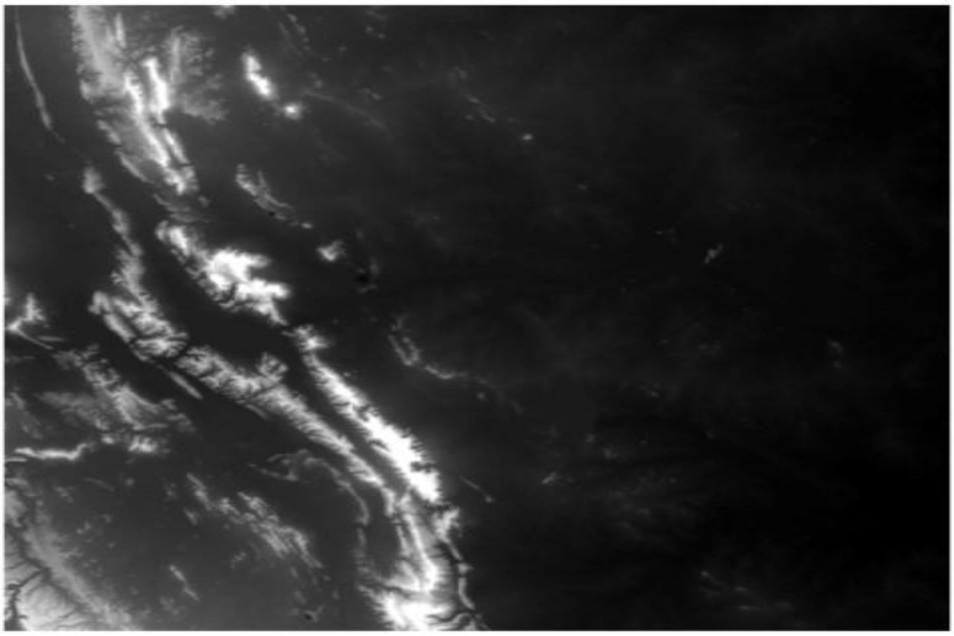


Fig 4.6 Slope Length and Steepness Data (Map)

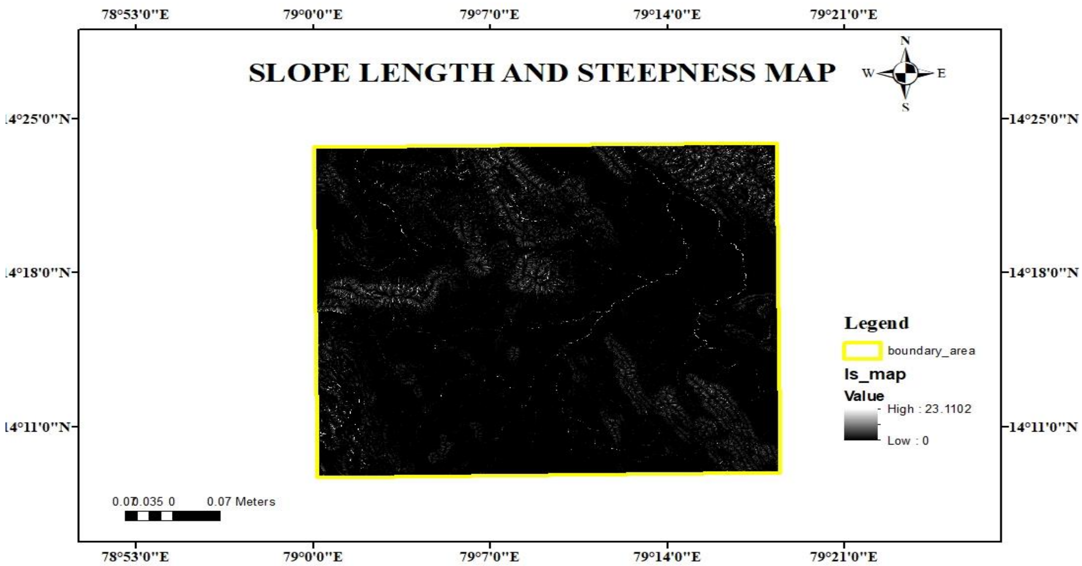


Fig 4.7 Slope Length and Steepness (LS-factors) for Study Area

4.1.4 LAND COVER MANAGEMENT(C-FACTOR):

The C-factor in the USLE model reflects the influence of vegetation cover on soil erosion. This factor applies to both agricultural land and areas where measures are taken to reduce soil erosion.

