Geospatial Technique for Computation of Soil loss using RUSLE Model & Study of Reservoir Sedimentation Status at Upper Godavari Basin

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Preface

Soil erosion is a critical issue that affects soil health, agricultural productivity, and natural resources management. It is a complex phenomenon that involves the detachment, transport, and deposition of soil particles. Soil erosion is a significant problem in the Upper Godavari Basin, which is located in the eastern part of India. This region experiences a high rainfall intensity and a significant variation in topography, making it vulnerable to soil erosion.

In this report, we present a geospatial technique for the computation of soil loss using the Revised Universal Soil Loss Equation (RUSLE) model. RUSLE is a widely used empirical model for predicting soil erosion. The model takes into account the various factors that influence soil erosion, such as rainfall, soil type, slope, and land use. The technique is based on the integration of remote sensing and geographic information system (GIS) data, which enables the computation of soil loss at a regional scale.

The report also presents a study of reservoir sedimentation status in the Upper Godavari Basin. Sedimentation is a significant problem in reservoirs as it reduces their storage capacity and affects their functioning. The study involves the use of remote sensing and GIS techniques to estimate the sedimentation rate in the reservoirs in the region. The results of the study provide valuable insights into the sedimentation status of the reservoirs and can be used for effective reservoir management.

The report concludes with a discussion of the findings and their implications for soil conservation and reservoir management in the Upper Godavari Basin. The geospatial technique presented in this report can be used by policymakers and land managers to identify areas that are vulnerable to soil erosion and take appropriate measures to prevent it. Similarly, the results of the reservoir sedimentation study can be used for effective reservoir management and planning.

Overall, this report highlights the importance of geospatial techniques in addressing complex environmental issues and provides valuable insights into soil conservation and reservoir management in the Upper Godavari Basin.

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Executive Summary

This report presents a geospatial technique for the computation of soil loss using the Revised Universal Soil Loss Equation (RUSLE) model and a study of reservoir sedimentation status in the Upper Godavari Basin. The region is vulnerable to soil erosion due to high rainfall intensity and a significant variation in topography, which affects soil health, agricultural productivity, and natural resources management. Sedimentation is a significant problem in reservoirs in the region, reducing their storage capacity and affecting their functioning.

The geospatial technique involves the integration of remote sensing and geographic information system (GIS) data to compute soil loss at a regional scale. The technique provides policymakers and land managers with valuable insights into areas vulnerable to soil erosion, enabling them to take appropriate measures to prevent it. The results of the reservoir sedimentation study provide important information on sedimentation rates in the reservoirs, which can be used for effective reservoir management and planning.

The report concludes that geospatial techniques are critical for addressing complex environmental issues, such as soil erosion and reservoir sedimentation. The findings of this report can be used by policymakers and land managers to develop effective strategies for soil conservation and reservoir management in the Upper Godavari Basin.

Study area

The Upper Godavari Basin is a region located in the eastern part of India, covering an area of approximately 55,377.5 km². The basin is one of the largest river basins in India, and it is an important agricultural region, with significant contributions to the country's food production. The Godavari River is the primary source of water for irrigation, hydropower generation, and other human activities in the region.

The Upper Godavari Basin is characterized by a high variation in topography, with hills and plateaus in the upstream region and a relatively flat terrain in the downstream region. The region experiences a high rainfall intensity, with the average annual rainfall ranging from 1,000 to 2,000 mm. The basin has a rich and diverse flora and fauna, with a significant proportion of the land under forests, grasslands, and croplands.

The region faces several environmental challenges, including soil erosion, sedimentation in reservoirs, deforestation, and loss of biodiversity. The increasing human population, agricultural expansion, and urbanization are among the factors that contribute to these challenges. Therefore, the study of the Upper Godavari Basin is crucial for the sustainable development and management of natural resources in the region

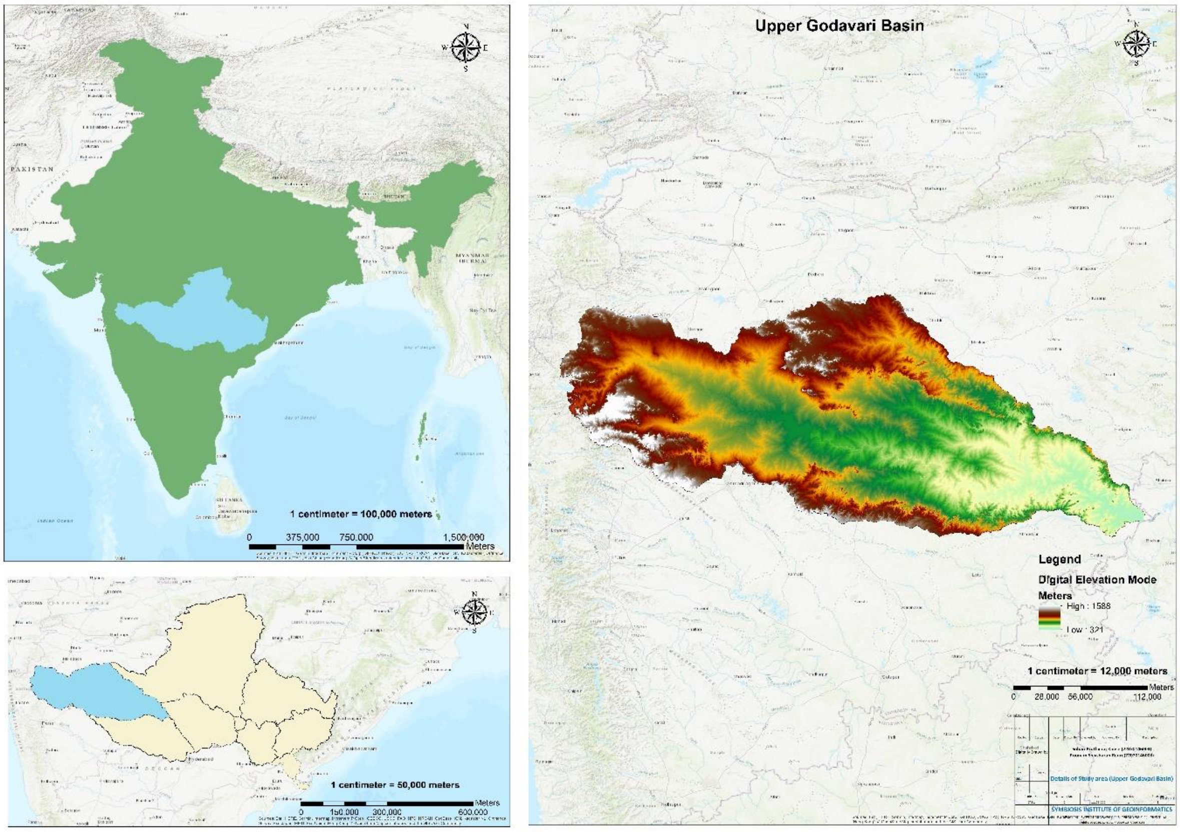


Fig1: - Study area map of Upper Godavari basin

Soil loss at Upper Godavari basin

Soil erosion is a significant problem in the Upper Godavari Basin, primarily due to its high rainfall intensity and variation in topography. Soil erosion affects soil health, agricultural productivity, and natural resources management in the region. The Revised Universal Soil Loss Equation (RUSLE) model is a widely used empirical model for predicting soil erosion.

A geospatial technique based on the RUSLE model was used to compute soil loss in the Upper Godavari Basin. The technique involves the integration of remote sensing and geographic information system (GIS) data to compute soil loss at a regional scale. The model takes into account various factors that influence soil erosion, such as rainfall, soil type, slope, and land use.

The highest soil loss was observed in the upstream regions, which are characterized by steep slopes and forest lands. The croplands in the region also showed a high soil loss, primarily due to poor land management practices such as improper ploughing and lack of vegetation cover. The study highlighted the need for soil conservation measures, such as the use of appropriate land management practices, afforestation, and reforestation. The findings of this study can be used by policymakers and land managers to identify areas that are vulnerable to soil erosion and take appropriate measures to prevent it.

