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Multi-sensor Mapping of Refugee Agricultural Land Cover/Land Use Change Hotspots in Uganda

Progress in Year 1

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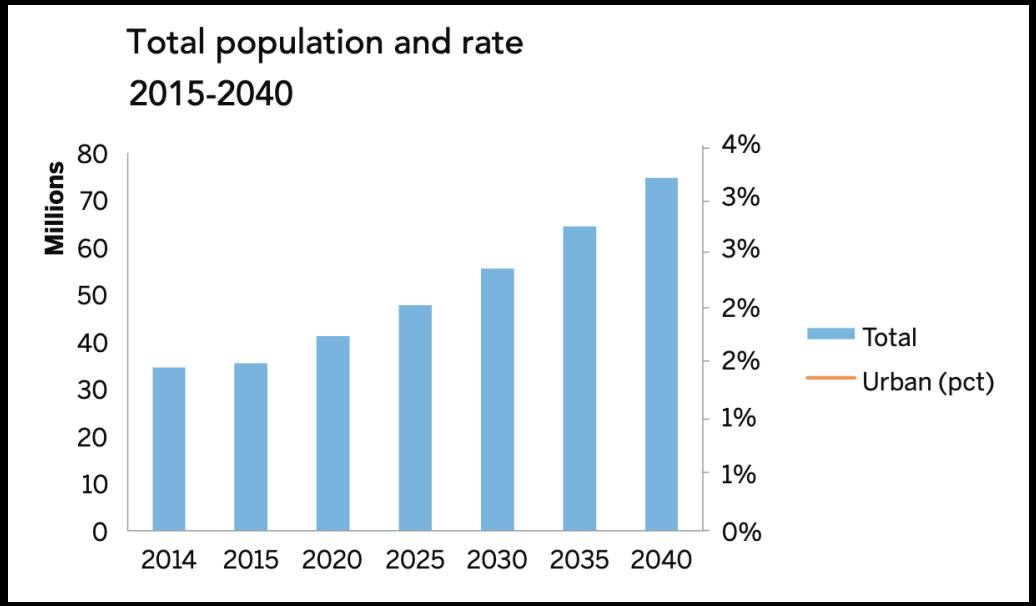
Ugandan cropland area grew more quickly than any other East African country since 1998

- 31,400 km^2 of new croplands at a 0.4% annual rate
- Agriculture in Uganda is predominantly smallholder and for subsistence farming
- Increasing household access to food is largely achieved through expanded cropland
- Long term changes in precipitation and temperature are reducing crop yield
- Future projected climate changes are expected to lead to more extreme events like droughts and floods, which will likely impact crop productivity

Photo Credit: World Potato Congress

Photo Credit: The New Humanitarian

United Nations Population Fund Brief, March 2017



- According to the World Bank, 42% of Ugandans were impoverished in 2019/2020
- Uganda produces more food than it consumes
- Yet poverty still limits people's access to nutritious food, especially in the north and east of the country

