Anand Agricultural University

- **Module 2 –** Risk Analysis and Modeling
- **Project Title:** Soil Erosion Mapping with USLE Model and GIS.

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INTRODUCTION

- **What is Soil Erosion?**

- Soil erosion is the process of the top layer of soil being worn away by natural forces such as water, wind, or human activities. It removes the nutrient-rich topsoil, leading to reduced fertility and negatively affecting agriculture.

- **Causes of Soil Erosion**

1. Water Erosion: Rainfall and surface runoff wash away soil particles.

Rivers and streams can erode riverbanks, contributing to soil loss.

2. Wind Erosion: Strong winds carry away loose, dry soil, particularly in arid regions.

3. Deforestation: Removing trees and vegetation leaves soil exposed to erosion.

4. Overgrazing: Livestock grazing removes vegetation cover, leading to soil compaction and erosion.

5. Agricultural Practices: Poor farming techniques like excessive tilling disturb the soil structure and lead to erosion.

6. Construction and Urbanization: Land development disturbs soil, increasing the risk of erosion.

OBJECTIVES

- To use the USLE model within GIS to map soil erosion risk in a Watershed area.
- To evaluate the effectiveness of current soil conservation practices in the region.

Importance of Monitoring Soil Erosion

- **Sustainable Agriculture:**
  - Monitoring helps protect topsoil, ensuring long-term crop productivity and food security.
- **Environmental Protection:**
  - Prevents habitat loss and protects ecosystems through effective erosion control strategies.
- **Water Resource Management:**
  - Reduces sedimentation in rivers and reservoirs, ensuring water quality and availability.
- **Land Use Planning:**
  - Informed decisions help prevent erosion-prone activities in vulnerable areas.
- **Climate Change Mitigation:**
  - Healthy soil stores carbon, and erosion reduces this capacity. Monitoring helps mitigate climate change impacts.

Universal Soil Loss Equation (USLE)

- **A = R * K * LS * C * P**

  A = Annual Soil Erosion (t ha^{-1} yr^{-1})

