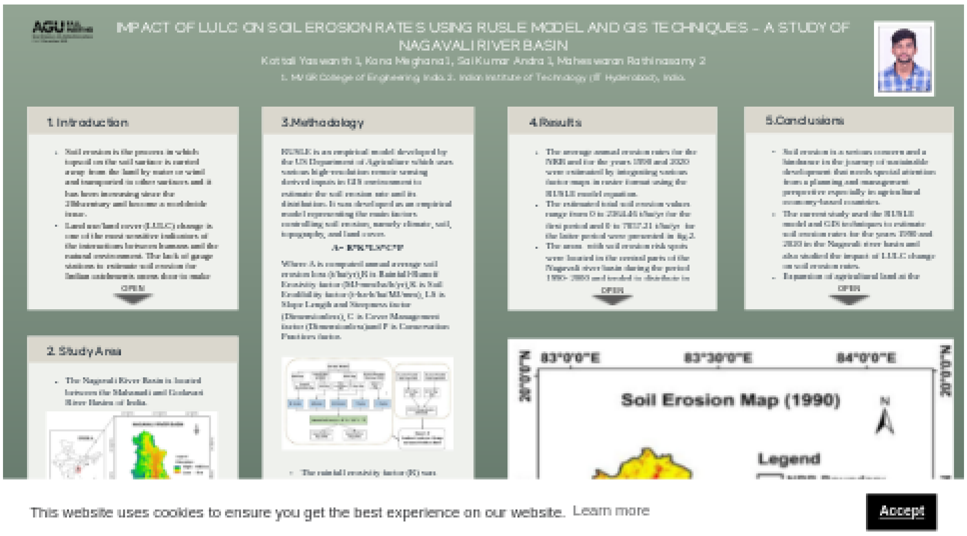
IMPACT OF LULC ON SOIL EROSION RATES USING RUSLE MODEL AND GIS TECHNIQUES – A STUDY OF NAGAVALI RIVER BASIN



Kottali Yaswanth 1, Kona Meghana 1, Sai Kumar Andra 1, Maheswaran Rathinasamy 2

1. MVGR College of Engineering, India. 2. Indian Institute of Technology (IIT Hyderabad), India.

PRESENTED AT:

1. INTRODUCTION

- Soil erosion is the process in which topsoil on the soil surface is carried away from the land by water or wind and transported to other surfaces and it has been increasing since the 20thcentury and become a worldwide issue.
- Land use/land cover (LULC) change is one of the most sensitive indicators of the interactions between humans and the natural environment. The lack of gauge stations to estimate soil erosion for Indian catchments opens door to make use of empirical methods with the help of GIS techniques.
- Despite the availability of various empirical models, Revised Universal Soil Loss Equation (RUSLE) is preferred over the physical-based models as the latter is time-consuming and necessarily require a large amount of data for soil erosion estimation (Dutta, 2016).
- Hence, the current study intends to calculate the average annual soil erosion rate for the Nagavali River Basin over the periods 1990 and 2020 using RUSLE model.

2. STUDY AREA

- The Nagavali River Basin is located between the Mahanadi and Godavari River Basins of India.

