# TOWARD PRECISION AGRICULTURE BY ASSESSING FAO SOIL DATA ACCURACY WITH LOCALISED SOIL MAPPING IN MID-WESTERN UGANDA

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## ABSTRACT

Proper soil mapping remains a major input for efforts that aim at developing context specific soil and crop management. Soil maps often enable policy makers and other agricultural extension programs to establish the suitability of land for various production systems. Currently, most soil maps have been developed basing in the FAO soil databases at a scale of 1:50,000 yet farmers and other local land users require fine scales to guide decision in the use of fertilizers and selection of suitable crop enterprises. A study was conducted in midwestern Uganda in Kikuube town council to establish the accuracy of FAO Soil maps for improving soil information for precision agriculture. The methodology involved use of ARCGIS 10.8, Google Earth Pro and SAGA GIS creating local mapping units, which are areas relatively homogeneous in soil composition. The mapping units were defined using a combination of slope percentage, topographic wetness index, remote sensing data and land cover. Field morphology surveys were conducted and soil samples collected basing on WRB guidelines in selected soil profiles along soil mapping units. Soil classification by harmonisation was conducted. A near-tool analysis in GIS was used to overlay the new soil profile data on mapped units basing on their proximity to sampled points. Findings from ground truthing and soil mapping activity indicate that Ferralsols, Plinthisols, and Gleysols cover 44.84%, 37.45%, and 17.71% of the aredca, respectively. The existing FAO classification identified four soil types: Dystric Regosols, Gleysols, Acric Ferralsols, and Histosols, covering 80.51%, 12.75%, 6.72%, and 1.78% of the area, respectively. The soil types under FAO-Database were somewhat different from soil types obtained in the re-mapping activity in Kikuube town council. Overall, local soil mapping is essential for farmers to accurately identify soil types to aid proper use of fertilizers. The study highlighted discrepancies between the FAO soil classification and field soil mapping activity, underscoring the importance of ground-truthing and re-doing soil morphology for accurate soil maps to guide precision agriculture.

## INTRODUCTION

Uganda is in the East region of Africa with a population of about 45.9 million people as per UBOS 2024 census. More than 75% of its population is employed in the agricultural sector mainly composed of peasant farmers (Okonya, 2014). Uganda was historically known for its fertile soils in the past decades, but now the fertility is decreasing from low to medium due to land degradation, soil erosion and population increasing leading to over utilization of land (Apanovich et al., 2018). Farmers are adopting to the use of fertilizers to boost their yields to cope with soil infertilities as noted by Rapsomaniki in 2015, though many smallholder farmers are reluctant to purchase fertilizer to increase crop yields, despite the evidence that fertilizer use increases yield that in turn increases income (Larson.2016). Efficient application of fertilizers requires knowing the type and composition of soils for optimal use of fertilizers (Singh et al., 2015). Proper soil mapping remains a major input for efforts that aim at developing context specific soil and crop management (Chen et al., 2022). Soil maps often enable policy makers and other agricultural extension programs to establish the suitability of land for various production systems (Apokti et al., 2019). Currently, most soil maps have been developed basing in the FAO soil databases at a scale of 1:50,000 yet farmers and other local land users require fine scales to guide decision in the use of fertilizers and selection of suitable crop enterprises (Campbell, 2018). This calls for farmers to map and analysis the soils before making selecting crops and making fertilizer use decisions.

