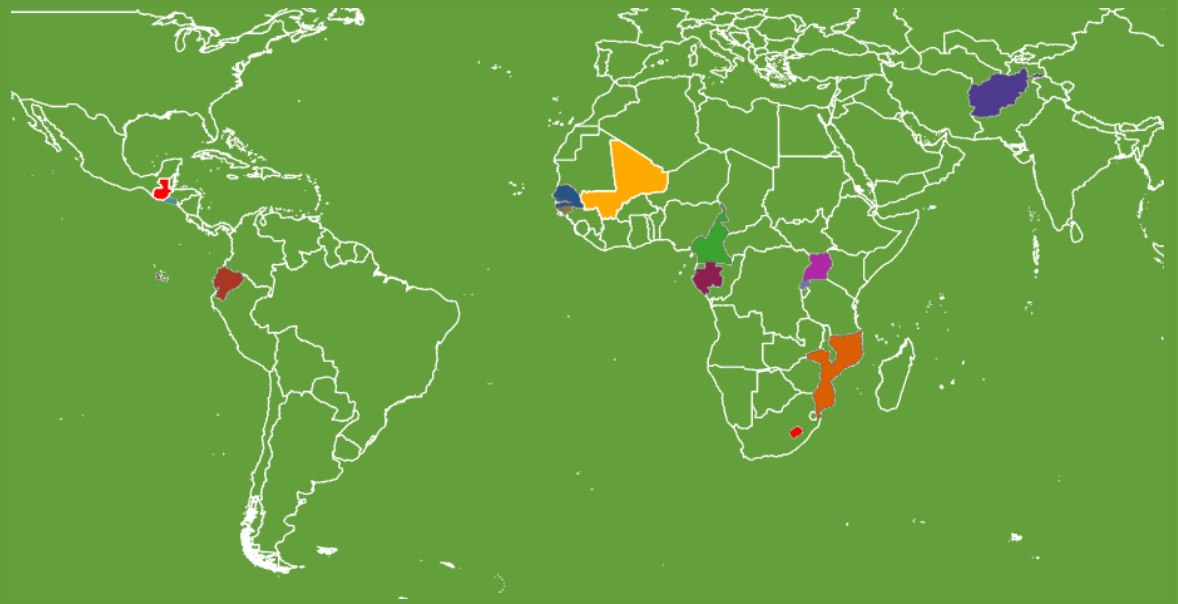
Food and Agriculture Organization of the United Nations

UNSC UN-CEAG Side Event
02/16/2023

EOSTAT

TRUSTED METHODS FOR THE USE OF EO DATA FOR CROP TYPE MAPPING AND CROP YIELD FORECASTING



EO-STAT

PROBLEM, OBJECTIVE, AND APPROACH

Problem: Collecting and predicating real time crop location and yield is difficult and expensive.

Support countries' capacity to consistently collect agricultural statistics through integrated earth observation data, physical modeling, and ground truth data collection.

Objective

Provide a third-party tool, publicly hosted for sustainable utility with pilot in-country collaboration and capacity building.

Approach

MAIN CHALLENGES IN CROP MAPPING AND YIELD ESTIMATION

- **Crop type mapping**

  - Limited availability of in-situ data of adequate quality in countries
  - High dependency of supervised classification methods on large amounts of in-situ data of adequate quality, while this resource is rare to find in countries
  - Low transferability of training data and models to different agricultural epochs and to different countries
  - High cloud coverage in specific climatic zones which impair the use of optical satellite data

- **Crop yield forecasting and Mapping**.

  - Traditional methods of yield estimation depend on crop cutting but they lack rigorous and standardized protocols for harmonized data collection. Yield forecasts based on limited number of crop cutting remains **highly uncertain due to the large spatial variability of samples**.

  - EO models based on regressions of crop yields on vegetation indexes derived from Satellite images have low accuracy

OBJECTIVE OF EOSTAT PROJECT

EO-STAT

Main Objective is to ssupport countries' capacity to consistently collect agricultural statistics through integrated earth observation data, physical modeling, and ground truth data collection

- Use of well tested method (Sen2Agri and Sen4Stat) which rely on Random Forest supervised classifier for crop mapping in countries where in-situ data is available with sufficient quality and quantity.

- Development and testing of data frugal algorithms (e.g. Dynamic Time Warping)

- Development of methods for the transferability of in-situ data based on establishment of augmented pheno spectral libraries

- Integration of physical based crop model (SALUS) with Earth Observations

- Deliver support in survey design using EO data to improve cost efficiency (less data to collect, but better distributed)

METHODOLOGICAL DEVELOPMENT

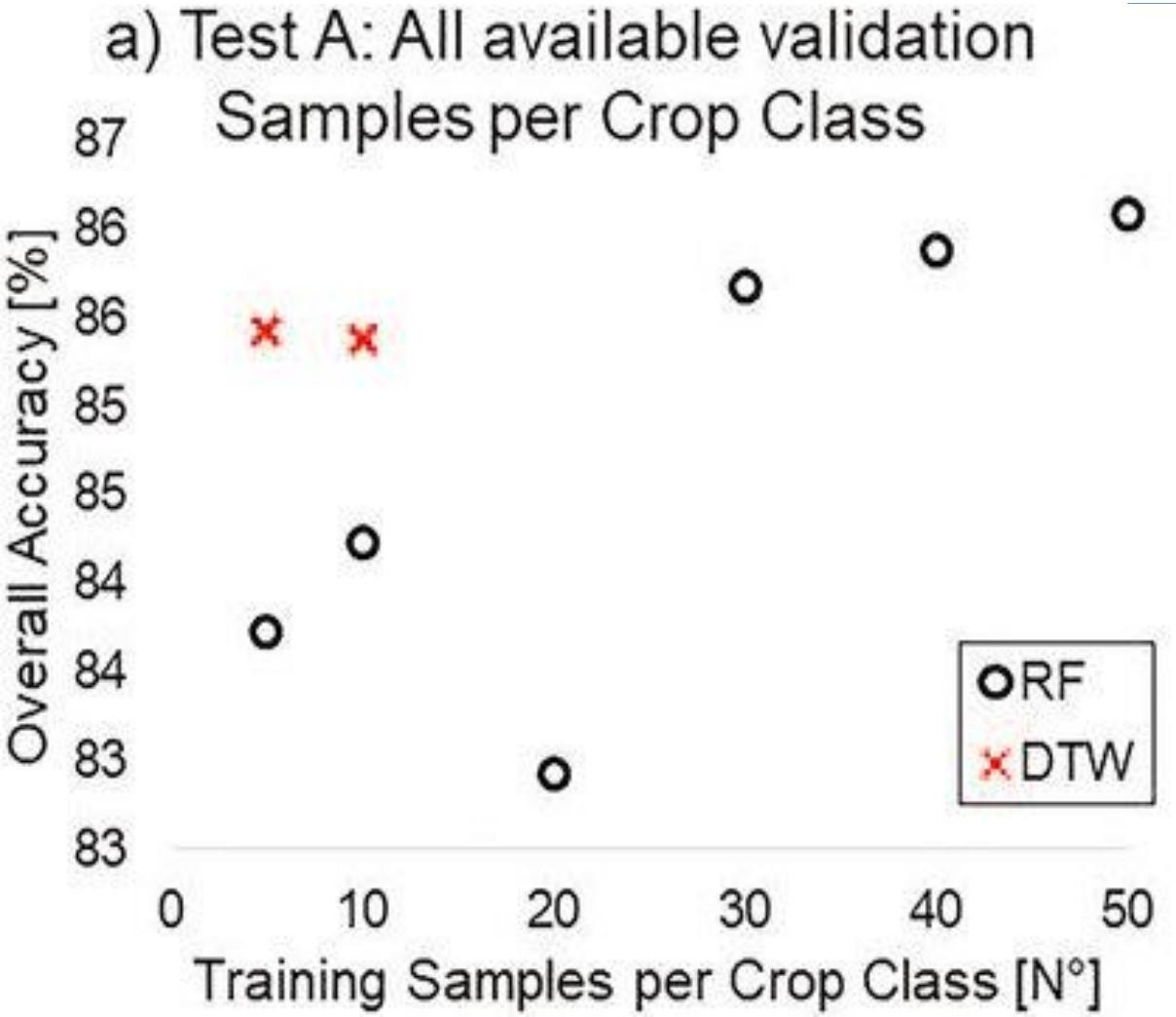
METHODOLOGICAL DEVELOPMENT

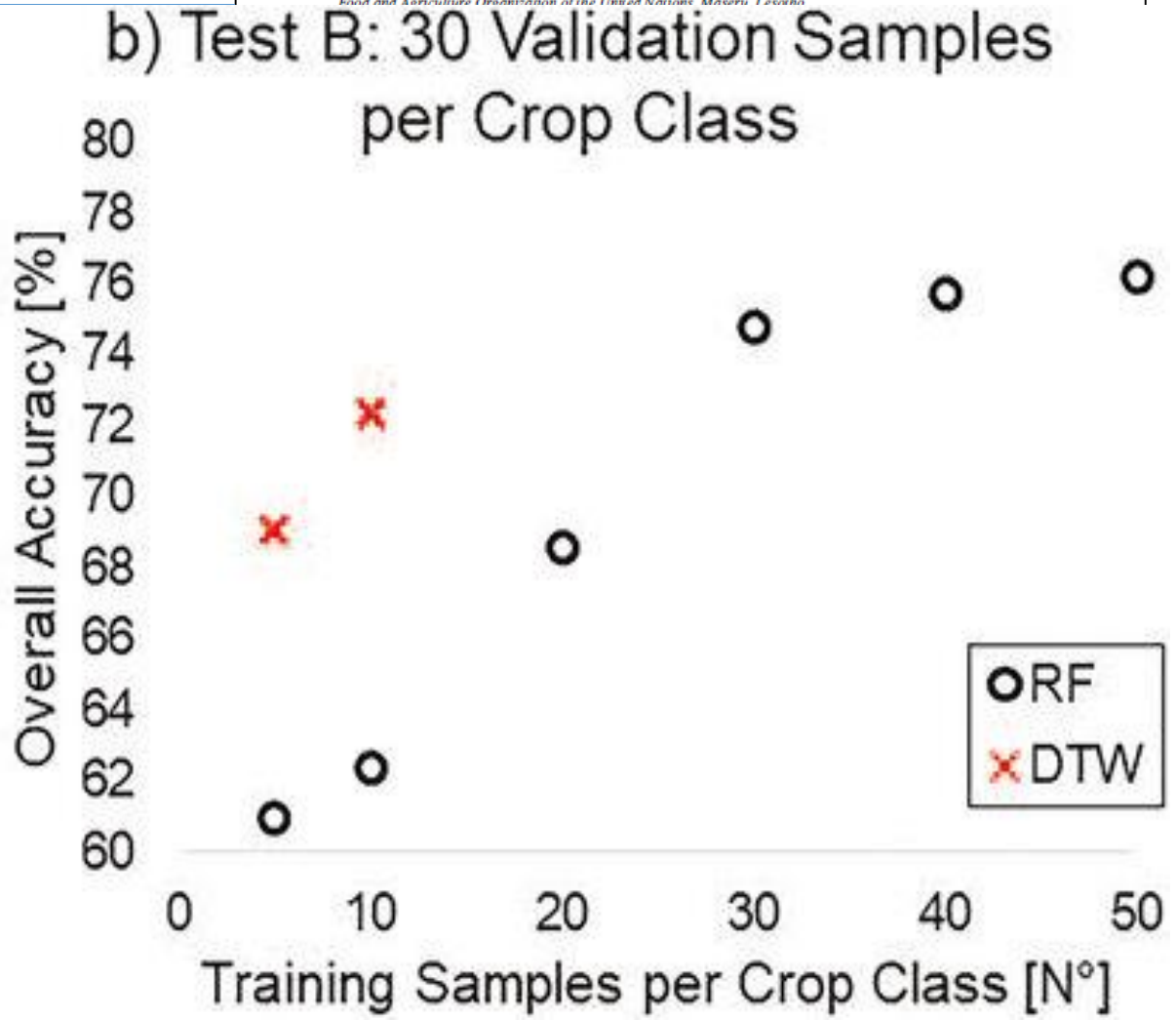
Comparative analysis of performance of Random Forest vs Dynamic Time Warping in the context of scarcity of in-situ data