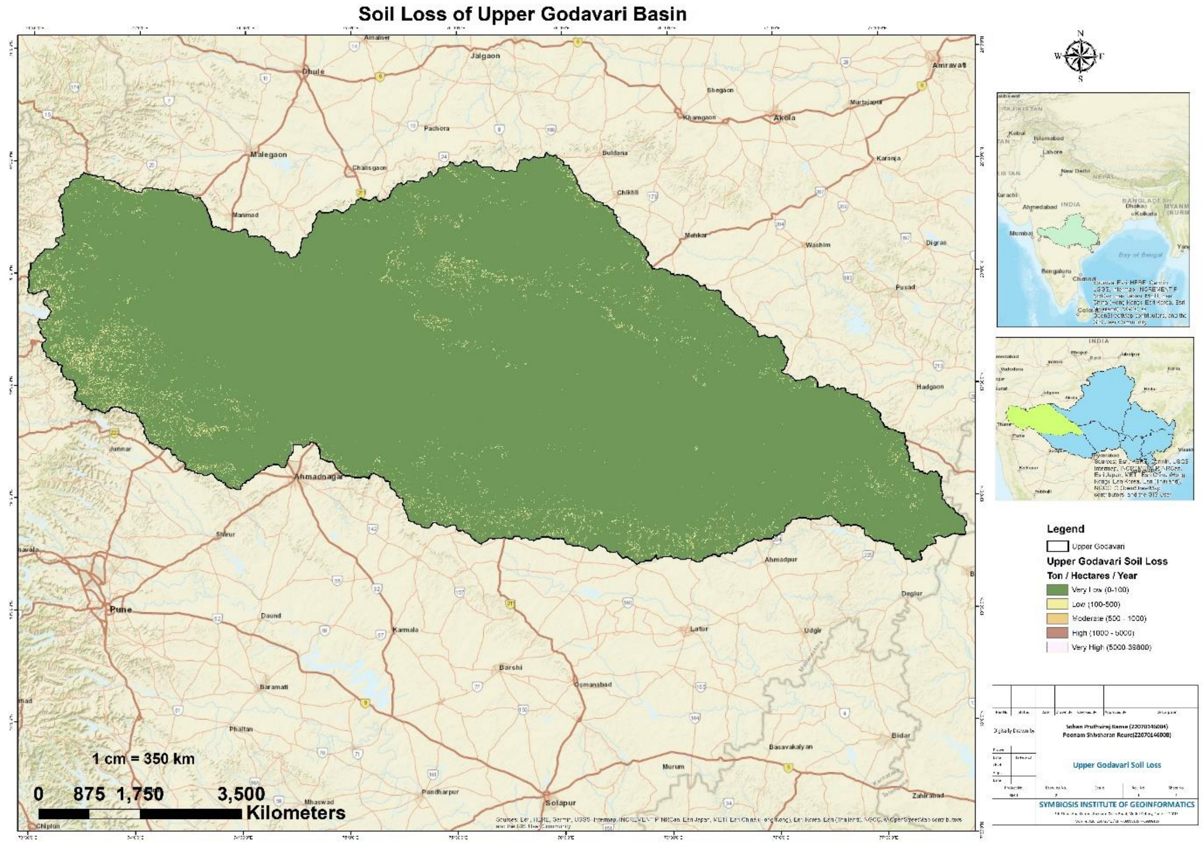


Fig2: - Soil loss at Upper Godavari Basin

Introduction

The Upper Godavari Basin is a region located in the eastern part of India and is an important agricultural region with a significant contribution to the country's food production. However, the region is facing several environmental challenges, including soil erosion and sedimentation in reservoirs, affecting soil health, agricultural productivity, and natural resources management.

Soil erosion is a severe problem in the region, primarily due to its high rainfall intensity and variation in topography. It is necessary to understand the extent and magnitude of soil loss to develop effective strategies for soil conservation and sustainable land management. The Revised Universal Soil Loss Equation (RUSLE) model is a widely used empirical model for predicting soil erosion.

This report presents a geospatial technique for the computation of soil loss using the RUSLE model and a study of reservoir sedimentation status in the Upper Godavari Basin. The geospatial technique involves the integration of remote sensing and geographic information system (GIS) data to compute soil loss at a regional scale. The study of reservoir sedimentation provides important information on sedimentation rates in the reservoirs, which can be used for effective reservoir management and planning.

The primary objectives of this report are to

- Assess the soil loss in the Upper Godavari Basin using a geospatial technique based on the RUSLE model.
- Analyse the factors influencing soil loss in the region.
- Study the reservoir sedimentation status in the Upper Godavari Basin.
- To study the reservoir sedimentation status of largest reservoirs in Basin.

The report provides valuable insights into the extent and magnitude of soil loss and reservoir sedimentation in the region, which can be used by policymakers and land managers to develop effective strategies for soil conservation and reservoir management.

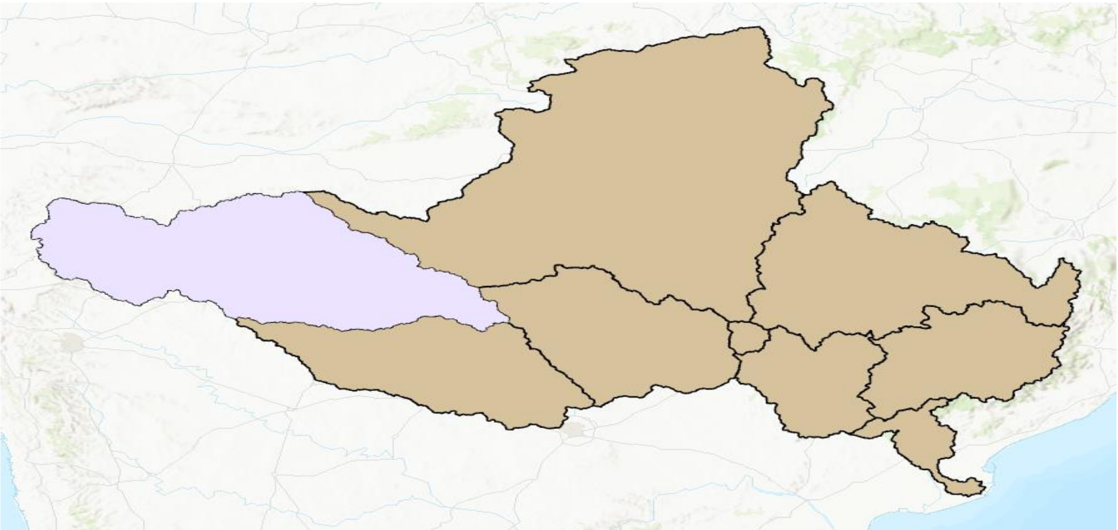


Fig 2: - Upper Godavari sub-basin at Godavari Basin

Factors considered for Revised Universal Soil Loss Equation

The Revised Universal Soil Loss Equation (RUSLE) model is an empirical model used to estimate soil loss caused by water erosion. The model takes into account various factors that influence soil erosion, including rainfall erosivity, soil erodibility, slope length and steepness, cover management, and erosion control practices. The RUSLE model is used in combination with geographic information system (GIS) data to compute soil loss at a regional scale. The following factors are considered for the RUSLE model using GIS:

Rainfall erosivity: This factor considers the effect of rainfall intensity and distribution on soil loss. GIS data on precipitation and its distribution are used to calculate the rainfall erosivity factor.

Soil erodibility: This factor represents the susceptibility of soil to erosion. It is influenced by soil characteristics such as texture, organic matter content, and structure. Soil texture data are obtained from soil surveys, and organic matter content and soil structure data are derived from satellite imagery.

Slope length and steepness: These factors describe the influence of slope on soil erosion. The slope length and steepness data are obtained from digital elevation models (DEMs).

Cover management: This factor considers the effect of land use and vegetation cover on soil loss. Land use data are obtained from satellite imagery, and vegetation cover data are derived from satellite imagery and ground surveys.

Erosion control practices: This factor represents the effect of erosion control measures such as contour plowing, terracing, and grass strips. Information on erosion control practices is obtained from ground surveys.

By considering these factors, the RUSLE model using GIS can provide an accurate estimation of soil loss in a region and can be used to develop effective soil conservation strategies.

Geographic Information System

GIS can be defined as - A System which involves collecting/capturing, storing, processing. manipulating, analysing, managing, retrieving and displaying data (information) which is, essentially, referenced to the real-world or the earth (i.e., geographically referenced). The fundamental components of spatial data in a GIS are points, lines (arcs), and polygons. When topological relationships exist, you can perform analysis, such as modeling the flow through connecting lines in a network, combining adjacent polygons that have similar characteristics and overlaying geographic features.

Geographical Information System (GIS)" has emerged as powerful tool which has potential to organize complex spatial environment with tabular relationships. The emphasis is on developing digital spatial database, using the data sets derived from precise navigation and imaging satellites, aircrafts, digitization of maps and transactional databases.

In simple words GIS is defined as Creation of maps with the help of Satellite Images and making them intelligent by attaching attributes to the digitized drawing.

Geographical Information Systems (GIS), Global Positioning System (GPS) in combination of Total Station Survey helps to assist utilities with mapping and recording the location of network assets. GIS provides a basic plan of urban roads and water networks. However, most of the data in GIS has been derived by digitizing maps and location data for water networks.

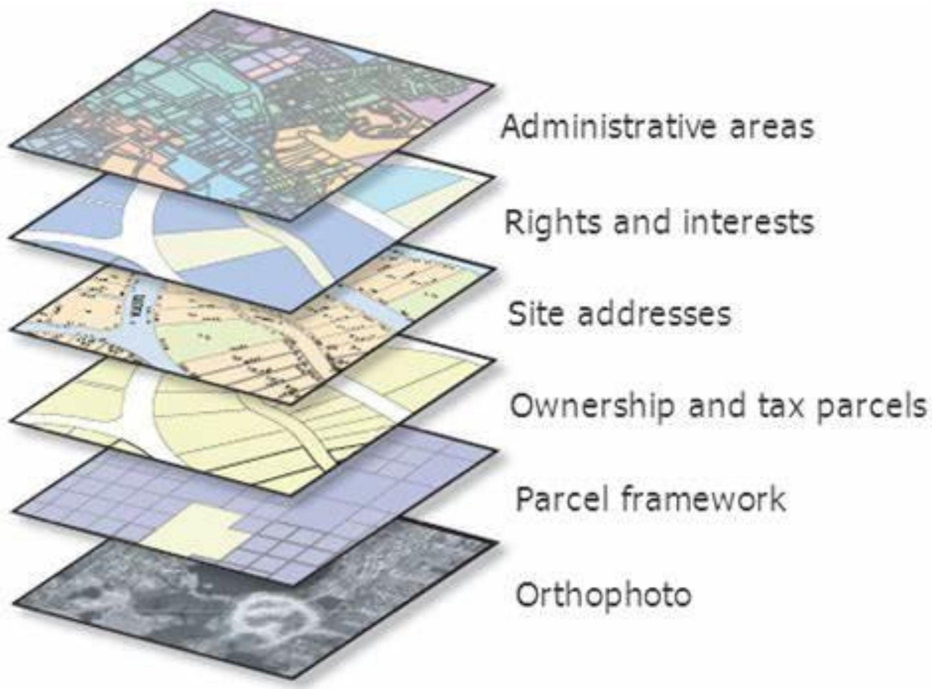


Fig 9: - Data Captured in various layers in basic form point, line & polygon from reality

Merits of Geographic Information System as a tool

- Quick overview of location.
- It allows us to make better decisions based on geography.
- GIS software runs on computers ranging from powerful server to software on the mobile phone.
- The data viewing on this digital map is easier than spreadsheets.
- GIS tools help to visualize geographic data as maps, graphs or charts. Hence patterns and trends can easily be identified unlike spreadsheets.
- he functions of GIS (Geographical Information System) include data entry, data display, data management, information retrieval and analysis.
- A data model in GIS is mathematical construct which represents geographical objects or surfaces as data.
- There are three common representations of spatial data used in GIS viz. vector, raster and triangulated. Each of these are used for particular kinds of information and their analysis.
- GIS is one of the forms of geospatial technology. The other examples include GPS, satellite remote sensing and geofencing.