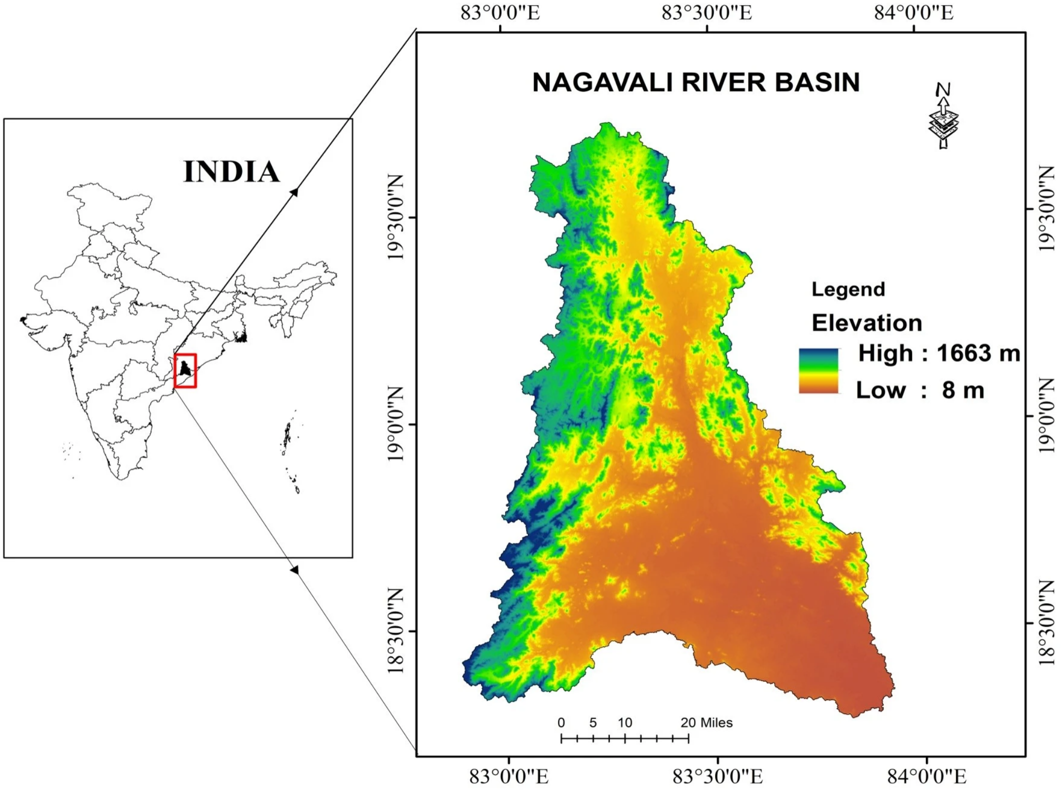


Figure.1. Nagavali watershed and its situation in India.

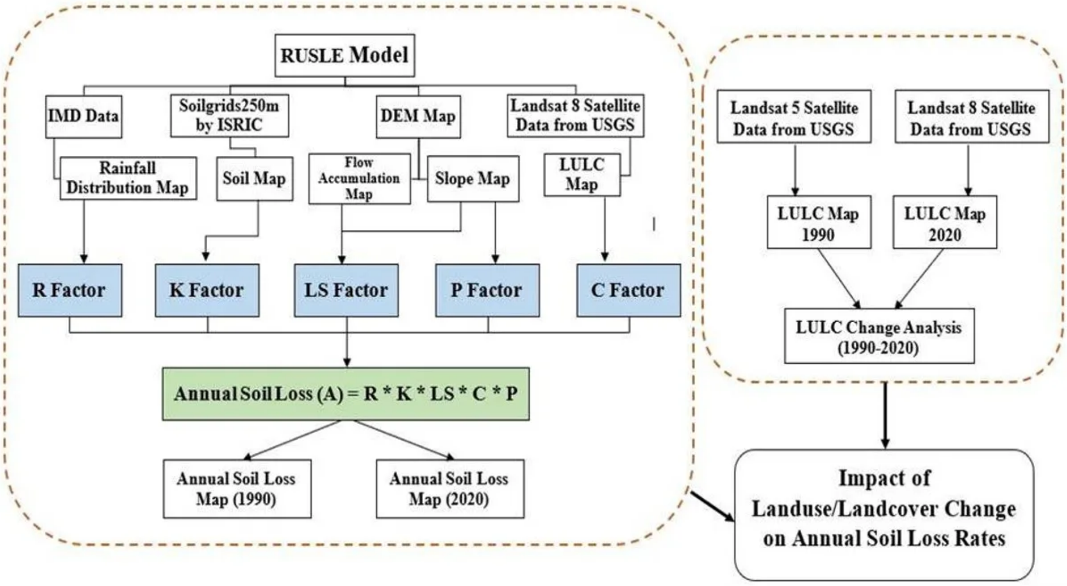
- Nagavali River (18° 12′–19° 44′N, 82° 53′– 83° 56′E) is an east-flowing river that extends over a drainage area of about 9510 sq. km.
- The elevation of the NRB varies from 8 m to 1663 m.
- Annual temperatures for NRB shows variations ranging from 32°C- 34.5°C during pre-monsoon, 29°C-31.2°C during monsoon, and 28.3°C - 31.7°C during post-monsoon periods.

3.METHODOLOGY

RUSLE is an empirical model developed by the US Department of Agriculture which uses various high-resolution remote sensing derived inputs in GIS environment to estimate the soil erosion rate and its distribution. It was developed as an empirical model representing the main factors controlling soil erosion, namely climate, soil, topography, and land cover.

