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Original Research Article

Integrating RUSLE and SWAT for Sediment-Yield Assessment and Watershed Prioritization in Abia State, Nigeria

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Abstract

Effective erosion management requires information on both hillslope soil detachment and sediment delivery through watershed networks. This study integrated the Revised Universal Soil Loss Equation (RUSLE), the Soil and Water Assessment Tool (SWAT), Geographic Information Systems and remote sensing to simulate sediment yield, evaluate model agreement and prioritize watersheds across Abia State, Nigeria. SWAT was configured using Shuttle Radar Topography Mission (SRTM) elevation, Sentinel-2 land cover, Food and Agriculture Organization (FAO) soil data, and daily climatic records for 1994-2024. RUSLE gross soil loss was converted to sediment yield with a sediment delivery ratio of 0.146, permitting comparison with SWAT outputs across 17 Local Government Areas. SWAT-predicted sediment yield ranged from 0.0136 to 23.01 t/ha/yr, with the highest values in northern and eastern uplands. RUSLE-derived sediment yield ranged from 0.29 to 54.70 t/ha/yr. The models showed a moderate positive association (Pearson Correlation (r) = 0.524; coefficient of Determination (R^2) = 0.275), with a Root Mean Square Error (RMSE) of 2.83 t/ha/yr and a Mean Absolute Error (MAE) of 2.09 t/ha/yr. Their differences reflected contrasting process representations: RUSLE identified potential hillslope sources, while SWAT represented runoff, routing, deposition, and channel transport. A two-factor matrix classified the state into Critical Priority (47.37%), Channel-Dominated Priority (20.09%), Slope-Dominated Priority (5.20%), and Low Priority (27.35%) zones. The integrated framework links dominant erosion processes to appropriate interventions and offers a transferable decision-support approach for data-scarce tropical watersheds. Because measured long-term sediment records were unavailable, the reported comparison was interpreted as comparative validation rather than full SWAT calibration.

Keywords: RUSLE, SWAT, soil erosion, sediment yield, GIS, remote sensing, watershed prioritisation, sediment delivery ratio, Abia State.

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1. INTRODUCTION

Soil erosion is a major environmental challenge affecting land productivity, watershed stability, water quality and the sustainability of agricultural and infrastructure systems. It involves the detachment and transportation of soil particles by rainfall, surface runoff and other erosive agents. Although erosion is a natural geomorphological process, its intensity is often increased by deforestation, inappropriate agricultural practices, vegetation removal, urbanisation and other forms of land-use disturbance. These pressures are particularly significant in tropical environments, where high rainfall, variable terrain and intensive land use can accelerate soil degradation. Beyond the loss of fertile topsoil, eroded materials are transported into drainage channels and receiving water bodies, contributing to sedimentation, reduced channel capacity and deterioration of aquatic environments. Effective erosion management therefore requires an understanding of both the spatial distribution of soil loss and the movement of sediment through watershed systems. This study aimed to: (i) simulate sediment yield across Abia State using SWAT; (ii) transform RUSLE gross soil loss to sediment yield using a sediment delivery ratio; (iii) quantify spatial agreement between the models; and (iv) develop a watershed priority matrix that links model behaviour to management intervention.

Southeastern Nigeria is particularly vulnerable to water-induced soil erosion because of its humid

tropical climate, substantial rainfall, undulating topography and increasing pressure on land resources. Abia State experiences different forms of erosion, including sheet, rill and gully erosion, which affect agricultural land, settlements, roads, drainage infrastructure and water resources. Areas such as Isuikwuato, Umu-Nneochi, Arochukwu, Bende and Ohafia have been identified as particularly susceptible to erosion, while urban expansion and inadequate drainage management further increase runoff-related problems in developed areas. The consequences extend beyond environmental degradation to include reduced agricultural productivity, damage to public infrastructure, loss of land and increased costs of erosion-control interventions. Although initiatives such as the Nigeria Erosion and Watershed Management Project (NEWMAP) have supported erosion-control and watershed-restoration activities, effective resource allocation still depends on reliable spatial information about erosion-prone areas and sediment movement.

Several studies have investigated soil erosion in Abia State and other parts of southeastern Nigeria using field surveys, geographical information systems (GIS), remote sensing and empirical erosion models. Nwilo et al. (2011) documented active gully erosion locations across Abia State and highlighted the influence of topography and geological conditions on gully development. Okoro and Uche (2014) applied GIS-based weighted overlay analysis to classify erosion susceptibility and identified vulnerable northern upland communities. Similarly, Uluocha and Uwadiegwu (2015) used GIS and remote sensing techniques to investigate gully erosion in Abia State, demonstrating the usefulness of geospatial approaches for identifying erosion-affected locations. More recently, Akinwale and Blessed (2025) applied RUSLE-based geospatial modelling in Isuochi Community and reported variations in soil-loss susceptibility associated with terrain and land-cover conditions. These studies have contributed valuable information on erosion distribution and susceptibility; however, their approaches largely concentrated on erosion mapping, selected locations or estimates of hillslope soil loss, with limited assessment of sediment transport across the wider watershed system.

The Revised Universal Soil Loss Equation (RUSLE) is one of the most widely applied empirical models for estimating long-term average annual soil loss from water erosion. It estimates soil loss through the interaction of rainfall erosivity, soil erodibility, slope length and steepness, cover-management and support-practice factors (Wischmeier and Smith, 1978; Renard *et al.,* 1997). When integrated with GIS and remote sensing, RUSLE enables the spatial representation of erosion-prone areas and supports the identification of locations requiring conservation interventions. Its application has been widely documented in different environmental settings, although variations in input data, factor estimation and spatial resolution can influence the reliability of its outputs (Benavidez *et al.,* 2018). An important limitation, however, is that RUSLE estimates gross soil loss from hillslopes and does not explicitly simulate runoff generation, sediment routing, deposition or transport through river channels. Consequently, estimated soil loss cannot be directly interpreted as sediment yield delivered to a watershed outlet.