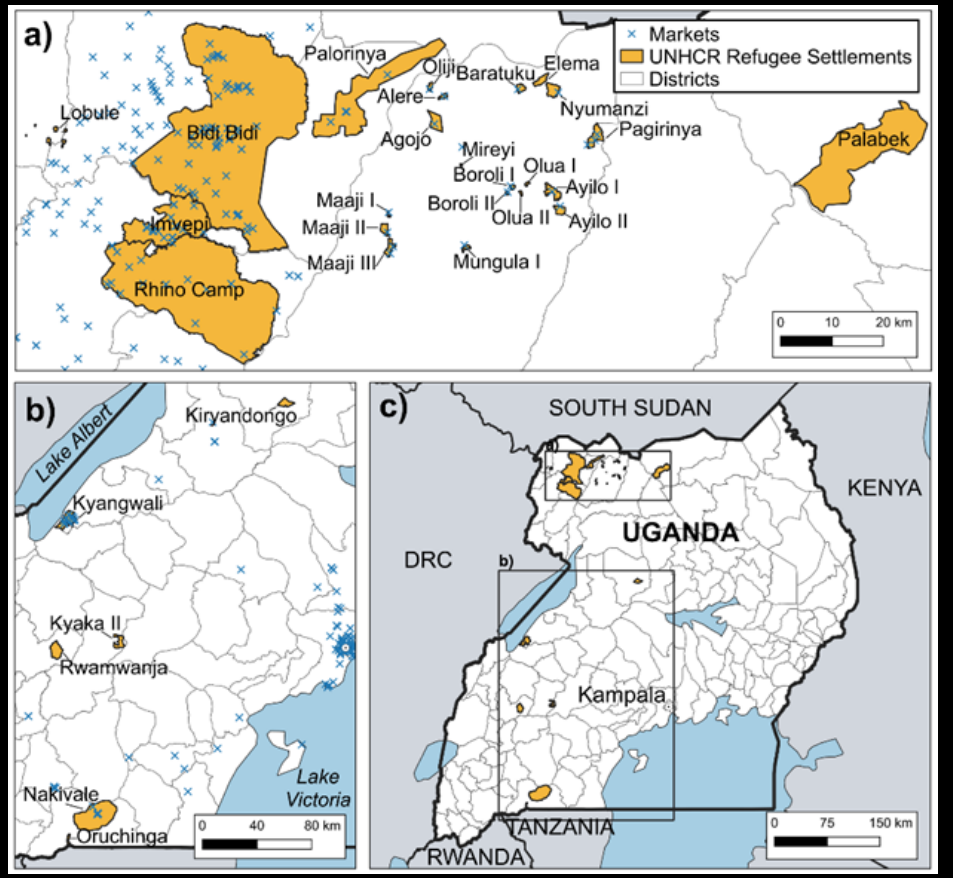
The World Bank in Uganda

Accelerated growth may reduce poverty from 41.7% in 2023 to 40.7% by 2025. But because households have limited adaptive capacity, the pace of poverty reduction will ultimately depend on how food access and affordability evolve, and on the incidence of weather and other environmental shocks.

Uganda hosts the largest refugee population in Africa with 1.6 million refugees

- **926,000** from South Sudan
- **508,000** from the Democratic Republic of the Congo (DRC)
- **52,000** from Somalia
- **44,000** from Eritrea
- **42,000** from Burundi
- **24,000** from Rwanda
- **16,000** from Sudan
- **10,000** from Ethiopia
- **1,300** from other countries

(UNHCR, 31 January 2024)



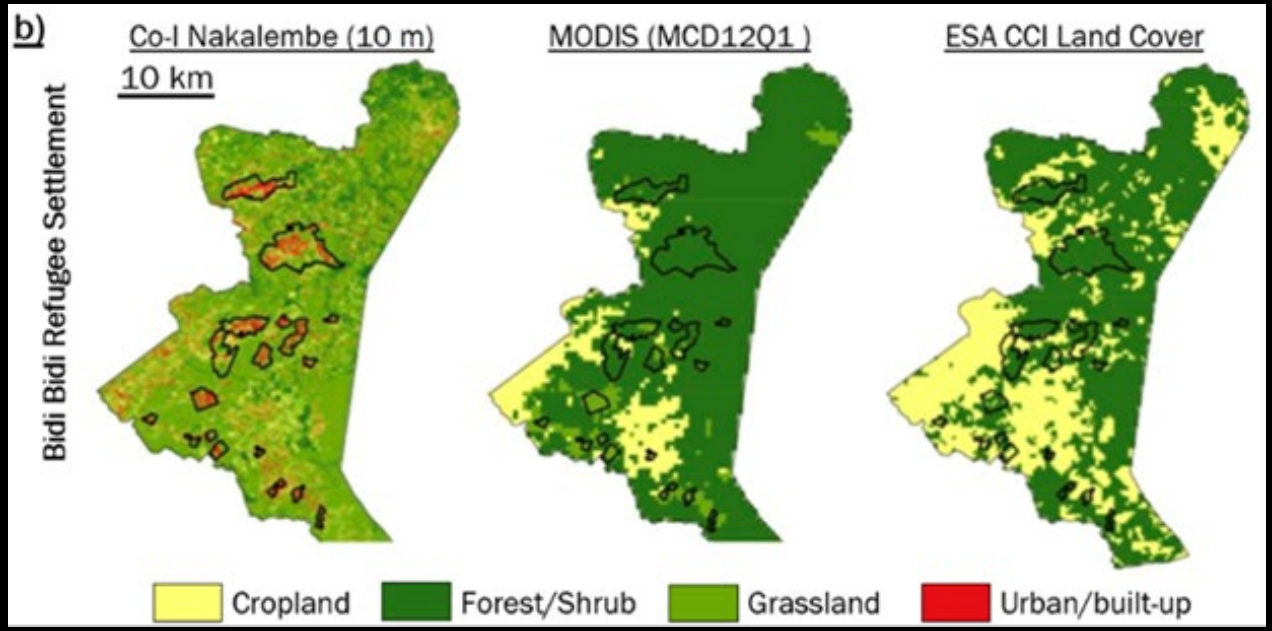
Study area map showing refugee settlement and market locations across 12 refugee-hosting districts in (a) Northern and (b) Western (c) Uganda

