Mapping field sizes in smallholder agriculture of Sub-Saharan Africa: assessing pathways to overcome the mismatch between spatial resolution and field size

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The mapping of field sizes is advancing rapidly. Current approaches based on high-resolution satellite imagery and machine learning algorithms provide quasi-operational workflows in consolidated agricultural systems across the globe. Contrastingly, field size mapping in smallholder agricultural systems in Sub-Saharan Africa is far from operational. With field sizes commonly not exceeding half a hectare, the spatial resolution of globally available optical satellite imagery such as Sentinel-2 and Landsat can be insufficient to delineate individual fields. Furthermore, the lack of distinct spatial boundaries between fields creates additional challenges for approaches relying on the identification of field edges. Therefore, assessing field size in smallholder landscapes requires alternative approaches which go beyond the delineation of individual fields and instead focus on distribution parameters of field sizes, such as average or maximum field size. Such approaches can allow for assessing field sizes in regions or for periods where the mismatch between spatial resolution and field size would not allow for the identification of individual fields.

This work explores multiple pathways for assessing local-level field size distribution combining field-based reference data, a variety of satellite image archives with varying spatial resolution, and machine learning regression models. Our reference dataset consists of 23 UAV-based images distributed across three provinces in Northern Mozambique (Niassa, Zambézia, and Nampula). The reference images cover between 6 and 10 hectares and contain between a few and up to dozens of fields. We demarcated individual fields from these images and derived local field size distribution parameters. We then generated a set of satellite image features, such as spectral-temporal and textural metrics, from intra-annual PlanetScope, Sentinel-2, and Landsat time series for the field sites. Finally, we trained multiple machine learning regression models to predict local field size distribution parameters and assessed the goodness of fit of the different models. While uncertainties remain high across all tested approaches, we discuss how particular combinations of sensors, image features, and distribution parameters could potentially be used to approximate field size distributions in complex smallholder systems across large areas.