The Soil and Water Assessment Tool (SWAT) provides a complementary modelling approach by representing watershed hydrology and sediment movement under varying climatic, soil, topographic and land-use conditions. The model divides a watershed into sub-basins and hydrological response units to simulate processes influencing runoff and sediment generation and transport (Arnold *et al.,* 1998; Neitsch *et al.,* 2011). Its continuous-time simulation capability makes it useful for assessing sediment dynamics across spatial and temporal scales. Nevertheless, SWAT performance depends on the quality of input datasets, model configuration and the availability of appropriate streamflow and sediment observations for calibration and independent validation (Arnold *et al.,* 2012; Abbaspour *et al.,* 2018). These requirements present particular challenges in data-scarce tropical watersheds, where long-term measured sediment records are often unavailable.

The complementary strengths of RUSLE and SWAT provide an opportunity to improve watershed erosion assessment. RUSLE identifies potential hillslope soil-loss sources, whereas SWAT represents hydrological processes and sediment movement through the watershed network. Integrating their outputs can therefore provide a broader understanding of the relationship between soil detachment and sediment delivery. Despite the application of GIS-based erosion models and hydrological modelling in Nigeria, comprehensive assessments combining hillslope erosion estimates with watershed-scale sediment-yield simulation remain limited for Abia State. In particular, there is a need for an approach that distinguishes areas experiencing high potential soil loss from those where sediment transport through drainage networks is comparatively significant. Such information is important because erosion-control measures should reflect the dominant processes operating within individual watersheds rather than rely solely on generalised erosion-risk classifications.

This study addresses this gap by integrating RUSLE, SWAT, GIS and remote sensing to assess soil loss, simulate sediment yield and prioritise watersheds across Abia State, Nigeria. The assessment uses SRTM elevation data, Sentinel-2 land-use and land-cover information, FAO soil data, and daily climatic records covering 1994–2024. Specifically, the study evaluates the spatial distribution of the RUSLE factors and estimates annual soil loss; simulates sediment yield using SWAT; converts RUSLE-derived gross soil loss into an

estimated sediment-yield measure using a sediment delivery ratio (SDR); examines the spatial and statistical agreement between the two model outputs across the state's 17 Local Government Areas (LGAs); and identifies watershed management priority zones based on their combined erosion and sediment-yield characteristics.

The principal contribution of this research is the development of an integrated GIS–RUSLE–SWAT framework that links hillslope erosion potential with watershed-scale sediment-yield patterns to support spatially differentiated management decisions. Rather than treating the outputs of the two models as equivalent measurements, the study uses their complementary information to classify watersheds into critical-priority, channel-dominated, slope-dominated and low-priority zones. This two-factor prioritisation approach provides a practical basis for distinguishing locations where hillslope conservation should receive greater attention from those where channel and sediment-transport management may be more appropriate. By combining long-term climatic records, satellite-derived land-cover information, soil data, terrain characteristics and field observations, the study provides a spatially explicit decision-support approach for erosion assessment and watershed management in data-scarce tropical environments. In the absence of long-term measured sediment records, the comparison between RUSLE-derived and SWAT-simulated sediment yield is interpreted as an assessment of inter-model agreement rather than independent validation against observed sediment discharge.

2. Experimental Section/Material and Methods

2.1 Study area and datasets

Abia State as shown in Figure 1, lies in humid southeastern Nigeria and contains uplands in the north and east, central undulating terrain, and southern lowlands. Annual rainfall generally exceeds 1,500 mm and often exceeds 2,000 mm. The analysis used SRTM elevation data, Sentinel-2 2024 land cover, FAO and field soil information, and daily rainfall, minimum and maximum temperature, solar radiation, relative humidity, and wind speed for 1994-2024.

