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Landscape-Based Mitigation of Agrochemical Runoff in Erodible Agricultural Catchments: A Terrain and Soil-Driven Approach from the Idemili Watershed, Southeastern Nigeria

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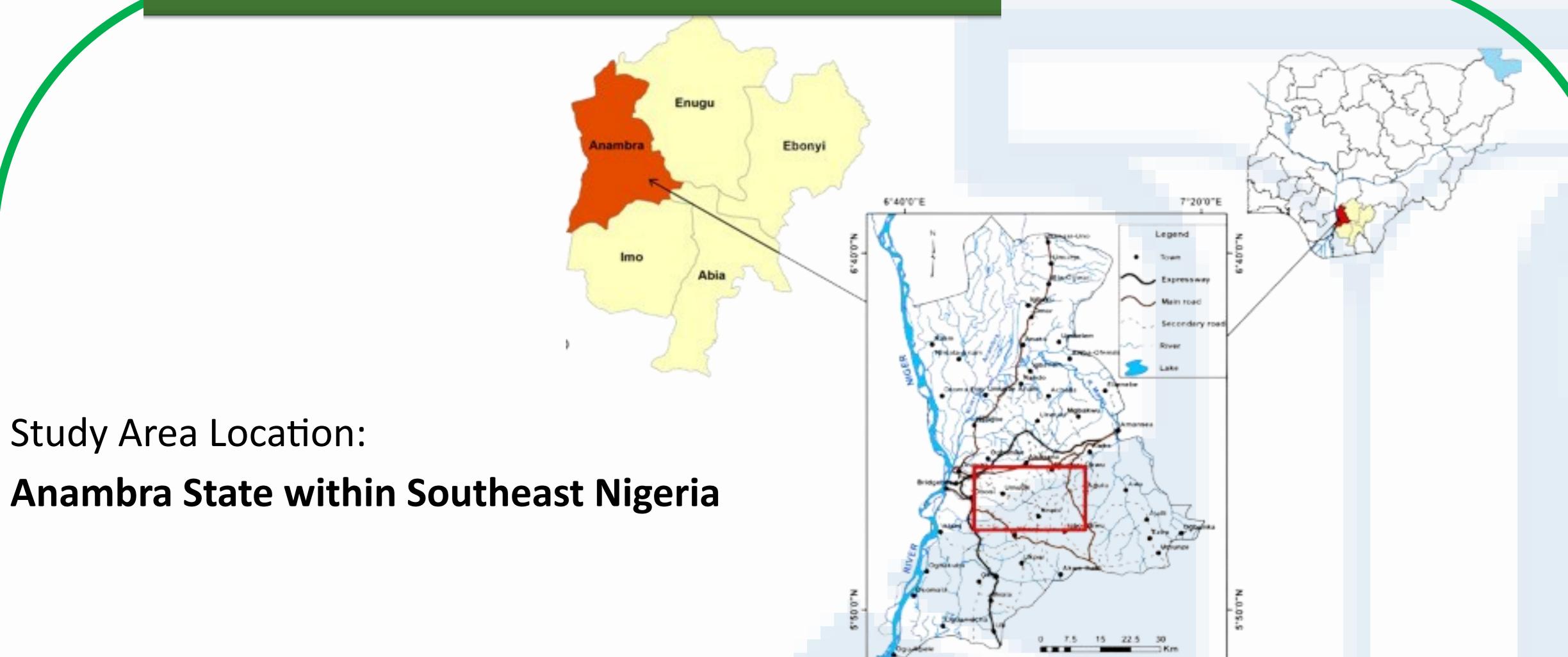
### INTRODUCTION & AIM

Southeastern Nigeria represents the country's most critical gully erosion zone, with the Idemili Watershed experiencing severe impacts. Characterized by a gently rolling to hilly terrain, heavy seasonal rainfall, and intensive land uses (agriculture, settlement, infrastructure), the watershed faces escalating pressures leading to widespread soil erosion and agrochemical runoff. This results in significant environmental degradation, infrastructure damage, water contamination, and socio-economic disruption.