A= R*K*LS*C*P

Where A is computed annual average soil erosion loss (t/ha/yr),R is Rainfall-Runoff Erosivity factor (MJ-mm/ha/h/yr),K is Soil Erodibility factor (t-ha-h/ha/MJ/mm), LS is Slope Length and Steepness factor (Dimensionless), C is Cover Management factor (Dimensionless)and P is Conservation Practices factor.



- The rainfall erosivity factor (R) was estimated by using the daily rainfall data retrieved from Indian Meteorological Department (IMD) for the period 1985 to 1994 and 2011 to 2020.
- The soil data downloaded from the SOILGRIDS250mat six standard depths (0, 5, 15, 30, 60and 100) was used to calculate the final K factor map.
- The LS-factor map which represents the overall contribution of topography to soil erosion was generated by using the DEM collected from the NSRC Bhuvan website.
- The present study used the land use land cover map of the river basin classified for the years 1990 and 2020 to obtain the C and P factor maps for those respective years.
- All the inputs obtained for the RUSLE model were converted into GIS datasets with a 30 m resolution and uniform coordinate system. They are multiplied to obtain the annual soil erosion map and to recognise its spatial distribution in the watershed using ArcGIS software.

4.RESULTS

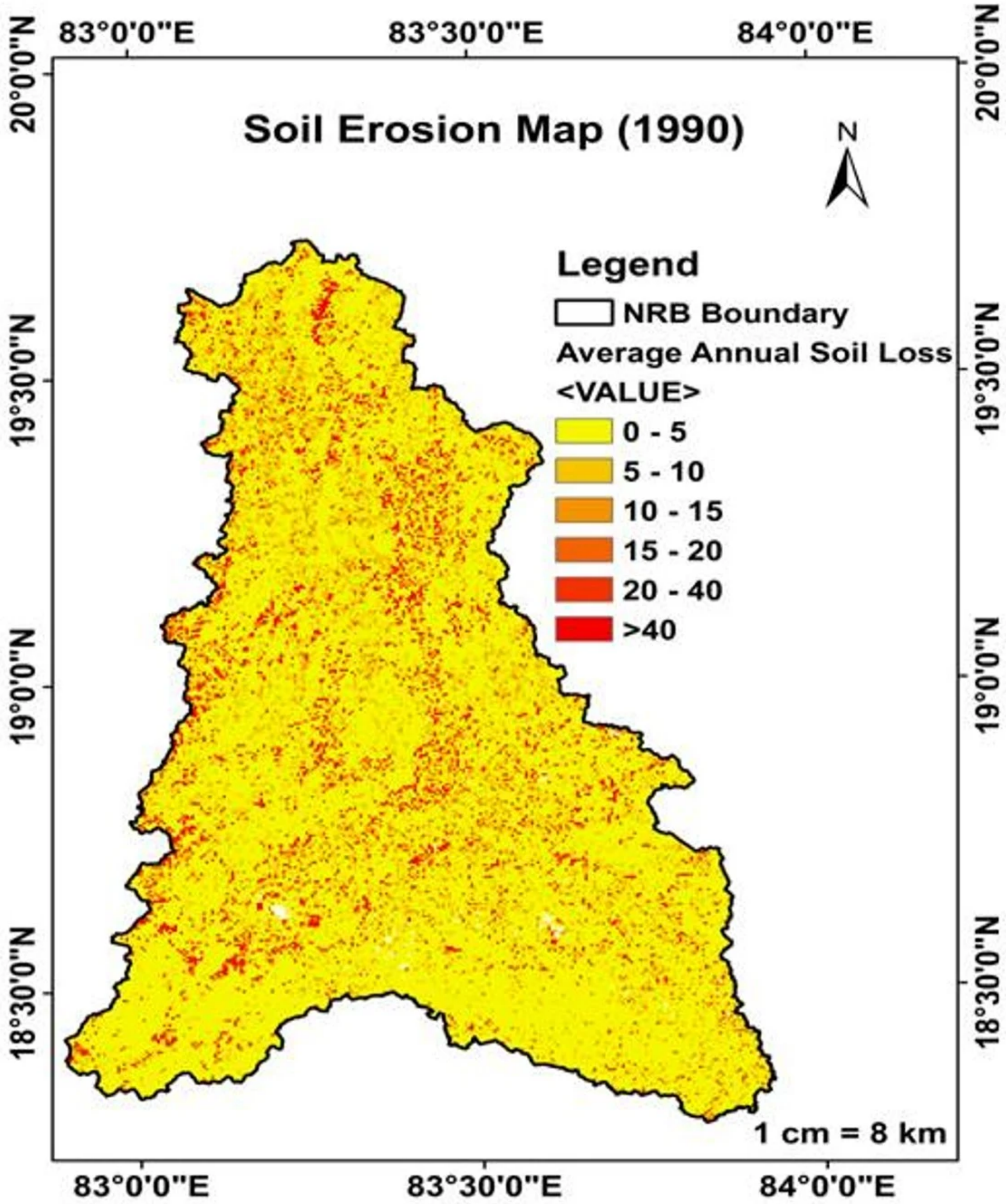
- The average annual erosion rates for the NRB and for the years 1990 and 2020 were estimated by integrating various factor maps in raster format using the RUSLE model equation.
- The estimated total soil erosion values range from 0 to 2364.46 t/ha/yr for the first period and 0 to 7857.21 t/ha/yr for the latter period were presented in fig.2.
- The areas with soil erosion risk spots were located in the central parts of the Nagavali river basin during the period 1990- 2000 and tended to distribute in the northern, eastern and western parts during the period 2010- 2020.
- The present study observed that significant LULC change (from 1990 to 2020) creates an impact on the runoff in the Nagavali river basin and this costs an increase in soil erosion rates.
- To understand the impact of LULC on soil erosion a spatial correlation was carried out between different LULC classes and soil loss change percentage using Karl Pearson's correlation.
- hanges in agricultural land area and waterbodies have very strong positive correlation on soil erosion, with correlation factors of 0.53 and 0.43, respectively. Indicating that the expansion of agricultural land areas and waterbodies over the last two decades in the NRB sub-basins clearly coincided with increased soil loss classes.