  - Estimated soil loss in tons per hectare per year

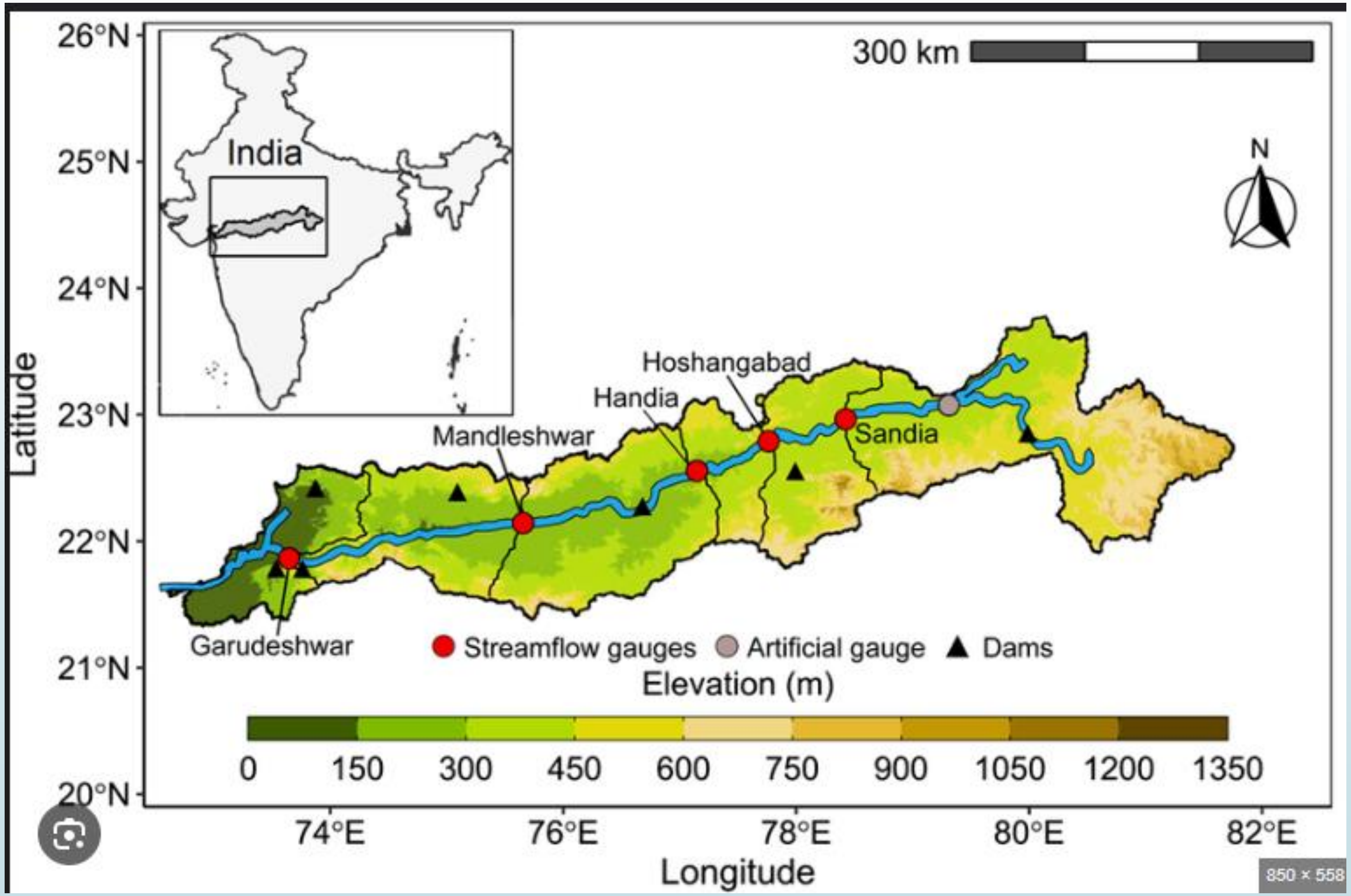
- **Factors Explained:**

- **R** = Rainfall Erosivity Factor (MJ mm ha^{-1} h^{-1} yr^{-1})
  - Measures the impact of rainfall intensity and volume on erosion
- **K** = Soil Erodibility Factor (t ha h ha^{-1} MJ^{-1} mm^{-1})
  - Indicates the susceptibility of soil particles to erosion based on soil properties
- **LS** = Slope-Length and Slope-Steepness Factor (Dimensionless)
  - Accounts for the influence of slope length and steepness on erosion rates
- **C** = Crop Management Factor (Dimensionless)
  - Reflects the effect of crop cover and management practices on soil protection
- **P** = Conservation Practice Factor (Dimensionless)
  - Represents the impact of conservation practices in reducing erosion

Data Sources

- **CHIRPS (Climate Hazards Group InfraRed Precipitation with Station Data)**
  Source: UCSB CHG
  Use: Rainfall data for R Factor calculation.
- **OpenLandMap Soil Data**
  Source: OpenLandMap
  Use: Soil texture classification for K Factor calculation.
- **SRTM (Shuttle Radar Topography Mission)**
  Source: USGS
  Use: Digital Elevation Model (DEM) for LS Factor calculation.
- **Sentinel-2 (Copernicus)**
  Source: European Space Agency
  Use: NDVI data for C Factor calculation.
- **MODIS Land Cover Type**
  Source: NASA MODIS
  Use: Land cover data for P Factor calculation.
- **WWF HydroSHEDS**
  Source: WWF
  Use: Basin boundary data for defining the Area of Interest (AOI).

