From Space to Soil: Advancing Crop Mapping and Ecosystem Insights for Smallholder Agriculture

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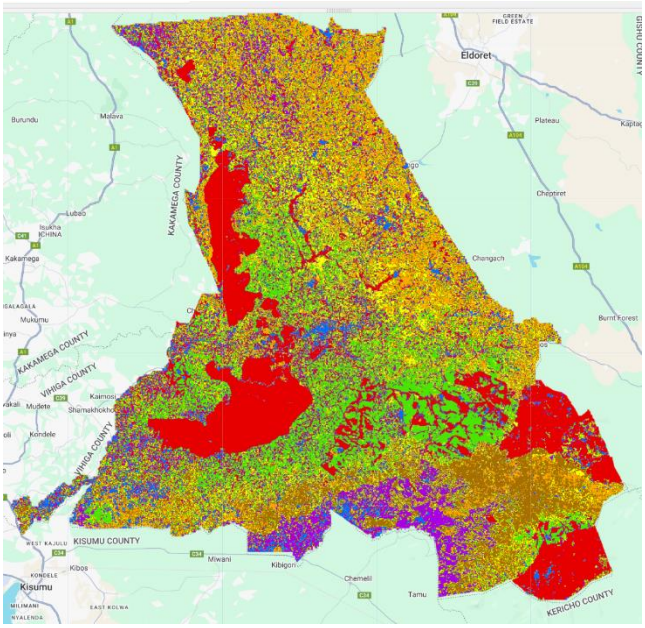
This project centers on in-season crop type mapping in Nandi County, Kenya, utilizing time-series Sentinel-2 imagery and supervised machine learning techniques. The objective is to produce accurate crop-type maps to support agricultural management activities such as yield estimation, acreage statistics, disaster damage assessment, and ecosystem evaluation. The approach leverages cloud-based computing, offering a customized and flexible solution that requires no prior knowledge of cloud infrastructure.

The study used a **Random Forest classifier** to process 15-day composite Sentinel-2 imagery spanning September 30, 2022, to September 30, 2023. The workflow included:



- **Ground Truth Data Collection**: 910 crop field polygons covering nine crop types (e.g., maize, coffee, tea, sugarcane) were surveyed. Data refinement addressed issues like mixed crop polygons and boundary errors to improve training sample quality.
- **Satellite Data and Preprocessing**: Sentinel-2 imagery with <30% cloud coverage was used, complemented by vegetation indices such as NDVI, NDMI, and MSI. ESA WorldCover 2021 data aided in identifying non-agricultural land covers like built-up areas and water bodies.
- **Classification**: The classifier trained with 819 samples achieved improved accuracy for major crops (e.g., tea and sugarcane) but faced challenges with fragmented fields and low acreage crops like legumes and vegetables. Category merging enhanced overall accuracy.
- **Validation and Smoothing**: A majority filter was applied to reduce noise, achieving reasonable classification performance.

Key Findings

- The mapping achieved high classification accuracy for tea, sugarcane, grassland, and trees (0.80-0.91). However, maize and coffee had lower accuracy (0.67-0.73) due to mixed pixels and fragmented fields.
- Temporal-spatial refinements and improved segmentation algorithms are recommended for further enhancement.
- The trained model was successfully applied to neighboring counties (Vihiga and Kisumu), demonstrating scalability.
- The output can be visualized at https://ee-zheguo.projects.earthengine.app/view/nandi-crop-types

Application example

- **Land-Use Changes analysis**: Significant reduction in tree cover (up to 20%) and an increase in cropland and urban areas were observed from 2000 to 2020. Urban expansion was highest in Kisumu, while Nandi exhibited a slight decrease in cropland area.
- **Carbon Stock Trends analysis**: Current estimates highlight the role of tea plantations in maintaining higher carbon stocks compared to annual crops like maize.
- **Scenario analysis**: A 20% expansion of tea plantations increases total carbon storage due to higher carbon sequestration potential. A 20% urban expansion results in decreased carbon stocks, particularly in Kisumu (-8.74%).