Statistical Journal of the IAOS 38 (2022) 1009–1019
DOI 10.3233/SJI-220054
IOS Press

Earth observations for official crop statistics in the context of scarcity of in-situ data

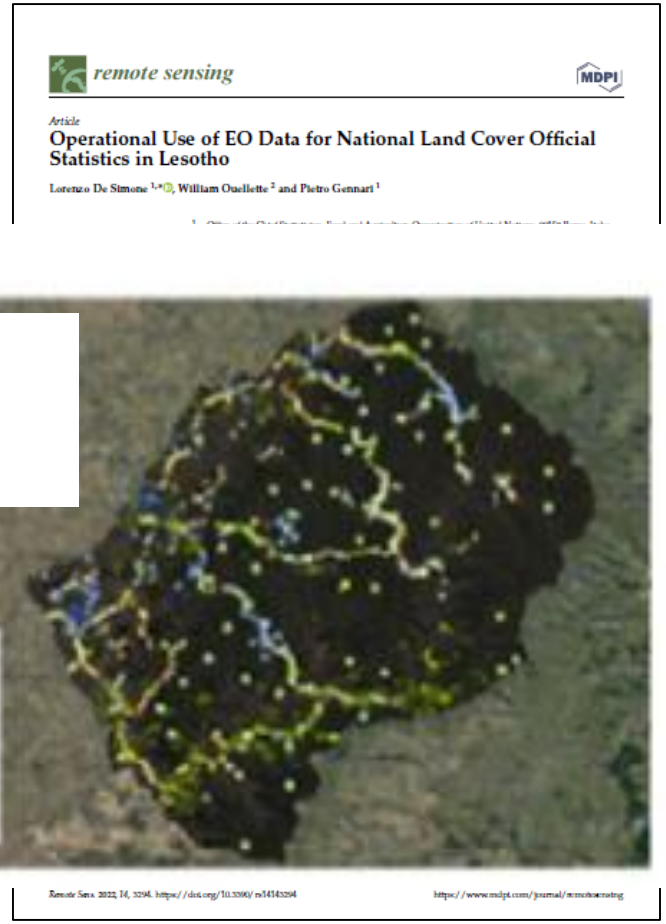
Lorenzo De Simone* and Pietro Gennari
Food and Agriculture Organization of the United Nations, Maseru, Lesotho

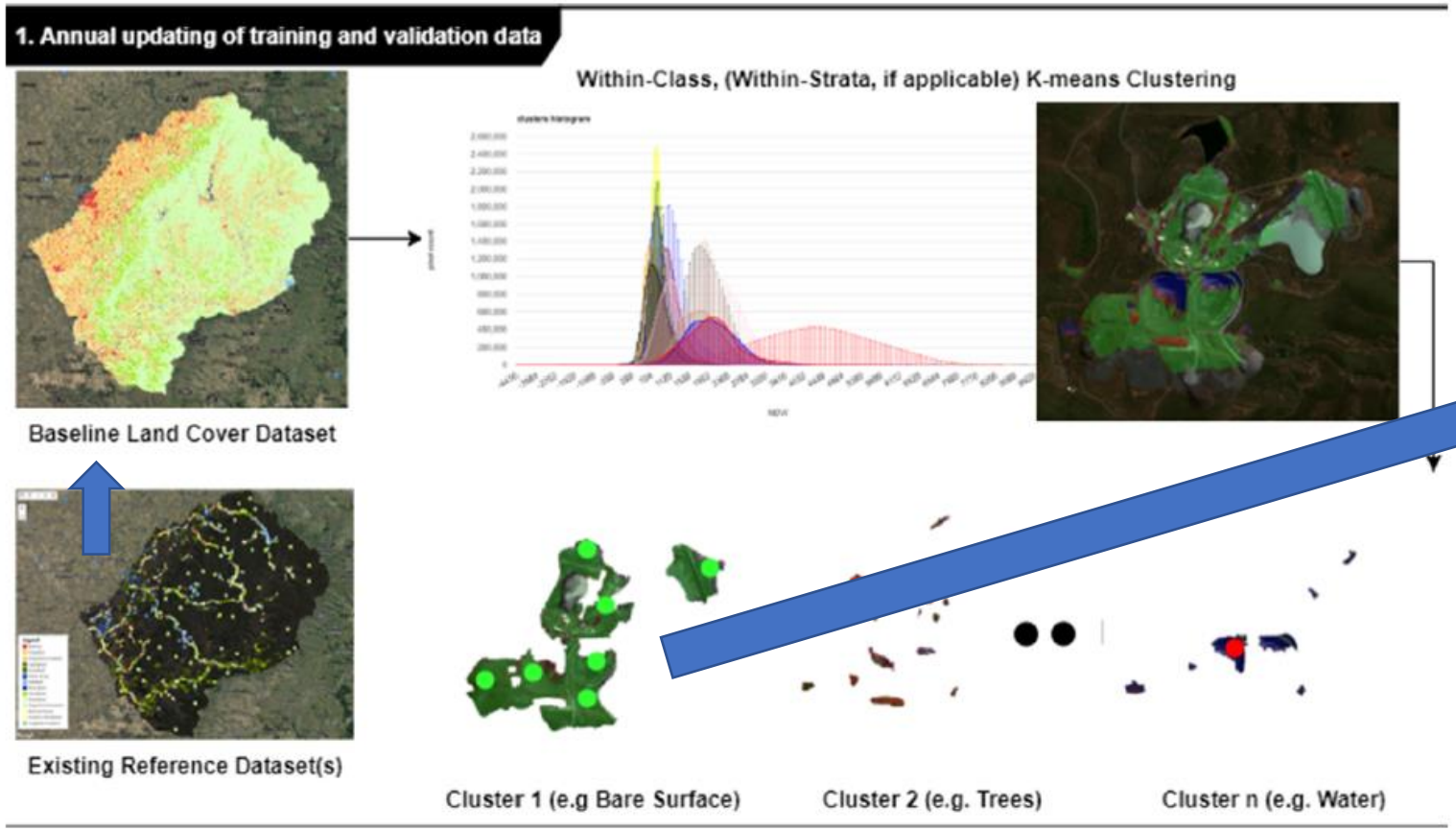




METHODOLOGICAL DEVELOPMENT

Curation of in situ data for reuse in different epochs





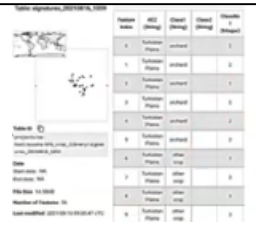
Updated In-situ dataset

TOOL DEVELOPMENT
EOSTAT CROP MAPPER

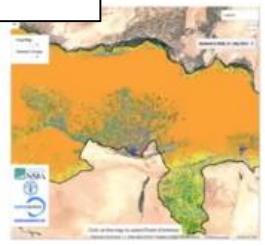
TOOLS DEVELOPMENT

Crop Mapper Tool

GEE JavaScript API



Administrator tool



Front end crop map

In-country Statistical service data collection and validation

USER INPUT

Select a Library

signatures_20220211_1518

Select an Agro-ecological Zone

Turkistan Plains

Select a Sub-Region (optional)