Study Area – Narmada River Basin



Methodology Overview

- **Step 1:** Data Collection and Preprocessing
  - Import datasets (DEM, Land Use, Rainfall, Soil)
- **Step 2:** Calculation of USLE Factors using GEE
  - Rainfall Erosivity (R)
  - Soil Erodibility (K)
  - Topographic Factor (LS)
  - Crop Management Factor (C)
  - Conservation Practices Factor (P)
- **Step 3:** Soil Loss Estimation (A)
  - Combine the factors to calculate soil erosion
  - Visualization of erosion risk areas on GEE Map

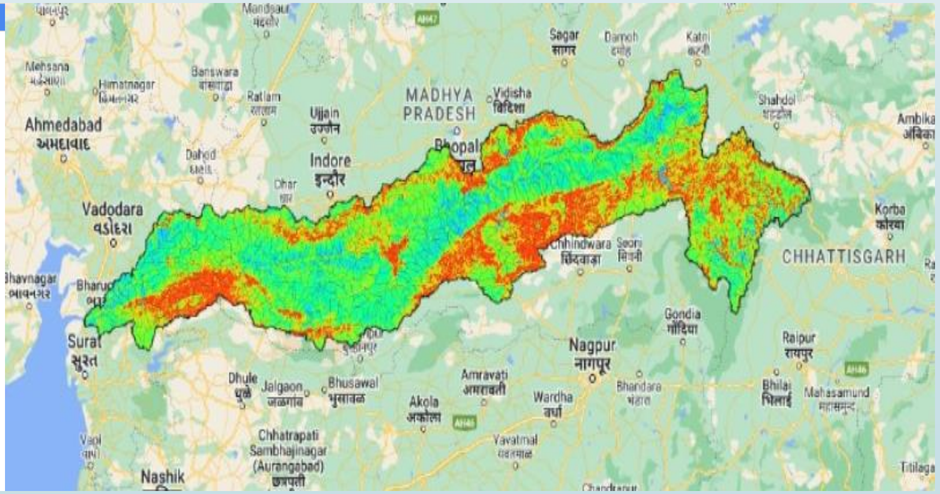
Implementation In GEE

- **Code Overview**
  1. Importing the datasets
  2. Applying calculations for each USLE factor
  3. Combining them to estimate soil loss
  4. Example: NDVI for C factor, DEM for LS factor