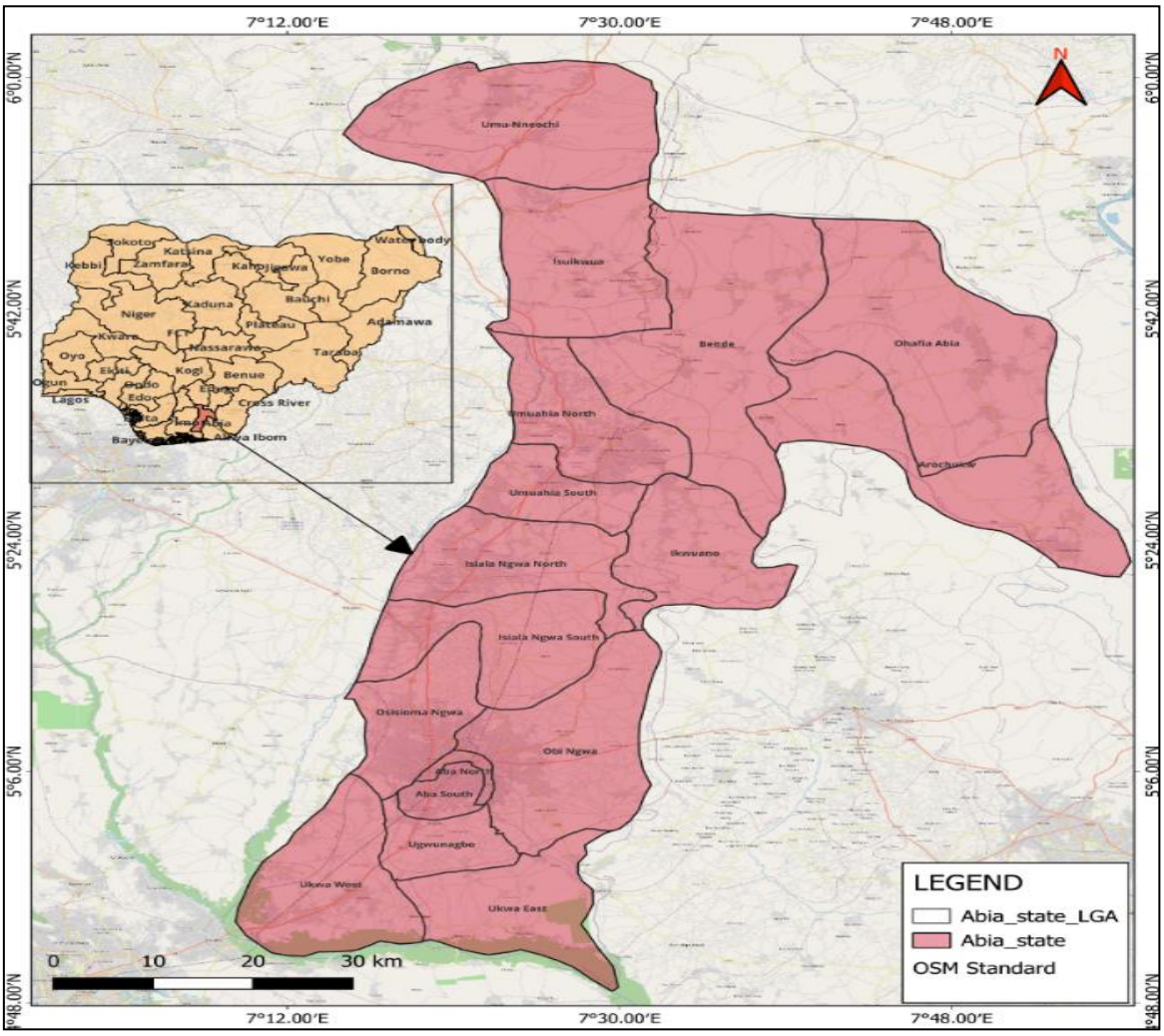


Figure 1: Map of the study area

2.2 Data sources and preparation

The study employed both primary and secondary datasets. Primary data comprised field observations, GPS coordinates, photographs of selected erosion locations, and soil samples collected for laboratory analysis. Secondary data included meteorological records, satellite-derived land-use/land-cover information, elevation data and soil information. The principal datasets and their applications are presented in Table 1.

Table 1: Datasets used for RUSLE and SWAT modelling

Dataset	Source	Application
Digital Elevation Model (DEM)	Shuttle Radar Topography Mission (SRTM), USGS	Terrain analysis, slope estimation, flow direction, flow accumulation and watershed delineation
Land-use/land-cover data	Sentinel-2 land-cover dataset, 2024	RUSLE cover-management factor and SWAT HRU definition
Soil information	FAO Digital Soil Map of the World and field soil samples	Soil erodibility estimation and SWAT soil database development
Daily rainfall records (1994–2024)	Nigerian Meteorological Agency (NiMet)	Rainfall erosivity estimation and SWAT precipitation input
Daily climate records (1994–2024)	NiMet	SWAT meteorological inputs, including temperature, relative humidity, wind speed and solar radiation
Field observations and GPS locations	Field investigations	Spatial verification of mapped erosion locations
LGA boundaries	Administrative boundary dataset	Zonal statistics and watershed prioritisation

The SRTM DEM was used for topographic processing and watershed delineation. The Sentinel-2 land-cover dataset was processed and clipped to the study boundary. Soil information from the FAO database was supplemented with field-derived soil properties to improve the representation of soil characteristics. Meteorological records covering 1994–2024 were prepared for the RUSLE and SWAT modelling procedures.

All spatial datasets were prepared in a common projected coordinate reference system to facilitate raster overlay, spatial analysis and extraction of model outputs. The dissertation specifies UTM Zone 32N, WGS 84, for DEM and land-cover preparation.

2.3 RUSLE modelling and estimation of hillslope soil loss

The Revised Universal Soil Loss Equation (RUSLE) was applied to estimate long-term average annual soil loss across Abia State. The model represents the combined effects of rainfall erosivity, soil erodibility, topography, land-cover conditions, and conservation practices.

Average annual soil loss was calculated as:

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

where:

- A = average annual soil loss (t ha\yr\);
- R = rainfall-runoff erosivity factor (MJ mm ha\ h\yr);
- K = soil erodibility factor;
- LS = slope length and steepness factor;
- C = cover-management factor; and
- P = support-practice factor.

The five factors were derived separately in the GIS environment and subsequently combined using raster algebra.

2.4 SWAT modelling and sediment-yield estimation

The Soil and Water Assessment Tool (SWAT) was employed to simulate watershed hydrology and sediment yield across Abia State. The model was implemented using the ArcSWAT extension in ArcGIS 10.6.

SWAT represents hydrological and sediment processes through the interaction of land use, soil characteristics, topography and climatic conditions. Sediment generation is estimated using the Modified Universal Soil Loss Equation (MUSLE), which incorporates runoff characteristics and peak flow to estimate sediment production. Generated sediment is subsequently routed through the drainage network, accounting for transport and deposition processes.

The SWAT modelling procedure comprised the following stages.

2.4.1 DEM processing and watershed delineation

The 90-m SRTM DEM was projected to UTM Zone 32N, WGS 84, and processed to remove artificial depressions that could interrupt surface-flow routing.

The processed DEM was used to derive flow direction and flow accumulation. A stream network was generated using a user-defined drainage-area threshold, after which watershed outlets were identified and the study area was subdivided into sub-basins.

The resulting drainage network and sub-basin boundaries provided the spatial framework for subsequent SWAT simulations.

2.4.2 Hydrologic Response Unit definition

Hydrologic Response Units (HRUs) were generated by overlaying the land-use/land-cover, soil and slope datasets.

The Sentinel-2 2024 land-cover classes were reclassified into corresponding SWAT land-use codes using the ArcSWAT lookup table. Soil information from the FAO Digital Soil Map of the World was used to develop the SWAT soil database, with available field soil information providing additional characterisation.

Slope classes were generated from the DEM. The three datasets were combined to define HRUs, each representing a unique combination of land use, soil type and slope characteristics.

Threshold percentages were applied during HRU definition to remove relatively small land-use, soil and slope combinations. The resulting HRUs provided the spatial units for simulating infiltration, runoff, evapotranspiration and sediment generation.

