Ministry of Agriculture, Food and Rural Affairs
Republic of Korea

STATISTICS FROM SPACE

Remote sensing for crop type mapping

Work Package 4

ITC/University of Twente, Netherlands

IFPRI

ITC UNIVERSITY OF TWENTE.

UNIVERSIDADE EDUARDO MONDLANE

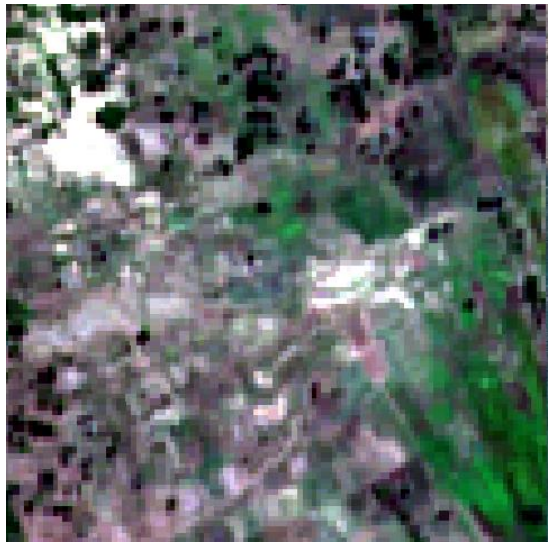
VERI TAS LUX MEA

Remote Sensing Data