This study focuses on evaluating the landscape-driven dynamics of agrochemical runoff within the erodible catchments of the Idemili Watershed, Southeastern Nigeria. The study integrates geospatial analysis and environmental modeling techniques to delineate critical erosion-prone zones. A multi-criteria decision approach was employed, synthesizing key parameters including terrain attributes (slope, Stream Power Index, and Topographic Wetness Index), soil erodibility (K-factor), and land use/land cover (LULC) characteristics. Spatial datasets were processed using advanced GIS platforms—ArcGIS Pro and Google Earth Engine—to derive, standardize, and integrate relevant indicators. The resulting analysis provides an evidence-based spatial decision support system for landscape-based agrochemical runoff mitigation planning.



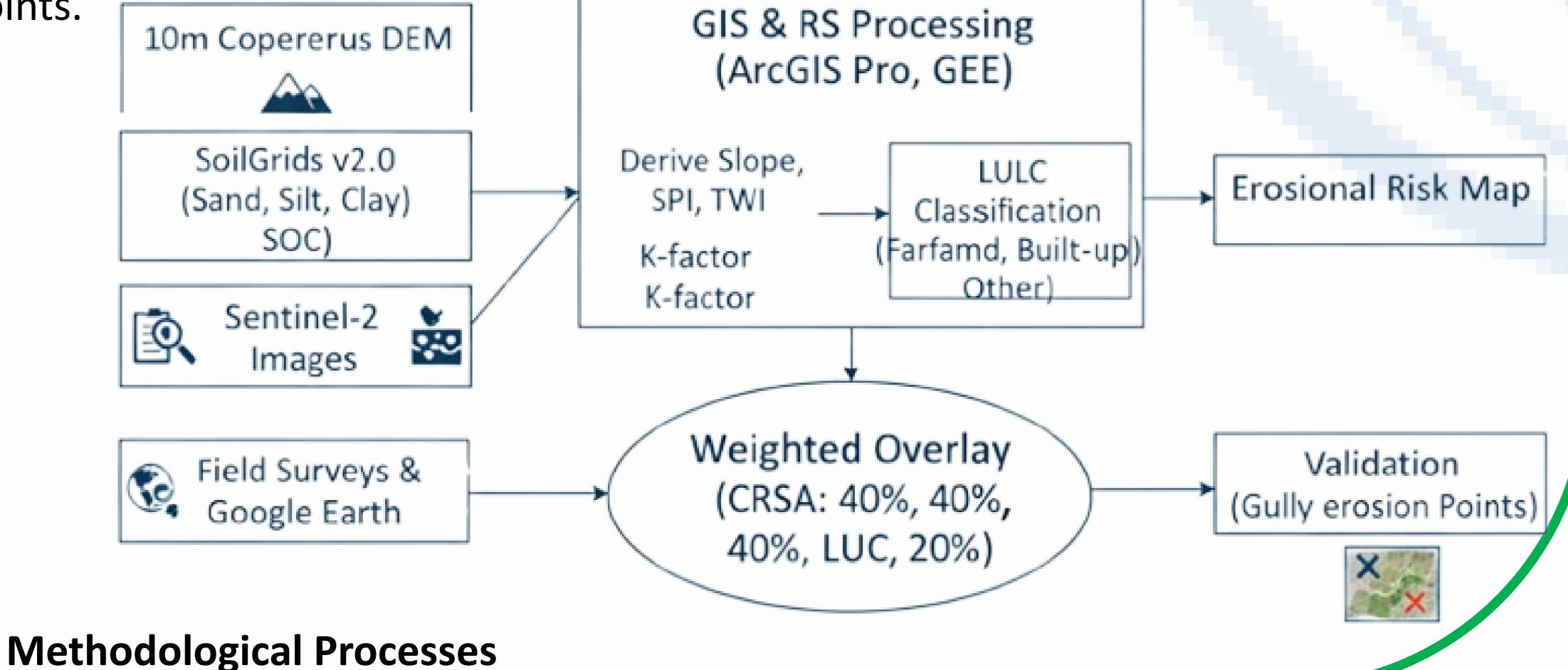
#### METHOD



The study employed a robust geospatial and environmental modeling approach. A 10m Copernicus DEM for elevation data, SoilGrids v2.0 for soil composition (sand, silt, clay, SOC), and Sentinel-2 images for land use and cover analysis were utilized. Field surveys and Google Earth were instrumental in validating existing gully erosion points.

All datasets were clipped to the watershed's extent and projected to WGS 1984 UTM Zone 32N. Critical topographic indices such as Slope, Stream Power Index (SPI), and Topographic Wetness Index (TWI) were derived using ArcGIS Pro 3.4. The K-factor, a measure of soil erodibility, was estimated based on soil texture. Google Earth Engine (GEE) was used to classify Land Use/Land Cover (LULC) into farmland, built-up areas, and other categories.

Critical Runoff Source Areas (CRSAs) were identified using a combination of slope, SPI, and TWI. Finally, a weighted overlay analysis (CRSA: 40%, K-factor: 40%, LULC: 20%) was performed to generate the final erosional risk map. This map was then validated against the observed gully erosion points.