2.4.3 Meteorological data preparation

Daily meteorological records covering 1994–2024 were obtained from NiMet and prepared for SWAT simulation.

The climatic variables included:

- Precipitation;
- Minimum air temperature;
- Maximum air temperature;
- Relative humidity;
- Wind speed; and
- Solar radiation.

The weather records were checked and formatted for compatibility with the SWAT model. These variables provided the meteorological forcing required to simulate watershed hydrology and sediment production over the study period.

2.4.4 SWAT simulation and sediment-yield extraction

Following watershed delineation, HRU definition, and meteorological data preparation, the SWAT model was executed to simulate watershed processes and sediment yield.

Sediment yield outputs were extracted at the sub-basin level using the SWAT sediment-yield variable (SYLD). The resulting outputs were spatially processed in ArcGIS to generate the sediment-yield distribution map.

Average annual sediment yield was expressed in tonnes per hectare per year (t ha\ yr\). The spatial outputs were subsequently used to compare SWAT sediment yield with RUSLE-derived sediment yield and to identify areas with contrasting hillslope erosion and sediment-routing characteristics.

2.3 Conversion of RUSLE soil loss to sediment yield

RUSLE estimates gross hillslope soil loss, whereas SWAT simulates sediment generation and subsequent movement through the drainage network. Direct comparison of their outputs therefore requires the RUSLE soil-loss estimates to be converted to an equivalent sediment-yield measure.

In this study, a sediment delivery ratio (SDR) of 0.146 was applied to the RUSLE soil-loss raster. The SDR was estimated using the empirical relationship attributed to Vanoni (1975), based on the analysed watershed drainage area of approximately 4,723.46 km². i.e

$$\text{SDR} = 0.42 \times \text{A}^{-0.125}$$

Where:

- SDR = Sediment Delivery Ratio
- A = Watershed drainage area (km²)

RUSLE-derived sediment yield was calculated thus as:

$$SY_{RUSLE} = A \times SDR$$

where:

- SY_{RUSLE} = RUSLE-derived sediment yield (t ha\yr);
- A = RUSLE-estimated average annual soil loss (t ha\ yr); and
- SDR = sediment delivery ratio (0.146).

The resulting raster represented the estimated proportion of hillslope soil loss delivered to the drainage network. This provided a common sediment-yield basis for comparing the RUSLE and SWAT model outputs.

2.4 Comparative evaluation

The spatial agreement between RUSLE-derived and SWAT-simulated sediment yield was evaluated using the mean sediment-yield estimates for the 17 LGAs of Abia State.

Zonal statistics were performed in ArcGIS to extract the mean sediment yield from both model outputs for each LGA. The resulting datasets were joined to the LGA attribute table to obtain paired values for statistical comparison.

Four statistical measures were used to assess the relationship and magnitude of differences between the two model outputs. They are Pearson correlation (r), coefficient of determination (R^2), root mean square error (RMSE) and mean absolute error (MAE). A SWAT-minus-RUSLE raster identified the sign and magnitude of spatial differences. Because observed long-term

sediment loads were unavailable, these statistics evaluate inter-model consistency rather than conventional predictive accuracy against measurements.

The Pearson correlation coefficient was calculated as:

$$r = \frac{\sum_{i=1}^{n}(X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum_{I=1}^{n}(X_i - \bar{X})^2 \sum_{i=1}^{n}(Y_i - \bar{Y})^2}}$$

Where:

- X_i = mean RUSLE sediment yield for LGA;
- Y_i = mean SWAT sediment yield for LGA;
- $\bar{X}$ and $\bar{Y}$ = mean values of the respective datasets;
- n = number of LGAs (17).

The Root Mean Square Error (RMSE) was computed as:

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(Y_i - X_i)^2}$$

The Mean Absolute Error (MAE) was calculated as:

$$MAE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}|Y_i - X_i|}$$

Where:

- X_i = RUSLE-derived sediment yield;
- Y_i = SWAT-simulated sediment yield;
- n = total number of LGAs.

A spatial difference raster was also generated by subtracting the RUSLE-derived sediment-yield raster from the SWAT sediment-yield raster:

$D = SY_{SWAT} - SY_{RUSLE}$

Positive difference values indicated locations where SWAT predicted higher sediment yield, whereas negative values indicated locations where the RUSLE-derived estimates were higher.

Because long-term observed sediment-load records were unavailable, the statistical analysis was interpreted as an assessment of inter-model agreement rather than conventional calibration or validation against measured sediment yields.

2.5 Watershed management prioritization

A two-factor watershed management matrix was developed by integrating the RUSLE-derived sediment-yield estimates with SWAT-simulated sediment yield.

The mean sediment-yield estimates were extracted for each of the 17 LGAs using zonal statistics. The paired values were then used to classify the LGAs into four management priority zones according to their relative hillslope erosion and sediment-routing characteristics.

The four categories were defined as follows:

- **Critical Priority:** LGAs with relatively high RUSLE-derived sediment generation and high SWAT sediment yield.
- **Channel-Dominated Priority:** LGAs with relatively low RUSLE-derived sediment generation but high SWAT sediment yield, indicating the importance of sediment transport and channel processes.
- **Slope-Dominated Priority:** LGAs with relatively high RUSLE-derived sediment generation but low SWAT sediment yield, indicating substantial hillslope erosion with comparatively limited sediment delivery.
- **Low Priority:** LGAs with relatively low values from both models.

The classification was implemented using the ArcGIS attribute table and Python Field Calculator. The resulting management zones were mapped to identify priority areas and provide a spatial basis for recommending appropriate erosion-control interventions.

The area and percentage coverage of each priority zone were subsequently calculated to assess the spatial distribution of watershed-management priorities across the study area.

3. RESULTS AND DISCUSSION

3.1 SWAT sediment yield

SWAT predicted average annual sediment yield ranged from 0.0136 to 23.01 t/ha/yr (Figure 2). High yields were concentrated in sub-basins draining Isuikwuato, Bende, Ohafia, Arochukwu and Umu Nneochi. These upland areas combine steep slopes, runoff generation and disturbed land cover. Central watersheds generally had moderate yields, while southern lowlands had lower values because of gentler terrain, lower runoff energy and greater opportunity for deposition.