Researchers used an algorithm to identify the dominant land cover types (LULC) in the study area, including shrublands, grasslands, croplands, urban areas, and forests. This analysis revealed lower C-factor values in the eastern and northern regions, where trees were the most common land cover. This indicates better soil protection in these areas.

In contrast, the southern and western parts had higher C-factor values. This is because these regions have a significant amount of bare soil and built-up areas, which offer less protection against erosion.

Based on the identified LULC types, a C-factor grid map was created. This map assigns corresponding C-factor values to different areas, providing a spatial understanding of how land cover affects soil erosion risk.

Fig 4.8 Land cover Management Data (Map)

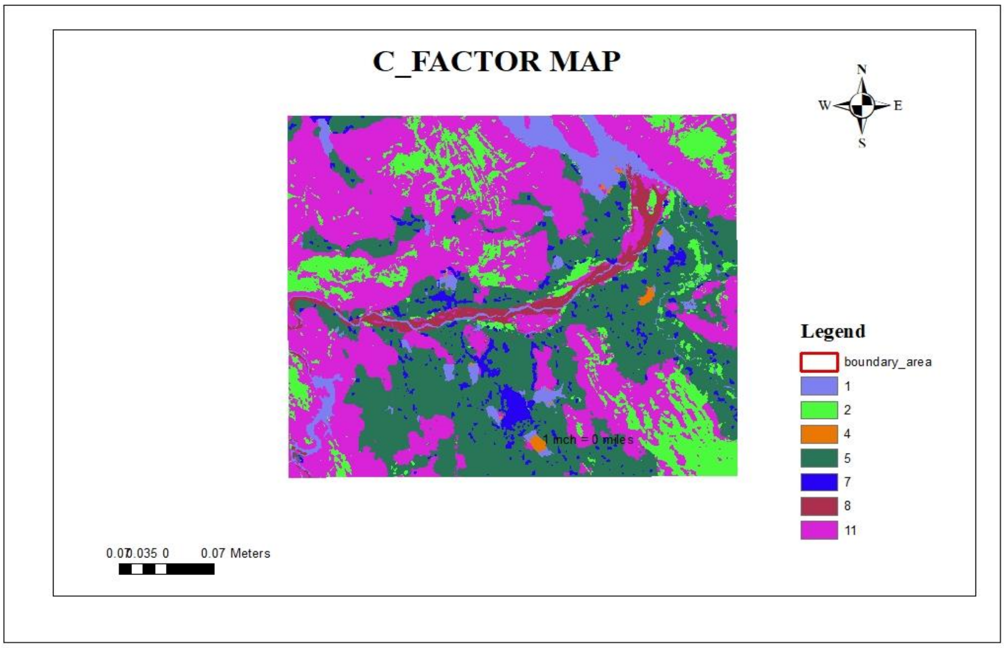


Fig 4.9 Land cover management(C-factor) For Study Area

4.2 ESTIMATION OF POTENTIAL SOIL EROSION

4.2.1 USLE Components

To Estimate Soil erosion using the Universal Soil Loss Equation (USLE) Model in ArcGIS Pro. The USLE model was developed in the 1950s and Estimates the long-term Average Annual rate of erosion based on factors like rainfall pattern, Soil type, Topography, Crop system, and Management practices. The formula includes Components such as Rainfall erosivity, Soil erodibility, Topographic factors, Cropping Management factors, and Practice Support Factors. To estimate rainfall erosivity, Global data sets can be used, but they may overestimate or underestimate soil erosion. The presenter demonstrates how to access global rainfall erosivity data through a specific link and download it by filling out a form.

To prepare a Layer in ArcGIS Pro using the Global Rainfall erosivity data. Next, the presenter discusses Soil erodibility, which represents the effect of soil properties on soil loss. The Harmonized World Soil Database version 1.2 is recommended for soil erodibility data and can be accessed through a provided link.