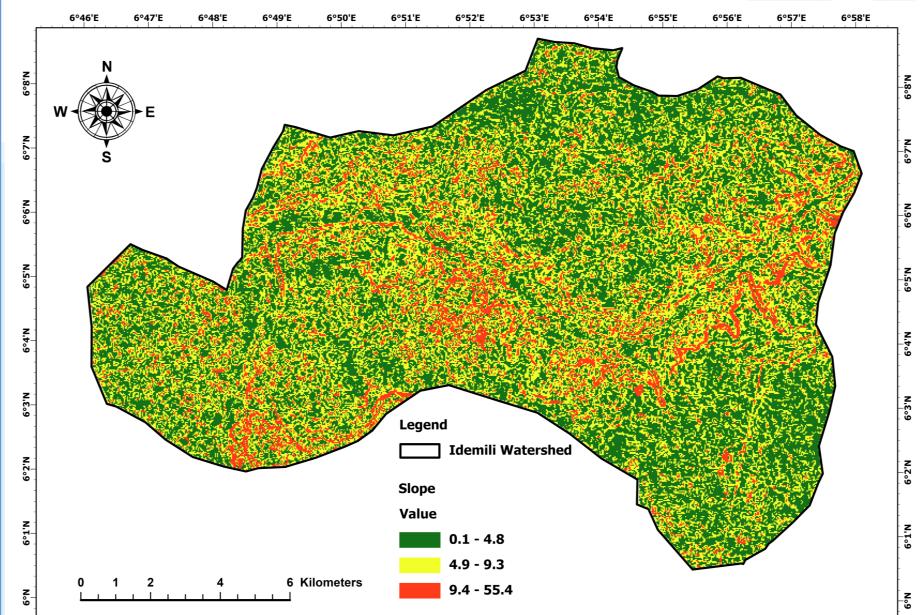


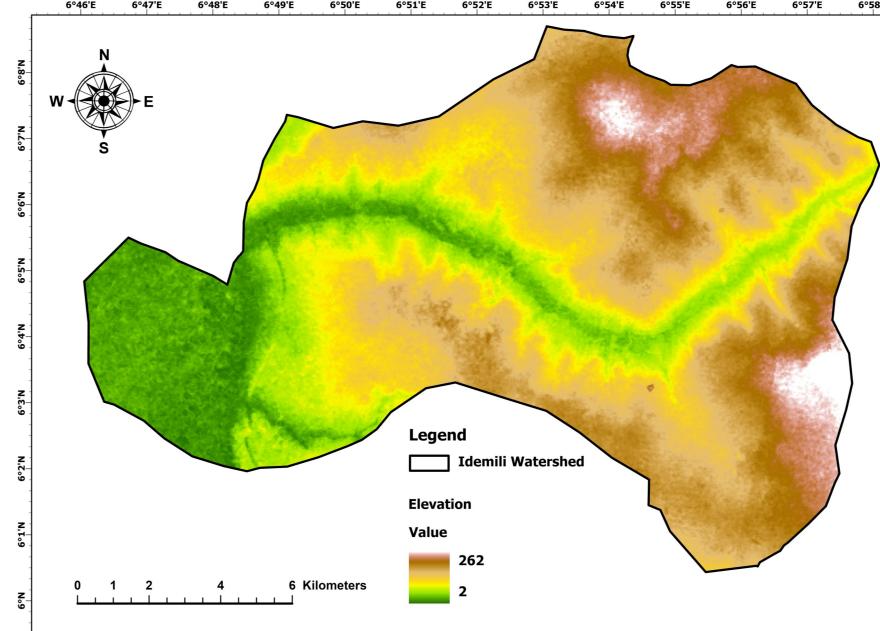
# CONCLUSION

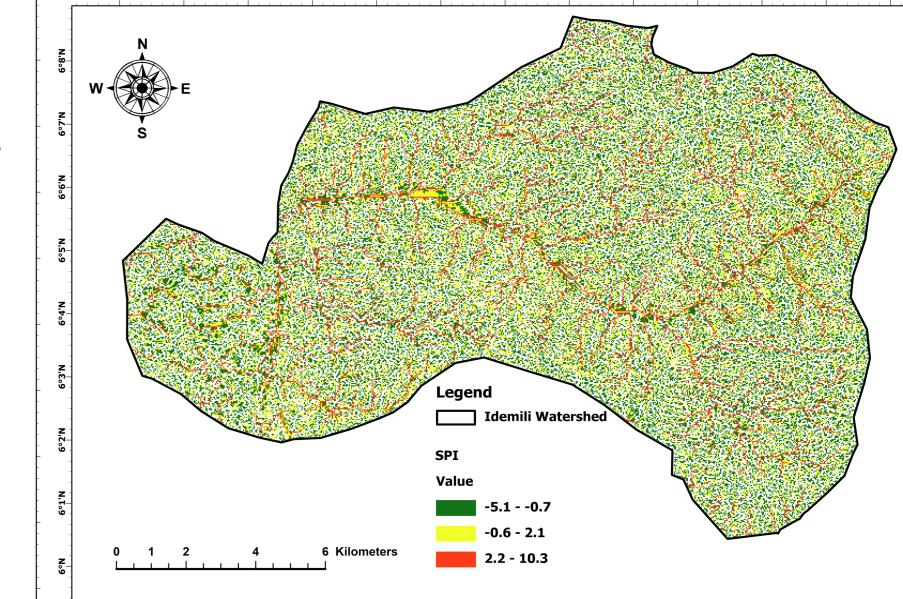
The integrated geospatial approach proved highly effective in pinpointing erosion hotspots and identifying priority areas susceptible to agrochemical runoff within the Idemili Watershed. These findings offer practical implications, providing a strong evidence base for developing targeted interventions. Such interventions are crucial for addressing current runoff problems and promoting more sustainable land use practices across the region.

## RESULTS & DISCUSSION

This analysis revealed significant variations in elevation across the watershed, ranging from 2 to 262 meters. The central steep slopes, reaching up to 55.4°, were strongly associated with high Stream Power Index (SPI) values, indicating a high potential for erosion. Topographic Wetness Index (TWI) values effectively highlighted areas where moisture tends to accumulate, further influencing runoff.