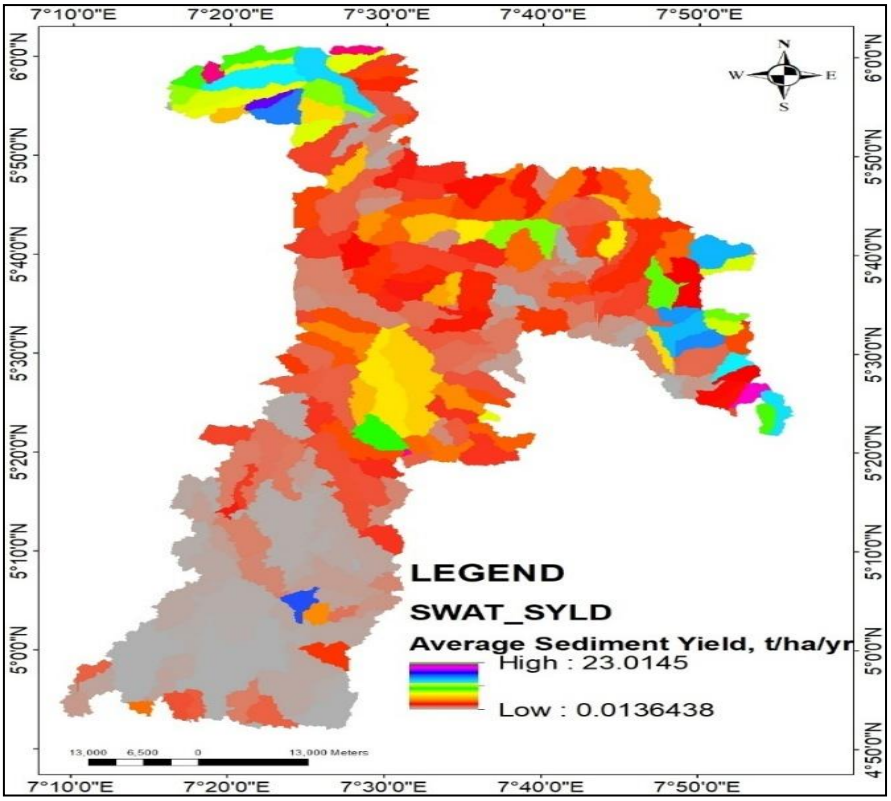


Figure 2: Sediment Yield in Abia State (SWAT Model, 1994–2024)

Localised elevated values occurred in the Aba urban watershed despite gentle topography. Impervious surfaces, altered drainage and channel erosion can enhance sediment delivery in urban systems, illustrating why topographic erosion susceptibility alone is insufficient for watershed management.

3.2 RUSLE-derived sediment yield and spatial differences

Application of the 0.146 SDR-converted RUSLE gross soil loss to estimated sediment yield ranging from 0.29 to 54.70 t/ha/yr as seen in Figure 3.

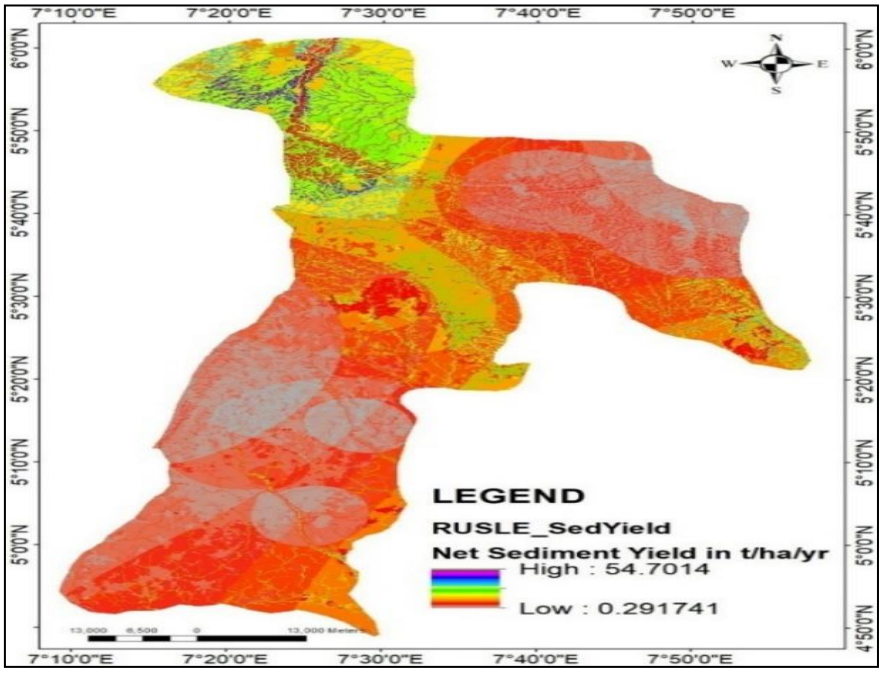


Figure 3: RUSLE-derived Sediment yield of Abia State

The spatial difference between SWAT-simulated and RUSLE-derived sediment yield(Figure 4) ranged from −52.66 to 22.72 t/ha/yr. Values near zero represented close agreement, positive values indicated higher SWAT predictions, and negative values indicated higher RUSLE-derived estimates.