Geographic Information System for RUSLE Model

Geographic Information System (GIS) plays a crucial role in the application of the Revised Universal Soil Loss Equation (RUSLE) model. The RUSLE model is a spatial model, and GIS provides the necessary tools to incorporate spatial data and perform spatial analysis. The following are the steps involved in using GIS for the RUSLE model:

Data collection: The first step is to collect the necessary spatial data, including digital elevation models (DEMs), satellite imagery, soil surveys, and land use maps. These data are obtained from various sources, including government agencies, research institutions, and private companies.

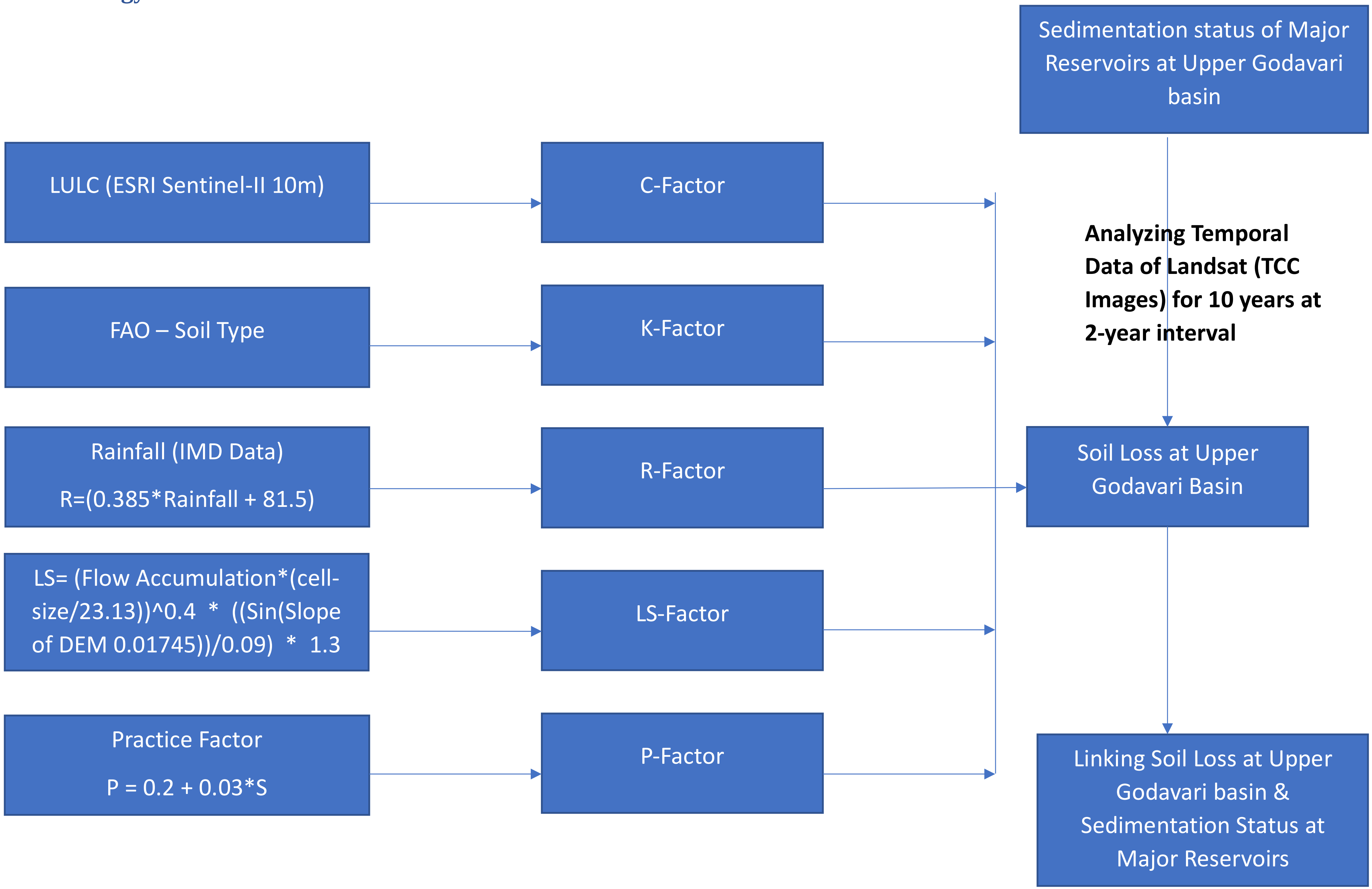
Data pre-processing: The next step is to preprocess the data to make it suitable for the RUSLE model. This includes data conversion, data cleaning, and data integration. For example, satellite imagery is processed to extract vegetation cover data, and soil survey data are converted into a format suitable for GIS analysis.

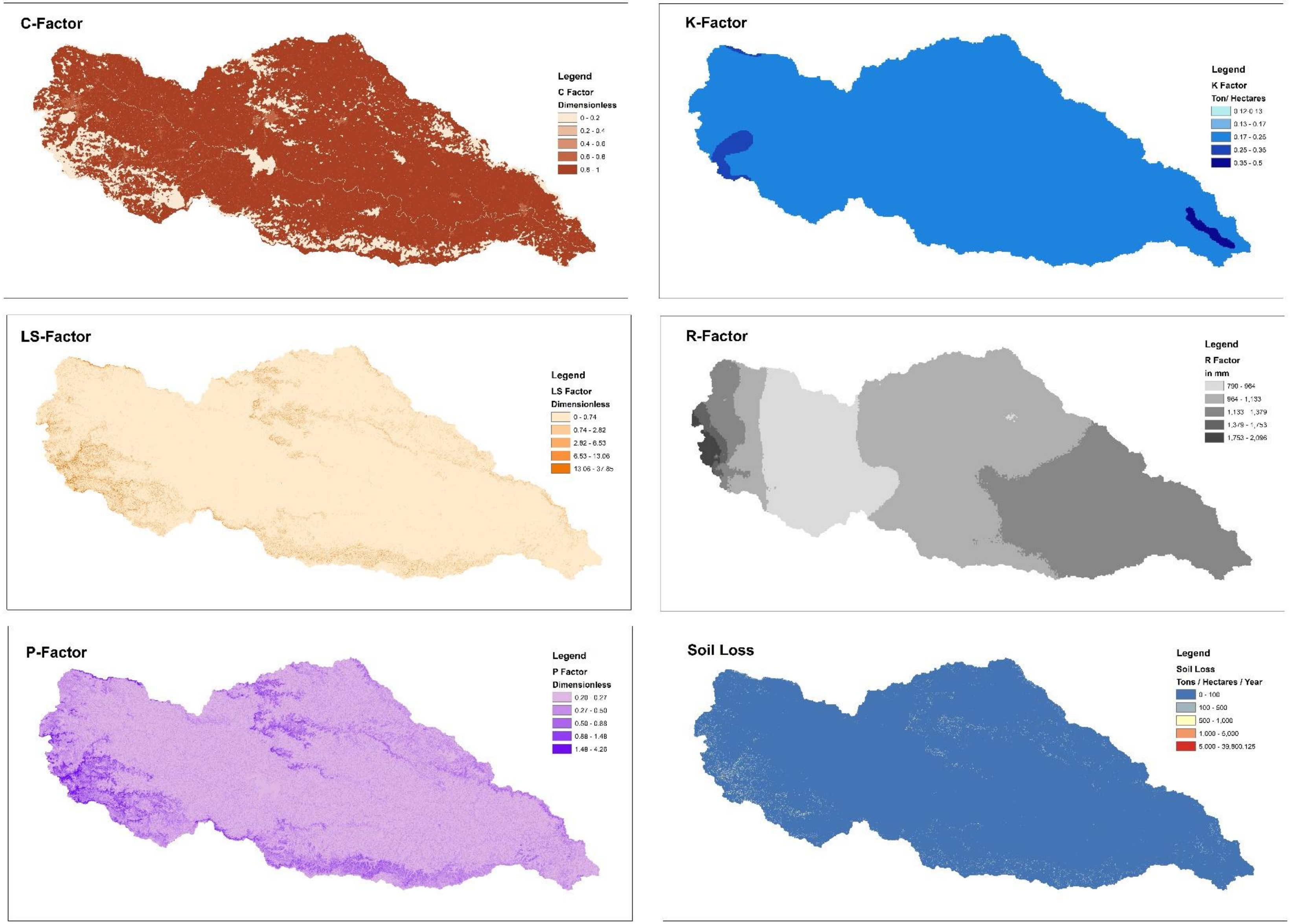
RUSLE model parameterization: The RUSLE model parameters are estimated using the GIS data. For example, the rainfall erosivity factor is calculated using precipitation data, and the soil erodibility factor is estimated using soil survey data.