Ugandan refugees are provided with shelter and land for settlement and crop cultivation

- Refugee farming is central to Uganda's "self-reliance" approach to supporting food security and livelihoods
- Nearly 60% of Western and 70% Northern refugee households consume their entire production
- However, 35% of refugee households primarily rely on food aid to meet basic needs
- Food aid varies between settlements and is influenced by differences in market access and agricultural quality

Photo Credit: Dr. Catherine Nakalembe

Existing maps of cropland in refugee-hosting regions of Uganda tell different stories of abundance and change



Comparison of land cover products at Bidi Bidi refugee settlements.

Note the marked differences in cropland extent across these maps.

This project examines the effects of the arrival of >1 million refugees to Uganda since 2015 on regional cropland dynamics

- What is the extent of cropland in refugee-managed lands, and how have broader cropland hotspots evolved with refugee arrivals over the last decade?
- How have refugee and host (non-refugee) farming practices adapted to changes in socioeconomic and environmental factors?
- What is the relationship between refugee production and regional market dynamics? Between refugee self-sufficiency and external aid?

Photo Credit: The Gender Policy Report

We have three objectives

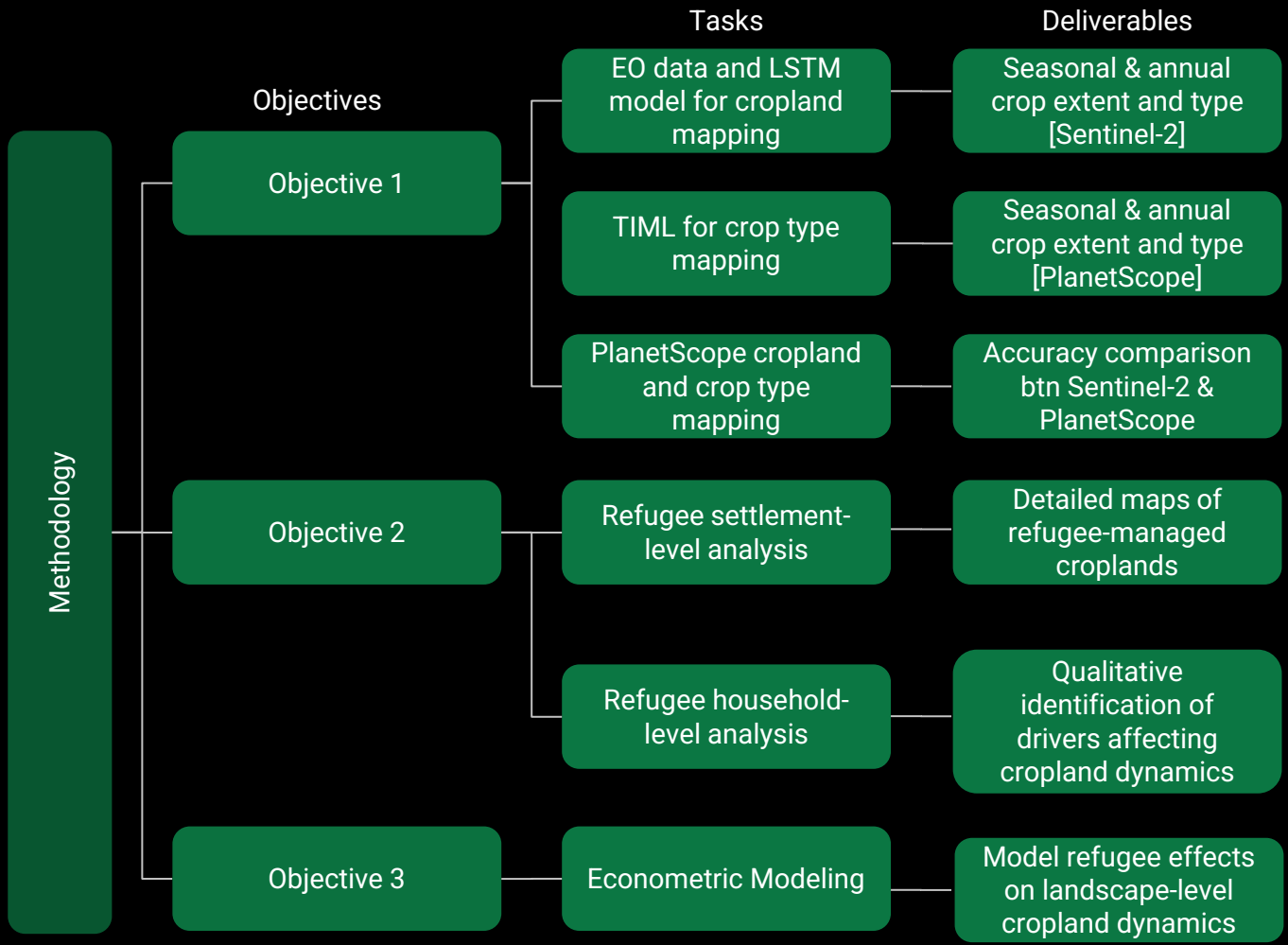
Map changes in crop area and type in refugee-hosting districts