## METHODS AND MATERIALS

### Study Area

The study was conducted in Kikuube town council that is in western Uganda in Bunyoro kingdom in Kikuube district. The district covers an area of about 2,097 $Km^2$, with Lake Albert covering 905.9 $Km^2$ (43.2%) according to Uganda Investment Authority (UIA) in 2021. The district has five sub-counties namely, Kiziranfumbi, Kabwoya, Buhimba, Bugambe and Kyangwali and two town councils, Kikuube and Buhimba. The district had a population estimation of 410,000 people in 2019 with 110, 000 refugees (UIA, 2021). The district's climate varies with altitude, featuring a bimodal rainfall pattern ranging from 800 mm in the Rift Valley floor to 1,500 mm in the escarpment. The soils are mainly ferralitic and acidic, with good organic matter in lower slopes and valleys and varying soil productivity, with some areas having fair to low productivity according to Kikuube district local government. Agriculture is the main source of livelihood for 90% of Kikuube's residents, who cultivate key food crops such as maize, rice, cassava, bananas, and beans. Important cash crops include tobacco, tea, and sugarcane. Livestock farming, including poultry and piggery, also contributes to the local economy. Fishing on Lake Albert boost the economy of the locals. Recent developments include oil and gas exploration in the Albertine Rift Valley (Nuwagaba, 2021), specifically in Kyangwali and Kabwoya Sub-Counties expected to have a major impact on Uganda's GDP and public revenue (Ddamulira, 2021).

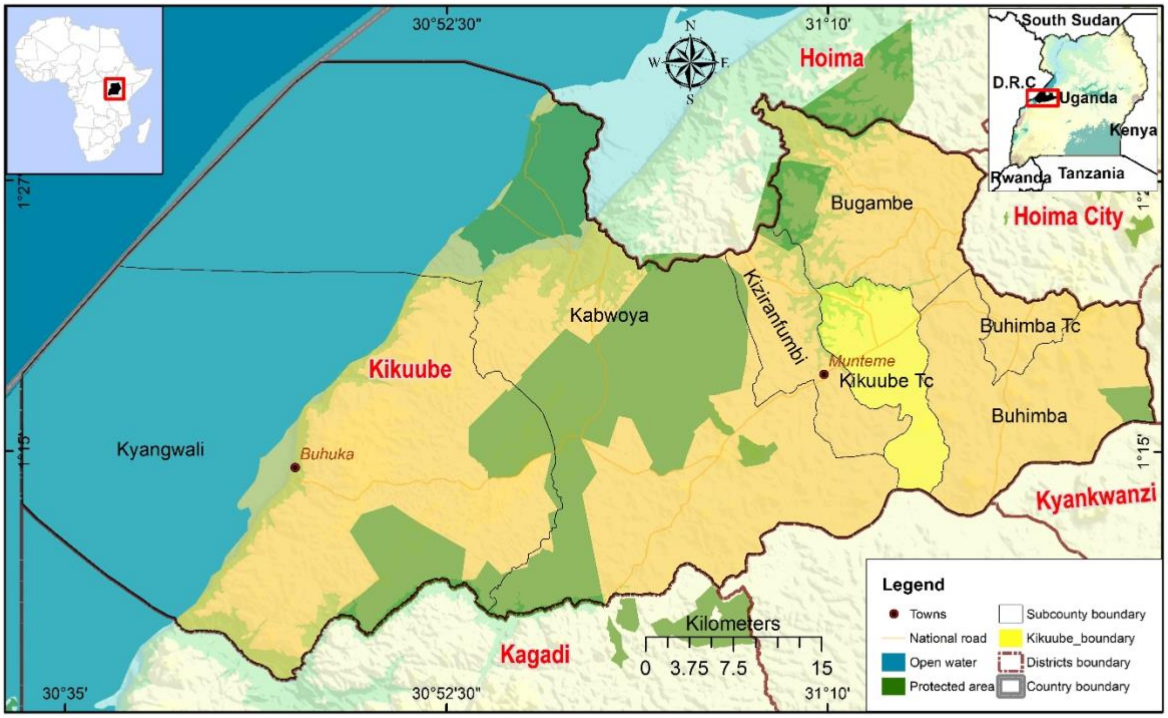


**Figure 3.** Location of Kikuube district

## Data Collection and Analysis

The methodology involved using ARCGIS 10.8, Google Earth Pro, and SAGA GIS to create local mapping units. Local mapping units were composed of slope percentage derived from digital elevation model, topographic wetness index derived from digital elevation model in SAGA GIS, FAO Soil maps, and land use/cover obtained from land use classification of satellite images. The datasets were then overlaid and soil mapping units created based on homogeneity. Map units were then used in field morphology soil surveys, and soil samples were collected based on the World Reference Base guidelines from selected soil profiles (IUSS, 2022). The collected soil samples were analyzed in the laboratory and results tabulated based on Fao classification (Fao, 2015) visa vie the sampled mapping units and soil types generated. The laboratory results were then used to classify the generated mapping units visa vie the Near-tool analysis in GIS used to overlay the new soil profile data on mapped units, considering their proximity to sampled points.