Working with a file in .bil Raster format, Specifically the Harmonized World Soil Database. The Process of Inputting the Raster file, Extracting Mapping units, and Accessing Metadata Information in an MS Access Database. We highlighted the importance of soil texture and composition of Sand, Silt, Clay, and Organic matter in determining soil suitability. They mention using a lookup Table Developed by Roost in 1996 to Estimate Soil Suitability based on soil texture and organic material content. The process involves Converting Organic Carbon to Organic matter and classifying soil units to determine their textural class and corresponding lookup table value. The Composition of Different Soil samples in terms of sand, silt, and Clay percentages. Identify the Texture Classes of the Soil Samples as Loamy Sand, Sandy Clay Loam, and Clay based on their composition. We also determine the soil erodibility values for each mapping unit, which are used in the soil erosion equation. The speaker explains the process of converting raster to polygon, assigning the soil erodibility values to each mapping unit, and converting back to raster format. This allows for the calculation of soil erodibility values for each pixel in the study area.

The Calculation of the Topographic Factor in the USLE equation. The Topographic factor (ls) consists of Slope Length (l) and Slope steepness (s). An increase in slope length or Slope Steepness can cause an increase in Erosion. The Slope Length is calculated using a formula involving flow accumulation and a parameter 'm', while the slope steepness is Calculated using a formula involving the Slope Angle (beta) and a parameter 'n'. The ls factor is the product of slope length and slope steepness divided by 100. To Calculate these Factors, a Digital Elevation Model (DEM) such as SRTM 30meter DEM can be used. The speaker demonstrates how to download the DEM, calculate Flow Accumulation, and Slope, and then use the Raster Calculator in ArcGIS to Determine the Slope length and Slope Steepness, Ultimately leading to the calculation of the topographic factor LS.

It explains the Components of the USLE (Universal Soil Loss Equation) and how to Determine the Third Component, Which is the Crop Vegetation and Management Factor denoted by "C”. This factor is used to Assess the Effectiveness of soil and Crop Management Systems in Preventing Soil loss.

Now using the Sentinel 2 Land use Land cover Data at a 10-meter Resolution to Assign values for different Land cover Classes. The final Component of the USLE equation is the Support practice factor denoted by "P," which reflects the Impact of Practices that Reduce Water Runoff and Soil erosion. The speaker States that for the Tutorial, they will use a value of one for this factor regardless of the land cover classes. The process of Accessing and Downloading the Land use and land cover data for a specific study area, in this case, Vietnam, is explained. The speaker shows how to extract and process the data in ArcGIS Pro, including converting raster data to polygons, assigning values for the crop management factor "c" based on literature references, and converting the polygons back to raster format. To input values for different land cover classes into an Excel sheet and then transfer them back to ArcGIS Pro to Generate the final Raster Map with the "C" values assigned to each Pixel.

It explains the Process of Assigning Values for Different Land use Classes using Filters and Symbology.

4.2.2 RESAMPLE THE USLE COMPONENTS

Here we need to resample Shown in (Fig 4.1) and reproject the data before using the USLE equation. The speaker demonstrates how to resample the data to a specific resolution and coordinate system using geoprocessing tools. They then resample all components of USLE and use the raster calculator to estimate average annual soil loss. The resulting soil erosion map is classified based on the threshold based on the Andhra Pradesh Government represented in the (Table 4.1)

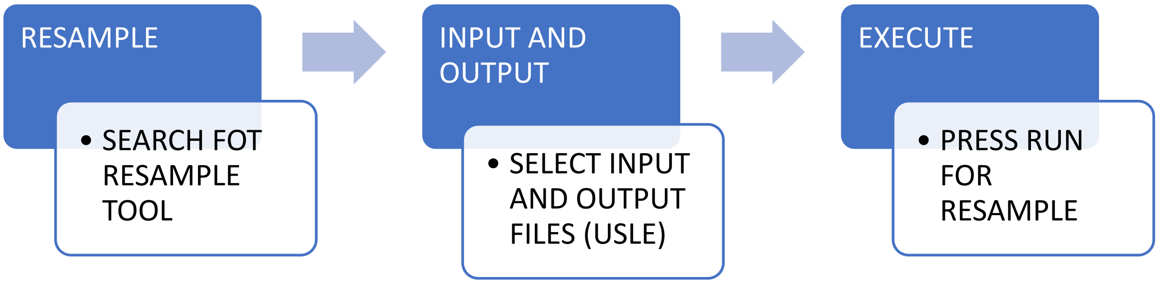


Fig 4.10 Flowchart of Resampling the USLE Components

Table 4.1: Soil Erosion Classes and Range of the Study Area

SL.NO	EROSION CLASS	SOILLOSS (%)
1	SLIGHT	12.79 %
2	MODERATE	1.38 %
3	HIGH	1.158 %
4	SEVERE	0.86 %
5	VERY SEVERE	0.81 %
6	EXTREMELY SEVERE	19.61%