Multi-sensor satellite time series analysis and transfer learning

Relate cropland dynamics to specific refugee settlements and households

Identify drivers of cropland dynamics through interviews and participatory mapping

Model and estimate causal effect of refugee population and food aid on cropland dynamics


Methodology
Objectives
Tasks
Deliverables
Objective 1
EO data and LSTM model for cropland mapping
Seasonal & annual crop extent and type [Sentinel-2]
TIML for crop type mapping
Seasonal & annual crop extent and type [PlanetScope]
PlanetScope cropland and crop type mapping
Accuracy comparison btn Sentinel-2 & PlanetScope
Objective 2
Refugee settlement-level analysis
Detailed maps of refugee-managed croplands
Refugee household-level analysis
Qualitative identification of drivers affecting cropland dynamics
Objective 3
Econometric Modeling
Model refugee effects on landscape-level cropland dynamics

In our first year, we had two main tasks:

- Evaluate accuracy of existing cropland maps in refugee-hosting regions
- Make initial cropland classification in refugee-hosting regions

2019 GLAD cropland dataset mask

MODIS NDVI
(5-year median composite within growing season)

↓

Arithmetic mean

↓

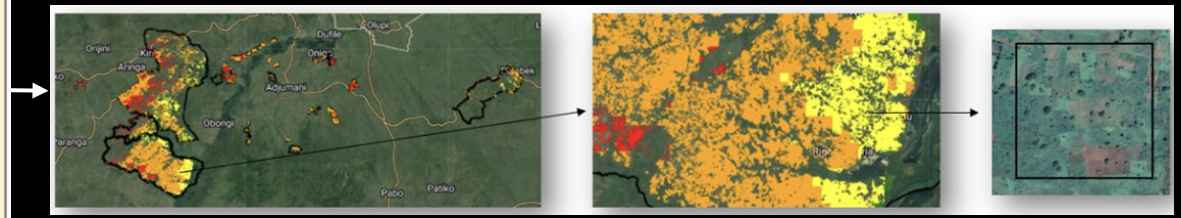
Threshold strata

↓

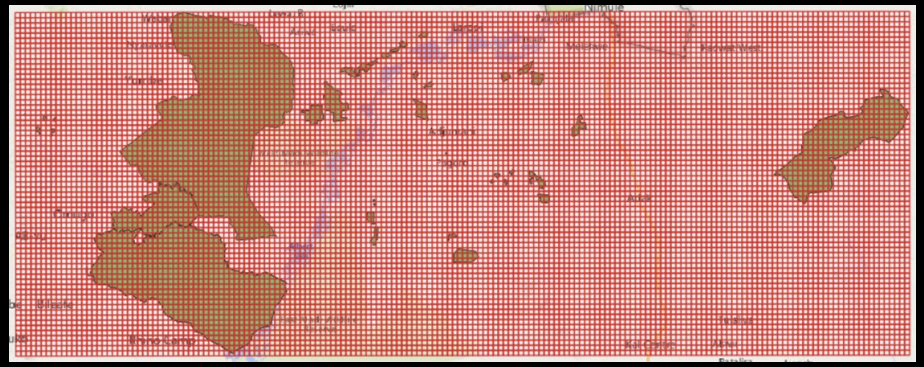
1km x 1km
(Within cropland and contained > 30% cropland)

