Understanding spatial variability of soil physical and hydraulic properties in agricultural land in Zambia and Malawi

Funded by LEG4DEV: https://leg4dev.org/ Grant Ref: FOOD/2020/418-901

CONCLUSIONS

- **Soils in small-holder farmers' fields have weaker structure and low organic matter content compared to commercial farms in the region.**
- **Saturated hydraulic conductivity is higher in commercial fields, despite their higher clay content.**

INTRODUCTION

The success of rainfed soybean and maize cultivation depends significantly on soil physical properties, influencing water availability, nutrient retention and overall soil health.

Remote sensing, coupled with ground-based measurements, offer valuable insights into spatial distribution of soil properties different scales, and their impact on cultivation, enabling precision agriculture and targeted management strategies.

RESEARCH OBJECTIVES

Objective 1: Observing variability of the soil's texture and agrophysical parameters in Zambia and how they affect soybean and maize cultivation for small-scale and commercial farmers.

Objective 2: Investigating hydraulic properties and their implications for water management strategies.

SITE SELECTION & DATA COLLECTION

Figure 1 includes the sites selected: Lusaka, Kalomo, and Katete; each representing a different farming type (commercial or small-scale) and agroclimatic conditions. Soil sampling was conducted during February and March 2024 (Figure 2):

- Physical, chemical, and hydraulic top- and subsoil properties according to the Land Degradation Surveillance Framework.
- Single ring infiltrometer measurements on selected fields.

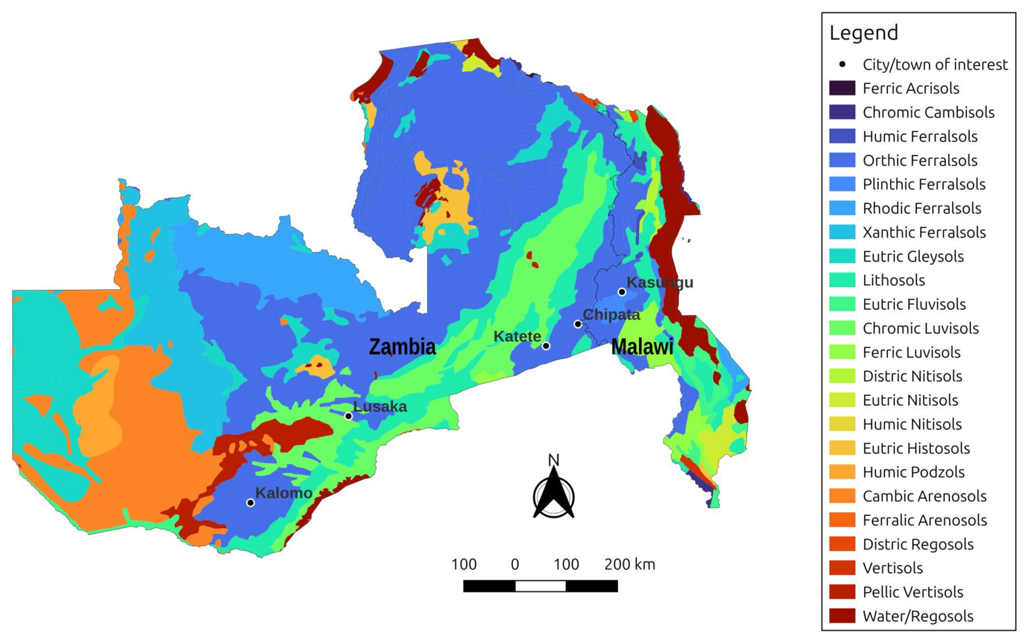

Figure 1: FAO soil map of Zambia and Malawi (produced in 1980), and important sites, including the sites of interest in our study.

RESULTS & DISCUSSION

Commercial fields in Lusaka higher clay content in the top and subsoil (40 and 45% mean clay content respectively) compared to fields in Kalomo (18 and 26% for top and subsoil respectively)(Figure 4). Commercial fields also have the highest organic carbon content (OC) in topsoil with 0.9% mean OC closely followed by Katete (0.8% mean OC), a region marked by topography induced micro-climates (Figure 3).