Goal: Quantitatively determine the feasibility of Sentinel-1 & 2 data given the fragmented agricultural scenario of Mozambique for crop type mapping.

Planet august 2023

Esri (maxar) august 2023



Sentinel-2 August 2023

Google Map August 2023

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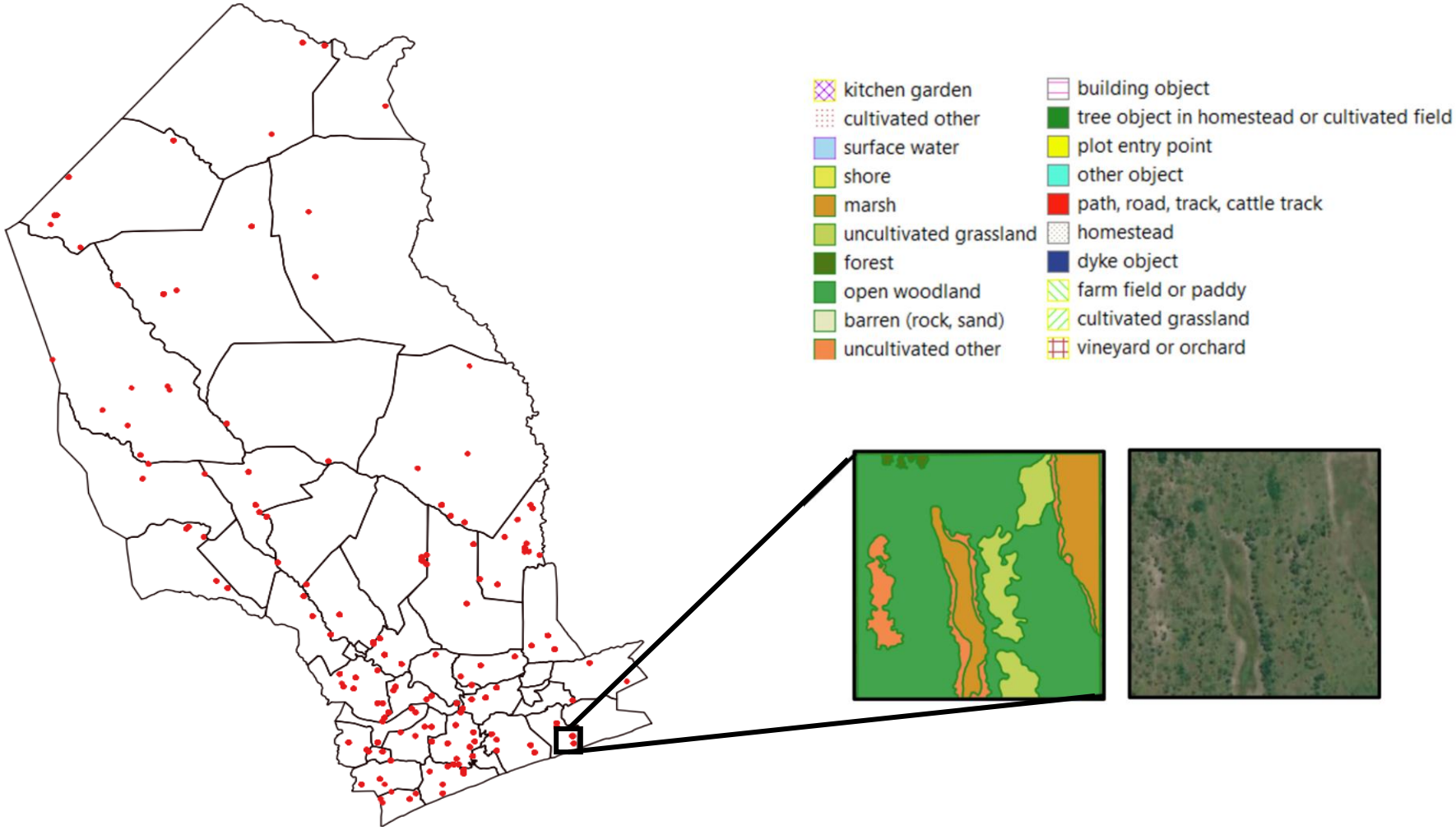
Field Data Collected: training data



