WAT-63 ORAL PRESENTATION · WATER TRACK · REMOTE SENSING, GIS & AI FOR WATER

Spatial Quantification, Prioritization, and Comparing Soil Erosion risk across Agro-Ecological Zones in Werie Watershed, Northern Ethiopia: A RUSLE Model, GIS and Remote Sensing Approach

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DOI: https://doi.org/10.31705/ICEWSE.2026.60

Abstract

Soil erosion by water is a critical environmental challenge in Ethiopia, particularly in the highlands, causing land degradation and reduced agricultural productivity. Localized assessments are needed for effective land management. This study quantifies soil loss, prioritizes hazard areas, and compares loss across agro-ecological zones in the Werie Watershed, Northern Ethiopia, using the Revised Universal Soil Loss Equation (RUSLE) and Geographic Information Systems (GIS). We integrated 31 years of rainfall for the Rainfall Erosivity (R) factor, soil data for Soil Erodibility (K), remotely sensed land cover for Cover Management (C), a Digital Elevation Model for Slope Length and Steepness (LS), and Support Practices (P) based on land use and slope. GIS processed and analyzed spatial data to generate a soil loss map. Mean annual soil loss was 9.73 t ha^{-1} yr^{-1} (0.09–436.37), showing high spatial variability. While 78.23% of the watershed experienced slight erosion (0.09–5 t ha^{-1} yr^{-1}), 10.65% was high to very extreme (>30 t ha^{-1} yr^{-1}). Comparison across Kolla, Weina Dega, and Dega zones showed distinct soil loss patterns. The Kolla zone had the highest average erosion (22.83 t ha^{-1} yr^{-1}), indicating high vulnerability despite smaller area. The Weina Dega zone, with moderate mean loss (8.77 t ha^{-1} yr^{-1}), contributed the largest total annual soil loss due to its size. The Dega zone exhibited the lowest mean rate (7.64 t ha^{-1} yr^{-1}). Given these findings, targeted soil and water conservation is urgently recommended, particularly in vulnerable lowlands and extensive mid-highlands, to promote sustainable management and mitigate erosion's adverse impacts.

Keywords: *erosivity; GIS; RUSLE; soil erosion; Werie watershed*