-

Select the Season and a Year

Summer Harvest | 2021

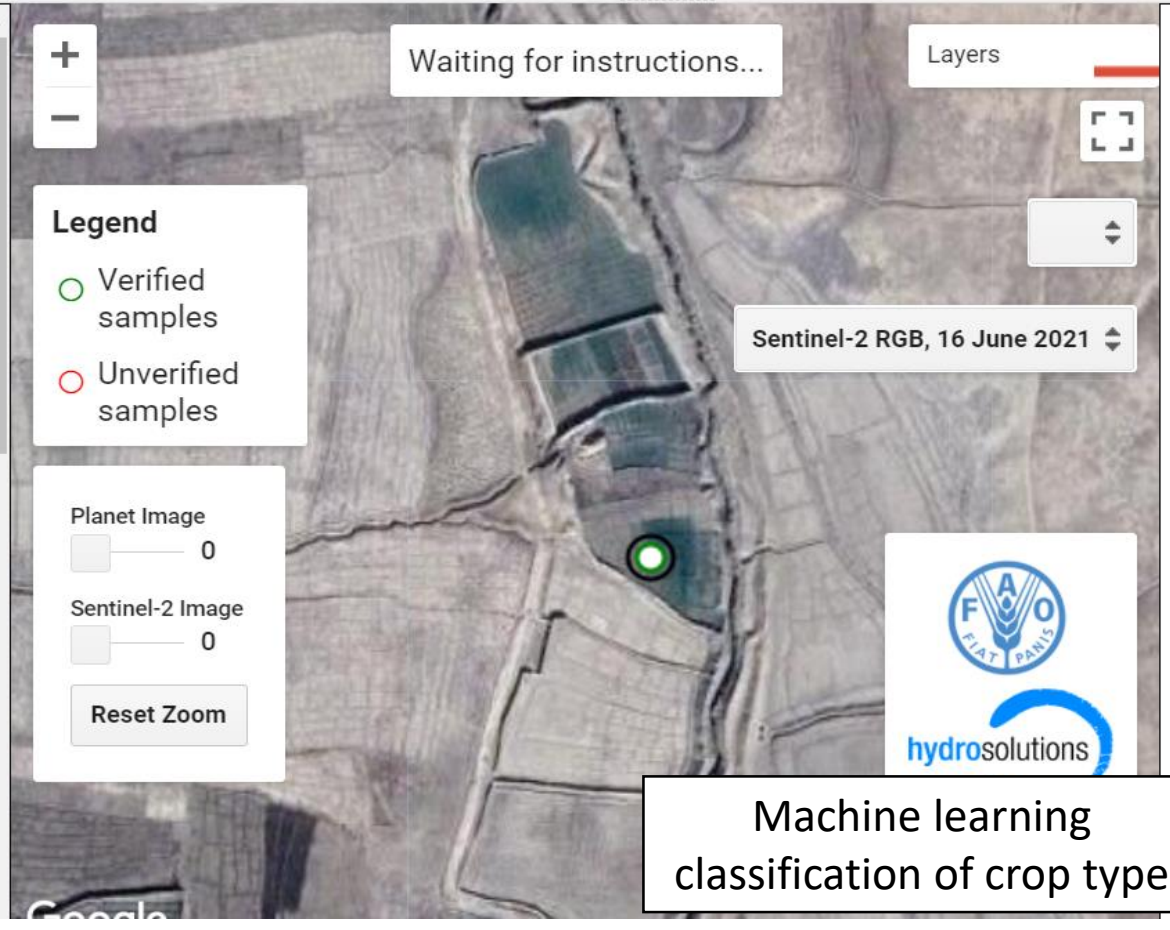
Select the main harvest month

June

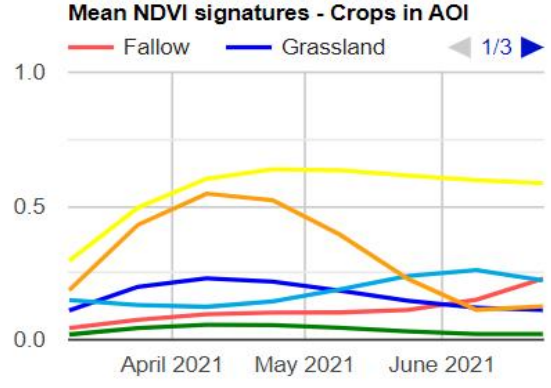
Search for samples

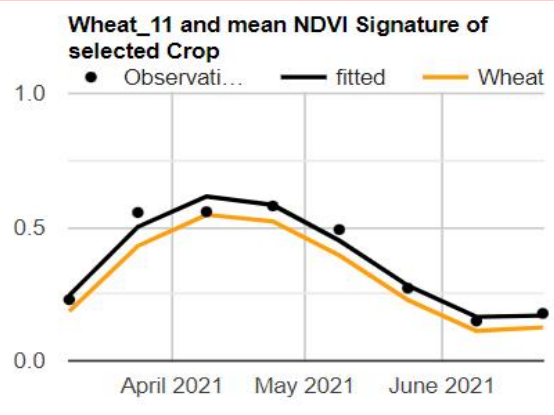
Select an existing sample or add a new point

Wheat_11 | ADD NEW SAMPLE



Machine learning classification of crop type



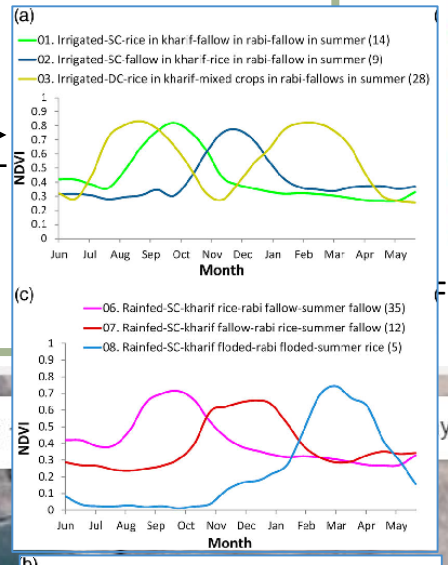


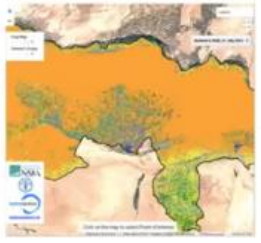
Crop Mapper Tool

GEE JavaScript API

Crop library

Administrator tool





Front end crop map

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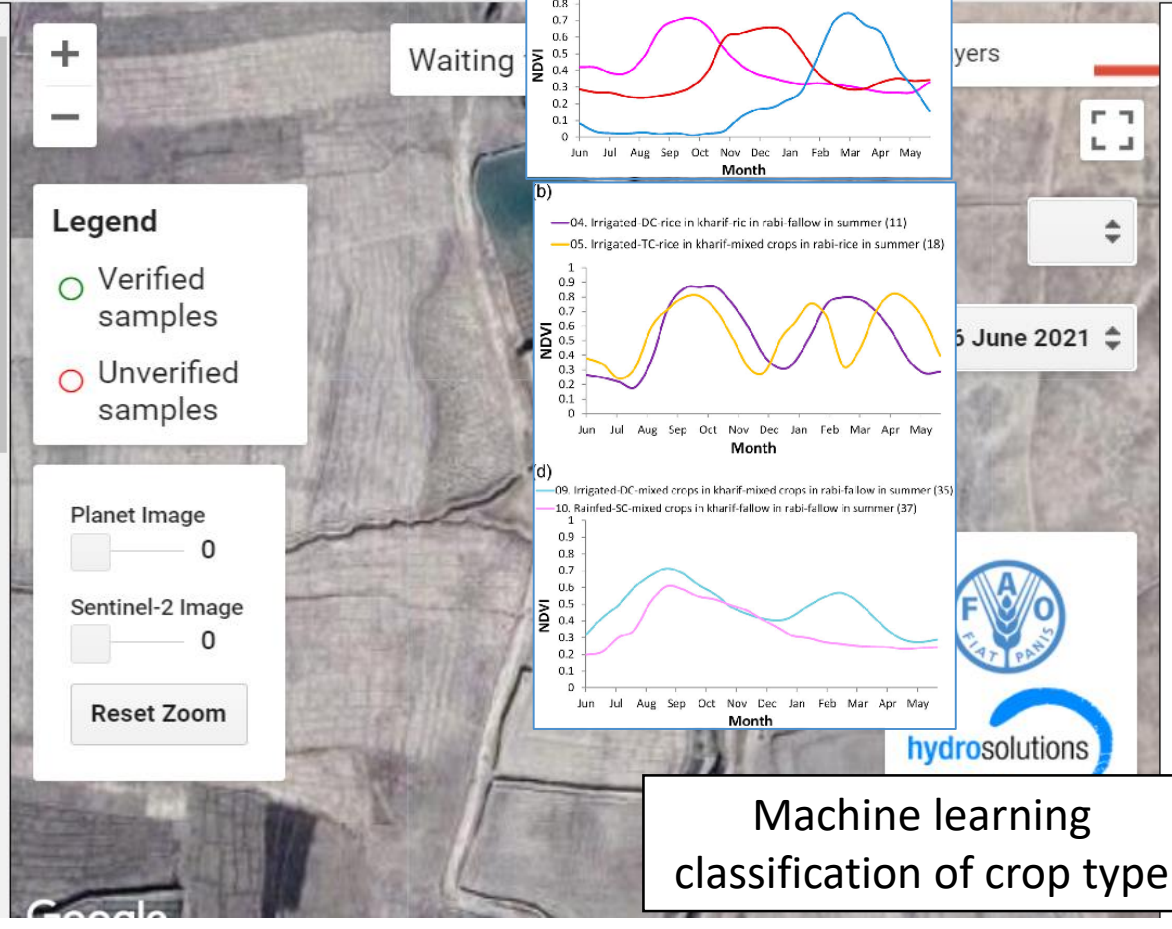

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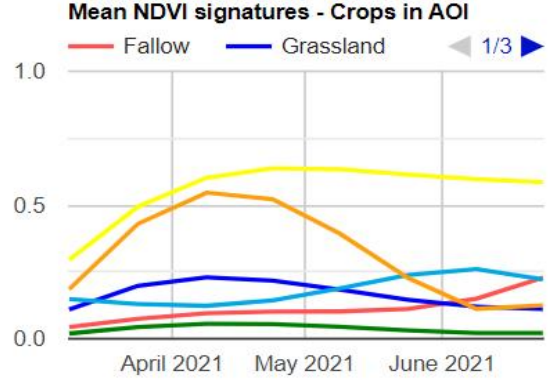
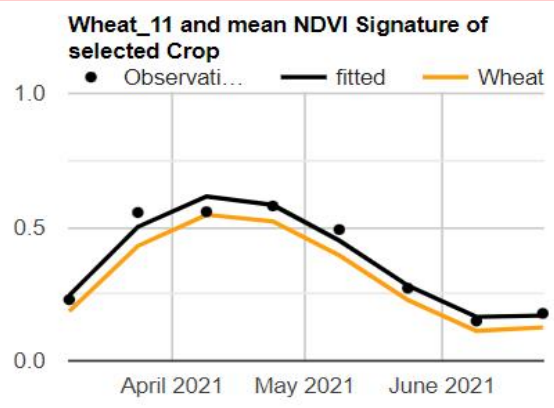
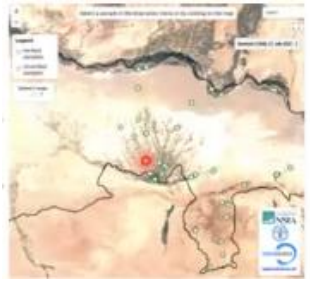