Field-saturated hydraulic conductivity (K_{fs}) was moderate but generally higher at commercial fields despite higher clay content (Figures 5). In Lusaka, K_{fs} was 134 mm h^{-1} on average, while it was 46 mm h^{-1} in Katete and 72 mm h^{-1} in Kalomo. A moderate correlation was observed between OC and K_{fs}.

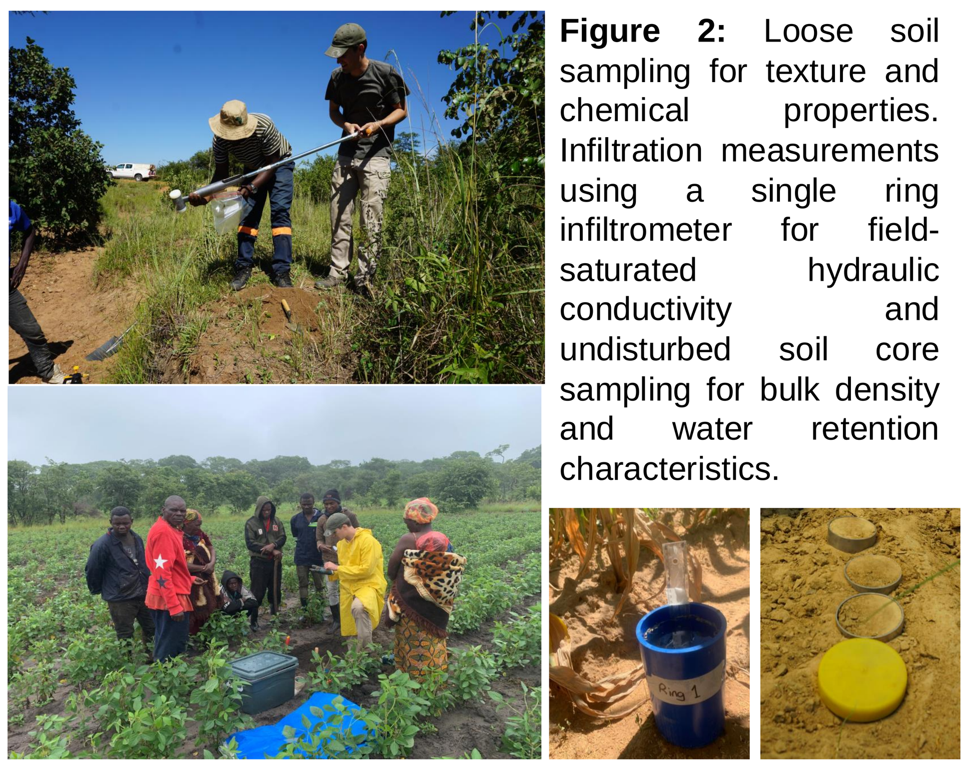

Figure 2: Loose soil sampling for texture and chemical properties. Infiltration measurements using a single ring infiltrometer for field-saturated hydraulic conductivity and undisturbed soil core sampling for bulk density and water retention characteristics.