Our sampling framework focused on 2 objectives:

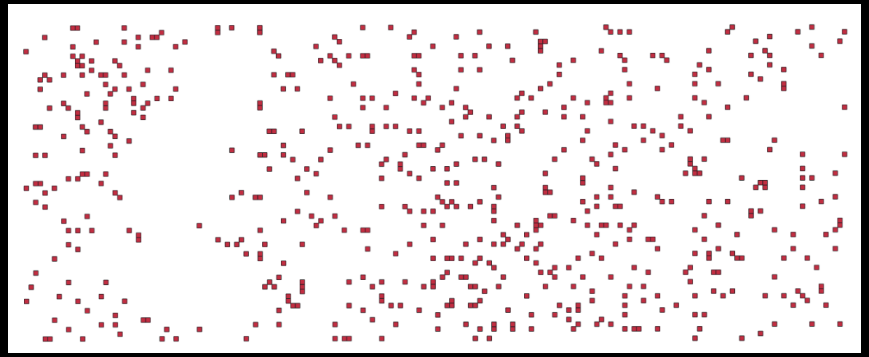
- Accurately capture distribution of cropland phenology
- Optimize the efficiency of field campaign process



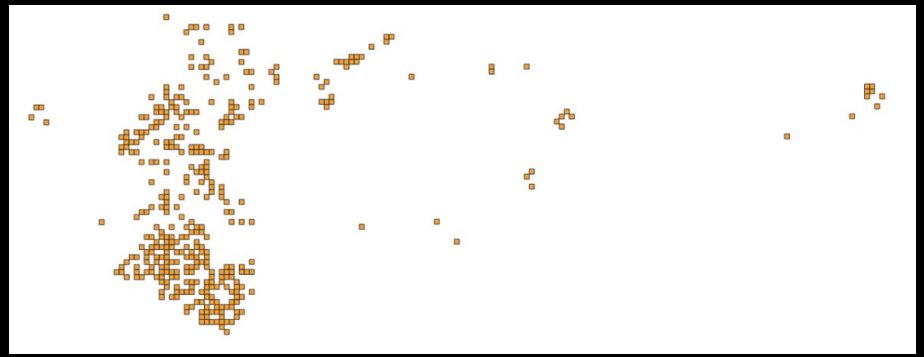
We identified grid cells that likely have cropland within and outside of refugee settlements



1km by 1km grids across study area



1km grid cells outside refugee settlements with > 30% cropland



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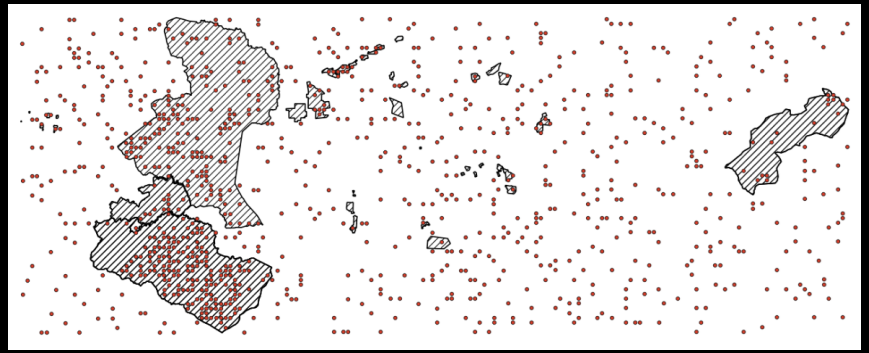


Spatial distribution of centroids for each block (1000 pts)