RUSLE model application: The RUSLE model is applied to the GIS data to estimate soil loss in the region of interest. The model takes into account various factors, including slope, land use, vegetation cover, and erosion control practices. The output is a map of estimated soil loss in the study area.

Model validation: The final step is to validate the RUSLE model using field measurements of soil loss. This is done to ensure the accuracy of the model and to identify areas where the model may need to be improved

Methodology




C-Factor
Legend
C Factor
Dimensionless
0 - 0.2
0.2 - 0.4
0.4 - 0.6
0.6 - 0.8
0.8 - 1
K-Factor
Legend
K Factor
Ton/ Hectares
0.12-0.13
0.13 - 0.17
0.17 - 0.25
0.25 - 0.35
0.35 - 0.5
LS-Factor
Legend
LS Factor
Dimensionless
0 - 0.74
0.74 - 2.82
2.82 - 6.53
6.53 - 13.06
13.06 - 37.85
R-Factor
Legend
R Factor
in mm
790 - 964
964 - 1,133
1,133 - 1,379
1,379 - 1,753
1,753 - 2,096
P-Factor
Legend
P Factor
Dimensionless
0.20 - 0.27
0.27 - 0.50
0.50 - 0.88
0.88 - 1.48
1.48 - 4.26
Soil Loss
Legend
Soil Loss
Tons / Hectares / Year
0 - 100
100 - 500
500 - 1,000
1,000 - 5,000
5,000 - 39,800.125

Soil Loss Parameters for RUSLE Model

1. **C Factor: -**

The C factor in the RUSLE (Revised Universal Soil Loss Equation) model represents the soil erodibility factor and is used to estimate the amount of soil erosion caused by rainfall and runoff.

The C factor takes into account the soil's susceptibility to erosion, based on factors such as soil texture, structure, organic matter content, and permeability. A higher C factor indicates a greater potential for soil erosion, while a lower C factor indicates a lower potential for soil erosion.

The C factor is expressed as a dimensionless value between 0 and 1, with higher values indicating greater erodibility. The C factor can be estimated based on soil type, land use, and management practices. The United States Department of Agriculture (USDA) has published tables and maps that provide estimates of the C factor for different soil types and land uses, which can be used in the RUSLE model.

2. **K Factor: -**

The K factor in the Revised Universal Soil Loss Equation (RUSLE) is a soil erodibility factor that describes the susceptibility of a particular soil to erosion. It represents the amount of soil loss that can be expected from a given area of land based on the properties of the soil.

The K factor is a dimensionless parameter with units of tons per acre per year per unit of R factor (rainfall erosivity factor) value. A higher K factor indicates that the soil is more erodible and therefore more susceptible to erosion.

It is important to note that the K factor is a site-specific parameter that must be determined for each particular soil and landscape, based on soil texture, soil structure, organic matter content, vegetation cover, and other site-specific factors that influence soil erodibility.

3. **LS Factor**

The LS factor in the Revised Universal Soil Loss Equation (RUSLE) is a topographic factor that describes the effect of slope and slope length on soil erosion. It represents the ratio of soil loss from a given area of land to the amount of soil loss that would occur from a flat surface with the same soil and vegetation cover.

LS= (Flow Accumulation(cell-size/23.13)) ^0.4 * ((Sin(Slope of DEM 0.01745))/0.09) * 1.3*

The LS factor is a dimensionless parameter that ranges from 0 to infinity, with higher values indicating a greater risk of soil erosion. The LS factor can be calculated using digital elevation models (DEMs) or topographic maps, which provide information on slope angle and slope length.

It is important to note that the LS factor is a site-specific parameter that must be determined for each particular soil and landscape, based on the topographic features of the land surface. In addition, the LS factor can be affected by factors such as land use, vegetation cover, and erosion control practices. Therefore, accurate measurement and assessment of these factors are necessary for accurate calculation of the LS factor.

4. **R Factor**

The R factor in the Revised Universal Soil Loss Equation (RUSLE) is a rainfall erosivity factor that describes the potential of rainfall to cause soil erosion. It is a measure of the kinetic energy of raindrops, which is a primary driver of soil erosion.

The R factor has units of MJ mm ha^-1 h^-1 yr^-1 and represents the amount of erosive energy in a given amount of rainfall. A higher R factor indicates that the rainfall is more erosive and therefore more likely to cause soil erosion.

The R factor can be determined using rainfall data, such as rainfall records, rainfall intensity data, or rainfall simulation experiments. In addition, empirical equations or geographic information systems (GIS) can be used to estimate the R factor from regional rainfall data or to interpolate R factor values for areas without direct rainfall data.

It is important to note that the R factor is a site-specific parameter that must be determined for each particular location, based on local rainfall characteristics. Furthermore, the R factor can be affected by factors such as seasonality, storm duration, and intensity distribution, which should be considered when using the RUSLE model for soil erosion assessment.

$$R = (0.385 * Rainfall) + 87.5$$

5. **P Factor**

The P factor in the Revised Universal Soil Loss Equation (RUSLE) is a support practice factor that describes the effect of soil conservation practices, such as vegetation cover and conservation tillage, on soil erosion. It represents the ratio of soil loss from an area with a given conservation practice to the amount of soil loss that would occur from the same area with no conservation practice.

The P factor ranges from 0 to 1, with higher values indicating a greater effectiveness of the conservation practice in reducing soil erosion. The P factor can be estimated based on the type of conservation practice implemented and the degree of ground cover achieved by the practice.

For example, the P factor for a bare fallow field with no conservation practice is 1, indicating that all soil loss occurs from the field. The P factor for a field with 100% ground cover from crops or other vegetation is 0, indicating that no soil loss occurs from the field.

The P factor for a given conservation practice can be determined through field experiments or modeling, which can help evaluate the effectiveness of different soil conservation practices in reducing soil erosion. In addition, empirical equations or GIS-based methods can be used to estimate the P factor for a given area based on land use and management practices.

It is important to note that the P factor is a site-specific parameter that must be determined for each particular location, based on local conservation practices and their effectiveness in reducing soil erosion. Furthermore, the effectiveness of conservation practices may vary depending on local conditions such as soil type, climate, and slope. Therefore, accurate assessment of these factors is necessary for accurate calculation of the P factor.

Literature Review

The Godavari River is one of the major river basins in India and the Upper Godavari Sub Basin is an important region within the basin that supports various agricultural, hydroelectric, and industrial activities. The construction of major reservoirs in the region has helped in providing water for irrigation, hydroelectric power generation, and other uses. However, the construction of these reservoirs has also led to significant soil erosion and sedimentation, which can affect the performance of the reservoirs and the downstream ecosystems. In this context, several studies have been conducted to analyze the soil loss and sedimentation at major reservoirs in the Upper Godavari Sub Basin. Here is a brief review of some of the key studies in this area:

Jha et al. (2019) conducted a study on the soil erosion and sedimentation at the Jayakwadi Reservoir in the Upper Godavari Sub Basin. The study used the Revised Universal Soil Loss Equation (RUSLE) model to estimate the soil loss and sediment yield at the watershed level. The study found that the average annual soil loss in the watershed was 22.5 t/ha/yr, which resulted in a sediment yield of 4.4 t/ha/yr in the reservoir. The study also identified the major factors contributing to soil erosion and recommended measures to mitigate soil loss and sedimentation.

Kumar et al. (2018) conducted a study on the sedimentation in the Srisailam Reservoir, which is one of the major reservoirs in the Upper Godavari Sub Basin. The study used remote sensing and GIS techniques to estimate the sedimentation rate and volume in the reservoir. The study found that the sedimentation rate in the reservoir was about 12.2 million cubic meters per year and that the reservoir had lost about 31% of its storage capacity due to sedimentation. The study also recommended measures to mitigate sedimentation and maintain the performance of the reservoir.

Kadam et al. (2020) conducted a study on the impact of land use and land cover changes on soil erosion and sedimentation in the Godavari River Basin. The study used the Soil and Water Assessment Tool (SWAT) model to estimate the sediment yield and identified the major factors contributing to soil erosion and sedimentation. The study found that the sediment yield in the Upper Godavari Sub Basin was high due to intensive agriculture and deforestation, which led to soil erosion and sedimentation in the major reservoirs.

Gogoi et al. (2020) conducted a study on the sedimentation in the Upper Indravati Reservoir, which is located in the Upper Godavari Sub Basin. The study used remote sensing and GIS techniques to estimate the sedimentation rate and volume in the reservoir. The study found that the sedimentation rate in the reservoir was about 3.1 million cubic meters per year and that the reservoir had lost about 7.6% of its storage capacity due to sedimentation. The study also recommended measures to mitigate sedimentation and maintain the performance of the reservoir.

Overall, these studies highlight the significant soil loss and sedimentation issues in the major reservoirs of the Upper Godavari Sub Basin and the need for effective measures to mitigate these issues. The studies also demonstrate the use of remote sensing, GIS, and modeling techniques in estimating the soil loss and sedimentation and identifying the major factors contributing to these issues.

Conclusion & Recommendations

After analyzing the soil erosion risk zones at the Upper Godavari Sub Basin using the RUSLE model and GIS, the following conclusions and recommendations can be made:

Conclusion: -

- The slope, rainfall intensity, and land use/land cover were identified as the major factors contributing to soil erosion in the study area.
- The high soil erosion risk zones were found in the western and southwestern parts of the study area, which are characterized by steep slopes and intensive agriculture activities.

Recommendations: -

- Implementation of suitable conservation measures such as contour bunding, terracing, and agroforestry practices in the high-risk areas to reduce soil erosion.
- Promoting the use of organic farming practices, which can help to increase soil fertility and reduce soil erosion.
- Promoting afforestation and reforestation programs in the high-risk areas, which can help to stabilize slopes and reduce soil erosion.
- Improving the drainage systems in the study area to reduce the impact of high-intensity rainfall events on soil erosion.
- Conducting regular monitoring and evaluation of the soil erosion risk zones to track changes and evaluate the effectiveness of the conservation measures implemented.