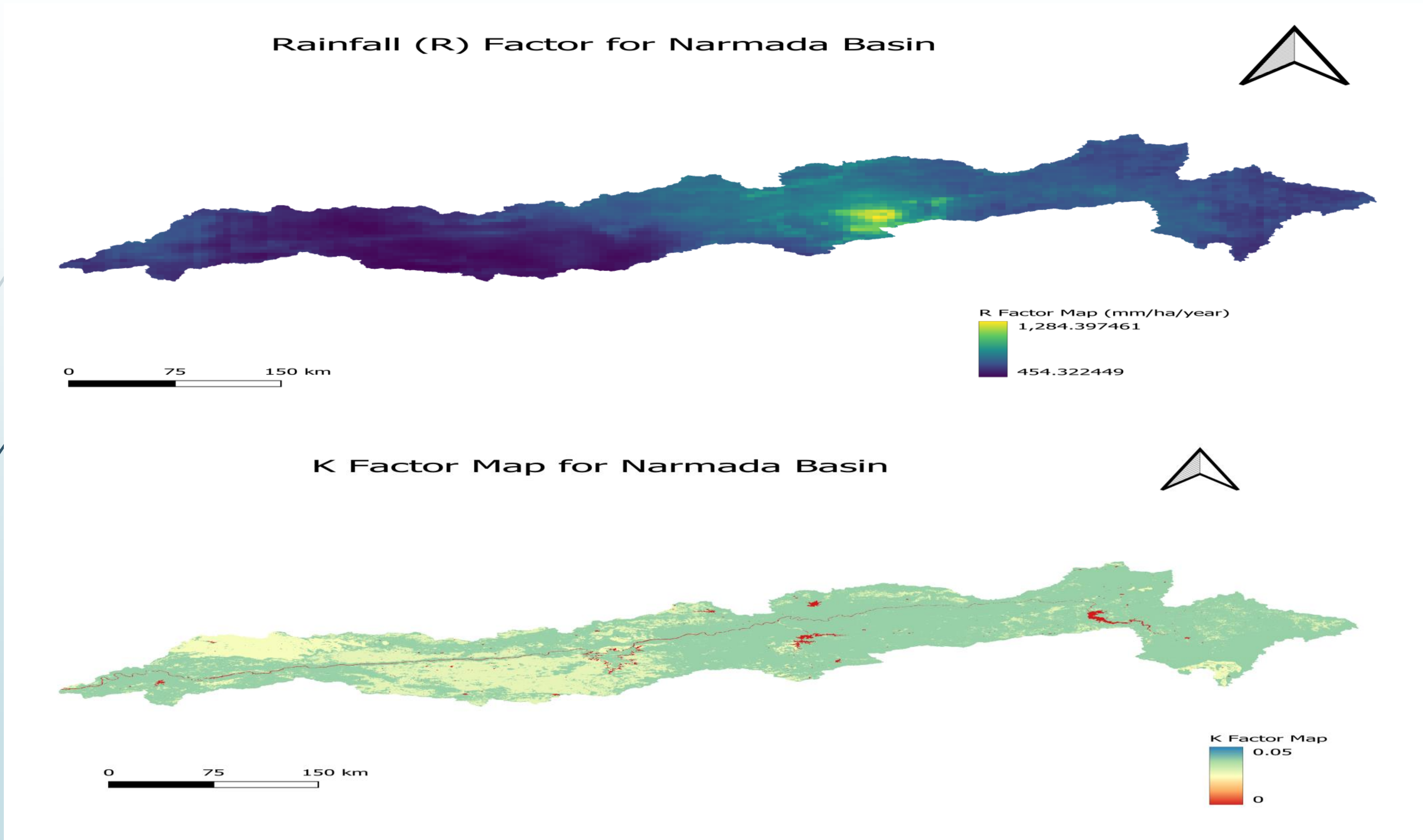
- **Code Snippet:**

https://code.earthengine.google.com/d338e8bd6e828ebccc5d5a619543b2e3

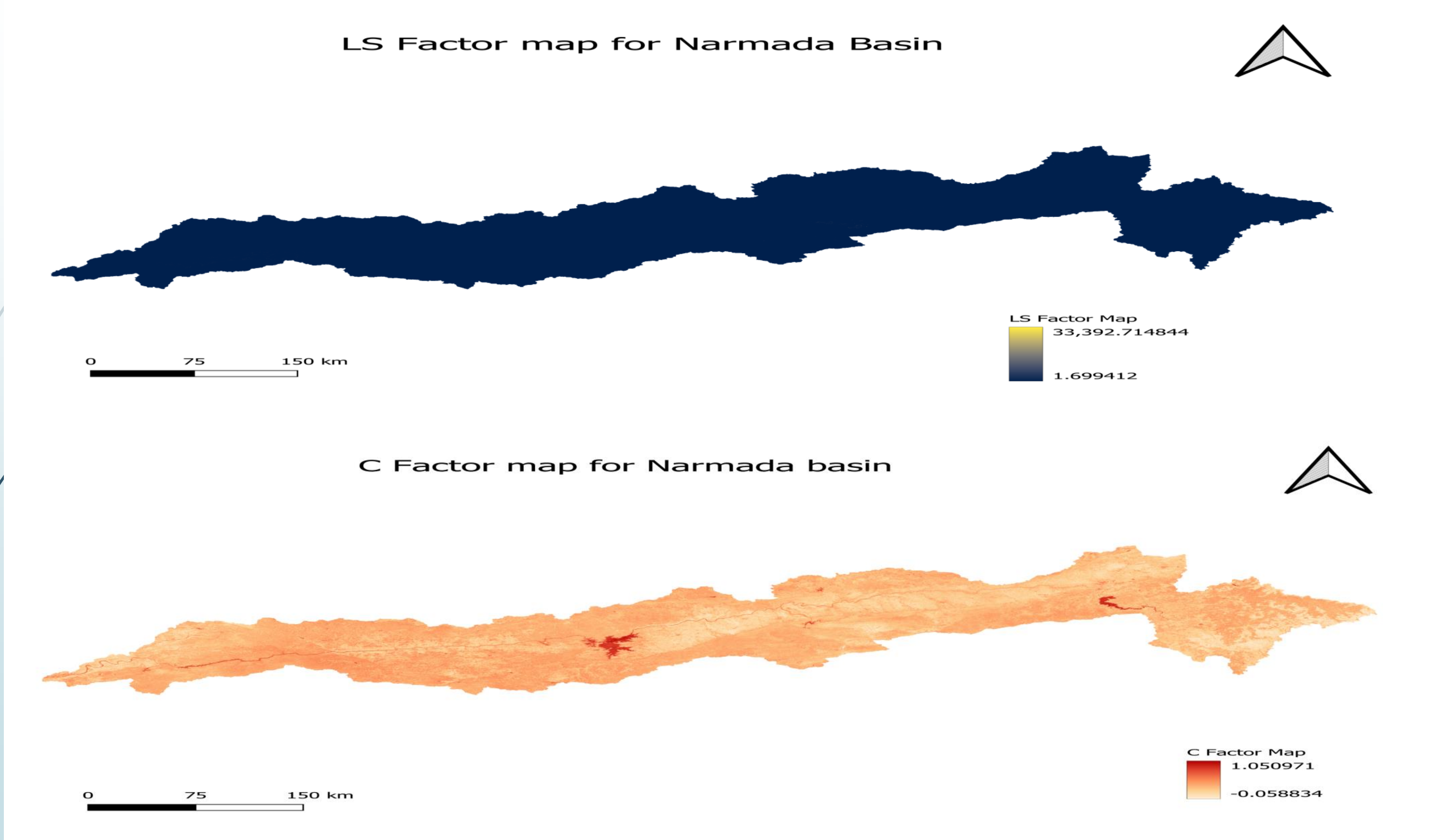

```
var CHIRPS = ee.ImageCollection("UCSB-CHG/CHIRPS/PENTAD"),
    soil = ee.Image("OpenLandMap/SOL/SOL_TEXTURE-CLASS_USDA-TT_M/v02"),
    DEM = ee.Image("USGS/SRTMGL1_003"),
    s2 = ee.ImageCollection("COPERNICUS/S2"),
    modis = ee.ImageCollection("MODIS/006/MCD12Q1");

//Defining Study Area

//For Basin Baoundary
var dataset = ee.FeatureCollection("WWF/HydroSHEDS/v1/Basins/hybas_12")
//Map.addLayer (dataset)

// var mainID = 4120031730 // Mahi Basin
var mainID = 4120031610 //ID for Narmada Basin
// var mainID = 4120025450 //for Ganga
// var mainID = 4120031730 //for Mahi Basin
// var mainID = 4120027100 // Mahanadi
// var mainID = 4120027940 //Krishna Basin

var main = dataset.filter(ee.Filter.eq('MAIN_BAS', mainID))
print('No of Subbasins:', main.size());
var aoi = main;

// Defining dates/year
var date1 = '2019-01-01';
var date2 = '2020-01-01';

Map.addLayer (aoi, {}, 'aoi')
```