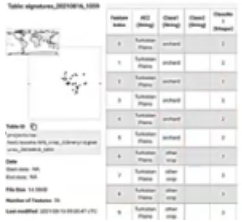
Crop Mapper Tool

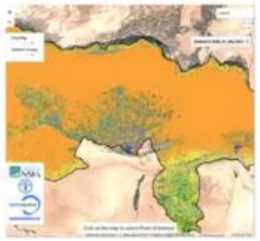
GEE JavaScript API



Administrator tool

Crop library





Front end crop map

In-country Statistical service data collection and validation

Sentinel-1 & Sentinel-2

Select a method

DTW

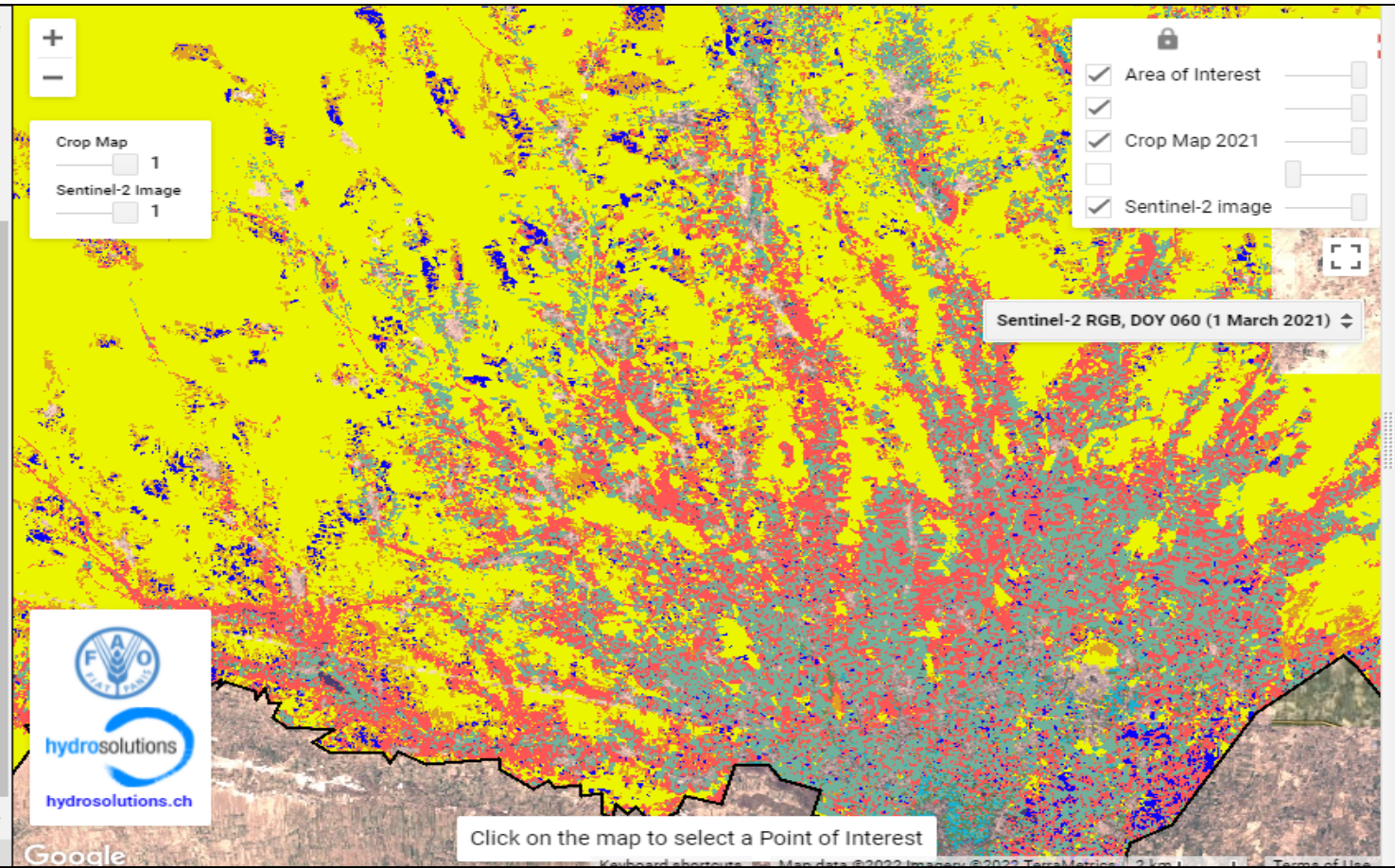
Submit

CROP MAP

Set label to <REMOVE> to remove a Class from the map. Classes with the same label will be merged.

Class 1	Wheat
Class 2	Other crop
Class 4	Non-crop
Class 5	Orchard
Class 6	Grassland
Class 10	Rice
Class 11	Potatoes
Class 16	Fodder_crop
Class 22	Cotton
Class 26	Wetland

Submit



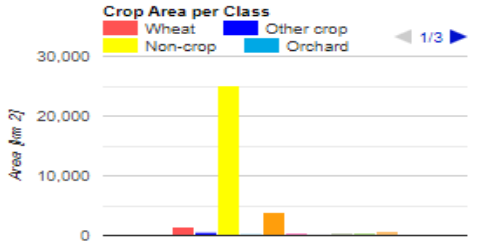
OUTPUTS

Total Area in sq. km: 34454.45

Total Cropped Area in sq. km: 33070.56

Open Crop Map Download Panel

Open Validation Panel

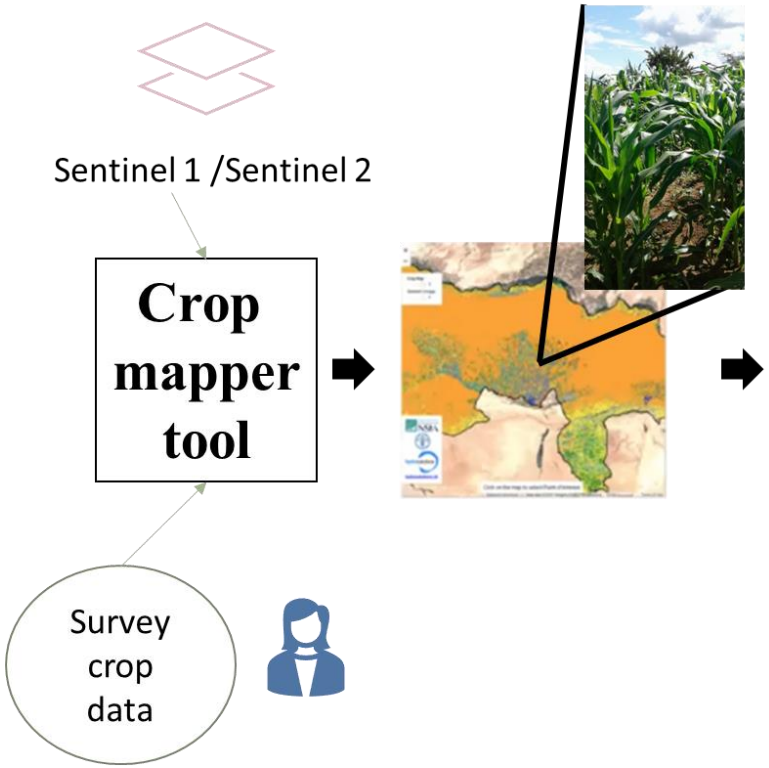


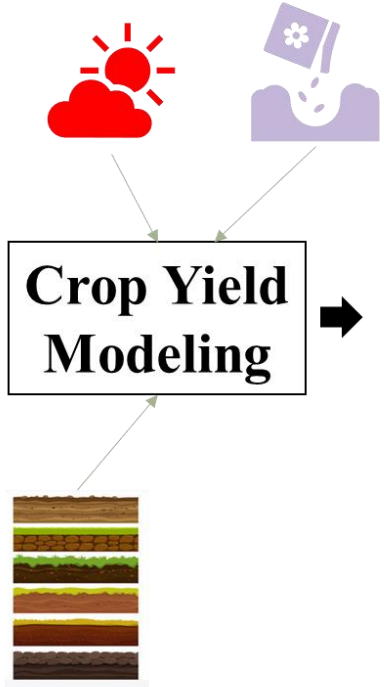
Class ID	Crop Type	Area (km2)	Area (%)
1	Wheat	1,367.464	4.135
2	Other crop	563.397	1.704
4	Non-crop	25,189.705	76.17
5	Orchard	179.722	0.543
6	Grassland	3,890.7	11.765
10	Rice	410.287	1.241
11	Potatoes	91.696	0.277
16	Fodder_crop	230.664	0.697

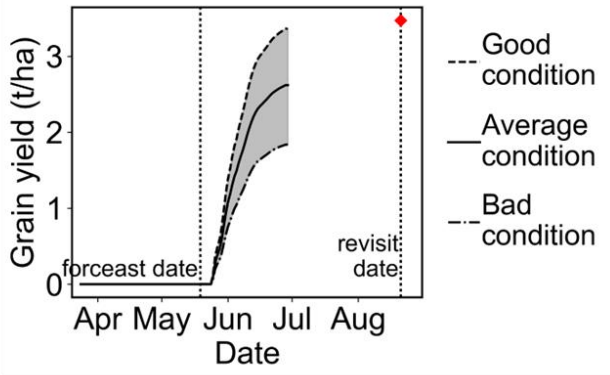
EOSTAT CROP MAPPER INTEGRATION WITH CROP PHYSICAL GROWTH MODEL

INTEGRATION OF EO DATA AND PROCESS-BASED CROP GROWTH MODELLING

Production of spatially explicit crop acreage and crop yield statistics







Total production by crop

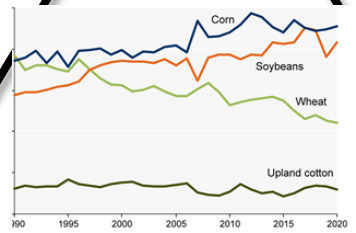
Innovation

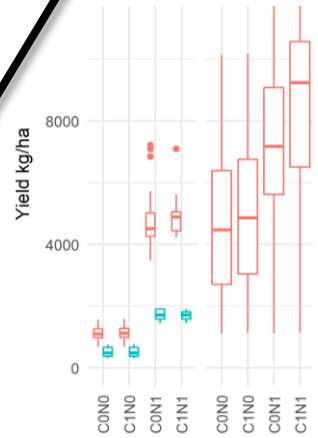
INTEGRATION OF EO DATA WITH SALUS
(SYSTEM APPROACH TO LAND USE SUSTAINABILITY)