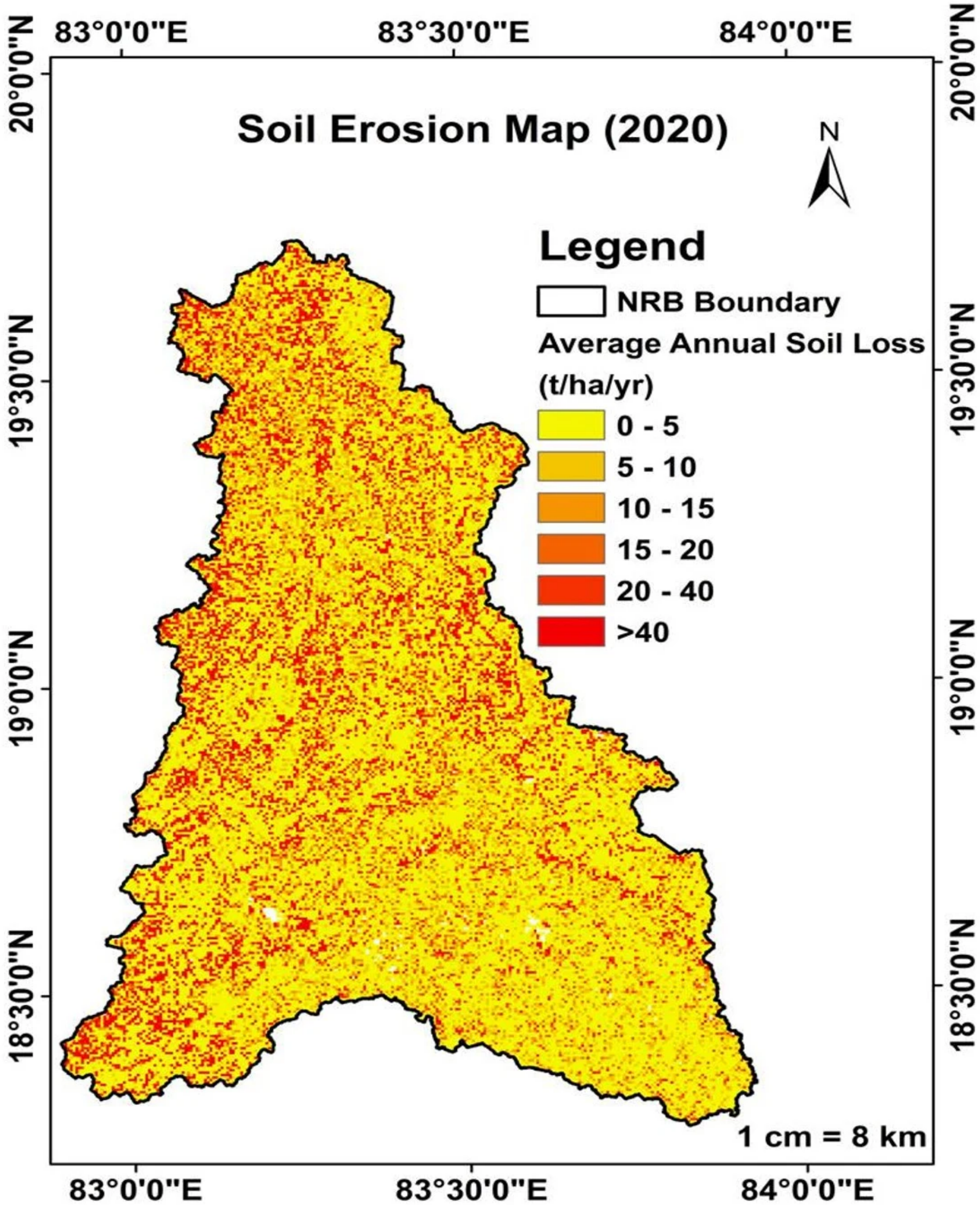
5.CONCLUSIONS

- Soil erosion is a serious concern and a hindrance in the journey of sustainable development that needs special attention from a planning and management perspective especially in agricultural economy-based countries.
- The current study used the RUSLE model and GIS techniques to estimate soil erosion rates for the years 1990 and 2020 in the Nagavali river basin and also studied the impact of LULC change on soil erosion rates.
- Expansion of agricultural land at the expense of orchards and scrublands was the most detrimental factor for severe soil erosion in the basin.
- The various water projects constructed across the river facilitated irrigation, resulting in the expansion of agricultural land. Construction of these water projects also leads to drastic land use land cover change from 1990-2020.
- The application of the RUSLE model identified the spatial distribution of the areas prone to erosion and quantified the annual average soil loss.

References:

Dutta, S. (2016). Soil erosion, sediment yield and sedimentation of reservoir: a review. *Modeling Earth Systems and Environment*, *2*(3), 1–18. https://doi.org/10.1007/s40808-016-0182-y


Soil Erosion Map (1990)
N
Legend
NRB Boundary
Average Annual Soil Loss
<VALUE>
0 - 5
5 - 10
10 - 15
15 - 20
20 - 40
>40
1 cm = 8 km
83°0'0"E
83°30'0"E
84°0'0"E
20°0'0"N
19°30'0"N
19°0'0"N
18°30'0"N


Soil Erosion Map (2020)
N
Legend
NRB Boundary
Average Annual Soil Loss
(t/ha/yr)
0 - 5
5 - 10
10 - 15
15 - 20
20 - 40
>40
1 cm = 8 km
83°0'0"E
83°30'0"E
84°0'0"E
20°0'0"N
19°30'0"N
19°0'0"N