Overall, the study highlights the need for a comprehensive approach to address the issue of soil erosion in the Upper Godavari Sub Basin. The implementation of suitable conservation measures can help to reduce soil erosion and improve soil health, which can have significant positive impacts on the local environment, agriculture, and livelihoods of the people in the area.

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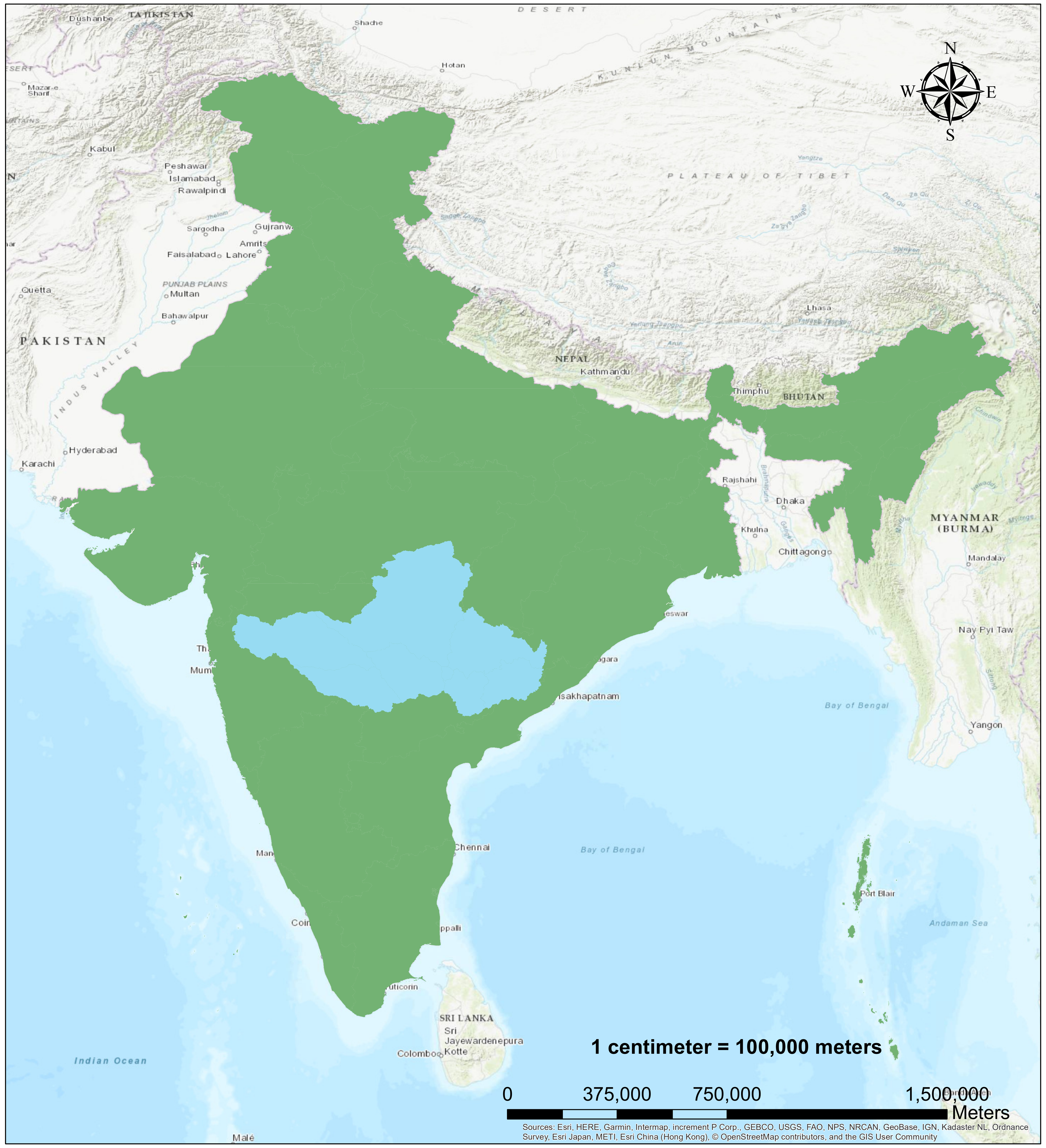
ANNEXURES



1 centimeter = 100,000 meters
0 375,000 750,000 1,500,000
Meters
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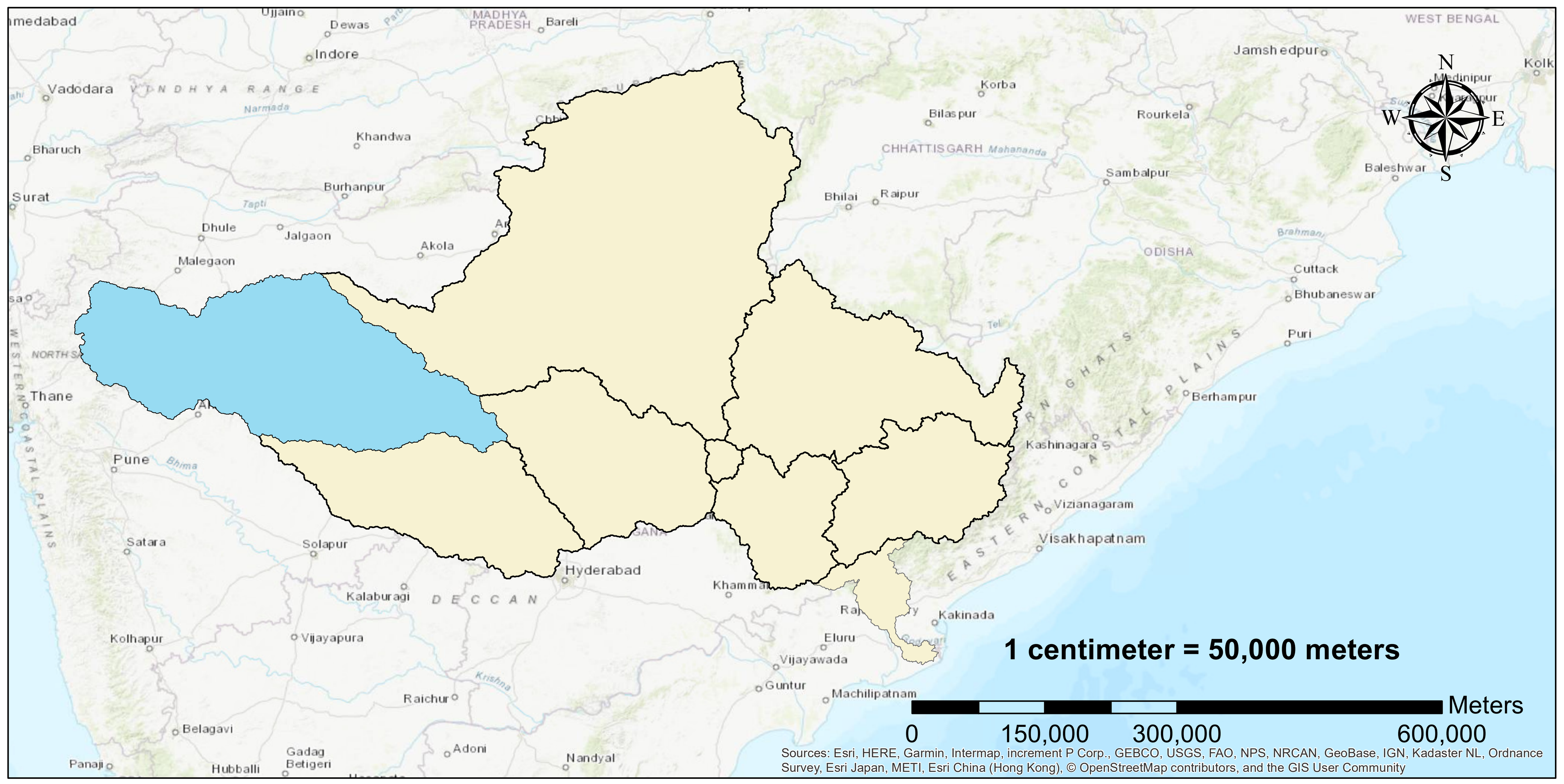

