United nations/Pakistan/PSIPW
4th International Conference on the Use of Space Technology for Water Management
February 26th – March 02, 2018 Islamabad Pakistan

Soil & Water Conservation Needs Assessment using Geospatial Techniques: A case Study of Potohar Region of Pakistan

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Soil and Water Conservation: Major Challenges

Climate Change/Extreme weather events

Extreme weather events are;

- Creating severe environmental problems,
- Accelerating the rate of land degradation
- Threatening agricultural production needed for food security

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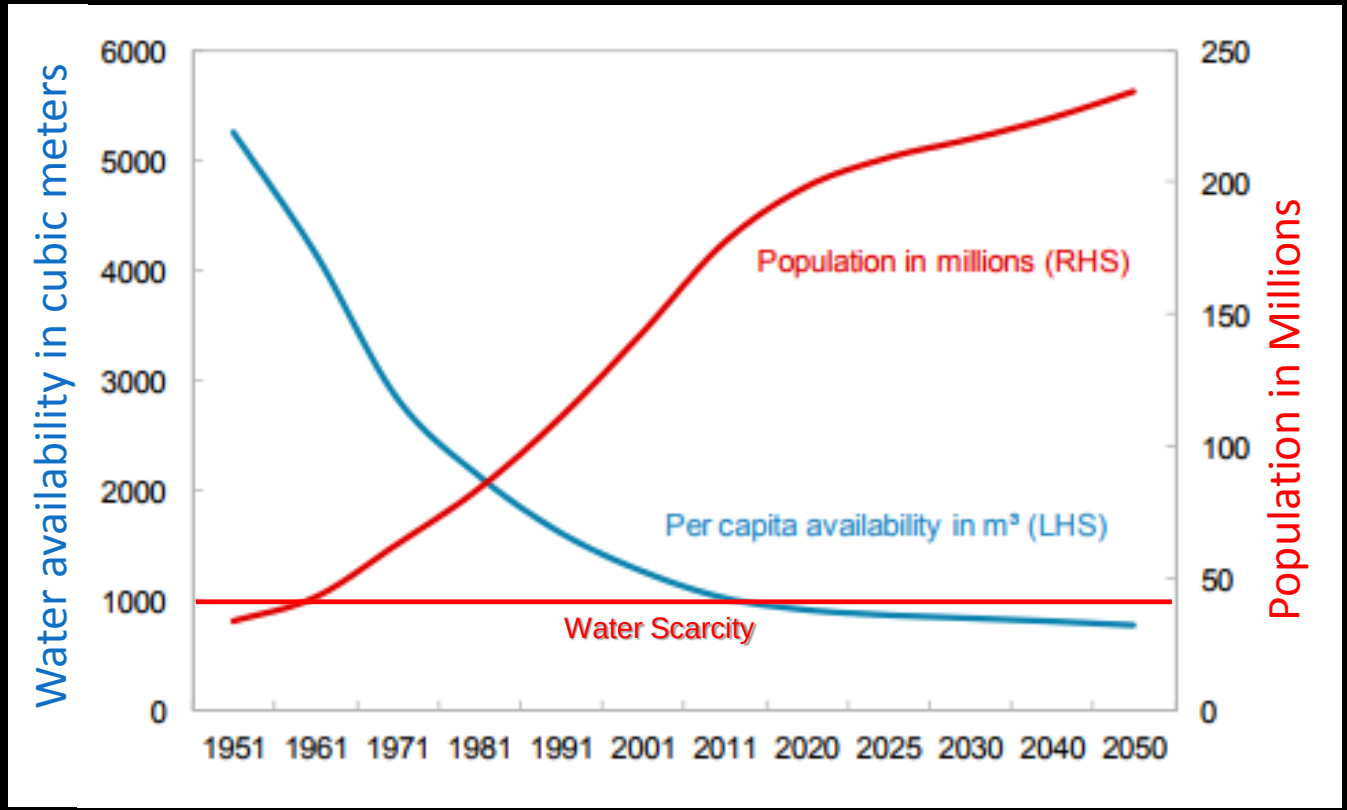
Soil and Water Conservation: Major Challenges

Declining per capita water availability



Source; Lal 2017

Soil and Water Conservation: Major Challenges

Squeezing per capita land resources

Land use	Hectare per person				
	1950	2015	2030	2050	2100
Agricultural land	0.95	0.18	0.15	0.12	0.10
Arable land	0.82	0.15	0.12	0.10	0.09
Irrigated land	0.29	0.10	0.08	0.067	0.057
Pasture land	0.13	0.025	0.02	0.015	0.014

Source; Lal 2017

Soil and Water Conservation: Major Challenges

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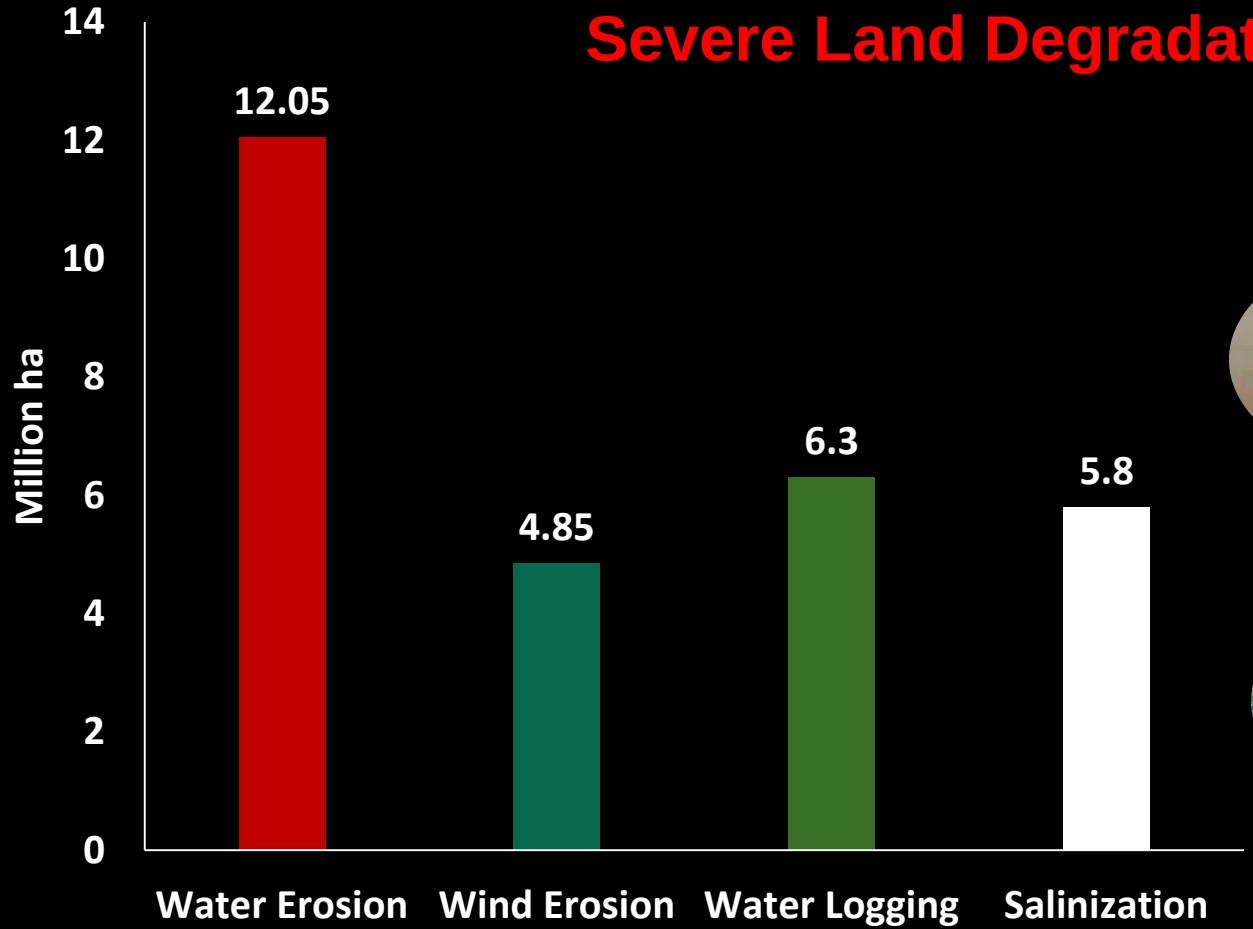
Severe Land Degradation