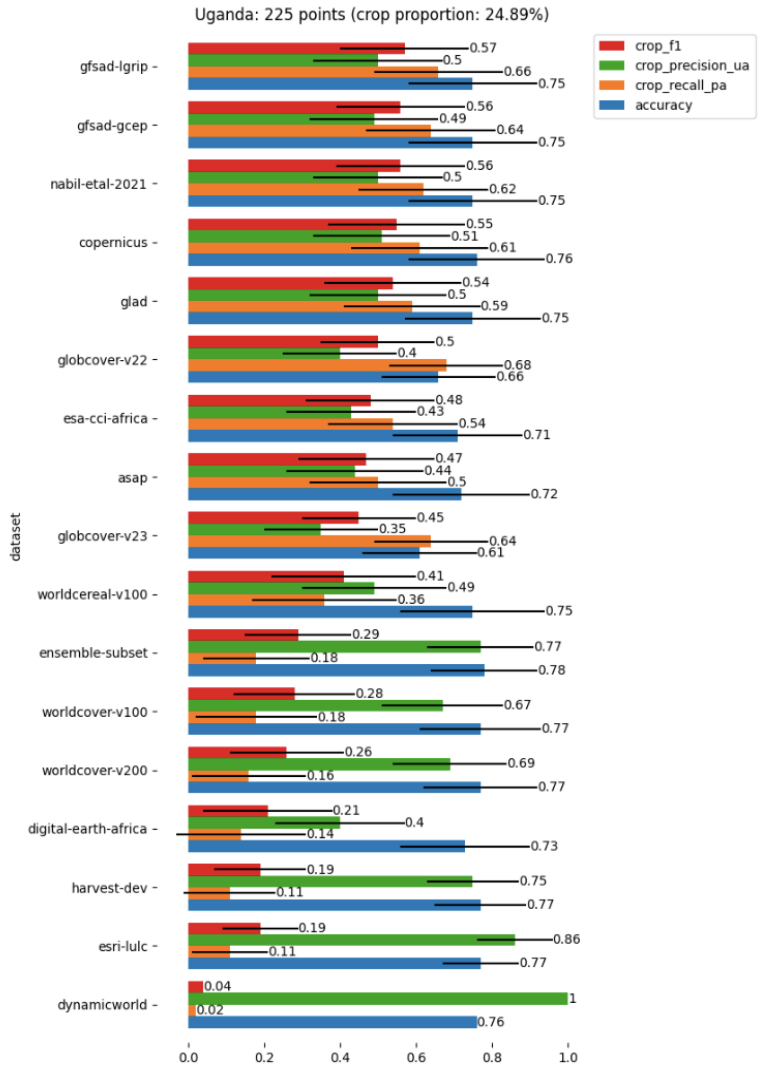
Collect Earth Online for labeling sampled data as crop and non-crop

This platform provides access to high-res time series satellite data including MapBox, PlanetScope, & Sentinel-2

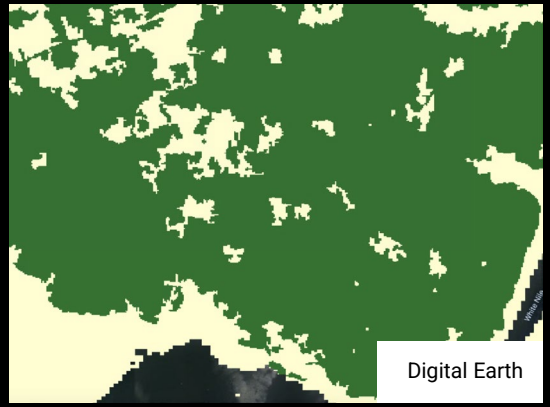
Intercomparison Analysis for Uganda North (2022)

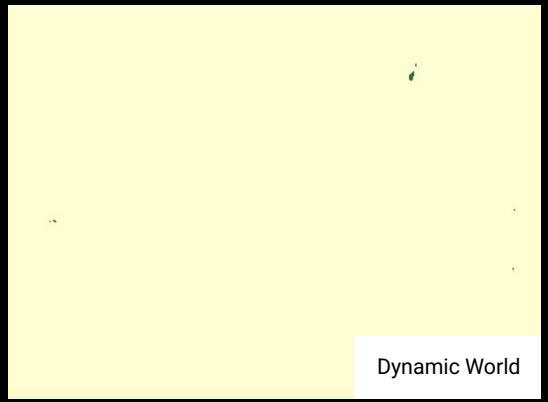
- This was done to evaluate the accuracy of existing cropland maps for the study site
- Superimposed labeled datasets on the various croplands maps & computed the F1-score, recall, precision & accuracy for each land cover product
- Analysis revealed that the F1-score for each of the existing cropland maps was < 0.7
- This indicated the need to generate high-resolution and accurate cropland maps