1 centimeter = 50,000 meters
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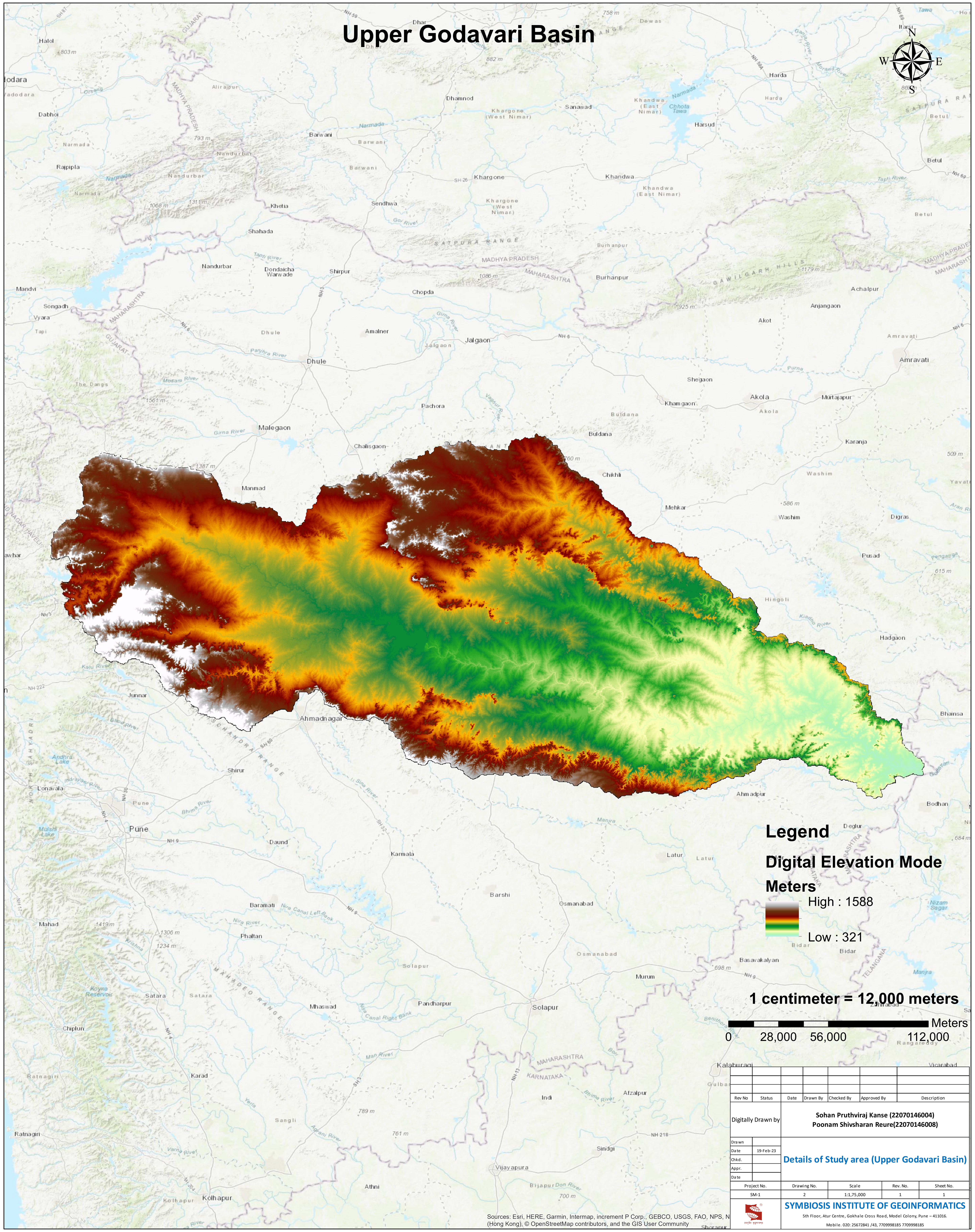
Meters
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), © OpenStreetMap contributors, and the GIS User Community