(Khan et al. 2012)

Pakistan's Erosion Issue

- About 12.05 Mha are affected by water erosion
- About 4.85 Mha are affected by wind erosion
- The Indus River in Pakistan ranked fifth in the world with a sediment load of 4.5 tons/h during 2007
- Capacity of our water reservoirs is reduced by 30%

Shah and Arshad, 2006; Anjum et al., 2010

Major Causes of Soil Erosion

Missing Information

- Despite severe economic and social impacts, the study field is neglected
- Few studies at water shed level while no larger scale studies
- Assessment is based on sediment load calculation while the process based approaches are rarely addressed
- Lack of systematic soil & water conservation needs assessment

Comprehensive studies involving advanced GIS and RS approaches and modeling are needed

Objectives of the study

- Estimating the soil erosion risk using geospatial techniques
- Identifying priority areas for soil and water conservation interventions
- Assessment of major conservation needs of the study area

Study Area: Potohar Region

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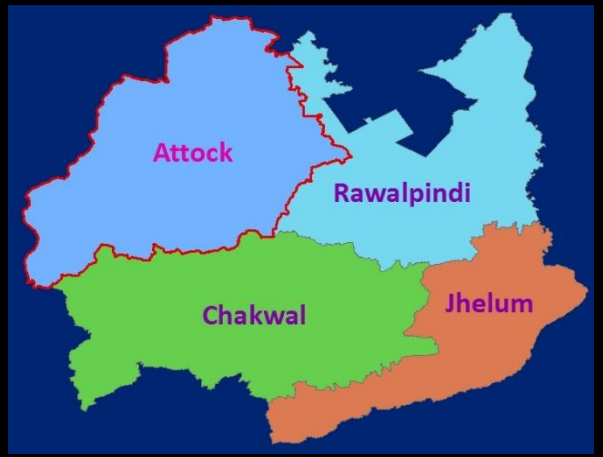
- A plateau comprising of 2.2 mha geographical area
- Yearly precipitation varies from 450 mm in South West to 1750 mm in North East
- Situated at the top of Indus river system between River Indus and River Jehlum
- Major tributaries: River Haro and River Soan
- Deep underground water, complex topography with high drainage density



Monthly Rainfall Pattern Potohar

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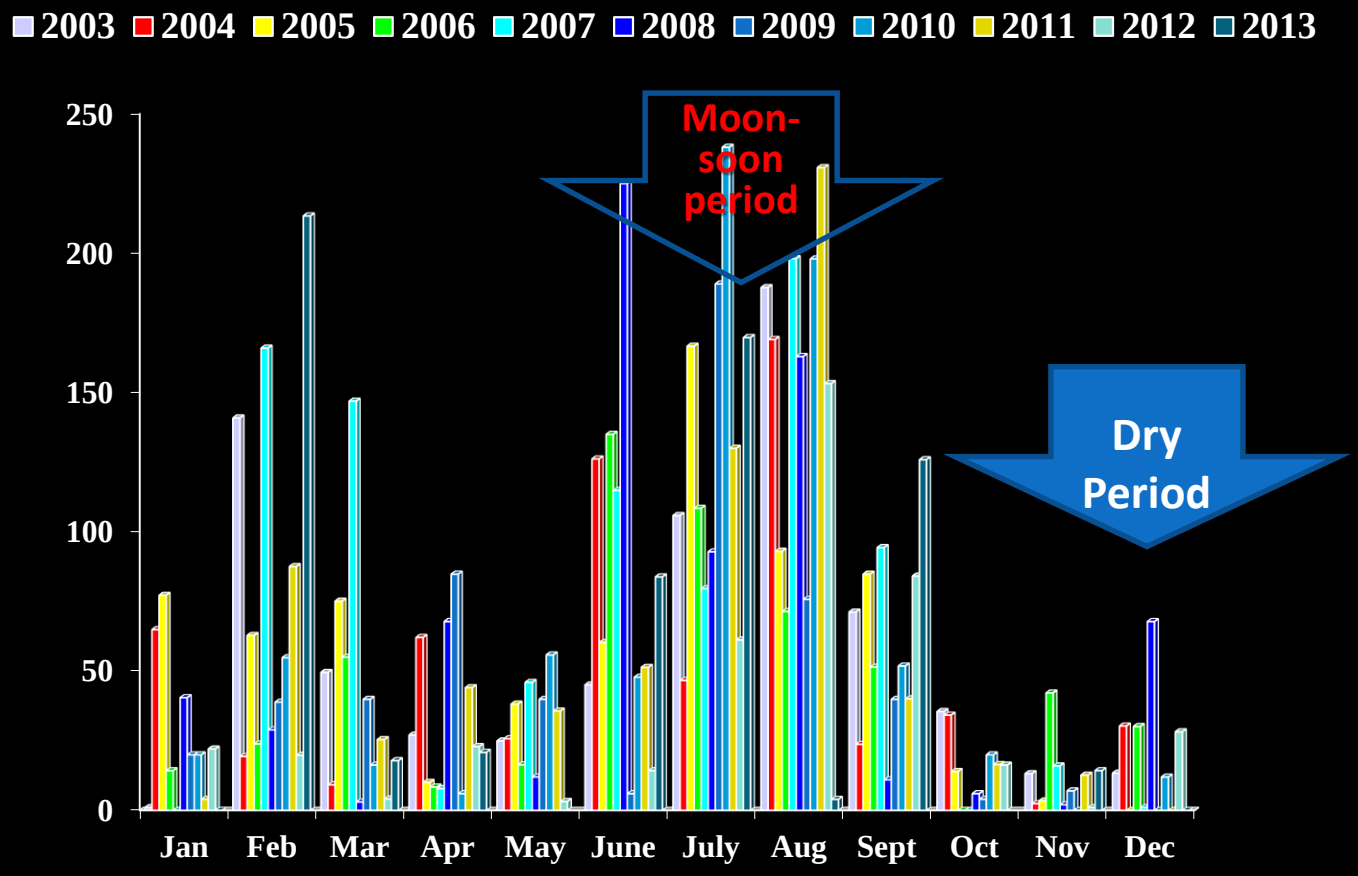