Field Data Collected: training data

Segments and field observations

High resolution imagery

Field photos

surface water
shore
kitchen garden
cultivated other
marsh
uncultivated grassland
path, road, track, cattle track
homestead
forest
open woodland
building object
tree object in homestead or cultivated field
plot entry point
other object
barren (rock, sand)
uncultivated other
dyke object
farm field or paddy
cultivated grassland
vineyard or orchard

Photo GPS location (metadata)

Field GPS location

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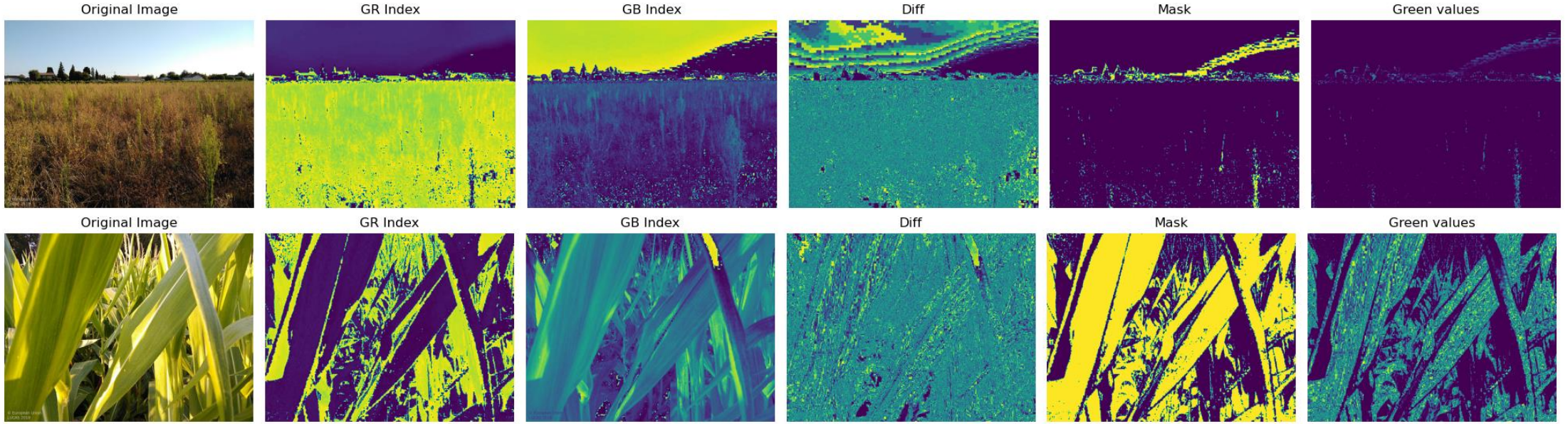
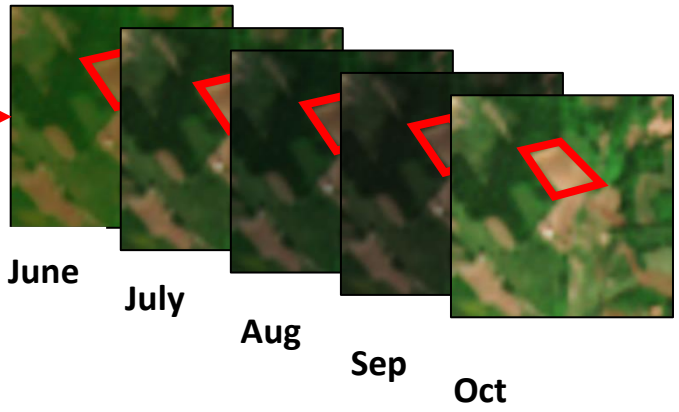
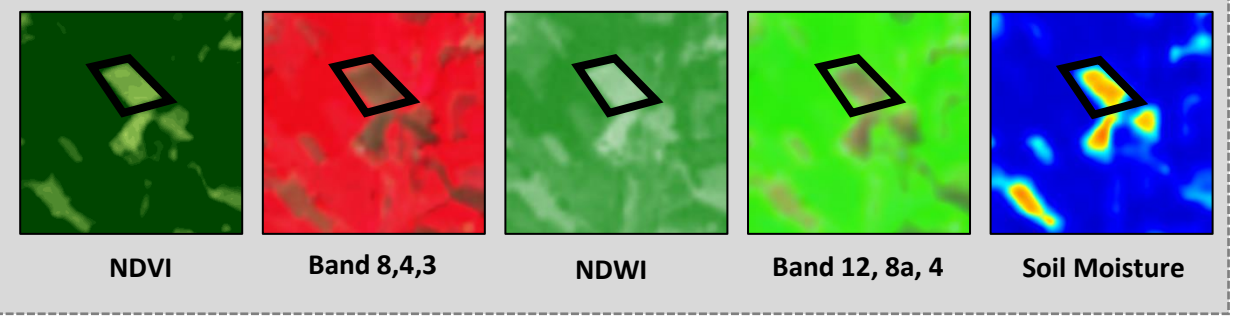
Field Photo and Satellite Data



