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Assessing the Variability of Soil Quality and Crop Productivity at Different Spatial Scales in three Settlement Schemes in NE Zimbabwe by Integrating Mid-Infrared Spectroscopy and Geostatistical Tools

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Abstract

Understanding spatial variations of natural resources is essential for monitoring and managing agro-ecosystems, making them more profitable and sustainable. However, most of the literature on spatial variability in crop production linked to soil quality generally refers to small or medium spatial resolutions (10–100 m), and rarely incorporates farmers' management and its link with the surrounding landscape. Therefore, three villages representing three settlement schemes in NE-Zimbabwe were studied to understand the spatial variations among cropping fields at different spatial scales, and to determine the main drivers of these changes. Cropping fields in each area were digitalized by using Landsat satellite imagery and field surveys. A nested non-aligned sampling design was subsequently applied by using sequentially grids at different spatial resolutions (750×750 m, 150×150 m and 30×30 m), which resulted in the selection of 159 sampling points in the three villages: 105 points in maize fields, 32 in fallow and 22 in other crops. Sampling points consisted of four sampling plots on a radial arrangement, where information on land, vegetation and soil surface characteristics were recorded. A composite topsoil (0–20 cm) sample and measurements of topsoil resistance to penetration were also taken on each plot. Crops were sampled by selecting two rows of 5 m length per plot and measuring crop response parameters. Fallows were sampled by using a 1 m^2 quadrate per plot. Soil samples were ground (<1mm) and analysed in the laboratory for pH, texture, C, N, P and cations. Additionally, all soil samples were ball-milled and analysed by mid-infrared spectroscopy (MIRS). Chemometric models were later constructed for predicting the physical-chemical characteristics of all samples. Geo-referenced soil and vegetation datasets were statistically analysed by using conventional (Anova) and geoestatistical (semivariograms) methods. Results demonstrated how soil and vegetation varied at each spatial scale in each village under study, and also identified the main drivers behind these spatial changes. We argue that coupling MIRS with geostatistical analyses is a useful tool for assessing spatial variations of natural resources from plot to landscape level.

Keywords: Maize performance, scaling-up, soil quality, spatial variations, vegetation productivity

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