Approach

Revised Universal Soil Loss Equation

$$A = R \times K \times LS \times C \times P$$

A = Annual soil loss

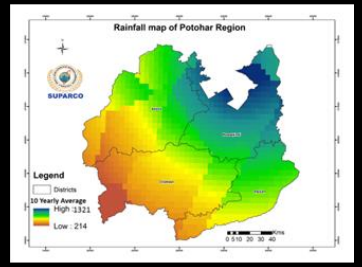
R = Rainfall Erosivity factor

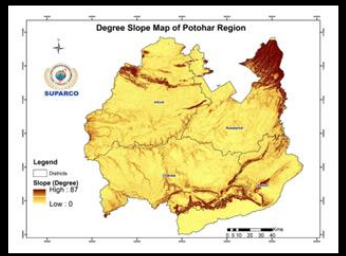
K = Soil Erodability factor

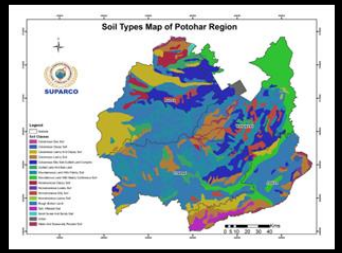
LS = Slope Length and steepness factor

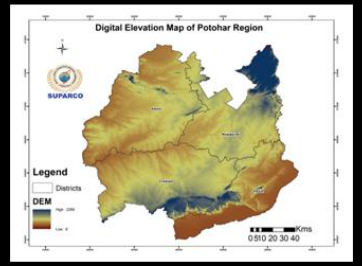
C = Cover factor

P = Conservation practices factor



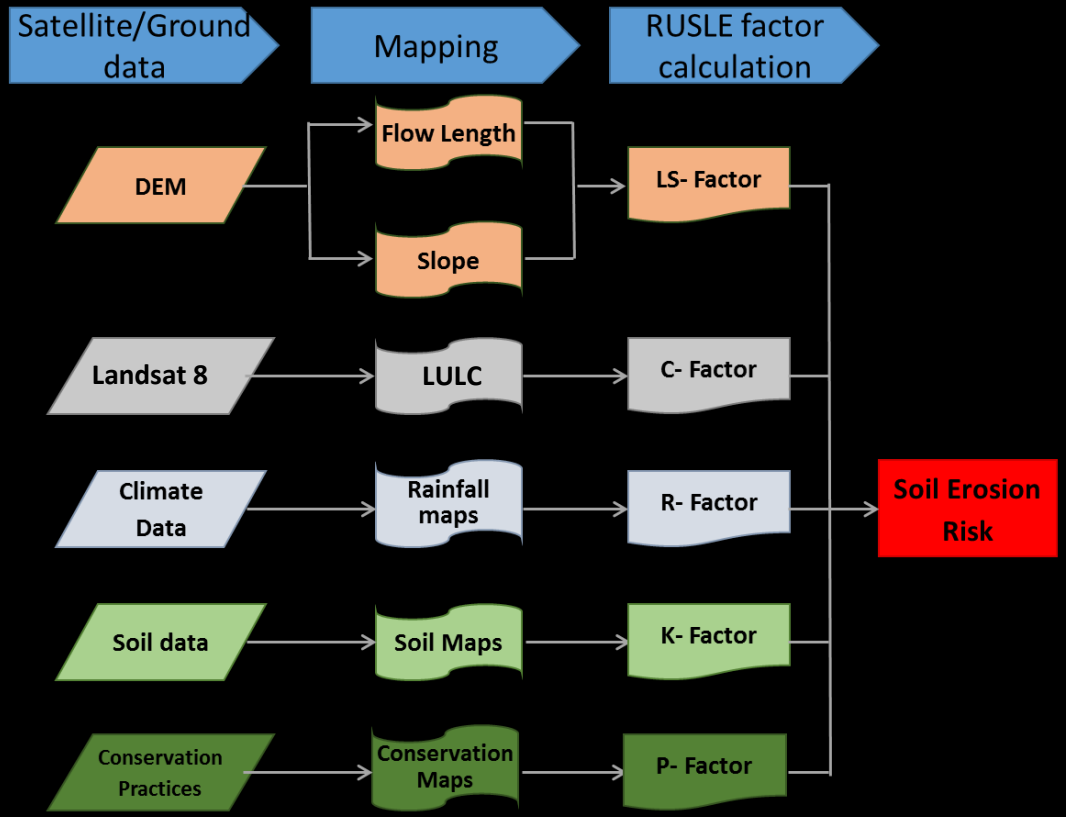






Approach

Satellite derived and ground parameters to be used



Datasets: DEM

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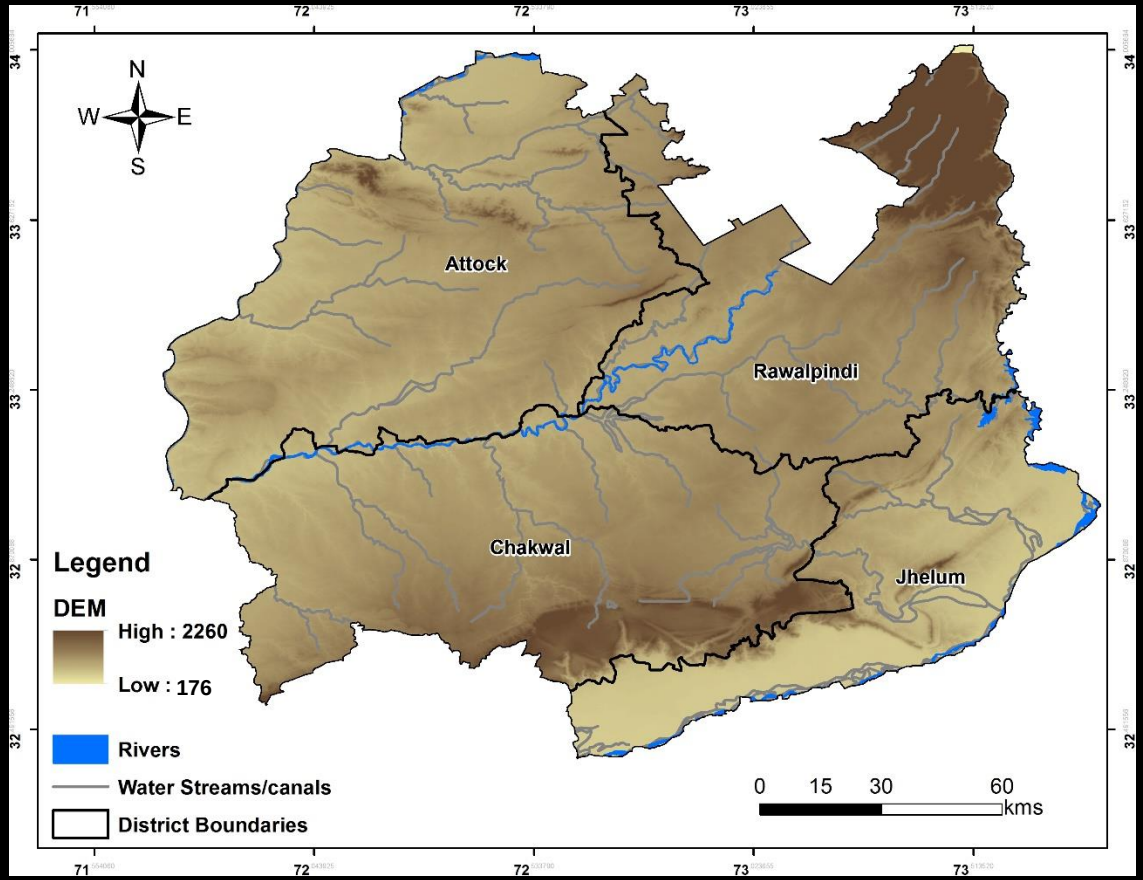

(ASTER GDEM V2: 30 m Spatial Resolution)