18°30'0"N

ABSTRACT

Soil erosion is the most common type of land degradation, and it has become a global environmental issue that reduces soil productivity and water quality. LULC change related with climatic and geomorphologic states of the area affects land degradation. This study aims at estimating the annual average soil erosion for the study area, Nagavali River Basin, and also focuses to analyze the impact of land use land cover change on the annual average soil erosion rates of the Nagavali river basin. In this study, the soil properties, elevation, and topography of the study are considered to be constant. This study was done by using the Revised Universal Soil Loss Equation (RUSLE) model. This equation includes factors like rainfall, soil, land cover, cultivation practices, and slope, for the estimation of soil erosion. Each layer of the factors affecting soil erosion was prepared and integrated using GIS techniques.

By using the RUSLE model, the present study identified that the soil erosion rates for the years 1990 and 2020 ranged from 0 - 2364.46 t/ha/yr and 0 - 7857.21 t/ha/yr respectively for the Nagavali river basin. The LULC change analysis for the years 1990 and 2020 revealed that the erosion rate increased from 2364.46 t/ha/yr to 7857.21 t/ha/yr in the Nagavali river basin. The results also depicted that the area under very severe erosion class increased drastically from 1990 to 2020 while the area under very slight erosion class decreased from 1990 to 2020. This shows that LULC change has a significant impact on increase of soil erosion rates in Nagavali River Basin.