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Landsat NDVI and Sentinel-2 for vegetation dynamics and maize field mapping in Kikuyu, Kenya

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Abstract

Vegetation indices such as the Normalized Difference Vegetation Index (NDVI), Green Normalized Difference Vegetation Index (GNDVI), Normalized Difference Red Edge (NDRE), and Chlorophyll Vegetation Index (CMI) are widely used in agricultural monitoring, land use assessment, and environmental studies. However, despite the global availability of Landsat and Sentinel-2 imagery, their application in many sub-Saharan African contexts, including Kenya, remains limited, particularly in smallholder-farmer systems. This study integrates Landsat-derived NDVI, GNDVI, NDRE, and CMI with Sentinel-2 optical data to analyse vegetation dynamics and map maize field distribution in Kikuyu sub-County of Kiambu County, Kenya. The 27-year NDVI time-series captured interannual vegetation dynamics, reflecting rainfall variability, drought periods, and land-use change across the sub-County. Several years such as 2001, 2004, 2012, 2016, 2019, 2021 show low NDVI values consistent with regional drought conditions in central Kenya. The peaks observed in 2007, 2013, 2020, and 2025 align with periods of favourable rainfall. Spatially, the NDVI composites showed persistent high-vegetation zones in forested and densely vegetated areas, while agriculture landscapes displayed more variability due to seasonal cropping cycles and land-use dynamics.

A multi-method approach combining threshold based classification, unsupervised K-Means clustering, and a supervised U Net deep learning model was applied for the 2025 growing season. Model performance improved progressively across the three approaches: K-Means shows low accuracy (IoU=0.013, F1-score =0.025, precision=0.013, recall=0.451), U-Net Option A using proxy labels achieved moderate gains (IoU=0.397, F1-score =0.568, precision=0.607, and recall=0.533), and U-Net Option B trained with field-surveyed maize polygons delivered better and most balanced results (IoU=0.403, F1-score =0.574, precision=0.540, and recall=0.613). The integrated outputs enabled delineation of maize field extents and provided insight into long-term vegetation trends. Overall, this study demonstrates the effectiveness of multi-sensor satellite imagery for crop monitoring, land-use mapping, and environmental assessment, offering a cost-effective tool to support agricultural planning, land-use management, and mitigating the effects of environmental change.

Keywords: Agroecosystems, climate variability, deep learning, google earth engine (gee), k-means, land use land cover (lulc), landsat, maize crops, NDVI, semantic segmentation, Sentinel-2; optical remote sensing, u-net

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