## Geospatial Mapping of Soil Fertility Status and Nutrient Imbalances in Reprasentative Zones of the Kotmale Highlands Agro-Ecosystems, Sri Lanka

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## Abstract

Soil fertility degradation presents a critical challenge to sustainable agriculture in Sri Lanka's central highlands, particularly in selected areas of the Kotmale Highlands, where intensive farming practices and unregulated agrochemical inputs have significantly altered soil nutrient dynamics. This study employs an integrated approach combining multi-parameter soil analysis with advanced geospatial techniques to characterize and map soil fertility variations across diverse agro-ecological zones. Soil samples were systematically collected from representative zones using GPS-guided stratified random sampling method and laboratory analyses were conducted to assess key fertility indicators: pH, organic matter content, available phosphorus (P), exchangeable potassium (K), cation exchange capacity (CEC), and electrical conductivity (EC). Results reveal widespread soil acidity problems, with pH values predominantly below 5.5, significantly constraining nutrient availability and microbial activity. Organic matter levels were critically depleted (<2%) in approximately 70% of sampled locations, indicating compromised soil biological health and reduced resilience to environmental stressors. Phosphorus deficiency emerged as a ubiquitous concern across all sampling zones, while potassium concentrations exhibited marked spatial heterogeneity, ranging from severe deficiency to excessive levels that risk creating antagonistic nutrient interactions. Interpolated fertility maps generated through GIS analysis identified distinct spatial patterns and critical hotspots requiring urgent intervention, enabling the development of site-specific management strategies. The study demonstrates the efficacy of integrating laboratory soil analyses with geospatial modelling to create comprehensive soil fertility assessments that can guide precision agriculture approaches and sustainable soil management policies in highland agro-ecosystems.

Keywords: agro-ecological zones, geospatial modelling, nutrient mapping