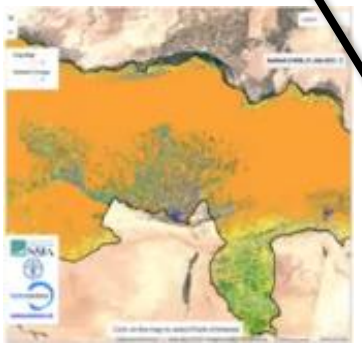
Accurate Yield Information Cycle

MICHIGAN STATE UNIVERSITY

Yield History







EO-STAT

Crop Modeling

Real time Crop mapper

Yield Predictor Tool

In-country Statistical service data collection and validation

Crop type and location

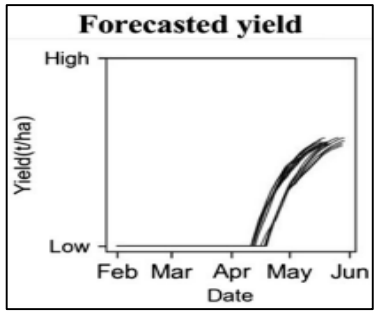
In-country Data

Remote sensing soil and climate data

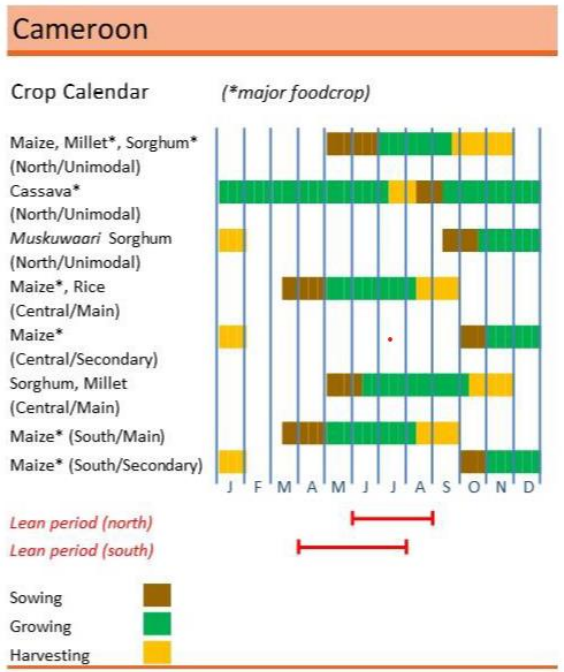
Season weather condition

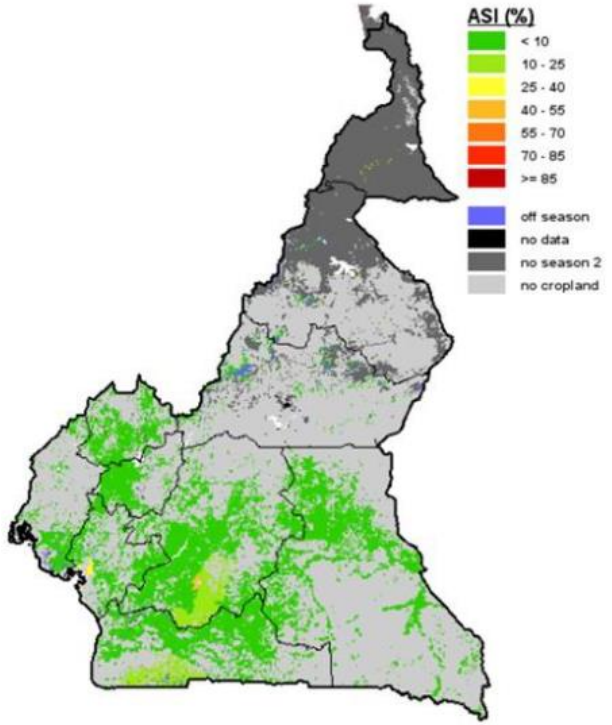
SALUS

Forecasted yield



Real-time Yield Prediction





Local management and crop stress data

Innovation

Yield Predictor Tool

Real-time weather conditions during the season can be evaluated

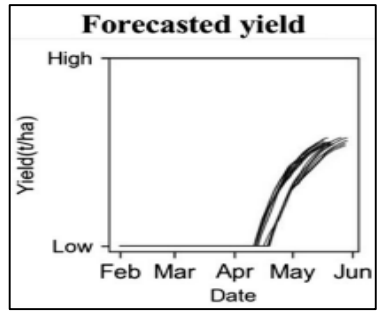
Crop type and location

In-country Data

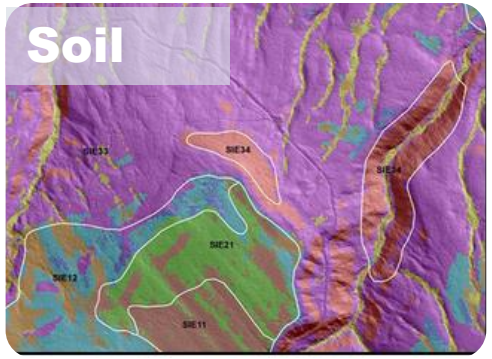
Remote sensing soil and climate data

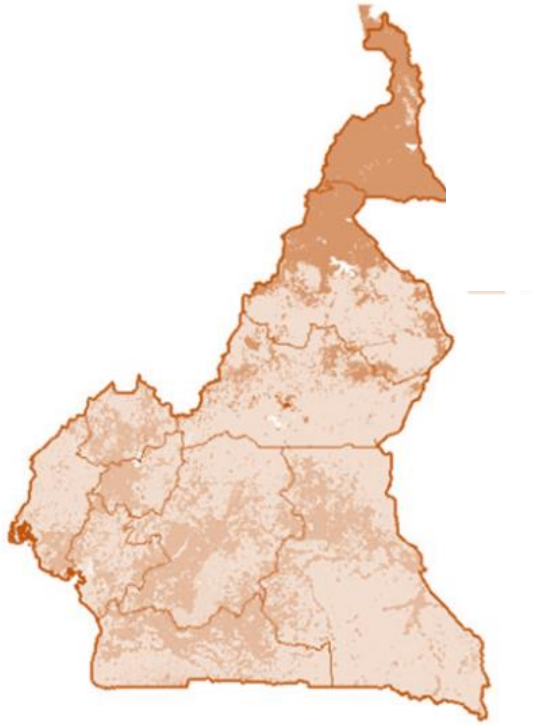
Season weather condition

SALUS



Real-time Yield Prediction



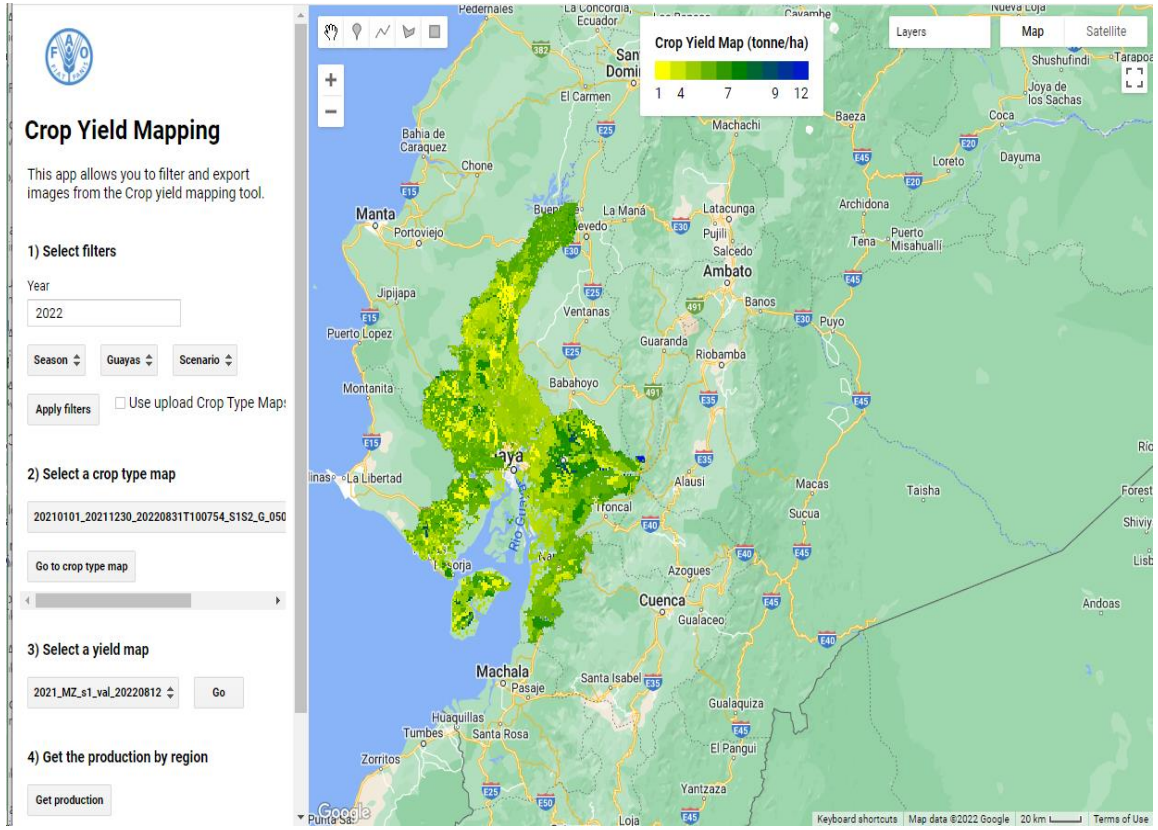


Simulation of all plausible yield outcome for major crops for each agroecological zone.

Innovation

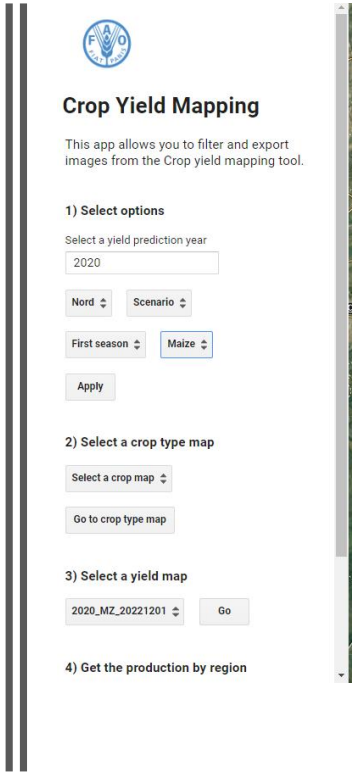
Ecuador End user tool: overview

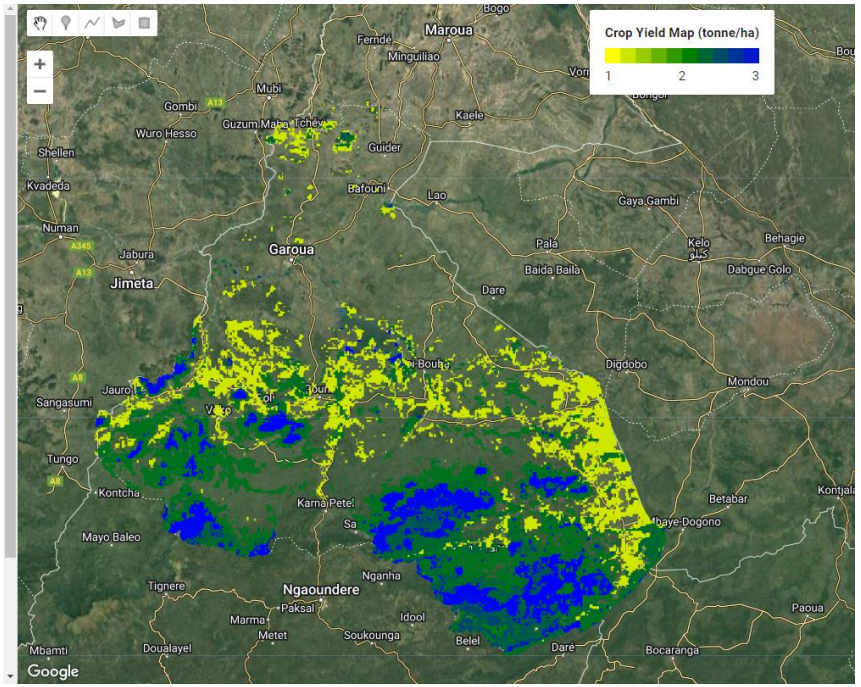
https://msu-cropmapper.users.earthengine.app/view/ecuador-end-user