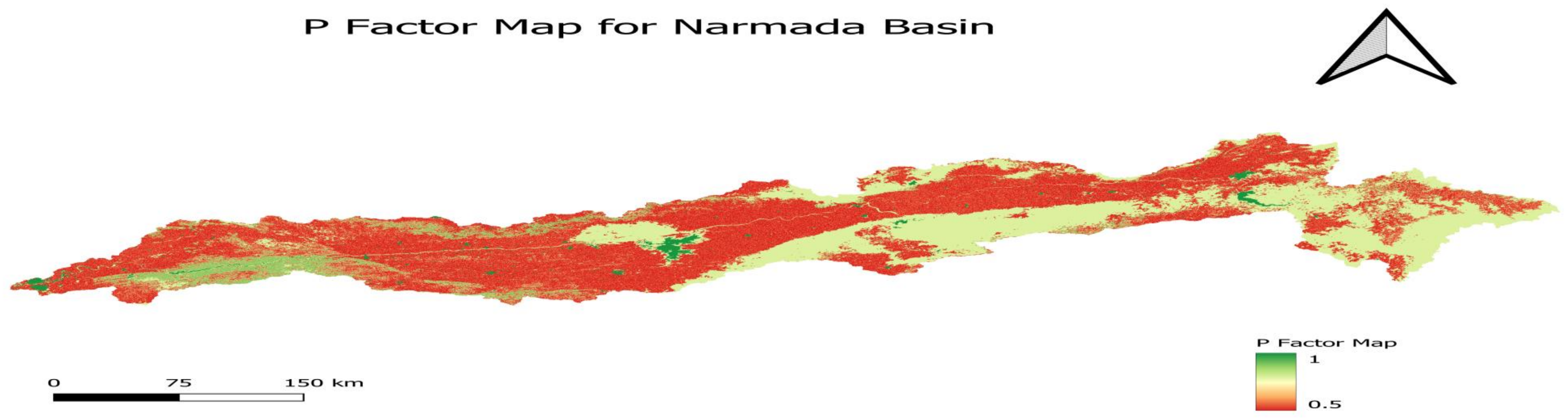
R and K factor Map

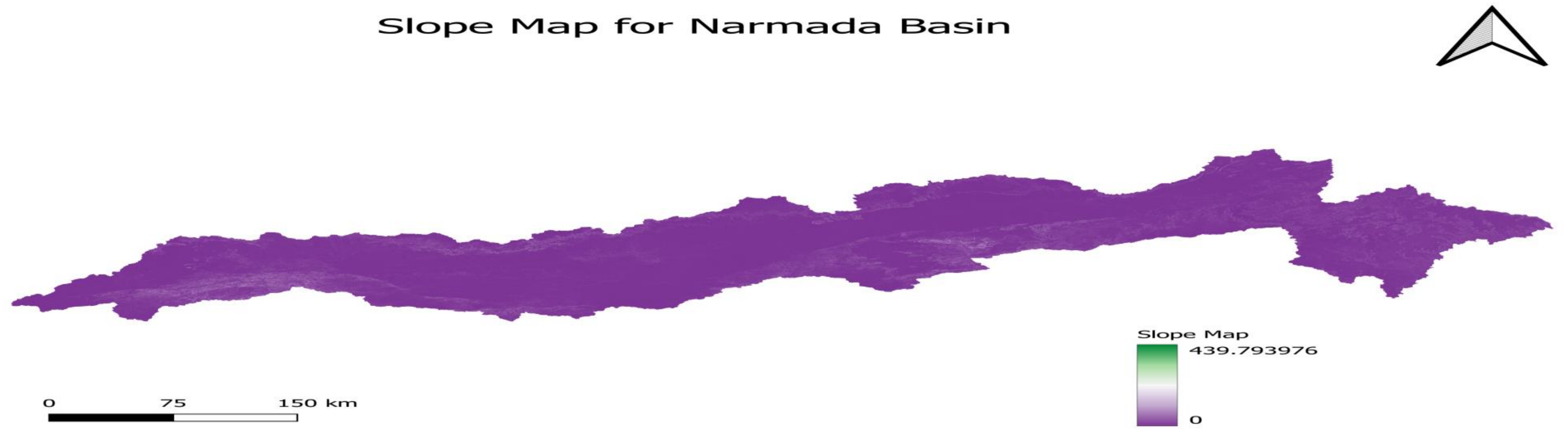


LS and C factor Map



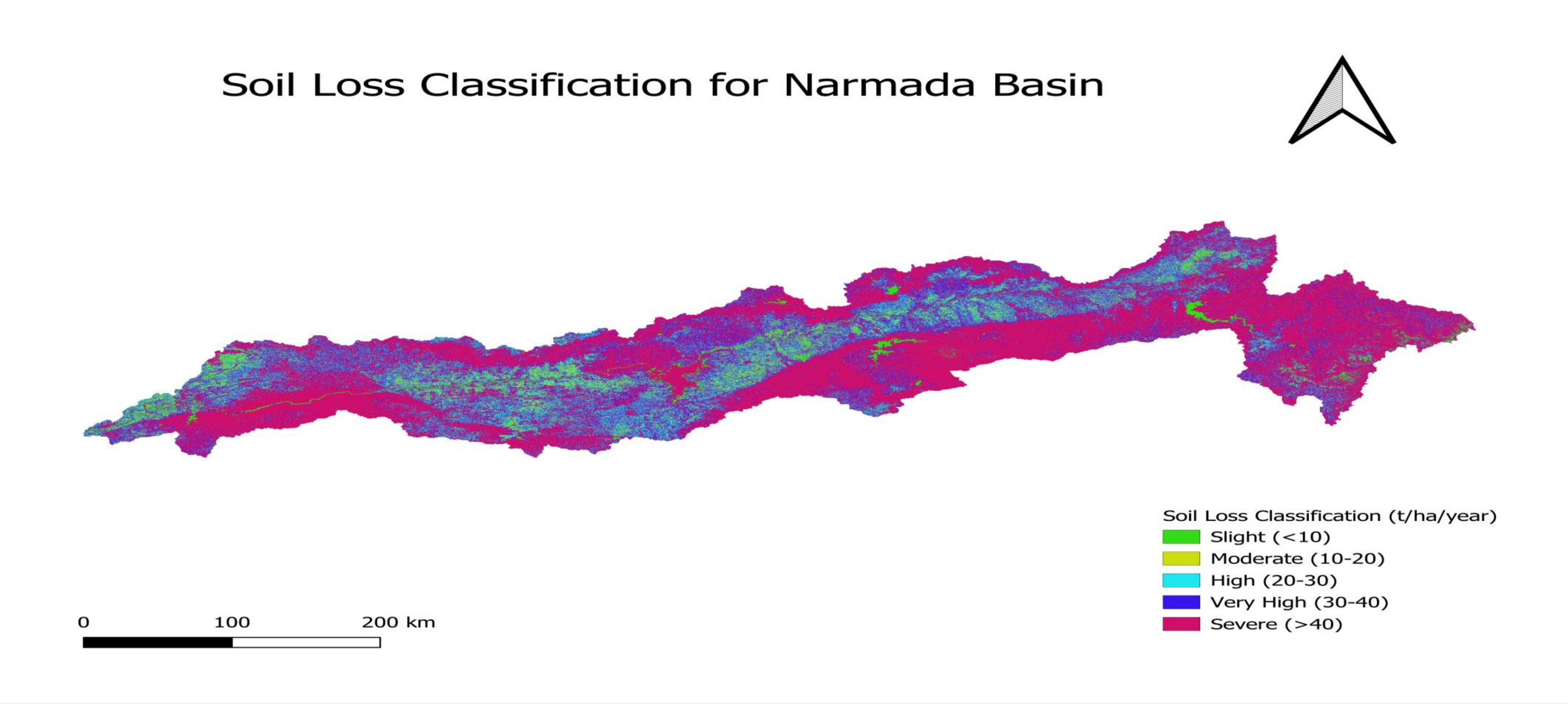
P factor and Slop Map





Results

- **Soil Erosion Map**



Conclusion

- **Summary of Findings:**
- Identified soil erosion hotspots in the study area.
- Areas with steep slopes and poor vegetation cover experience the highest erosion rates.
- Significant variation in soil loss based on topography, land cover, and rainfall patterns.
- **Insights:**
- **Rainfall** is a major contributor to soil erosion, especially in areas with high precipitation.
- **Land cover** plays a critical role in reducing erosion, with vegetated areas showing lower soil loss.
- **Topography** affects erosion, with steeper slopes being more prone to higher soil loss.

Thank You!