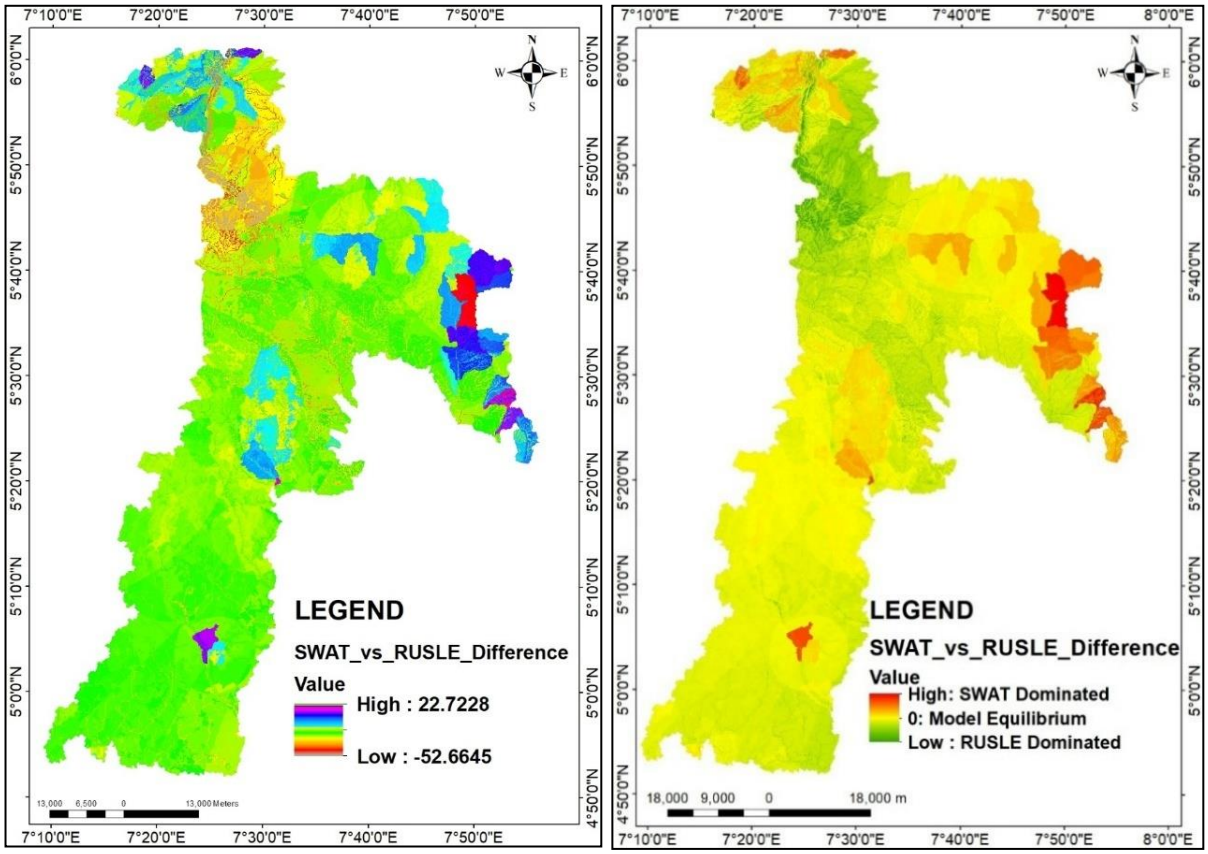


Figure 4: Spatial variation between SWAT and RUSLE Sediment Yield

Most LGAs had negative mean differences, consistent with deposition and storage between eroding hillslopes and channels. Isuikwuato had the largest reported negative LGA mean difference (-8.752 t/ha/yr), followed by Ukwa East (-3.212) and Ugwunagbo (-2.311). Positive mean differences occurred in Ohafia (4.792), Isiala Ngwa North (0.789), and Umuahia South (0.247), suggesting a stronger influence of runoff, channel routing, or streambank processes. Arochukwu recorded a difference of approximately −0.002 t/ha/yr, representing the closest agreement between the two estimates in the reported LGA comparison.

Based on the sub-basin (Abia State LGAs), zonal statistics command in ArcGIS was used to extract average difference values for each sub-basin. Interpreting why specific sub-basins show major differences based on their topography. These are given in Table 2

Table 2: Average/Mean sediment yield for each Abia State LGA

Abia State LGA	Mean SWAT SYLD	Mean RUSLE SYLD	Mean SWAT-RUSLE Difference	Interpretation
Aba North	0.469	1.499	-1.021	RUSLE-dominated
Aba South	0.209	1.499	-1.290	RUSLE-dominated
Arochukwu	4.270	4.480	-0.002	RUSLE-dominated
Bende	2.825	4.577	-1.743	RUSLE-dominated
Ikwuano	4.107	4.936	-0.844	RUSLE-dominated
Isiala Ngwa North	2.684	1.807	0.789	SWAT-dominated
Isiala Ngwa South	0.887	1.204	-0.311	RUSLE-dominated
Isuikwua	2.652	11.589	-8.752	RUSLE-dominated
Obi Ngwa	1.441	2.239	-0.710	RUSLE-dominated
Ohafia Abia	6.660	1.842	4.792	SWAT-dominated
Osisioma Ngwa	0.620	1.463	-0.847	RUSLE-dominated
Ugwunagbo	0.167	2.479	-2.311	RUSLE-dominated

Abia State LGA	Mean SWAT SYLD	Mean RUSLE SYLD	Mean SWAT-RUSLE Difference	Interpretation
Ukwa East	0.602	3.915	-3.212	RUSLE-dominated
Ukwa West	0.557	2.321	-1.729	RUSLE-dominated
Umuahia North	2.958	4.664	-1.680	SWAT-dominated
Umuahia South	3.288	2.930	0.247	SWAT-dominated
Umu-Nneochi	8.556	9.919	-1.472	RUSLE-dominated
Average	2.526	3.727		
Total	434.385	42.950		

Table 2 show that the majority of LGAs have negative mean SWAT–RUSLE difference values, indicating that the RUSLE-derived sediment yield is generally higher than the SWAT-simulated sediment yield. This is expected because RUSLE estimates gross hillslope erosion, whereas SWAT accounts for sediment deposition, storage, and channel routing before sediment reaches the stream network.

3.3 Statistical agreement

The statistical agreement is given in Table 3.