Cameroon End user tool: overview

https://msu-cropmapper.users.earthengine.app/view/cameroon-crop-yield-mapper



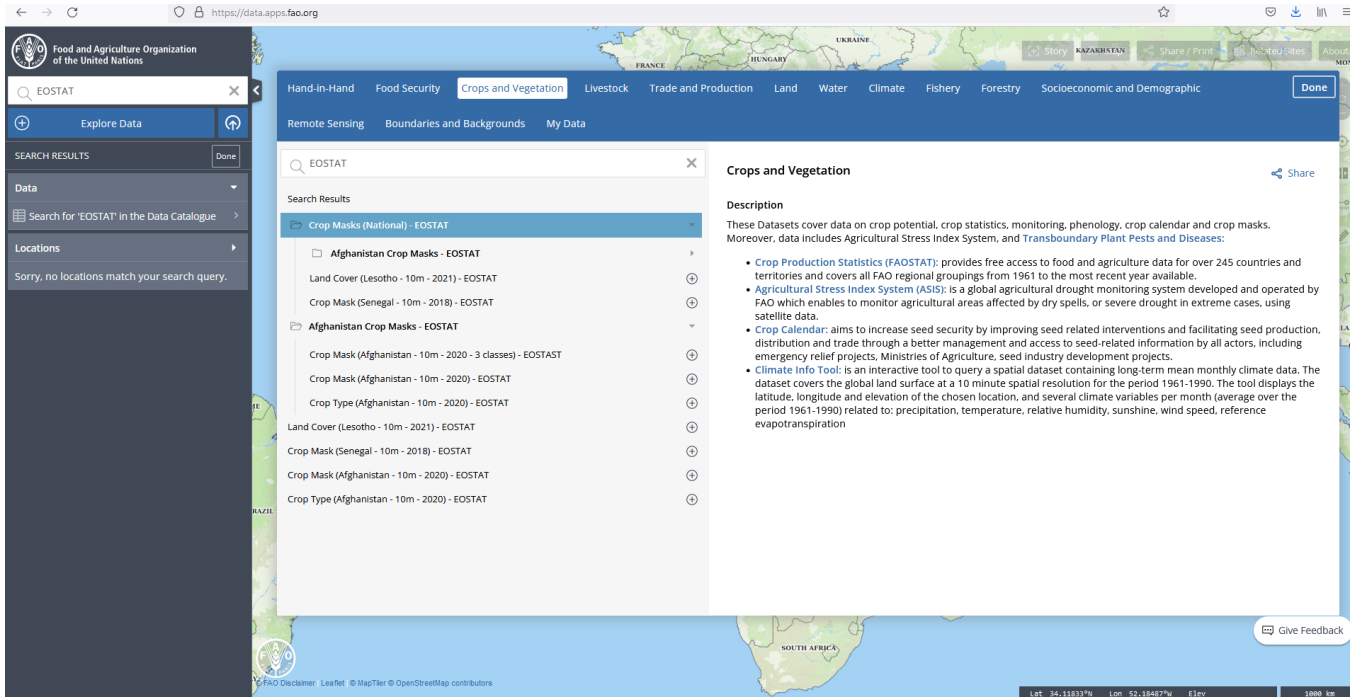


MAPS PRODUCED

COUNTRIES / DATA & MAPS PRODUCED

Country	Crop Type 10m	Crop yield 10m	Land Cover 10m	In Situ data
Afghanistan	X	X		X
Cameroon	X	X		X
Ecuador	X	X		X
El Salvador	X	X		X
Gabon	X	X		X
Guatemala	X			X
Mali	X	X		X
Mozambique	X	X	X	X
Rwanda	X	X	X	X
Senegal	X			X
Lesotho	X		X	X

HIGH-RES GEOSPATIAL DATA PUBLISHED TO THE FAO HIH GEOSPATIAL PLATFORM



- 19 Datasets already shared in 2022

- **42 crop type** and **crop yield maps** ready to be shared (El Salvaor, Ecuador, and Cameroon)

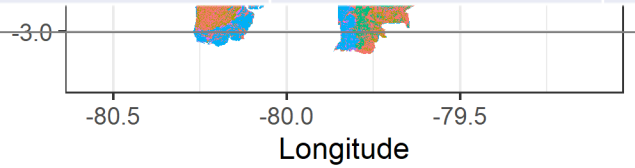
- 2 crop maps to be finalized in December 2023

- 2 to be finalized before April 2023

ECUADOR

MAIZE & RICE, AREAGE AND YIELD, FROM 2018 THROUGH 2023

2023	Crop	National	Guayas	Los Rios	Manabi	Loja
1st season	Maize	118127Mt ±0.1%	17464Mt ±1.3%	34944Mt ±0.4%	47602Mt ±2.1%	18117Mt ±6.6%
	Rice	37081Mt ±8.4%	21586Mt ±1.6%	12947Mt ±1.8%		
2nd season	Crop	National	Guayas	Los Rios	Manabi	Loja
	Maize	30296Mt ±0.4%	2522Mt ±0%	25423Mt ±0.7%	1318Mt ±0.2%	1033Mt ±4.9%
	Rice	77884Mt ±9.6%	51486Mt ±0.7%	17248Mt ±0.3%	1972Mt ±0.4%	
3rd season	Crop	National	Guayas	Los Rios	Manabi	Loja
	Maize					
	Rice	27380Mt ±4%	19207Mt ±1.9%	6740Mt ±1.4%	794Mt ±1%	



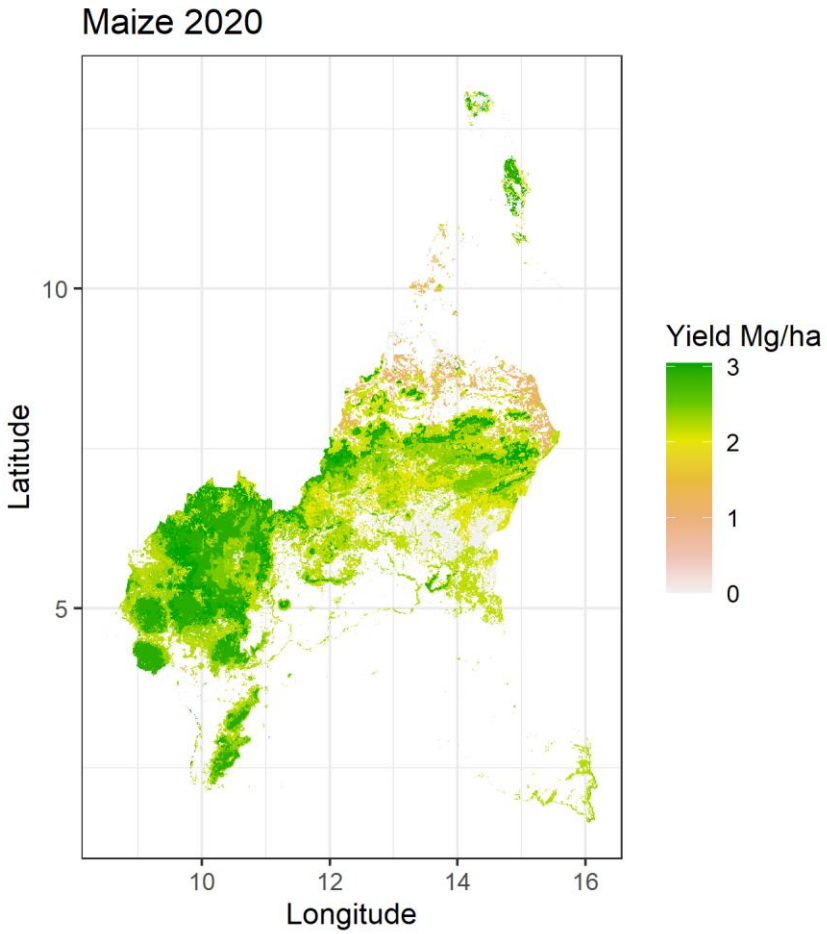
Lesotho	X		X	X

Crop production statistics at national and subnational level (Mega Tons)