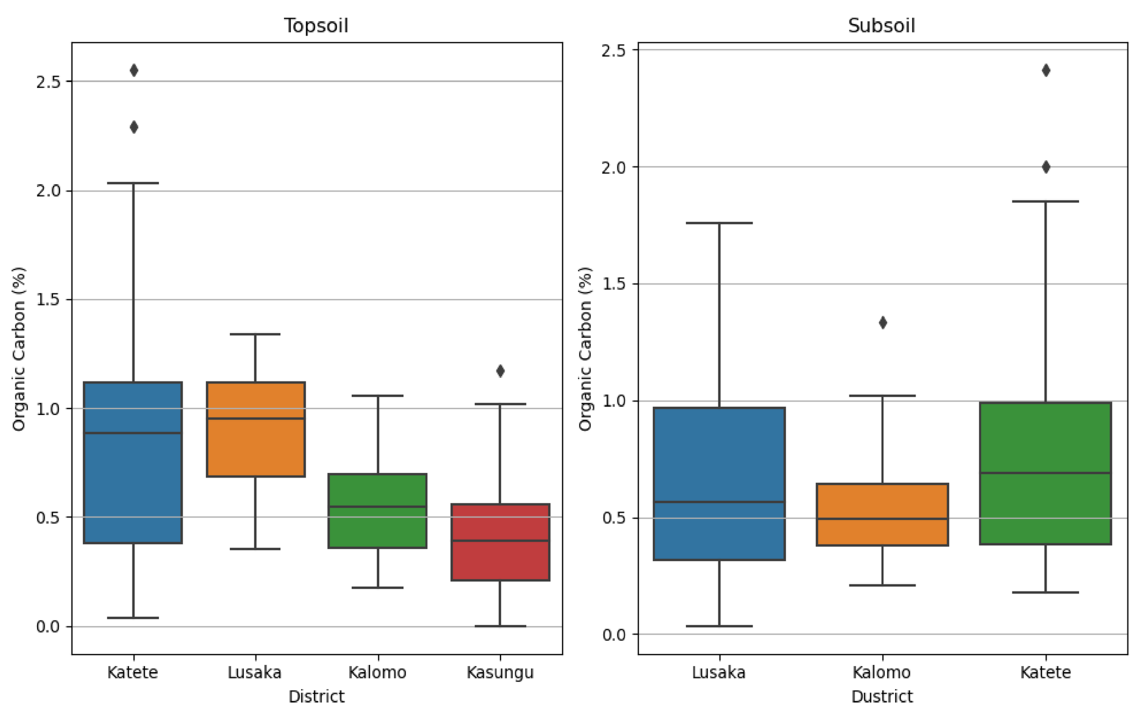

Figure 3: Organic carbon content of topsoil (0-10cm) and subsoil (30-40cm) in Lusaka, Kalomo, Katete, and Kasungu.