Datasets: Land Use Land Cover

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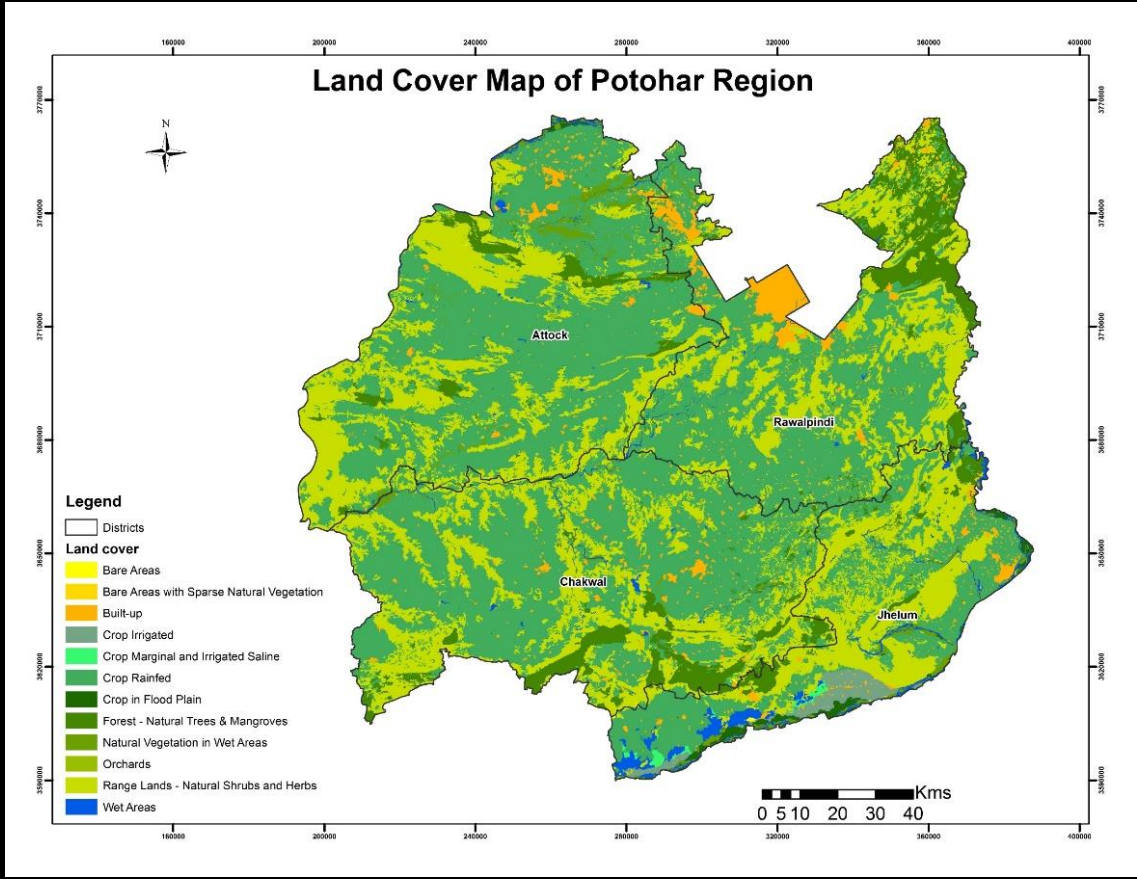
Landsat - 8 Data

↓

Supervised Classification

↓

LULC



Datasets: Rainfall

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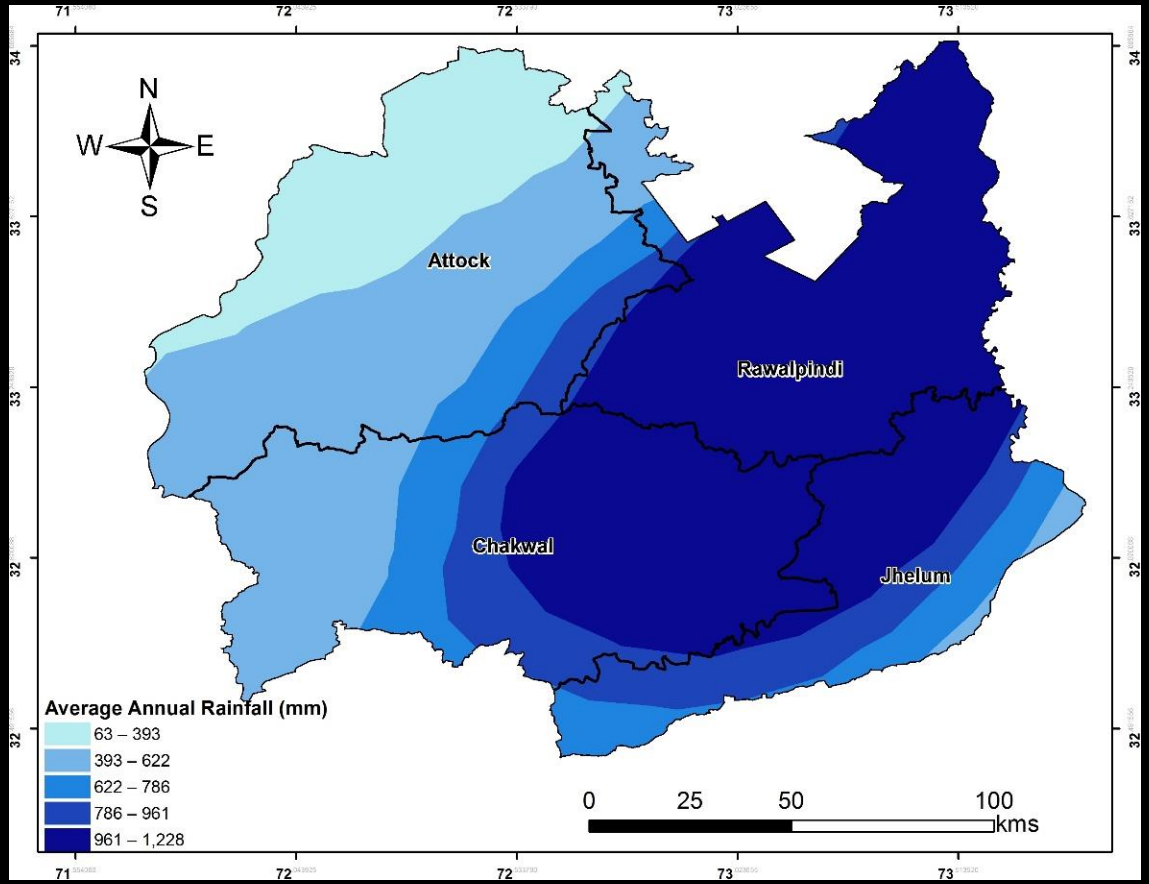
PMD Data (2005-15)

↓

Interpolation

↓

Rainfall map



Datasets: Soil Data

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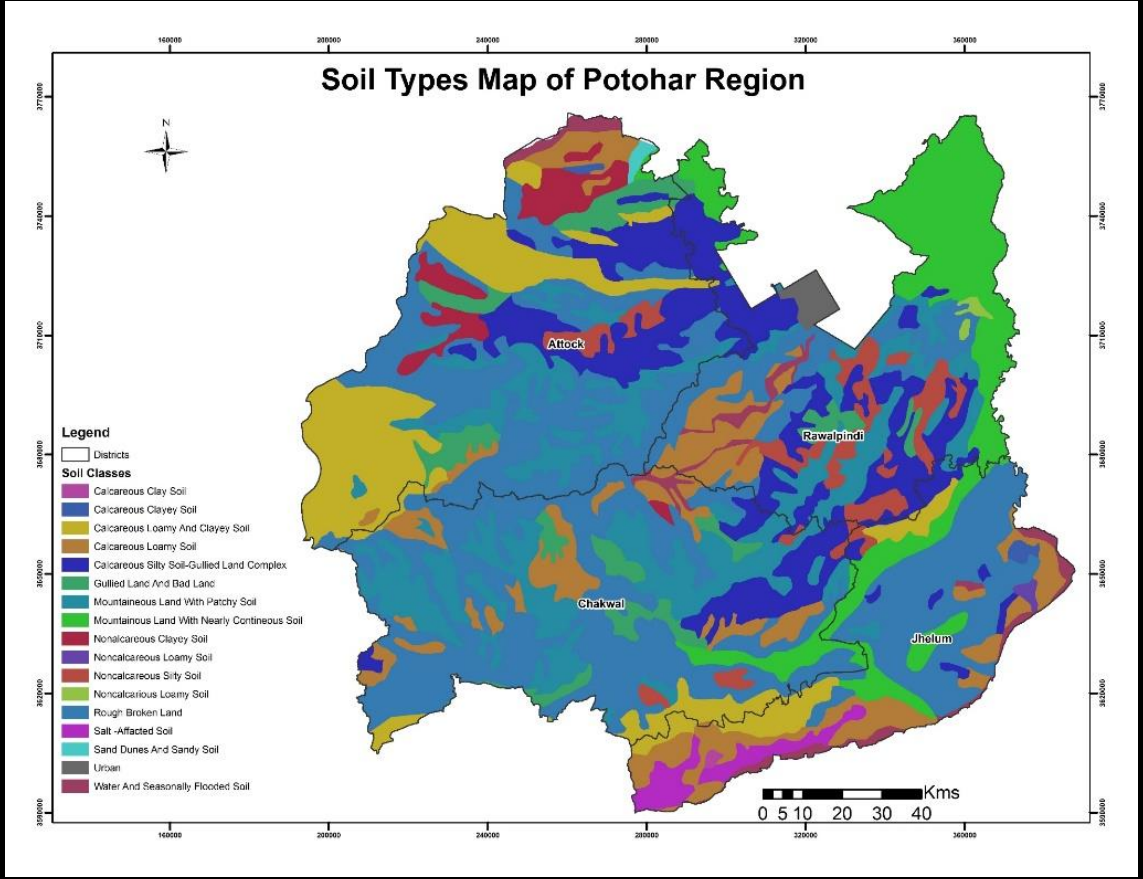
Soil Survey Legacy Maps/Data