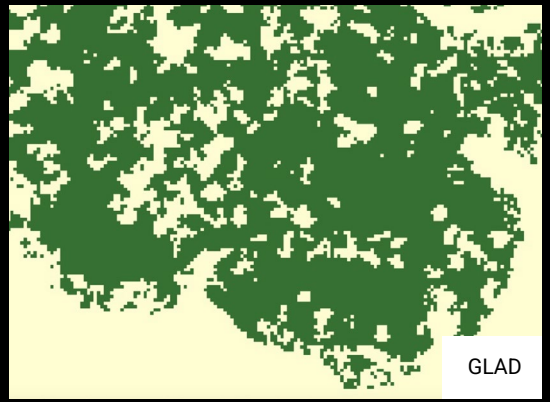
QR code to paper!

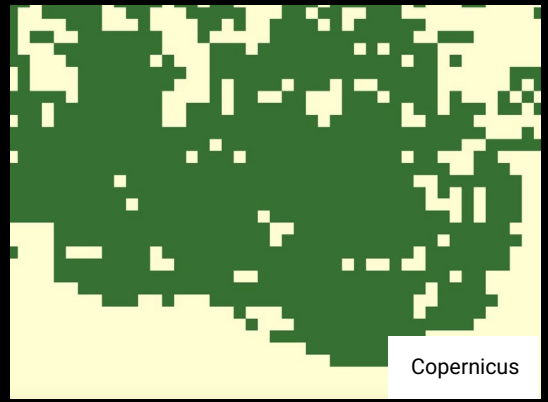


Pre-existing Land Cover products used in the Intercomparison analysis







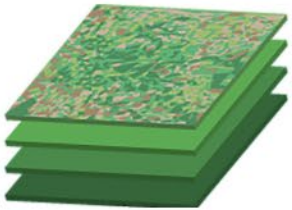


Crop

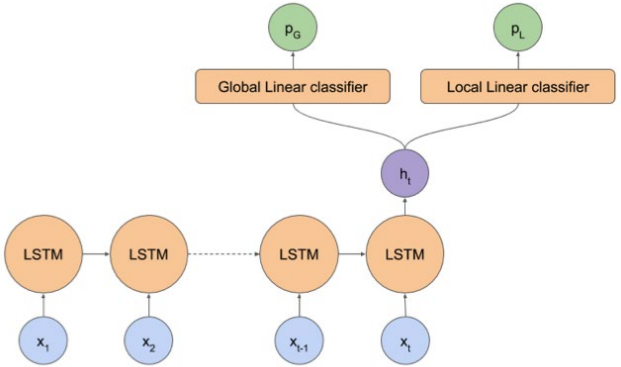
Non crop

Model Training

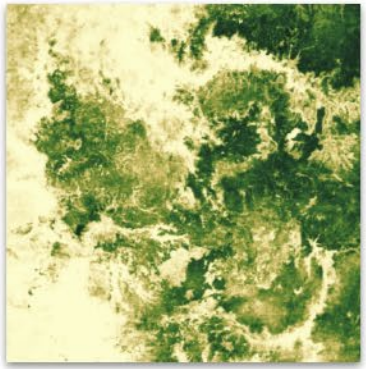
QR code to paper!