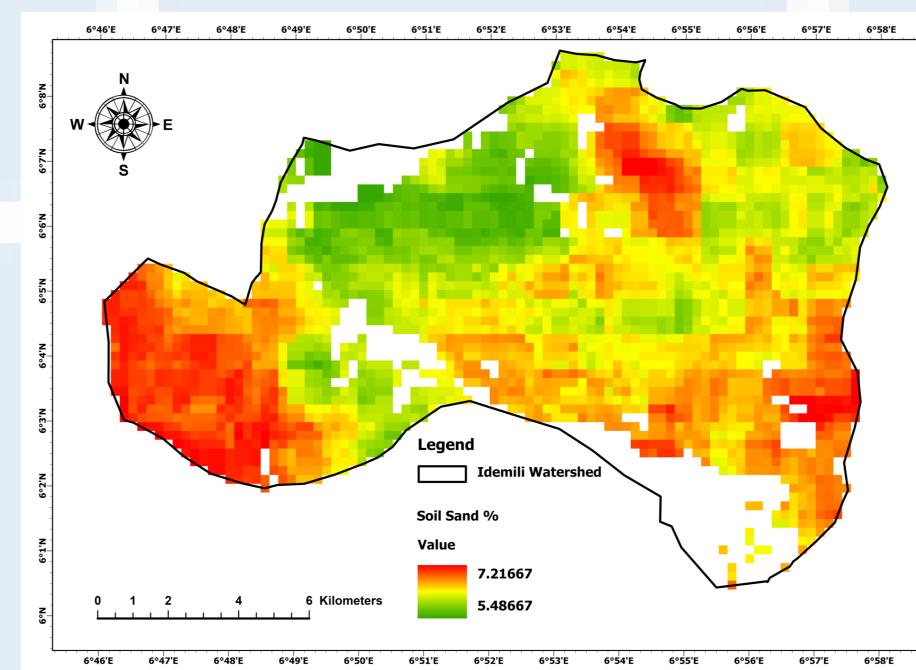


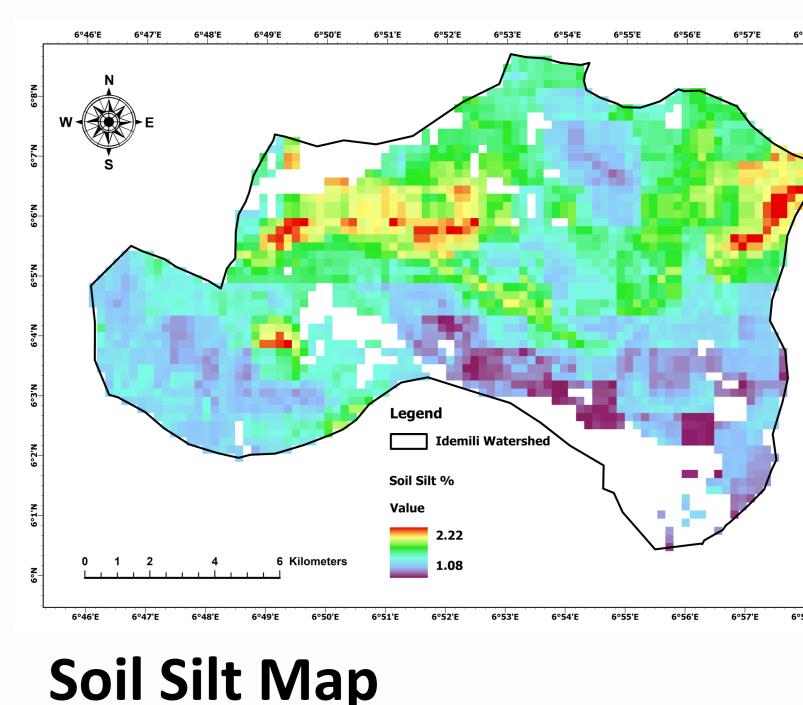
Slope Map

**Elevation Map** 

SPI Map

Soil composition analysis showed that the silt and clay soils prevalent in the northeast and central regions contributed to moderate-to-high erodibility across 78% of the watershed. Land Use/Land Cover (LULC) classification indicated that farmland and built-up areas collectively covered over 30% of the land area.

