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Digital Soil Mapping and GIS-based Land Evaluation for Rice Suitability in Kilombero Valley, Tanzania

Abstract

A GIS-based multi-criteria land evaluation was performed in Kilombero Valley, Tanzania in order to avail decision makers and farmers with an evidence based decision support tool for improved and sustainable rice production in this important region for agricultural investment. The five most important criteria for rice production in the area were identified through a literature search and discussion with local agronomists and farmers. The identified criteria were 1) soil properties, 2) surface water resources, 3) accessibility, 4) distance to markets, and 5) topography. Spatial information of these criteria for the study area was generated.

A field survey and lab analyses were conducted to generate spatial soil information using base map generated from a legacy soil map and 30 m DEM. OSACA. A *k*-means based clustering application was used to perform distance metric numeric classification of soil profiles. The profiles were classified into 13 clusters. The clusters were demonstrated to be different from each other through comparison of modeled continuous vertical variability of selected attributes of modal soil cluster centroids by using equal area spline functions. Two decision tree based algorithms, J48 and Random Forest (RF) were applied to construct models to spatially predict the soil clusters using environmental correlates derived from 30 m DEM, 5 m RapidEye satellite
image and legacy soil map using the *scorpan* digital soil mapping framework. The RF predicted soil cluster map was picked for land evaluation because the algorithm demonstrated superiority by having comparatively higher predictive rate and pixel contiguity. Topsoil attributes values of predicted soil clusters were used to produce soil physical and chemical properties maps.

On-screen digitization, reclassifications and overlays in ArcMap and Whitebox GIS softwares were used to create spatial layers of the other identified criteria. Rivers were digitized from the satellite image and topographic map of the study area to create surface water resources map. Roads were digitized to create accessibility map and market centers coordinate points were digitized to create distance to market map. Slope gradient derivative from DEM was used to create topography map.

The analytical hierarchy process (AHP) method was used to score criteria by the local extension staff and lead farmers on a scale of 0.0 – 1.0. Surface water resources scored the highest weight (0.462) followed by soil chemical properties (0.234). Other criteria and their weight in paranthesis are soil physical properties (0.19), topography (0.052), accessibility (0.036), and distance to market (0.025).

The multi-criteria land evaluation results showed that about 8% of the study area was classified as having low suitability for rice production while only 2% was highly suitable. The majority of the area (about 89%) was classified as having medium suitability for rice production. Since the suitability decision was dominated by the surface water resource criterion, the rice suitability in the study area can be greatly improved by improving the water resources management.