Satellite Time Series Data



Deep Learning Model



Predicted Cropland Map

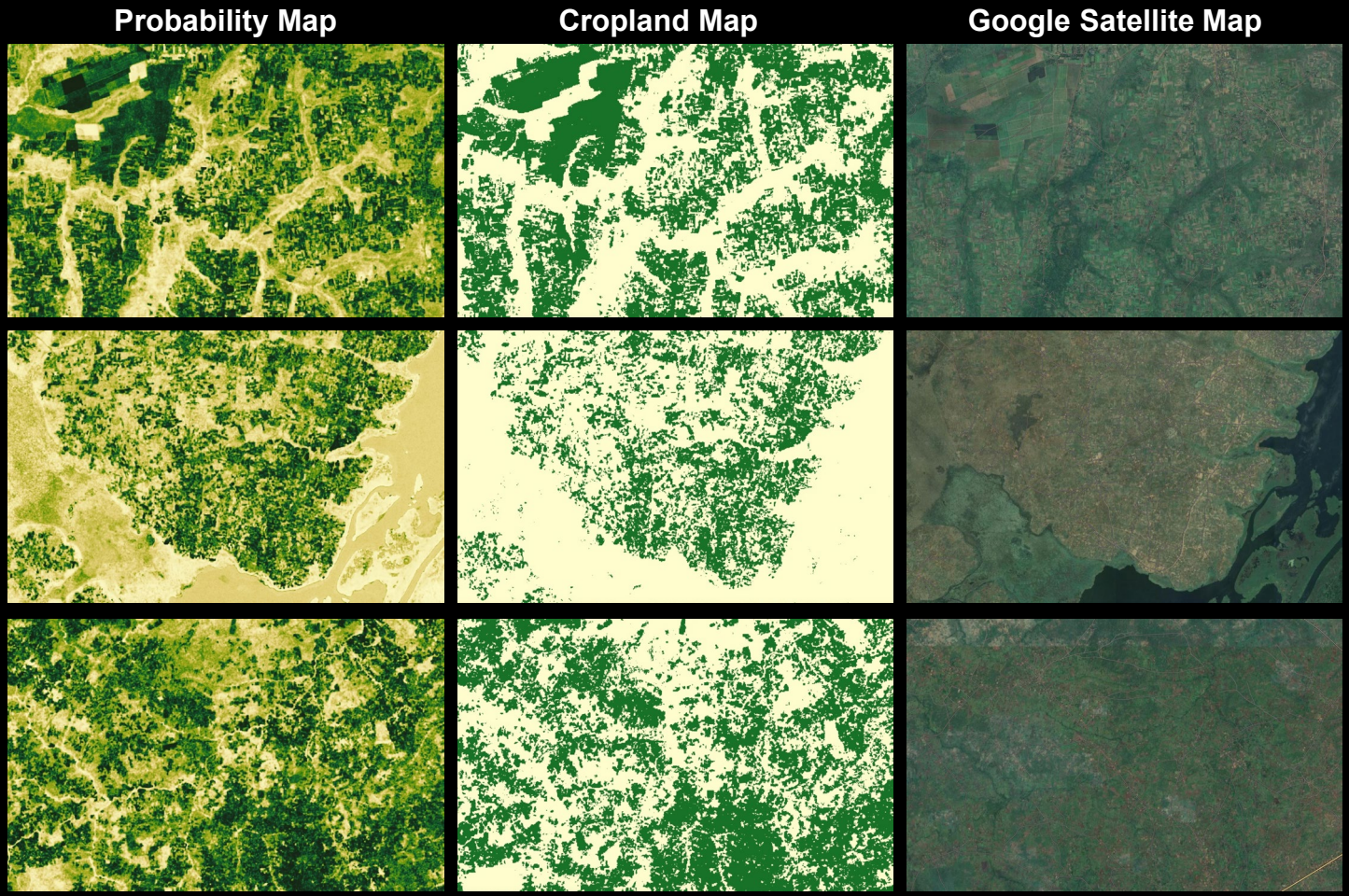
Feb 22 - Feb 23 Time Series

Sentinel-2

Sentinel-1

SRTM

Long Short-Term Memory (LSTM) Model



LSTM metrics

Accuracy: 0.80

F1 score: 0.64

Recall: 0.73

Precision: 0.86

Good results for a **heterogenous** and **complex** landscape. However, there is the need to collect **more training** data to improve the **performance** of the model

Our plans for Year 2

- Collect field data on crop presence and type across refugee hosting regions in northern Uganda (May 2024)
- Finalize classification of refugee cropland maps using LSTM deep learning approach (Summer 2024)
- Detect individual plots in refugee-hosting regions using very-high resolution imagery and quantify change in count and area since 2015 (Summer 2024)
- Connect cropland dynamics to specific refugee households/settlements through participatory mapping (Fall 2024)

Thank you! Any questions?

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