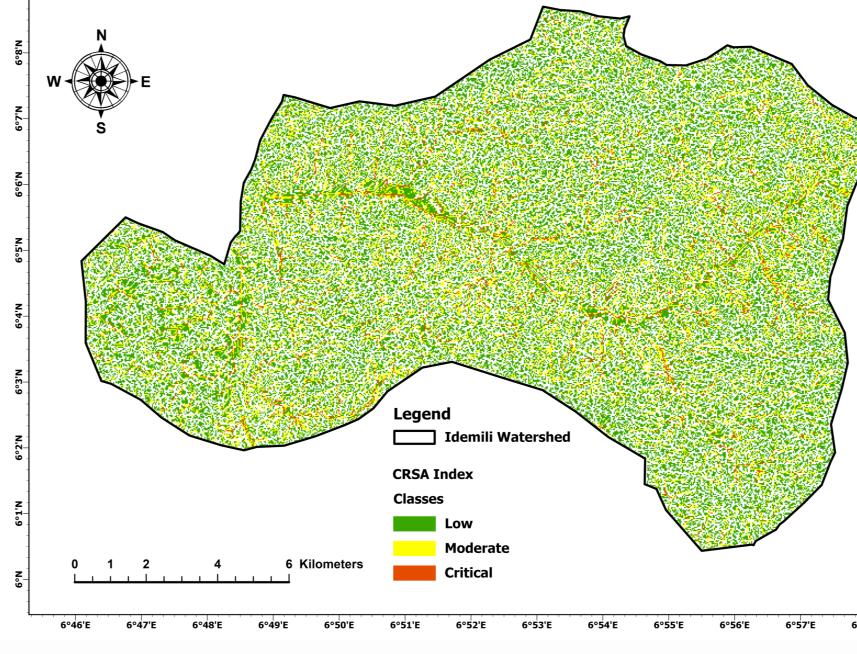


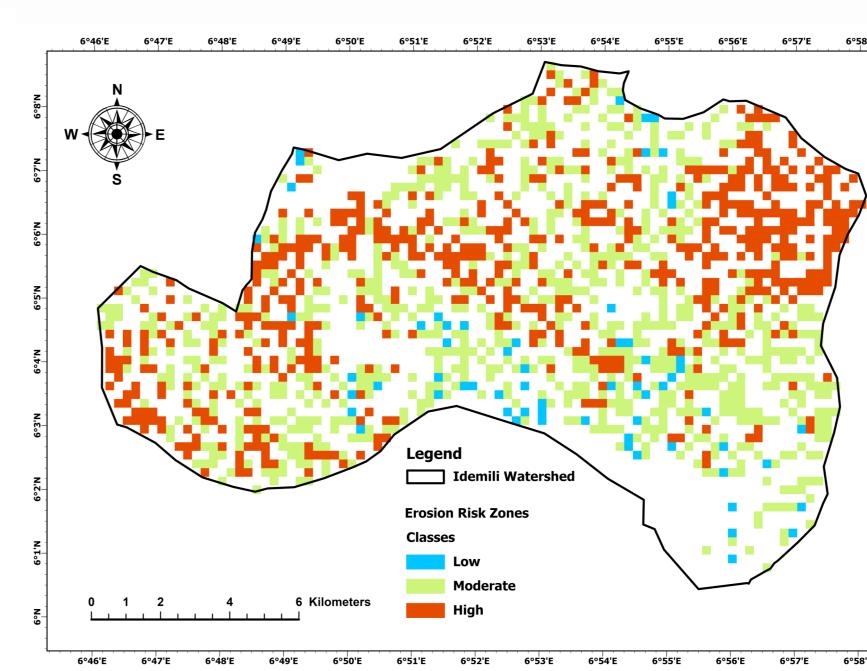


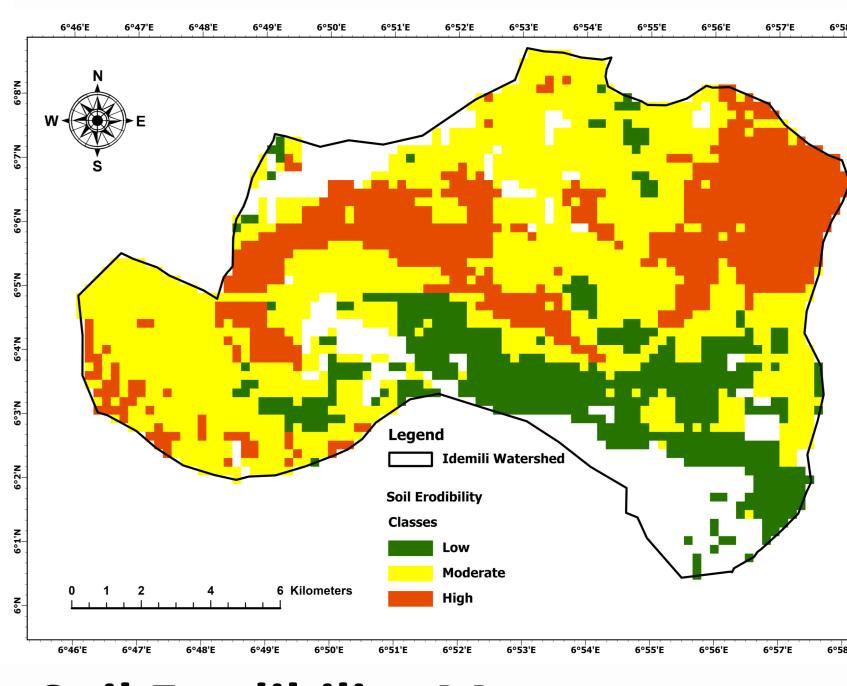
Soil Sand Map

Soil Clay Map

Crucially, the erosional risk map identified that areas of high erosion risk (36.5%) and moderate vulnerability (41.6%) largely overlap with these steep, actively farmed, and erodible terrains. This underscores the significant impact of both natural topography and human land use on erosion and runoff potential in the Idemili Watershed.







**CRSA Index** 

Risk Map

Soil Erodibility Map

The convergence of steep slopes, erodible soils, and agricultural land use creates a perfect storm for soil loss and agrochemical contamination of water bodies. The model successfully identifies these critical zones.

The success of this model is demonstrated by the strong spatial correlation between the predicted highrisk zones and the validated gully erosion points from field surveys. This confirms that the weighted overlay of CRSA (40%), K-factor (40%), and LULC (20%) effectively captures the real-world processes governing erosion in the Idemili Watershed.

The implication is clear: in areas where steep, erodible slopes are under cultivation, the natural propensity for erosion is dramatically amplified. Resulting not only to the loss of fertile topsoil—threatening agricultural productivity, but also to the contamination of downstream water bodies with sediment, nutrients (eutrophication), and pesticides.

## FUTURE WORK / REFERENCES

Future research should focus on incorporating a rainfall erosivity factor (R-factor) to create a more dynamic erosion model (e.g., RUSLE), conduct water sampling at key outlets to directly measure agrochemical concentrations and validate runoff potential and model the potential transport paths for specific nutrients and pesticides used in the watershed.

[1]Al-Bawi, Ahmed & Al-Abadi, Alaa & Pradhan, Biswajeet & Alamri, Abdullah. (2021). Assessing gully erosion susceptibility using topographic derived attributes, multi-criteria decision-making, and machine learning classifiers. Geomatics, Natural Hazards and Risk. 12. 3035-3062. 10.1080/19475705.2021.1994024.

[2] ESRI ArcGIS 10.8 Documentation. https://www.esri.com

[3] Wischmeier, W.H. and Smith, D.D. (1978) Predicting Rainfall Erosion Losses. A Guide to Conservation Planning. The USDA Agricultural Handbook No. 537, Maryland.