Table 3: Statistical agreement between SWAT and RUSLE sediment yield predictions

Metric	Value	Interpretation
Pearson correlation, r	0.524	Moderate positive association
Coefficient of determination, R^2	0.275	27.5% shared spatial variability
RMSE	2.83 t/ha/yr	Moderate difference in magnitude
MAE	2.09 t/ha/yr	Mean absolute inter-model difference

The correlation shows that the models broadly identified similar sediment-producing regions, especially in the northern uplands. The relatively low R^2 and non-zero errors are expected because RUSLE estimates potential hillslope erosion whereas SWAT represents the complete sediment-delivery sequence. The results therefore support complementarity rather than interchangeability.

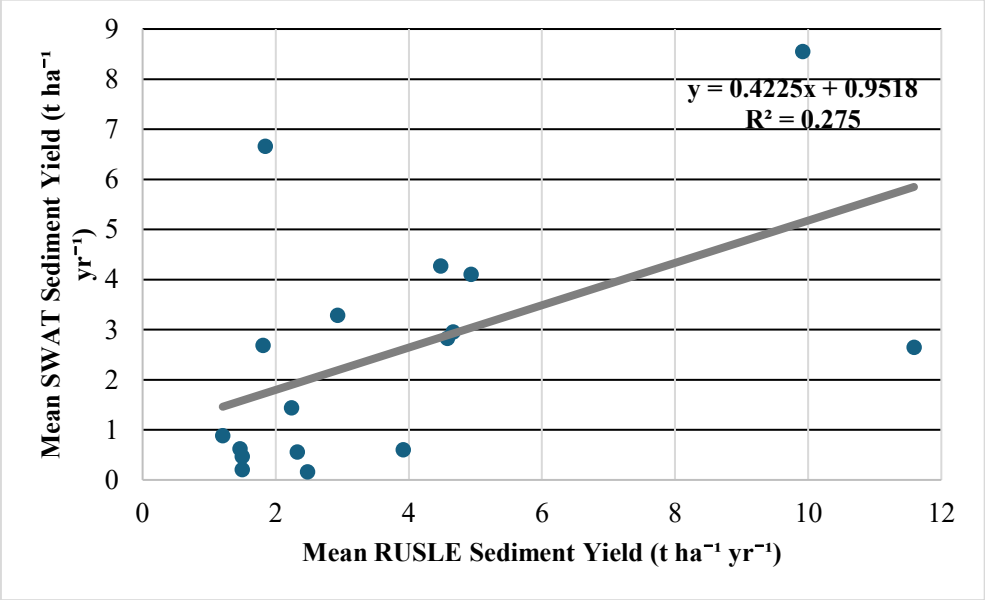


Figure 4: Scatter plot showing the relationship between SWAT-derived and RUSLE-derived mean sediment yields

Figure 4 illustrates the relationship between the mean sediment yields predicted by the RUSLE and SWAT models across the seventeen LGAs of Abia State. A positive linear relationship was observed between the two models, with a coefficient of determination (R^2 = 0.275), indicating that approximately 27.5% of the spatial variation in SWAT sediment yield is explained by the RUSLE-derived sediment yield. Although the relationship is moderate, it demonstrates that both models identify similar spatial trends in sediment production across the study area.

3.4 Watershed priority zones

The priority map is given in Figure 5, as derived from the integration of RUSLE and SWAT outputs, resulting in the classification of the 17 LGAs into four

watershed management priority zones. The classification combined the erosion conditions represented by RUSLE with the hydrological and sediment-yield conditions represented by SWAT.