↓

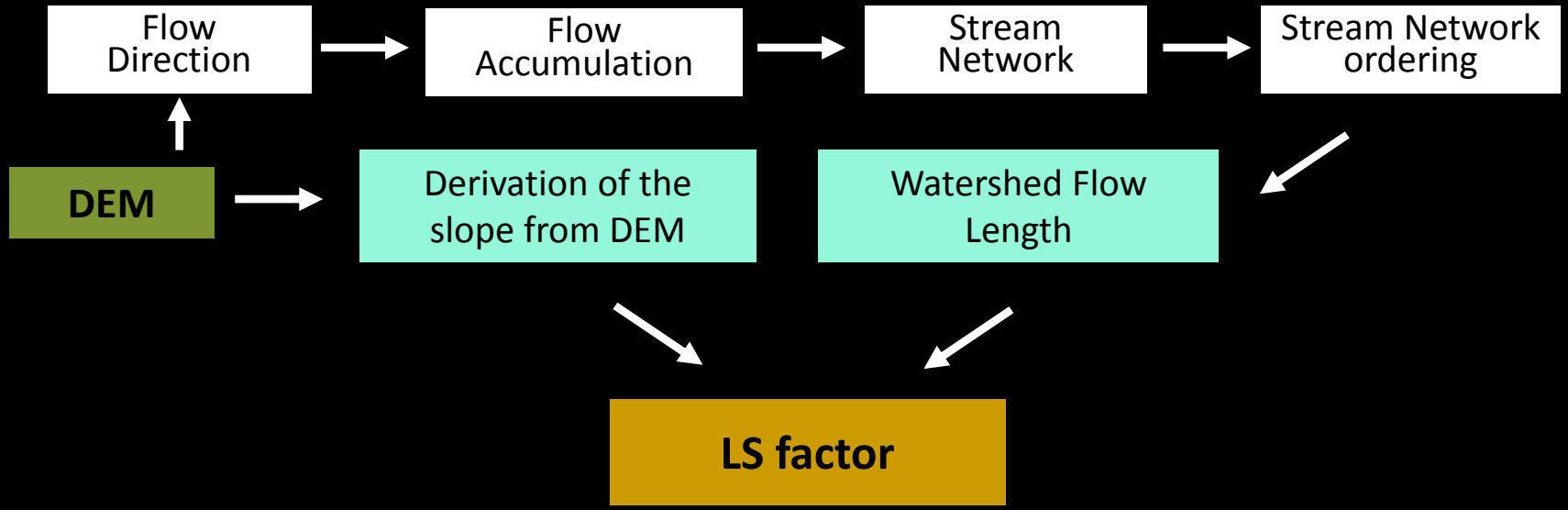
Digitization/ Interpolation

↓

Soil maps



Data Analysis: LS Factor Estimation



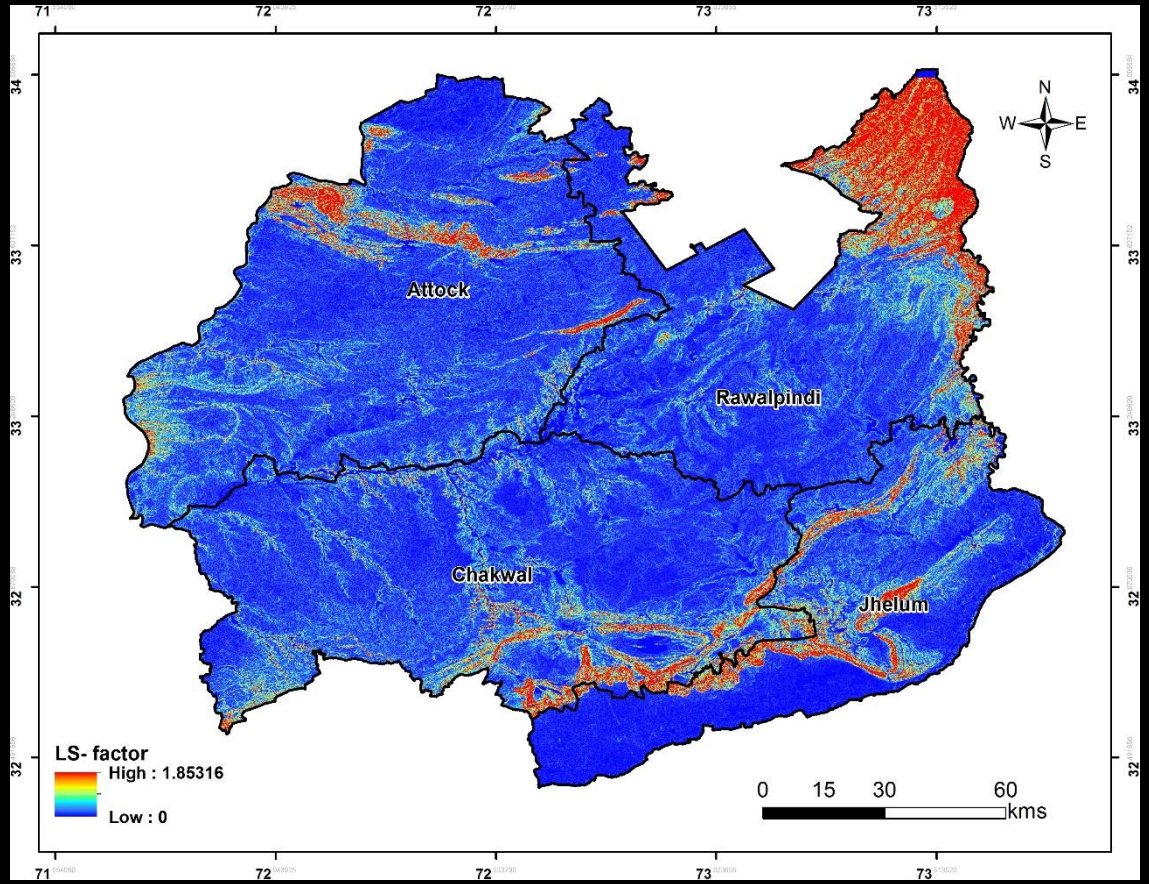
$$LS = \sqrt{\frac{l}{22}}(0.065 + 0.045^{*}s + 0.0065^{*}S^{2})$$

l = slope length in meter and s = percent slope (%)

(Morgan and Davidson, 1991)