Upper Godavari Basin
Legend
Digital Elevation Mode
Meters
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Low : 321
1 centimeter = 12,000 meters
0 28,000 56,000 112,000
Meters
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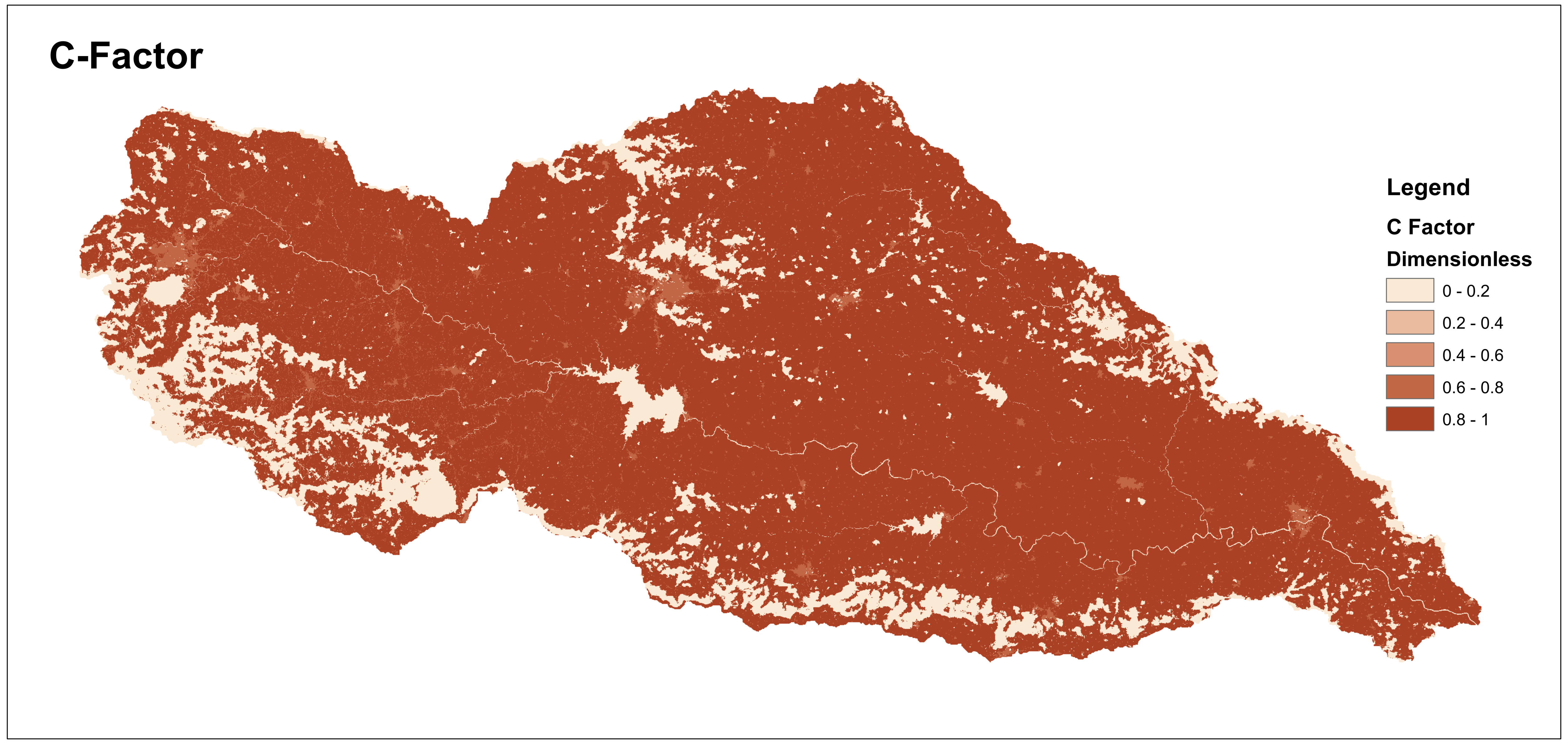
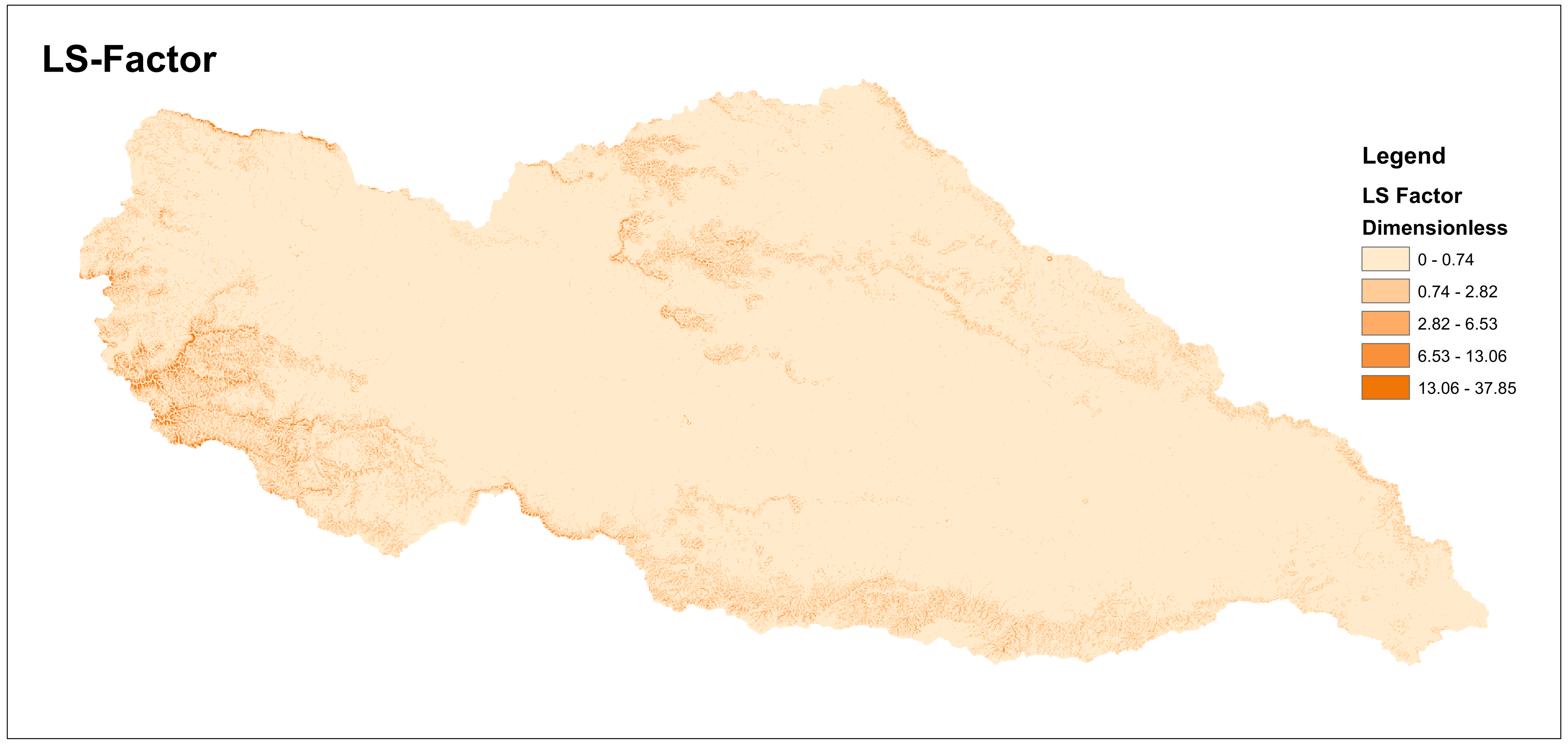
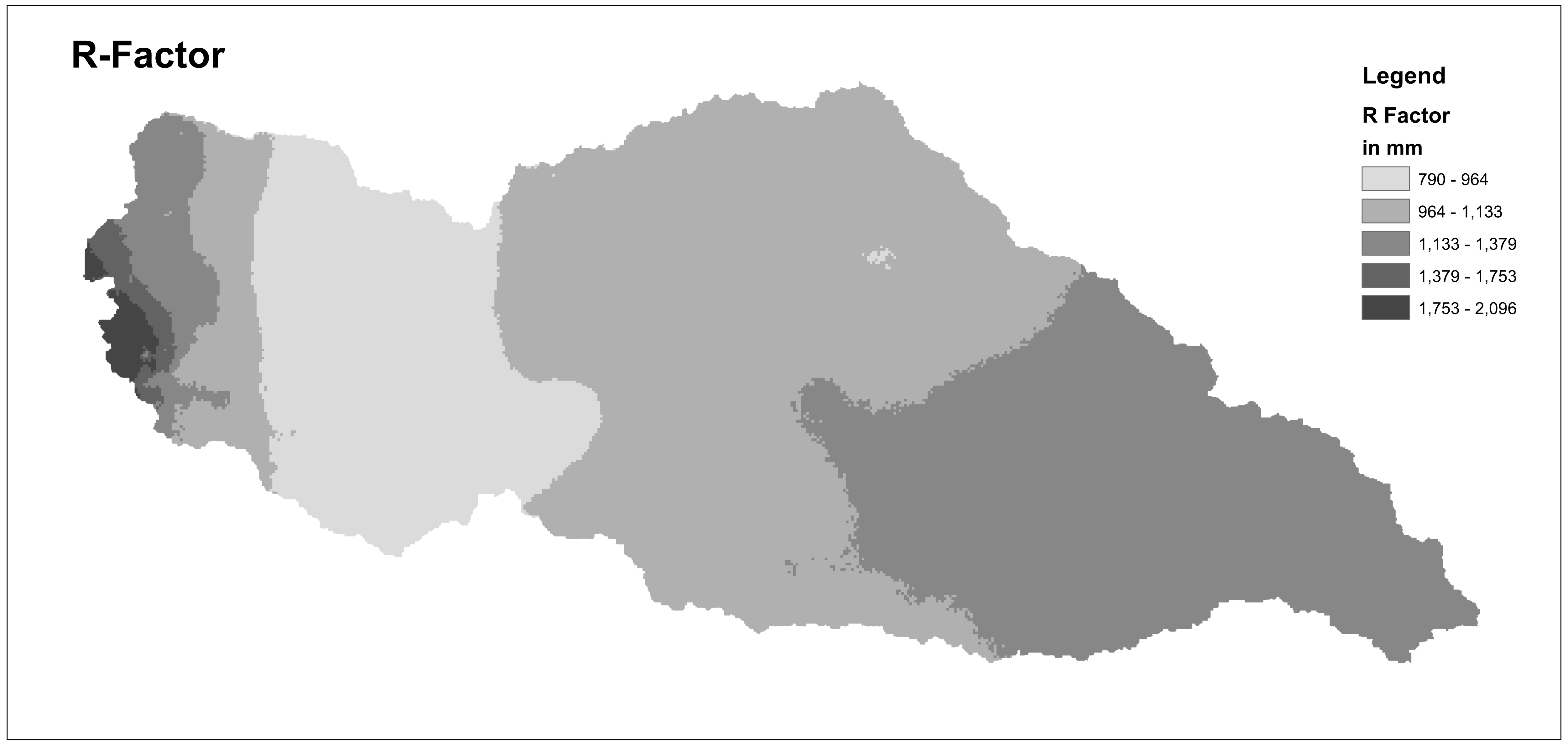
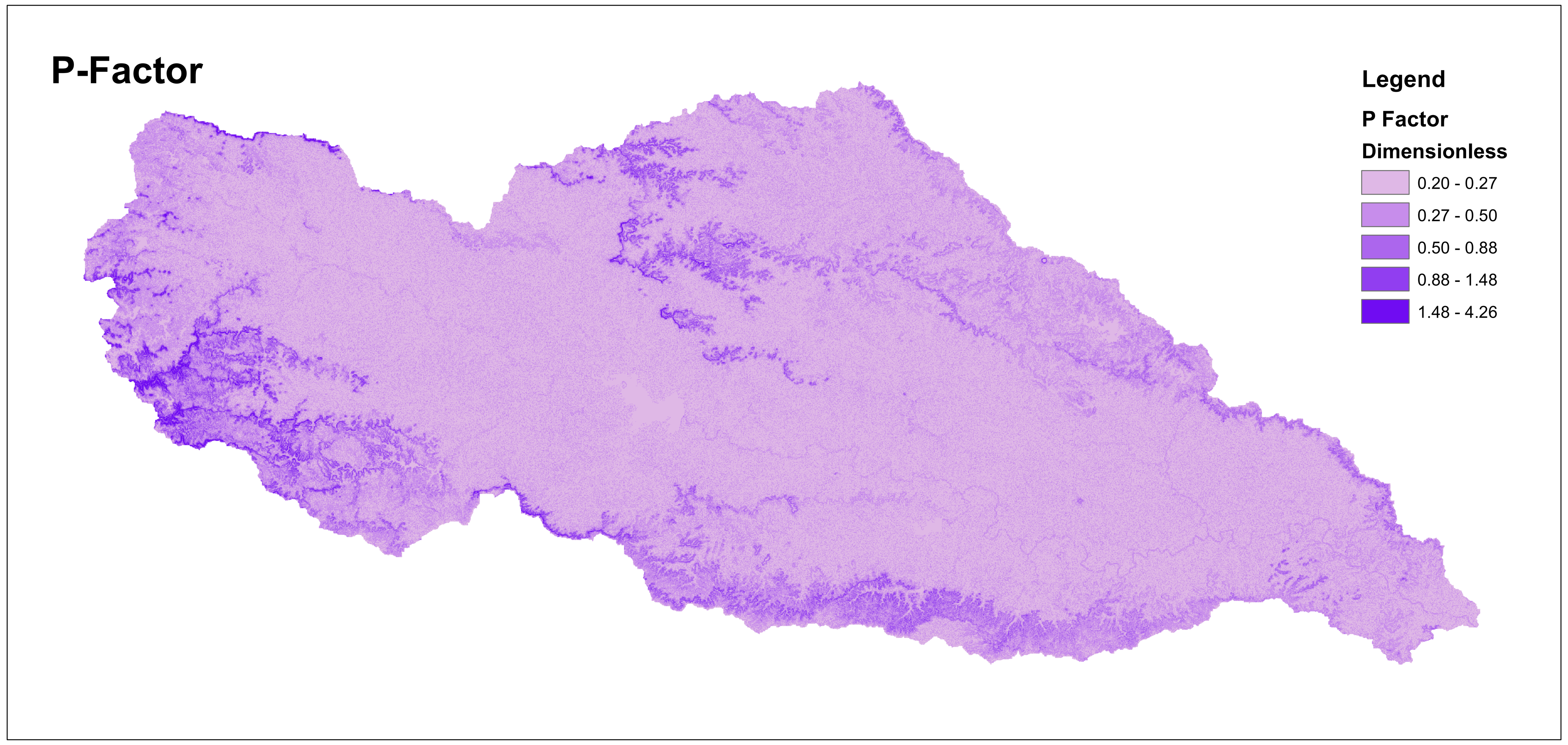
Sohan Pruthviraj Kanse (22070146004)
Poonam Shivsharan Reure(22070146008)
Details of Study area (Upper Godavari Basin)
SYMBIOSIS INSTITUTE OF GEOINFORMATICS