MICHIGAN STATE UNIVERSITY

CAMEROON

RICE, CASSAVA, MAIZE, SORGHUM, FROM 2012 THROUGH 2020



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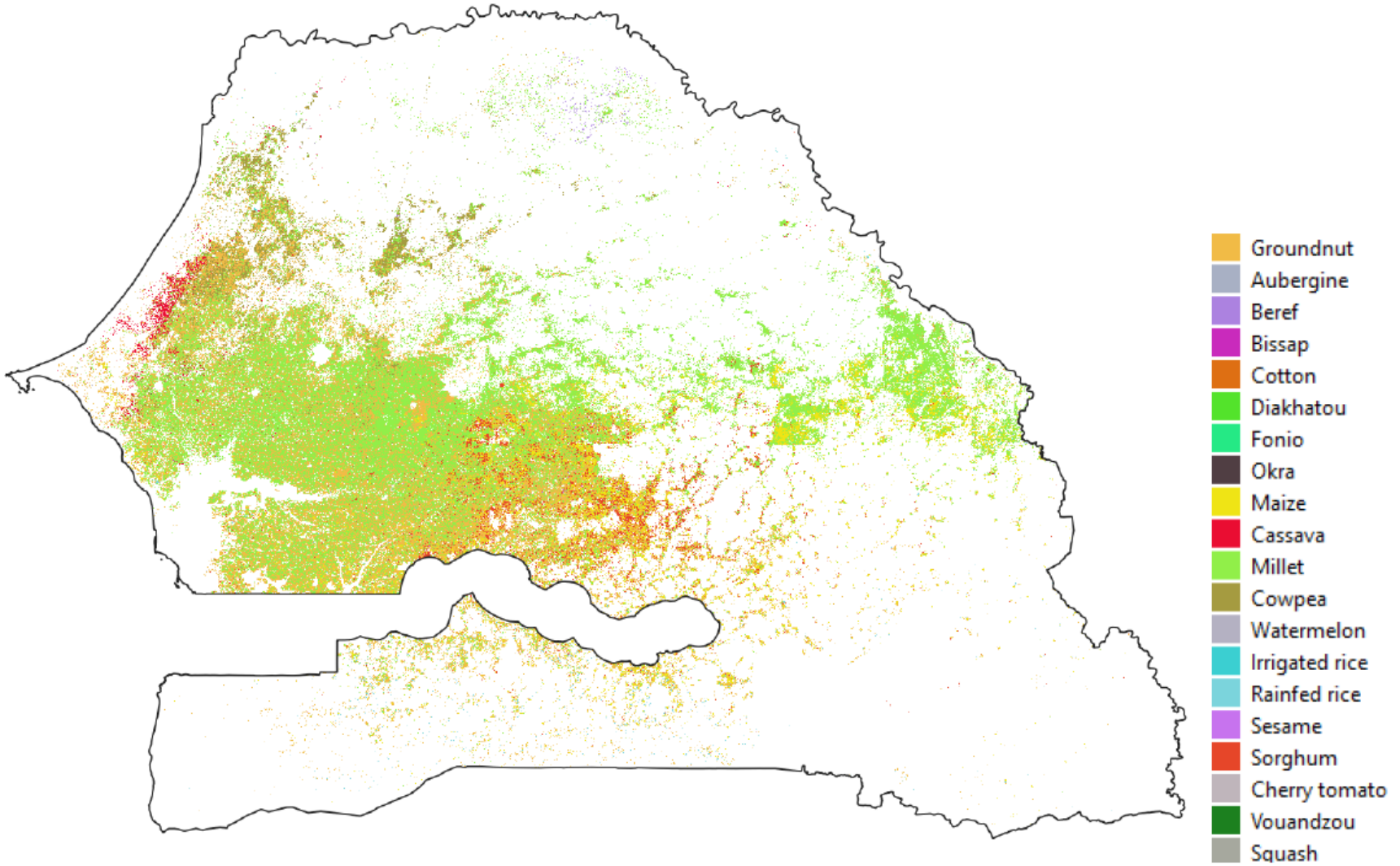
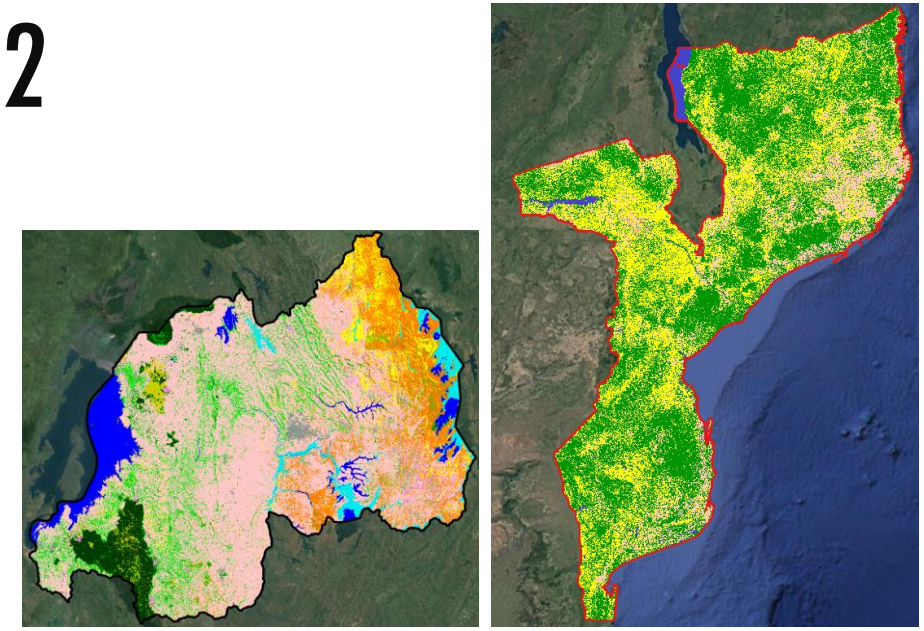
SENEGAL CROP TYPE MAP 2018

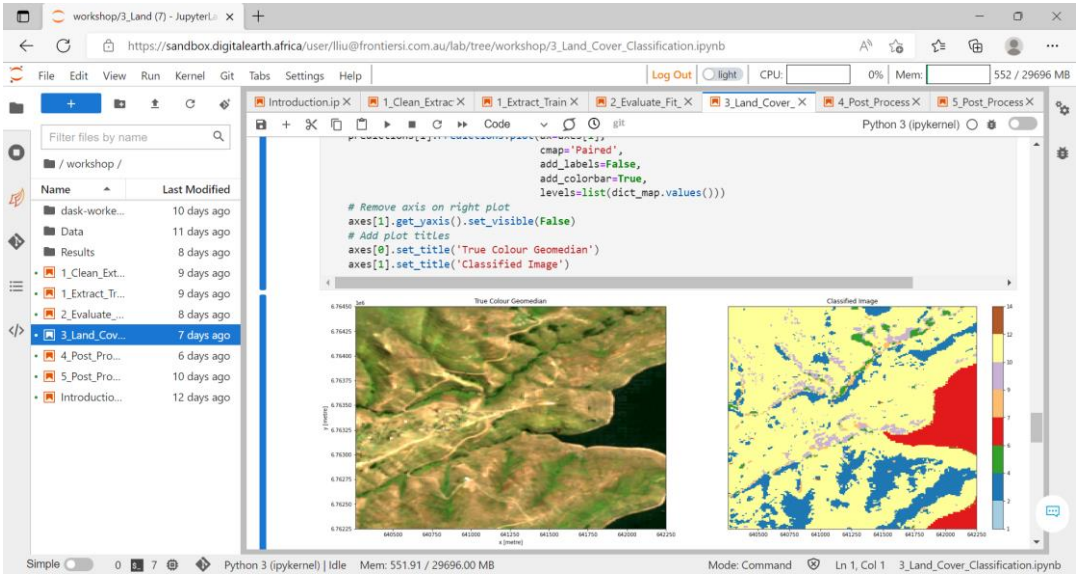


UCLouvain

RWANDA AND MOZAMBIQUE, LC 2022

- Updated land cover maps for Rwanda and Mozambique 2022
- Land cover mapping workflow prototype – open source, user friendly
- Upcoming online workshop training:
- Introduction webinar
- Two online training sessions through DE Africa Sandbox

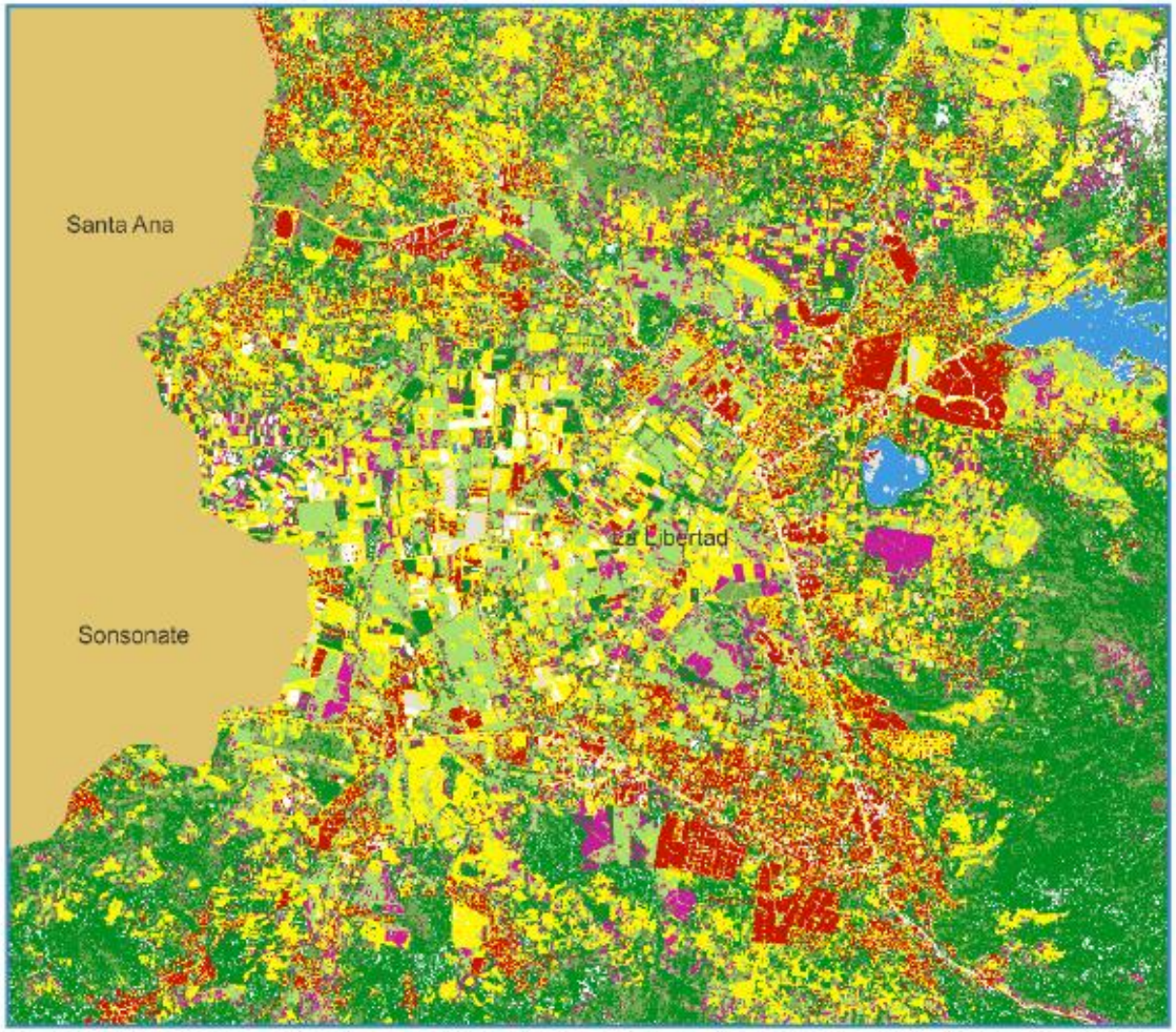


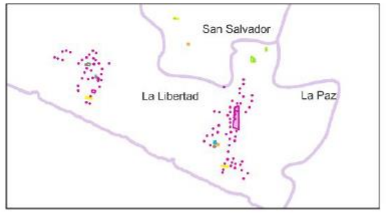


Digital Earth AFRICA

EL SALVADOR, 2022

Ad hoc survey implemented in the departments of La Libertad and Cuscatlán until the end of December 2022.