Data Analysis: LS Factor Estimation

- Raster data of LS factor
- Higher value in north east area, (steep slope of Murree hills)



Data Analysis: C Factor Estimation

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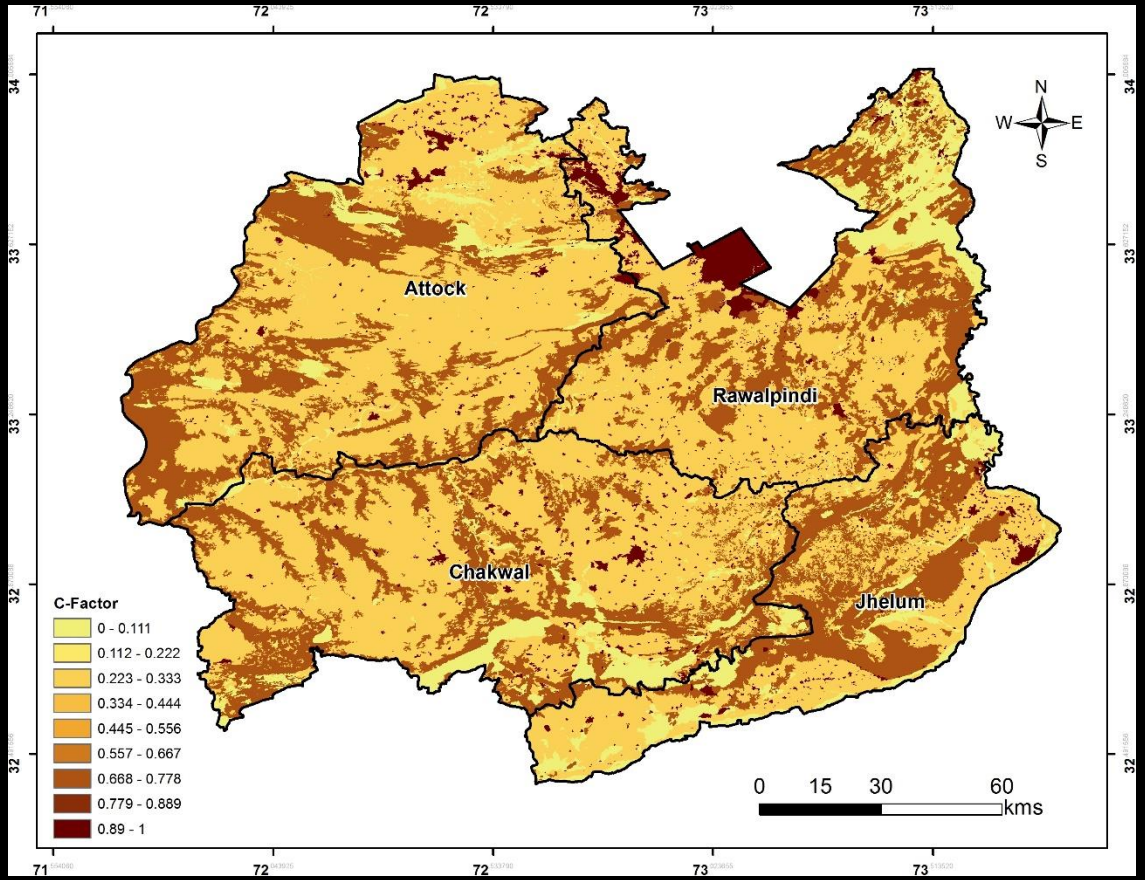
- A ratio comparing the soil loss from a specific type of land cover.
- C value assigning to each land cover on the basis of literature
- GIS Function: Feature to raster



Data Analysis: K Factor Estimation

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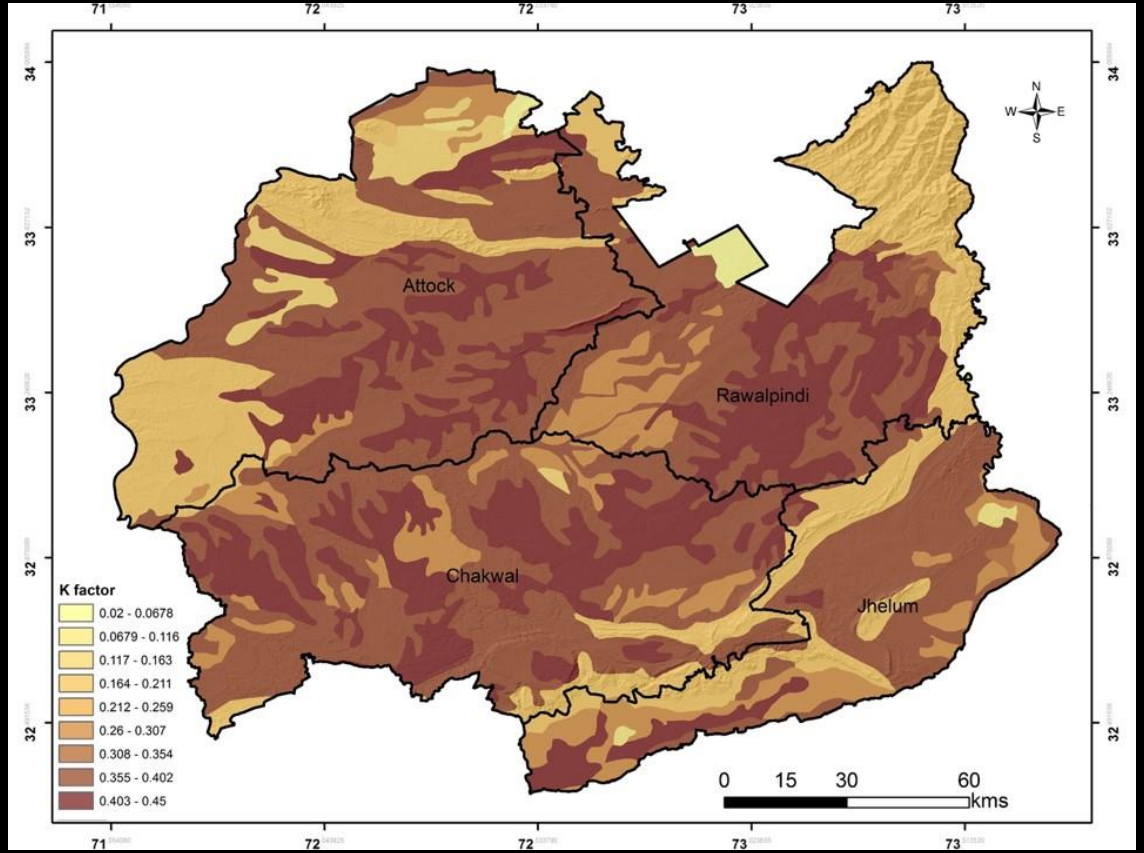
- Accounts for soil texture, structure, organic matter, and even permeability.
- K value assigning to each soil type on the basis of literature
- GIS Function: Feature to raster