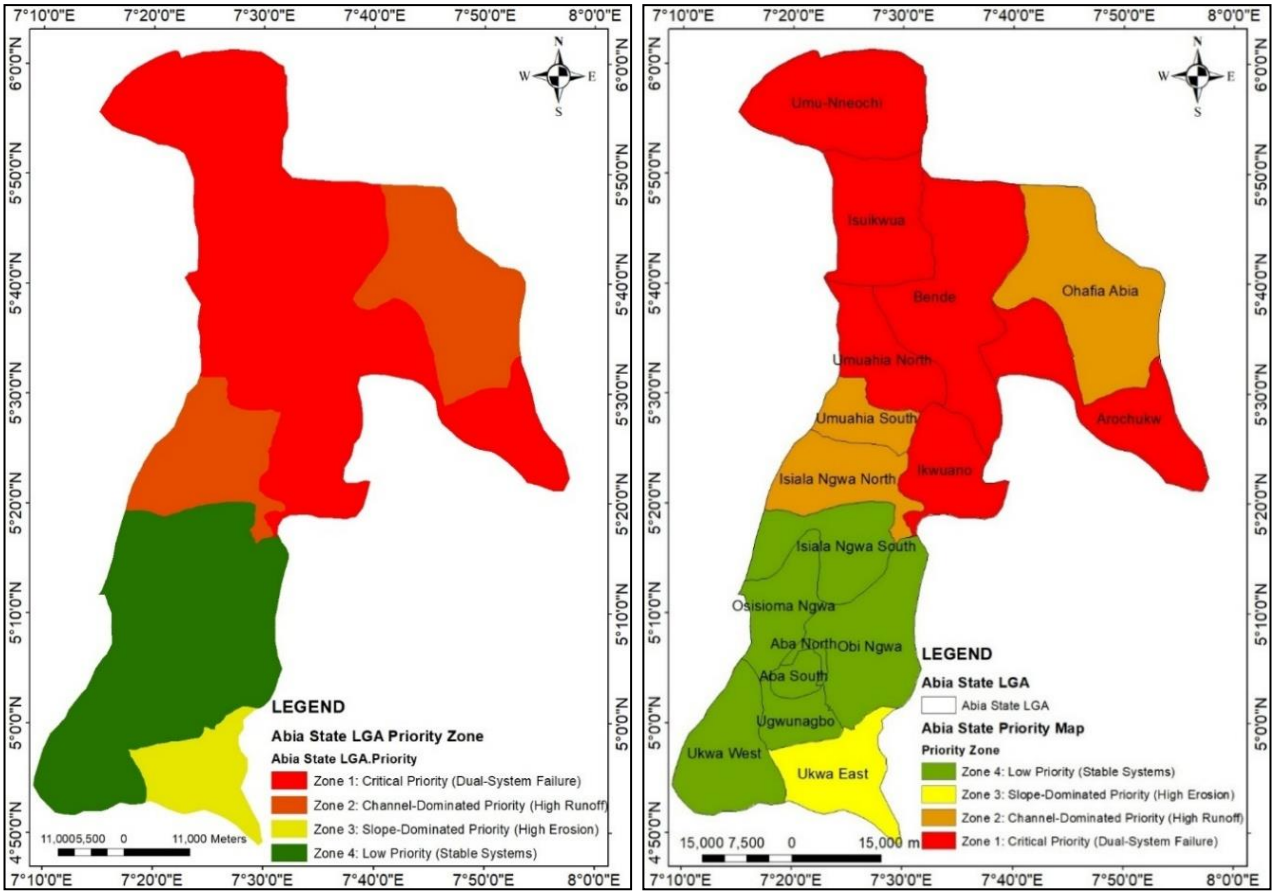


Figure 5: Watershed Priority Map of Abia State

Table 4: Priority Erosion-Management Zones

Zone	Area (km²)	LGAs	Management emphasis
Critical Priority	2,237.37	Arochukwu; Bende; Ikwuano; Isuikwuato; Umuahia North; Umu Nneochi	Integrated hillslope, gully and runoff control
Channel-Dominated	948.81	Isiala Ngwa North; Ohafia; Umuahia South	Riparian restoration, bank stabilisation and channel management
Slope-Dominated	245.42	Ukwa East	Contour farming, mulching, strip cropping and afforestation
Low Priority	1,291.86	Aba North; Aba South; Isiala Ngwa South; Obi Ngwa; Osisioma Ngwa; Ugwunagbo; Ukwa West	Monitoring and preventive land management

Critical Priority was the largest zone, covering almost half the analysed area. Its dominance indicates that neither hillslope conservation nor channel engineering alone is sufficient. Six LGAs require integrated packages combining source control, runoff management, gully stabilisation and vegetation restoration. The other zones permit more targeted allocation according to their dominant processes.

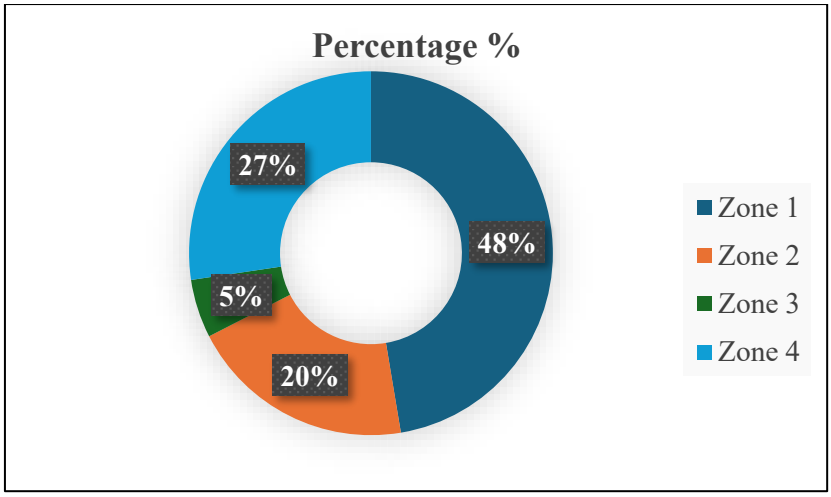


Figure 6: Percentage distribution of the total study area among the four erosion management zones in Abia State

3.5 General Discussion

The spatial agreement between models supports the conclusion that the northern and eastern uplands are the principal sediment-source regions. However, the magnitude differences are equally informative. RUSLE generally produced larger estimates because it describes detachment before storage and deposition. SWAT can produce larger values where hydrological connectivity, channel erosion and routing increase delivered sediment. The difference surface therefore helps distinguish source-limited from transport-connected watersheds.

The moderate correlation should not be interpreted as weak performance without considering the models' conceptual differences. A perfect match would be neither expected nor necessarily desirable. Instead, common hotspot identification increases confidence in regional priorities, while disagreement identifies locations where process diagnosis is particularly important.

The priority matrix converts this process information into management guidance. Critical watersheds require terracing, check dams, gully-head stabilisation, reforestation and managed drainage. Channel-dominated watersheds require riparian buffers, bank protection and stream restoration. The slope-dominated watershed requires cover and contour measures. Low-priority watersheds require preventive land management and monitoring so that changing land use does not raise future risk.

4. CONCLUSIONS

SWAT and RUSLE provided complementary descriptions of sediment dynamics in Abia State. SWAT sediment yield ranged from 0.0136 to 23.01 t/ha/yr, while SDR-adjusted RUSLE yield ranged from 0.29 to 54.70 t/ha/yr. Moderate inter-model association and common hotspot patterns supported their combined use, while spatial differences revealed the importance of deposition and channel connectivity.

The integrated matrix classified 47.37% of the state as Critical Priority, 20.09% as Channel-Dominated, 5.20% as Slope-Dominated and 27.35% as Low Priority. This process-based classification offers a practical basis for directing conservation resources. The framework is transferable to other humid tropical watersheds, provided that future applications clearly distinguish comparative model agreement from validation against observed sediment records.

The absence of observed discharge and sediment time series prevented formal calibration and validation of SWAT. RUSLE-derived sediment yield is itself model-based, and the SDR is a regional simplification that may obscure sub-basin variation. Moderate-resolution topography may not resolve small gullies and engineered drainage. The priority classes are therefore strategic screening outputs rather than substitutes for site-scale engineering design.

Future work should establish gauging and sediment-monitoring stations, apply calibration and uncertainty analysis following established SWAT practice (Arnold *et al.,* 2012; Abbaspour *et al.,* 2018), estimate spatially variable SDRs, use higher-resolution DEMs and test climate and land-use scenarios. Sensitivity analysis should quantify how parameter and data uncertainty affect zone membership.

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