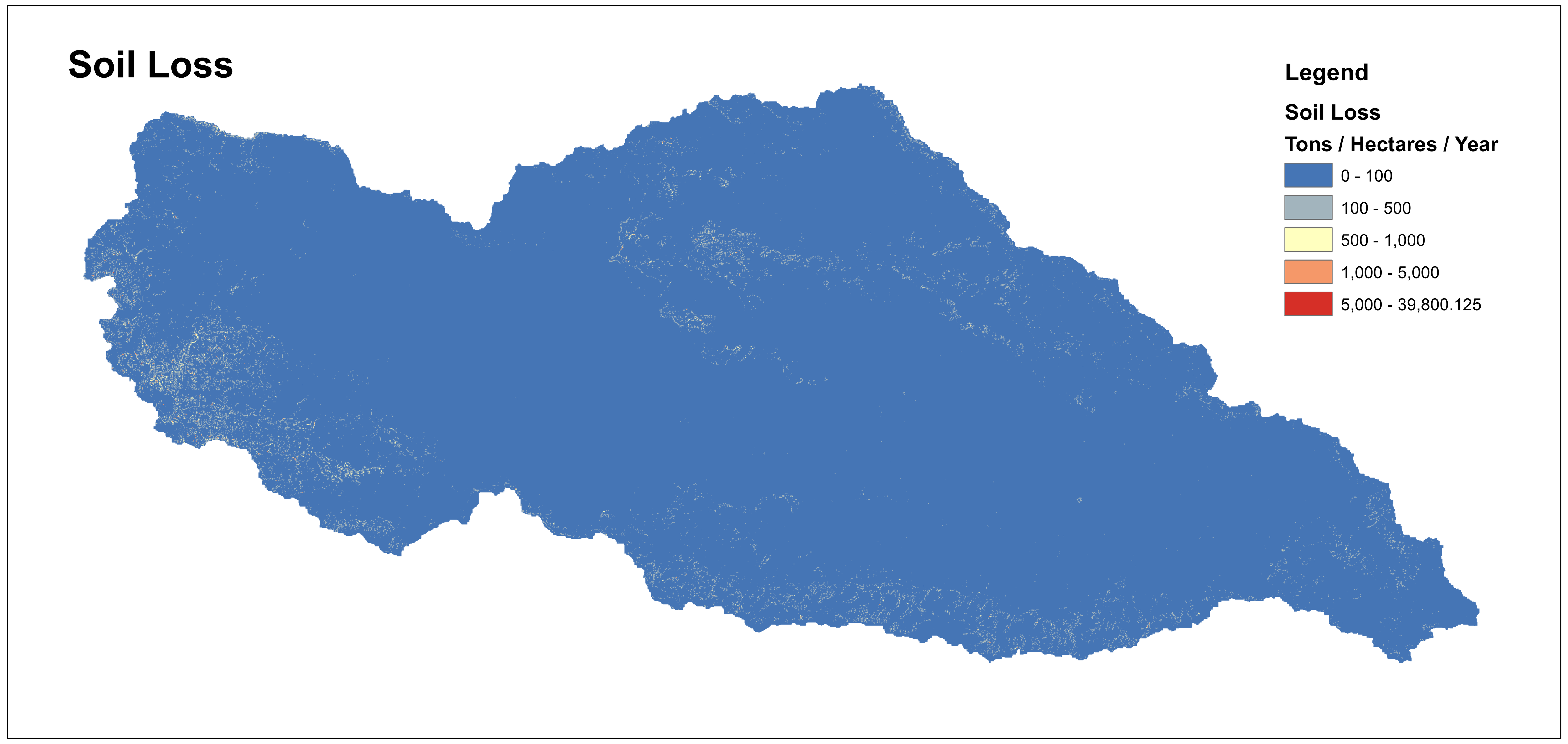

C-Factor
Legend
C Factor
Dimensionless
0 - 0.2
0.2 - 0.4
0.4 - 0.6
0.6 - 0.8
0.8 - 1


K-Factor
Legend
K Factor
Ton/ Hectares
0.12-0.13
0.13 - 0.17
0.17 - 0.25
0.25 - 0.35
0.35 - 0.5

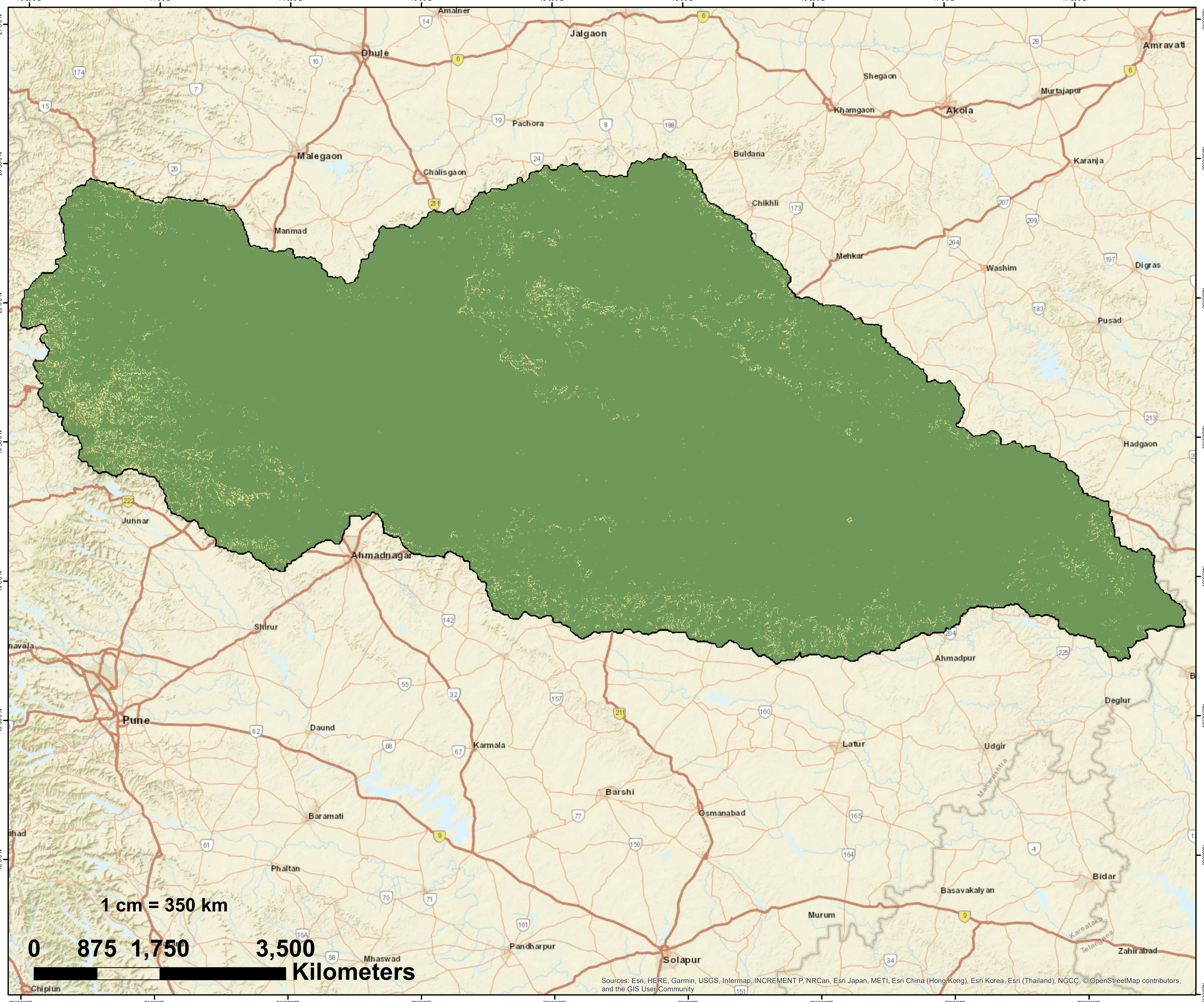

LS-Factor
Legend
LS Factor
Dimensionless
0 - 0.74
0.74 - 2.82
2.82 - 6.53
6.53 - 13.06
13.06 - 37.85

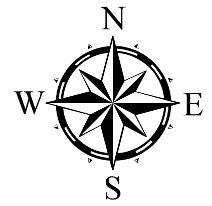

R-Factor
Legend
R Factor
in mm
790 - 964
964 - 1,133
1,133 - 1,379
1,379 - 1,753
1,753 - 2,096

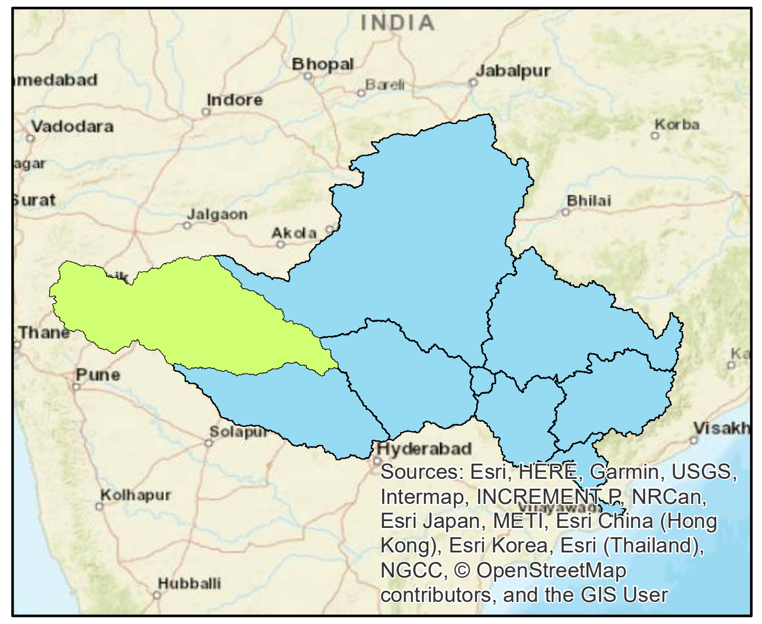

P-Factor
Legend
P Factor
Dimensionless
0.20 - 0.27
0.27 - 0.50
0.50 - 0.88
0.88 - 1.48
1.48 - 4.26


Soil Loss
Legend
Soil Loss
Tons / Hectares / Year
0 - 100
100 - 500
500 - 1,000
1,000 - 5,000
5,000 - 39,800.125

Soil Loss of Upper Godavari Basin







Legend

Upper Godavari

Upper Godavari Soil Loss

Ton / Hectares / Year

- Very Low (0-100)
- Low (100-500)
- Moderate (500 - 1000)
- High (1000 - 5000)
- Very High (5000-39800)

Rev No	Status	Date	Drawn By	Checked By	Approved By	Description

Digitally Drawn by	**Sohan Pruthviraj Kanse (22070146004)** **Poonam Shivsharan Reure(22070146008)**
Drawn	
Date	19-Feb-23
Chkd.	
Appr.	
Date	

Upper Godavari Soil Loss

Project No.	Drawing No.	Scale	Rev. No.	Sheet No.
SM-1	2		1	1

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