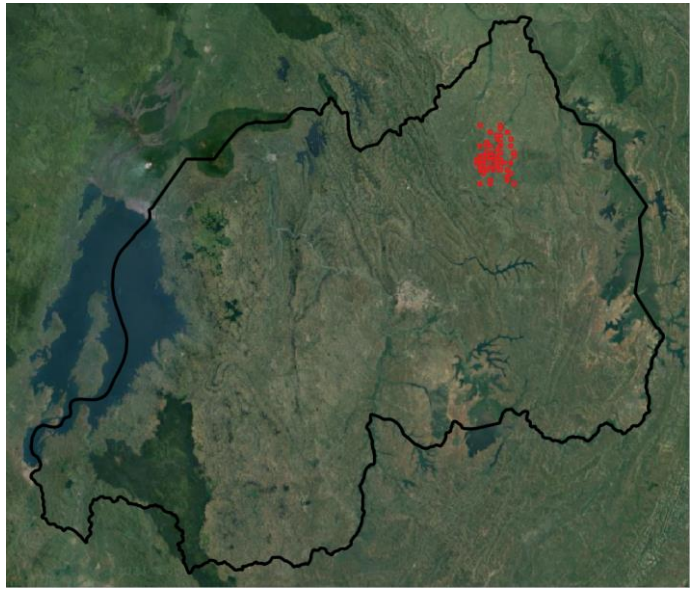


Rice
Sugarcane
Granos basicos (maize, beans, sorghum)
Grassland
Shrub
Tree cover
Water bodies
Artificialized land
Bare soils
Other land cover

UCLouvain

FIELD BOUNDARIES MAPPING

Crop boundary delineation - Progress



Rwanda:

- Use of NASA Harvest Competition dataset
  - 70 tiles (256*256 pixels) of Planet imagery
  - Validation dataset covering 1532 individual crop fields
- Processings conducted:
  - Batch preparation of imagery and ground-truth data (band stacking, convertion from boundary to extent)
  - Field extent prediction using Sherrie's module/function and pre-trained model
  - Field instance segmentation using Sherrie's module/functions
  - Prediction and segmentation results assessment, export (with geospatial information added)

Mozambique:

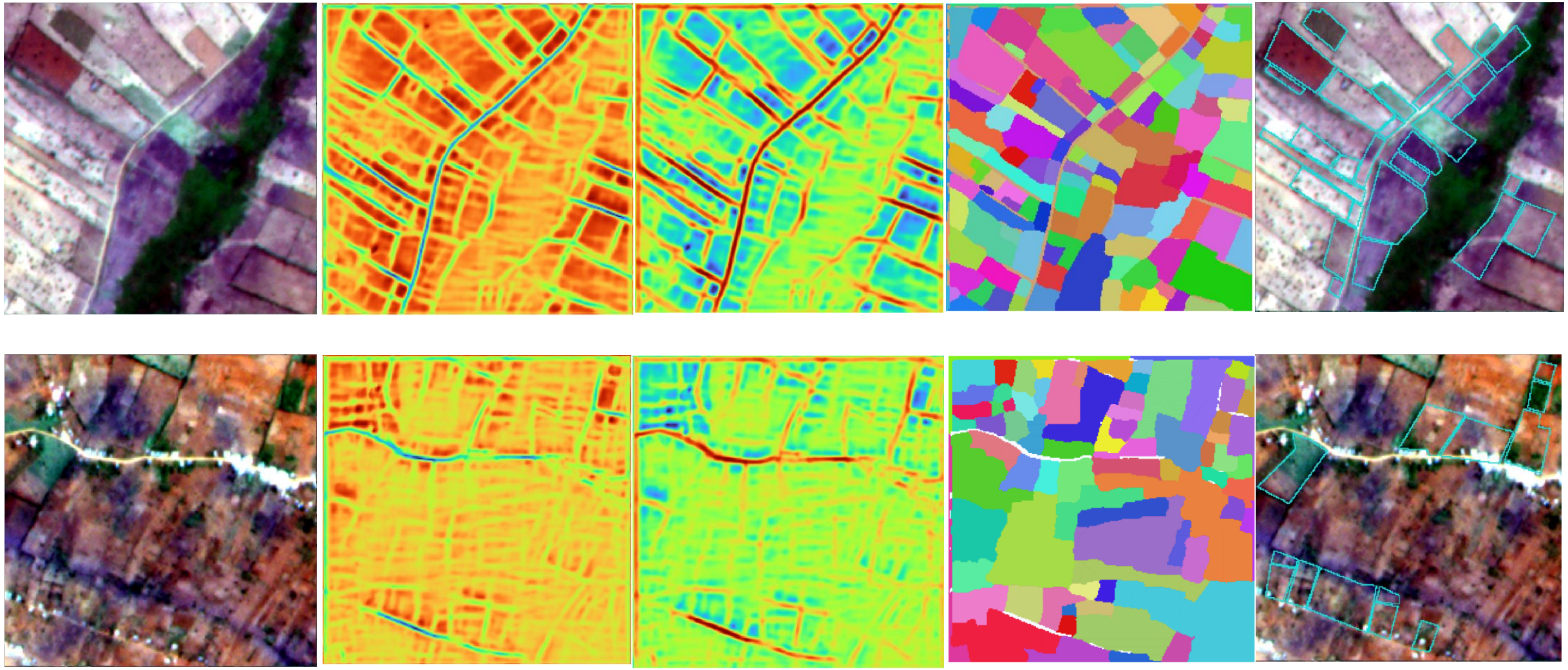
- Selected areas with dense crops from user provided large AOIs
- Processings conducted:
  - Script to batch download Planet imagery using API
  - Batch preparation of Planet images (clipping and band extraction)
  - Field extent prediction and instance segmentation, export (with geospatial information added)

planet.

Digital Earth AFRICA

Crop boundary delineation – Rwanda Results

Planet RGB | Predicted extent probability | Predicted boundary probability | Instance segmentation result | Ground-truth field boundary

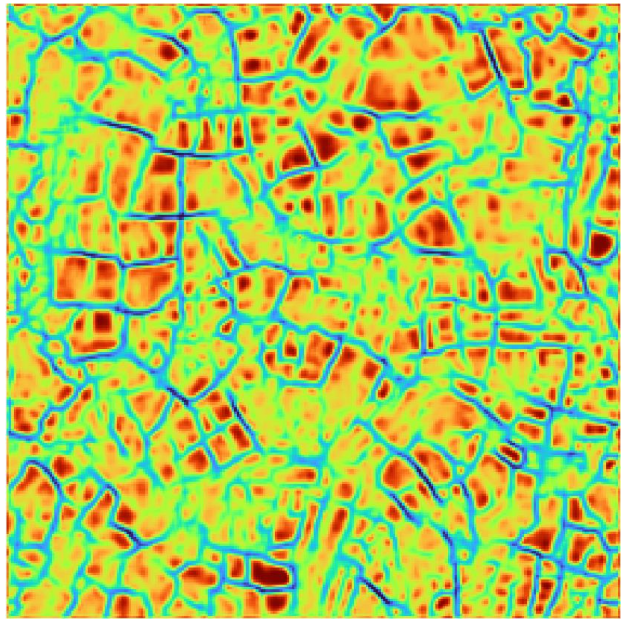


Mean F1 score: 0.91
Median IoU: 0.42

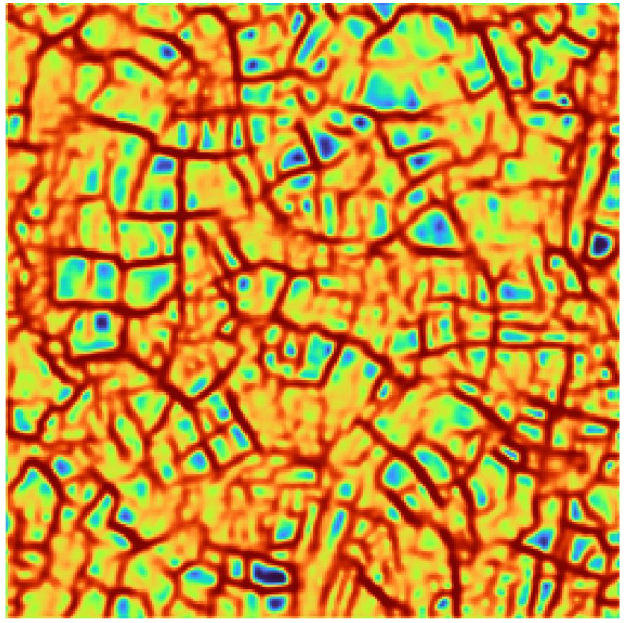
Crop boundary delineation – Mozambique Results

Planet RGB

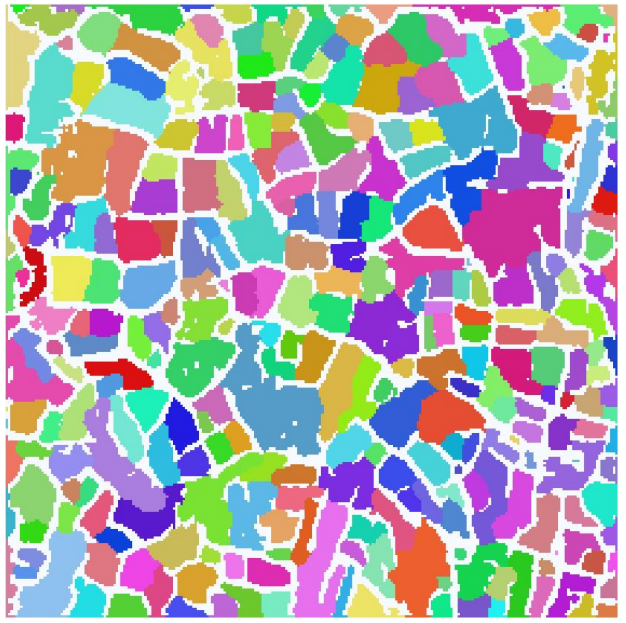
Predicted extent probability



Predicted boundary probability



Instance segmentation result



ADVANTAGES OF EOSTAT APPROACH

Advantages of using the FAO EO-STAT Crop Mapper

- The novel method developed by FAO and the Basso Lab at Michigan State University has the great advantage of being independent of self-reporting data coming from local authorities and scalable.
- Earth Observation (EO) have shown to be capable of quantifying areas and type of crops under cultivation at the district, region and country level.

- EOSTAT can cope with in situ data scarcity

- The application of the FAO EO-Stat Crop Mapper has shown to be able to reproduce measured yield observation. The systems is able to scale up results to larger areas beyond the small sample of costly data collection.

- EO-model based results are science-based and demonstrated to capture the complex feedbacks between soil, climate, management and genetics.

- The FAO-STAT Crop Mapper based on EO linked with process-based crop simulation models can revolutionize how crop yield and areas are estimated.

Innovat

WAY AHEAD - 2023

Opportunities and priorities - 2023

- Augumented crop phenospectral signatures
- In-situ data transferrability
- Strenghen activities in current country pilots – Repetition of mapping excerise to make an impact for the future
- Scale up to other 6 pilot countries (HiH priority list)
- Innovation fund: demonstrate innovative solution for field data collection

THANK YOU

LORENZO.DESIMONE@FAO.ORG