



FACULTY OF ENGINEERING.

DEPARTMENT OF WATER RESOURCES ENGINEERING.

FINAL YEAR RESEARCH

**DEVELOPMENT OF A SEDIMENT MONITORING MODEL FOR
RIVER SYSTEMS.**

**CASE STUDY: RIVER MALABA CATCHMENT, KALAIT SUB COUNTY
(TORORO DISTRICT).**

By;

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This final year project research is submitted to the Department of Water Resources Engineering in partial fulfillment of the requirement for the award of a Bachelor of Science in Water Resources Engineering of Busitema University.

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ABSTRACT.

This study presents a comprehensive framework for monitoring and managing sedimentation in River Malaba, a transboundary river shared by Uganda and Kenya within the Malaba sub-catchment. The research integrated hydrological modeling, hydraulic simulation and machine learning to address challenges related to sediment yield estimation, sediment dynamics and real-time sediment monitoring.

The Soil and Water Assessment Tool (SWAT) was used to simulate catchment hydrology and estimate sediment yield. Model calibration and validation were performed using SUFI-2, with a Nash-Sutcliffe Efficiency (NSE) of 0.72 and R^2 of 0.76 for calibration, and NSE of 0.68 and R^2 of 0.74 for validation. The simulation revealed an average annual sediment yield of 142,248.7 tons with spatial variability across sub-basins ranging from 1.72 to 86.93 tons/km², highlighting sediment hotspots in the catchment. Hydraulic modeling was carried out using HEC-RAS 6.4.1 to evaluate sediment transport and deposition patterns along a critical reach of the river within Kalait Sub-County. The model achieved an NSE of 0.70 and R^2 of 0.73 during calibration (1999–2008) and NSE of 0.69 and R^2 of 0.71 during validation (2009–2022). Key outputs included sediment routing characteristics, trap efficiency estimations and the identification of erosion-prone and deposition-prone reaches along the river corridor. To facilitate real-time sediment prediction, a soft sensor was developed using a Multi-Layer Perceptron (MLP) Artificial Neural Network. Rainfall, temperature and flow velocity were used as input parameters due to their influence on sediment concentration. The model was trained and optimized using grid search and achieved R^2 scores of 0.90 for the training set, 0.80 for validation, and 0.85 for the testing set, indicating strong generalization and predictive performance. A sediment concentration heatmap was also generated using geospatial coordinates and predicted concentrations. River segments were ranked and categorized into low, moderate and high sediment concentration zones. The heatmap visually identified critical locations that require dredging thus offering actionable insights for maintenance planning.

This integrated approach offers a robust decision support tool for sediment monitoring and management in river basins.

KEY WORDS: Sediment Monitoring model, Hydrological Models and Machine Learning Soft Sensor model.

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DEDICATION.

I dedicate this research to my dear parents, **Mr. Elayu Julius & Mrs. Aloba Scovia**, in honor of their unwavering love, support and encouragement throughout my academic journey. Their sacrifices and guidance have been the foundation of my success.

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Lastly, I dedicate this research to all river water users whose needs and challenges have inspired the focus of this study.

DECLARATION

I **EDIMA JAMES**, declare that I wrote this report. I confirm that I did the research for this report carefully using trustworthy sources and proper methods. All outside sources used have been correctly cited and credited.

This report has not been used by anyone to gain an academic award at any learning Institution.

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APPROVAL.

I hereby confirm that the research report was written and compiled by **EDIMA JAMES** and is now ready for submission to the Department of Water Resources Engineering, Faculty of Engineering and Technology at Busitema University.

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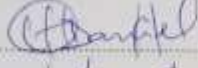
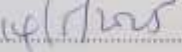
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List of Acronyms

1D:	One-Dimensional.
2D:	Two-Dimensional.
ANN:	Artificial Neural Network.
DEM:	Digital Elevation Model.
FAO:	Food and Agriculture Organization.
GIS:	Geographic Information System.
GPS:	Global Positioning System.
HEC RAS:	Hydrologic Engineering Centre - River Analysis System.
LULC:	Land Use Land Cover Changes.
MLP:	Multi-Layer Perceptron.
MWE:	Ministry of Water and Environment.
NSE:	Nash-Sutcliffe Efficiency.
R ² :	Coefficient of Determination.
RMSE:	Root Mean Square Error.
RNN:	Recurrent Neural Network.
RUSLE:	Revised Universal Soil Loss Equation.
SDR:	Sediment Delivery Ratio.
SDGs:	Sustainable Development Goals.
SEDMOD:	Sediment Model.
SMS:	Short Message Service.
SWAT:	Soil and Water Analysis Tool.
USGS:	United States Geological Survey.

Zones 1, 2, 3, 4 and 5 require minimal dredging as the high-energy flow naturally prevents fine sediment buildup. However, occasional dredging may be needed if obstructions sedimentation impact river flow.

Conclusion

This study demonstrates the potential of integrated hydrological, hydraulic and machine learning models to assess and manage sedimentation in river systems. The SWAT model provided a detailed sediment yield profile, HEC-RAS offered insight into in-stream sediment transport, and the soft sensor enabled real-time sediment prediction. These combined outputs offer a scalable decision-support tool for catchment managers and policymakers to plan timely interventions such as dredging and erosion control. The predictive accuracy and spatial outputs like heatmaps enhance maintenance scheduling and resource prioritization.

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