Data Analysis: R Factor Estimation

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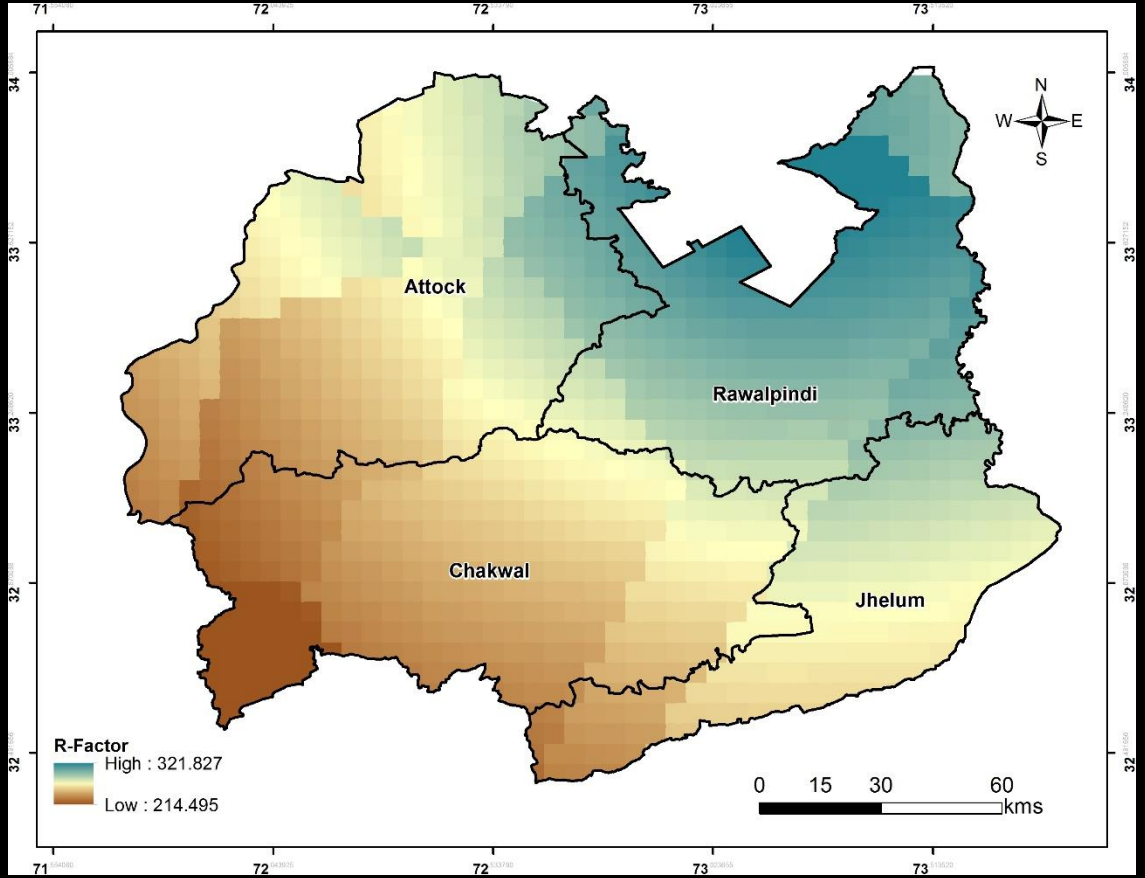
- Accounts for the energy and runoff of rainfall
- An empirical equation to determine R factor.

$R = 1.24 \times P^{136}$, $r^2 = 0.57$ (by Kurt cooper, 2011)

P is mean annual precipitation (inches)

- GIS Function: Raster Calculator



Data Analysis: P Factor Estimation

- Represents the ratio of soil loss by a support practice for adopted for soil conservation.
- There are no special practices are adopted in the area except some localized practices
- So for this project the value is kept at 1 for the whole study area

Annual Soil Loss

- Average annual soil erosion (tons/ha/year) = R x K x LS x C x P.
- There are no special practices are adopted in the area except some localized practices
- GIS function : Raster calculator.

Soil Loss Susceptibility Potohar Region

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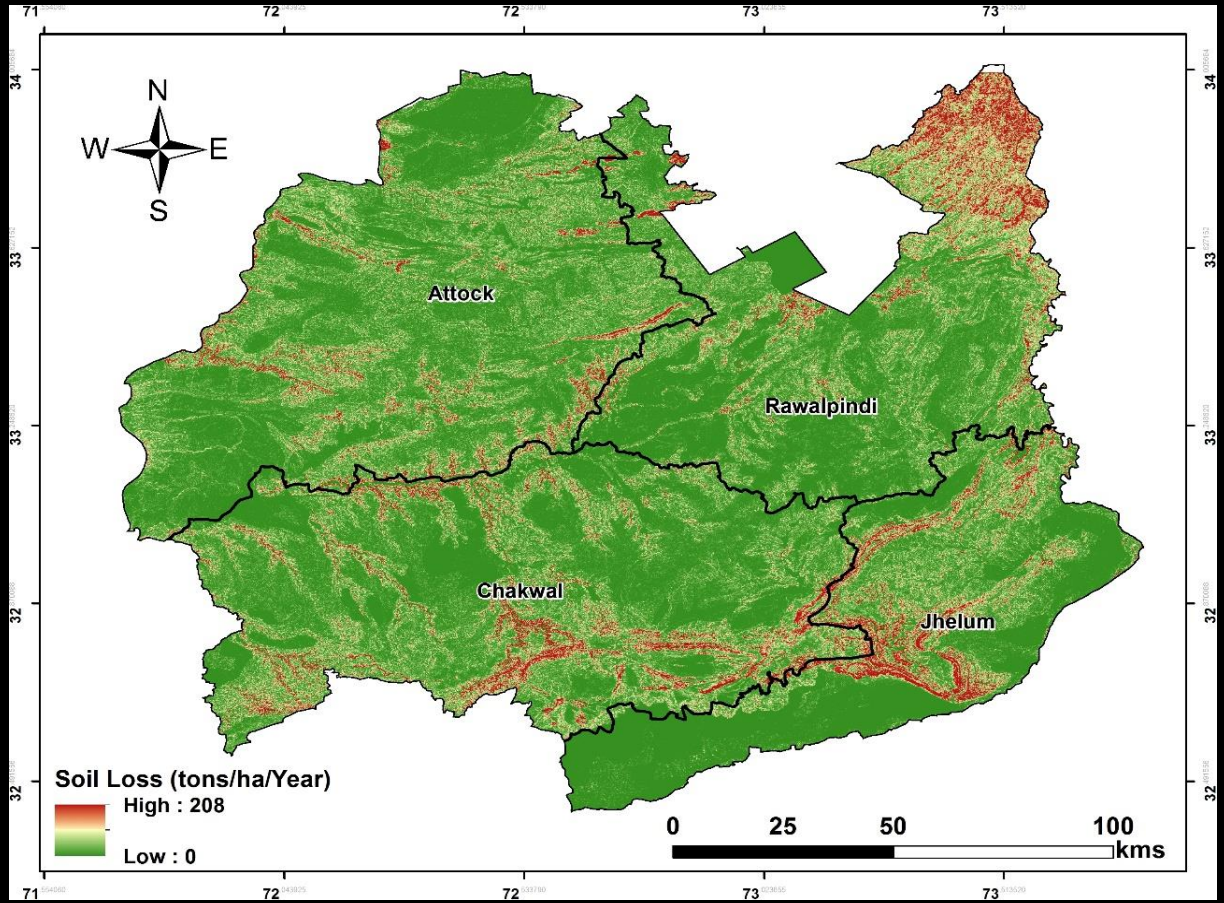