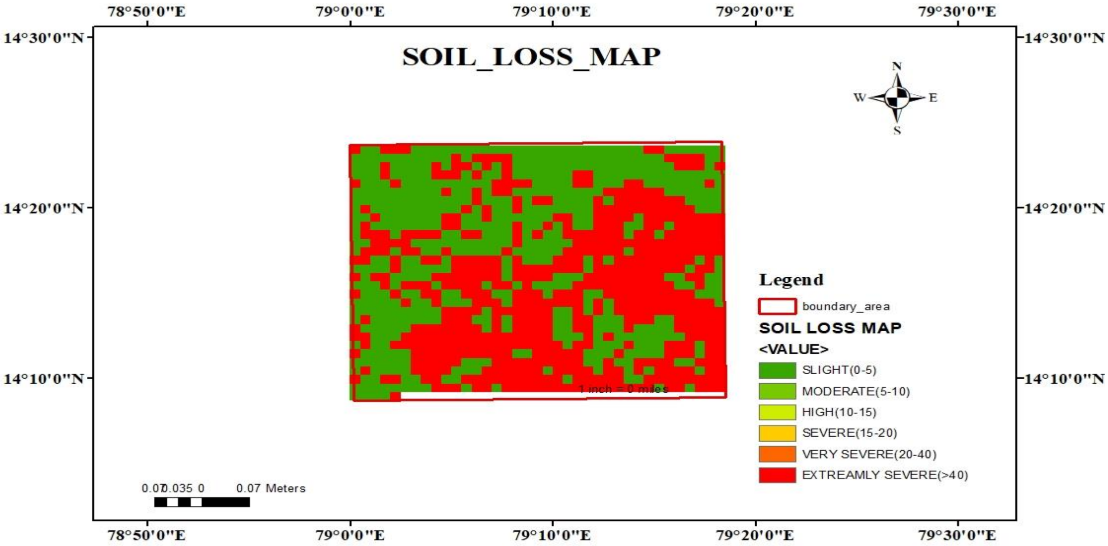


Fig 4.11 The Potential Soil Erosion Map of the Study Area

CHAPTER – 5

CONCLUSIONS

5.1 GENERAL

This study demonstrates the effectiveness of using the USLE model alongside Remote Sensing (RS) and Geographic Information Systems (GIS) to assess soil erosion potential in Rajampet. The analysis focused on how land use and land cover changes affect erosion rates.

The RUSLE model estimated an average annual soil loss of 6.10% per year in the Rajampet area. However, this value varies considerably depending on factors like topography and land cover.

Our results suggest that slope length, steepness, and rainfall erosivity are the most critical factors influencing soil erosion in Rajampet. Rainfall erosivity, a climate-related component of the USLE model, plays a significant role in spatial soil erosion patterns.

Areas with natural forest cover, particularly in headwater regions, experienced the lowest erosion rates. Conversely, areas with human activity had the highest erosion rates

The study identified five land cover types in Rajampet using a specific method: shrublands, grasslands, croplands, urban and built-up areas, and forests. The potential soil loss across these classes ranged from 0.81% to 19.61% per acre per year.

On average, Rajampet loses about 25% of soil per acre per year, representing roughly 19.61% of the total area most affected by erosion.

5.2 SCOPE FOR FUTURE STUDY

This study highlights the value of the USLE model and GIS technologies in evaluating soil erosion and estimating soil loss in Rajampet. We observed higher erosion rates in areas with steeper slopes and in regions classified as "moderate forest" land cover. The significant erosion potential in these moderately forested areas is likely due to the presence of a highly erodible soil group.

To improve the accuracy of future studies, researchers should consider using high-resolution satellite imagery from recent years, such as MODIS MCD12Q1 images. This would enhance the precision of land cover maps and Digital Elevation Models (DEMs) used to calculate slope gradients.

Additionally, validating soil erosion loss estimates using local data would further improve the reliability of the findings. Determining accurate P-factor values specific to the Rajampet region is also crucial for a more precise assessment of potential soil erosion.

The insights gained from this research can guide the implementation of appropriate erosion control measures in severely affected areas of Rajampet. This data can also inform policymakers in developing effective strategies to combat soil erosion threats.

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