| Ferrallsols | Gleysols | Plinthisols |
|---|---|---|

**Figure 4.** Field Soil Type Mapping.

## RESULTS AND DISCUSSION

FAO Soil mapping comprised of four soil types namel;-Acric Ferralsols, Dystric Regosols, Gleysols and Histosols covering 6.72%, 80.51%, 12.75% and 0.02% respectively. Whereas the Field Soil Mapping comprised of Ferralsols, Gleysols and Plinthisols covering 44.84%, 17.71% and 37.45%. An overlay of FAO soil map and Field mapping Soil map show FAO Soil Mapping Classification was generic, and it was noted that each Fao soil type comprised of the three field mapping soil types except the Histosols that were 100% Classified as Gleysols as shown in Table 1.

### Comparison of Soil Classification Area

The FAO maps indicated Dystric Regosols as dominant soil types covering more than three quarters of the soil types of which 44.47% were Ferralsols, 15.78% were Gleysol and 39.75 were Plinthisols (Table 2). The Local Field Mapping identified Ferralsols as the most commom soil type covering 44.84% of the soils in the study area. More than half of the Fao Classified Ferralsols were on a local precise scale classified as Plinthisol. This was also noted in the Fao Gleysols classification, that locally on a precise scale comprised of a mixture of three locally mapped soil types dominated by Ferralsols. The generalization of Fao Soils on a scale of 1:50,000 which on ground represents several mapping units underscores the importance of ground-truthing and re-evaluating soil morphology to produce accurate soil maps.

**Table 3.** Results from FAO and Field Soil Classification

| **FAO Soil Map** | | | **Field Soil Mapping** | | |
|---|---|---|---|---|---|
| **Soil Type** | Area (ha) | Area (%) | Soil Type | Area (ha) | Area (%) |
| **Acric Ferralsols** | 695.93 | 6.72 | Ferralsol | 4,645.11 | 44.84 |
| **Dystric Regosols** | 8,341.54 | 80.51 | Gleysol | 1,834.86 | 17.71 |
| **Gleysols** | 1,321.14 | 12.75 | Plinthisol | 3,880.42 | 37.45 |
| **Histosols** | 1.78 | 0.02 | Total | 10,360.39 | 100 |
| **Total** | 10,360.39 | 100 | | | |

**Table 4.** Soils Comparison

| Soil Classification | | Area (ha) | Area (%) |
|---|---|---|---|
| Fao Dataset | Field Mapping | | |
| Acric Ferralsols | Ferralsol | 296.19 | 42.56 |
| | Gleysol | 18.80 | 2.70 |
| | Plinthisol | 380.95 | 54.74 |
| Dystric Regosols | Ferralsol | 3,709.77 | 44.47 |
| | Gleysol | 316.32 | 15.78 |
| | Plinthisol | 3,315.45 | 39.75 |
| Gleysols | Ferralsol | 639.15 | 48.38 |
| | Gleysol | 497.96 | 37.69 |
| | Plinthisol | 184.02 | 13.93 |
| Histosols | Gleysol | 1.78 | 100.00 |

Therefore, accurate soil mapping is essential for farmers to make informed decisions about fertilizer use and crop selection. The study's findings suggest that localized soil mapping provides a more accurate representation of soil types, which is crucial for precision agriculture. By identifying the correct soil types, farmers can optimize their agricultural practices, improve crop yields, and ensure sustainable land management.

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