Soil Loss Susceptibility Potohar Region

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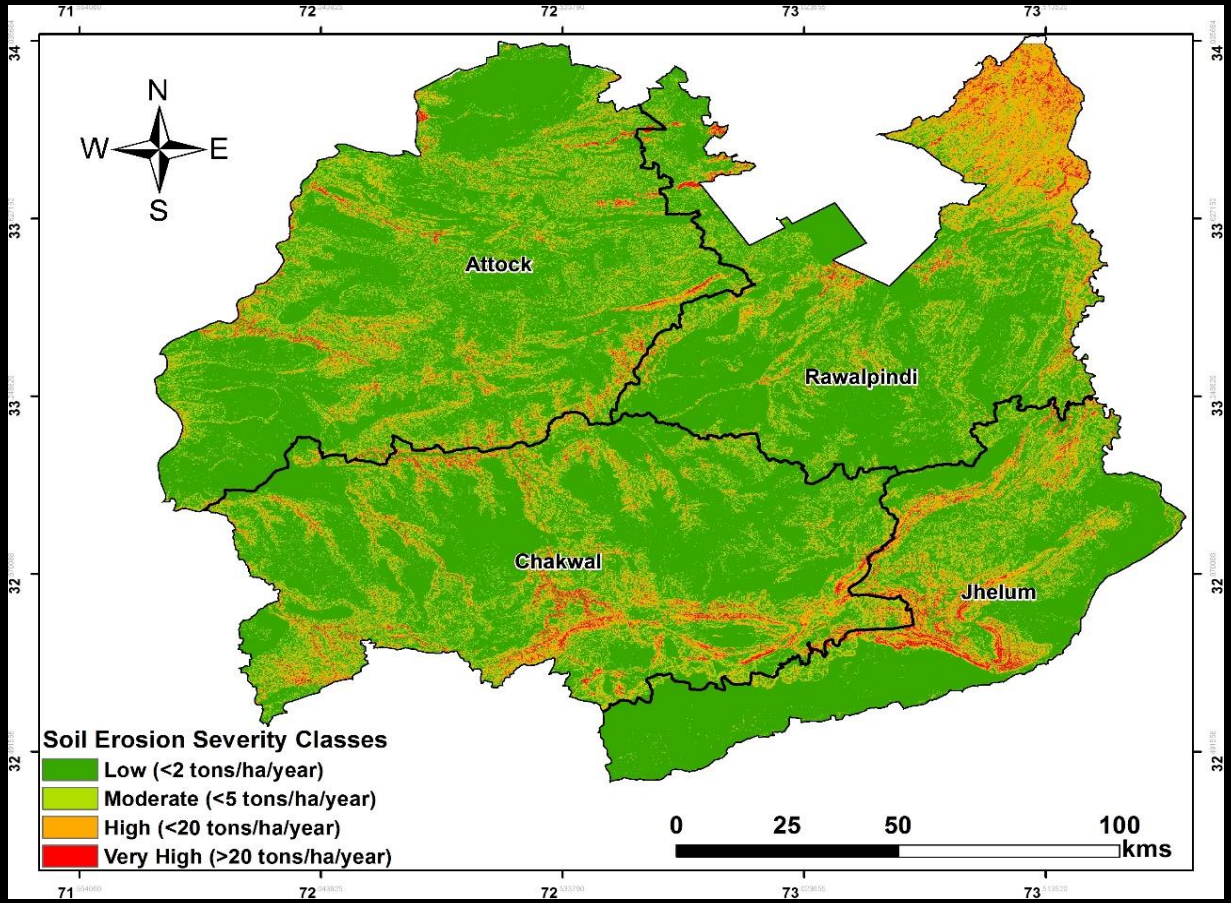

Soil Loss of Potohar Region

District	Annual Soil loss (Million Tons)
Attock	81.4
Chakwal	94.9
Jehlum	83.4
Rawalpindi	164.7
Total	**424.4**

Conservation Prioritization Criteria

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Soil Texture	Light, Medium, Heavy, very heavy	More light the Soil texture, less the Priority
Vegetation Cover	Sparse. Low, Medium and Dense	More Dense the vegetation, less the Priority
Rainfall	Less. Moderate, High, very high	Higher the Rainfall More the Priority
Slope	Less, Medium, High, very high	Higher the slope More the Priority
Soil Loss Risk	Low, medium, High, Very High	Higher the Average Annual Soil Loss Risk. More the Priority

Conservation Priority Areas

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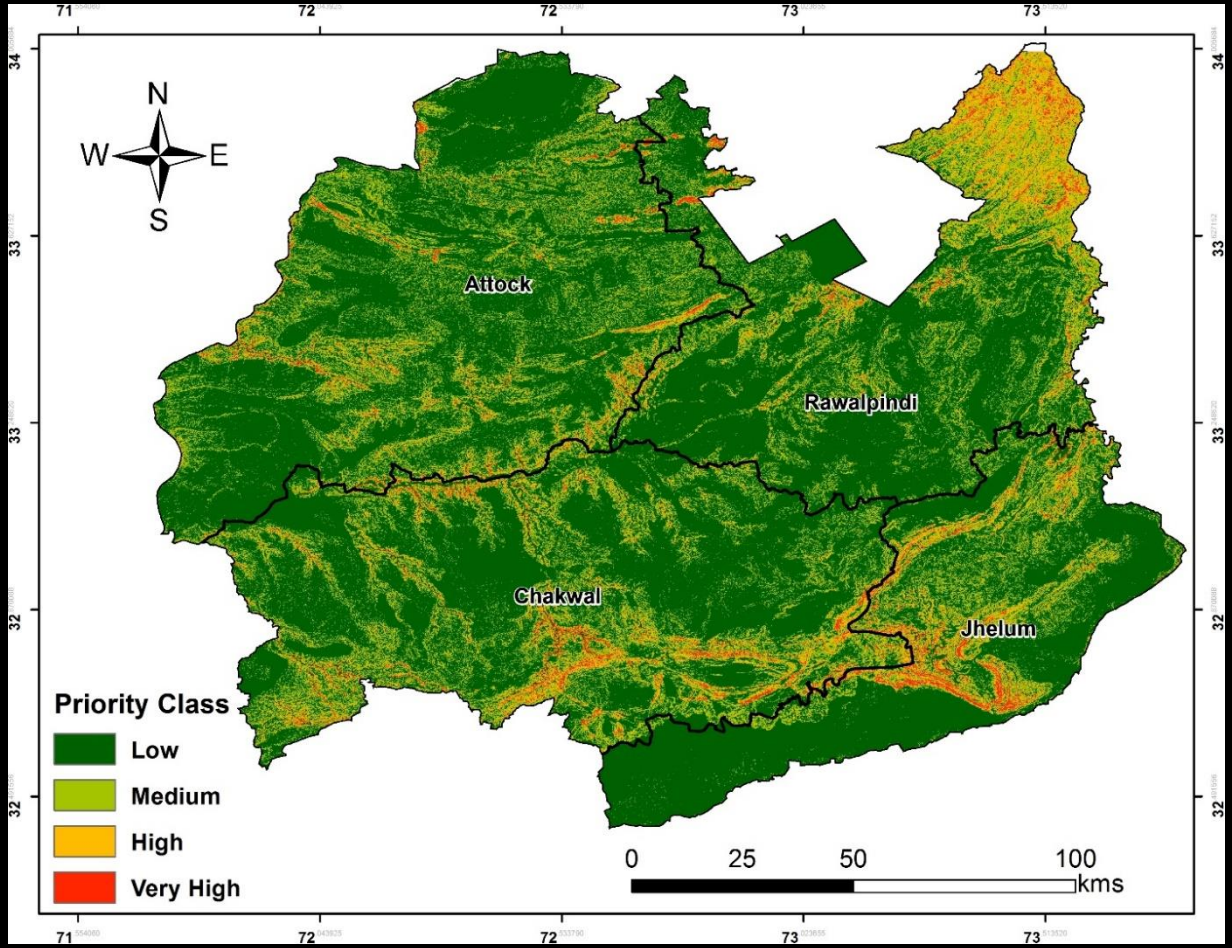

Conclusion

- Potohar region is highly susceptible to soil erosion
- It may lead to the soil degradation and thereby to desertification rendering the cultivable land unfit for cultivation
- Continuous monitoring of erosion is necessary for sustainable land management
- Geospatial techniques offer tremendous potential for fast, accurate and cost effective means for erosion assesment

Way Forward

- Identification of interventions for reducing rainwater runoff
  - Prioritization of watersheds and sub watersheds
  - Identification of rain water storage sites
- Assessment of site specific conservation approaches
  - Suitability assessment of perennial crops/trees
  - Interventions in agriculture practices
- Public awareness and community mobilization


Thanks