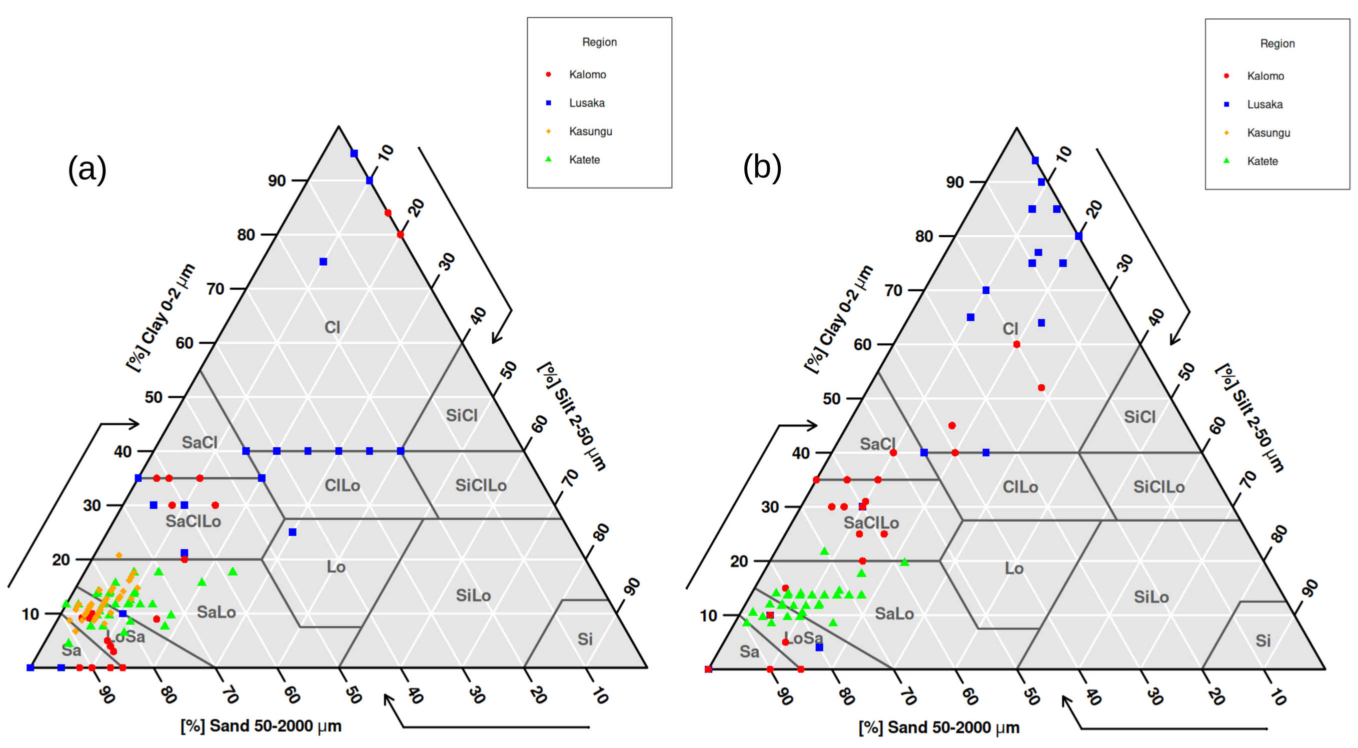

Figure 4: Texture Triangles of **(a)** topsoil (0-10cm) and **(b)** subsoil (30-40cm) in Lusaka, Kalomo, Katete, and Kasungu.

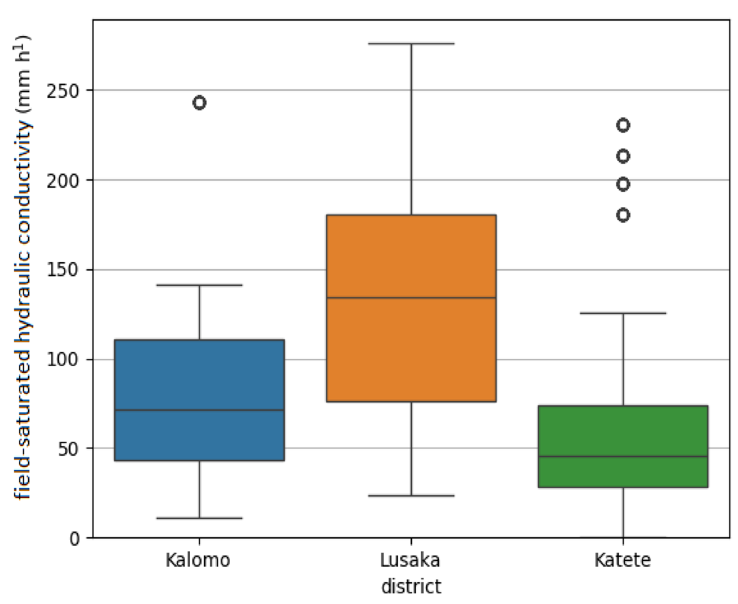

Figure 5: Field-saturated hydraulic conductivity for the different fields determined using single ring infiltration measurements.

NEXT STEPS

- Measuring soil moisture vs crop and farming properties.
- Monitoring NDVI and yield in the 2023-2027 farming seasons.
- Determine relationship between water retention characteristics and maize and soybean yield in the region

WHAT DOES THIS STUDY ADD?

- The addition of open soil data to the mostly incomplete and patchy sub-Saharan African soil dataset.
- Promoting precise understanding of farmers soil and crop health.
- Enhanced understanding of the spatial variation of soil physical properties and its impact on soybean and maize yield.

Emmanuel Ngonga
PhD Candidate
emmanuel.ngonga@slu.se

Yannic Janal
Dipl.-Ing.
yannic.janal@boku.ac.at

Jennie Barron
Professor
jennie.barron@slu.se

SCIENCE AND EDUCATION FOR SUSTAINABLE LIFE