Field Photos





RS data

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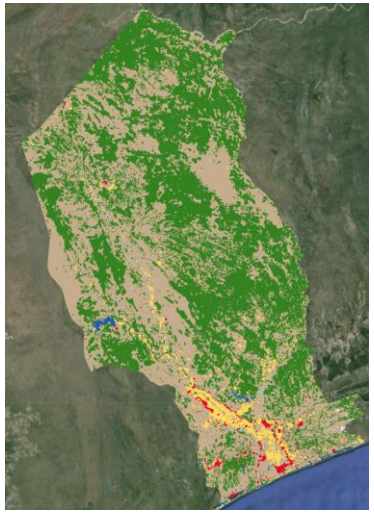
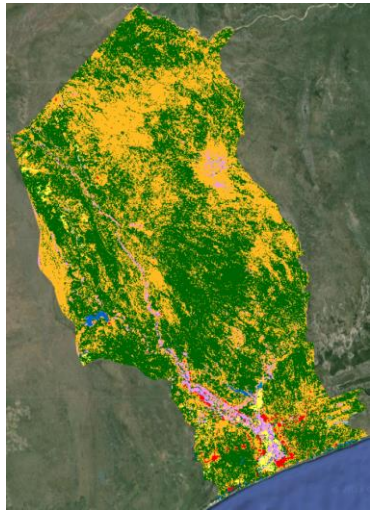
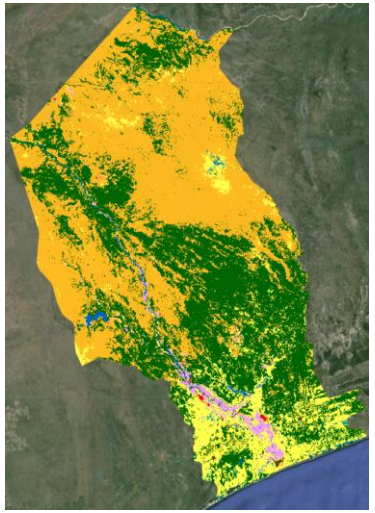
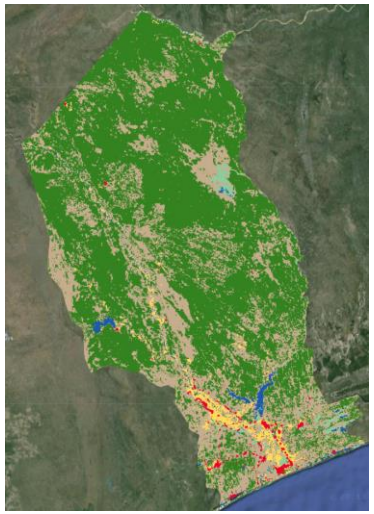
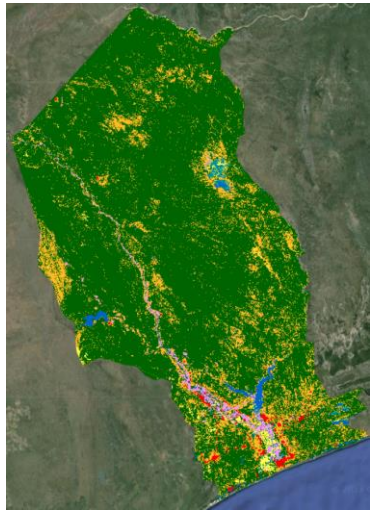
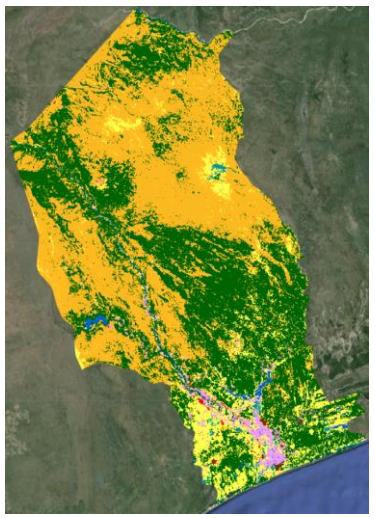
Global Land Cover Product

Water
Trees
Flooded Vegetation
Crops
Built Area
Bare Ground
Clouds
Rangeland

	ESRI	DW	WORLDCOVER
2020			
2021			

Water
Cropland
Grassland
Built up
Shurb
Trees
Bare
Wetland

- ✓ Dynamic World [1];
- ✓ Esri LULC Map [2];
- ✓ World-Cover [3].

Base don Sentinel-2 data and publicly available at global scale at **10m spatial resolution**.

[1] Brown, C. F., Brumby, S. P., Guzder-Williams, B., Birch, T., Hyde, S. B., Mazzariello, J., Czerwinski, W., Pasquarella, V. J., Haertel, R., Ilyushchenko, S., et al., "Dynamic world, near real-time global 10 m land use land cover mapping," Scientific Data 9(1), 251 (2022).
[2] Karra, K., Kontgis, C., Statman-Weil, Z., Mazzariello, J. C., Mathis, M., and Brumby, S. P., "Global land use/land cover with sentinel 2 and deep learning," in [2021 IEEE international geoscience and remote sensing symposium IGARSS], 4704–4707, IEEE (2021).
[3] Venter, Z. S., Barton, D. N., Chakraborty, T., Simensen, T., and Singh, G., "Global 10 m land use land cover datasets: A comparison of dynamic world, world cover and esri land cover," Remote Sensing 14(16), 4101 (2022).

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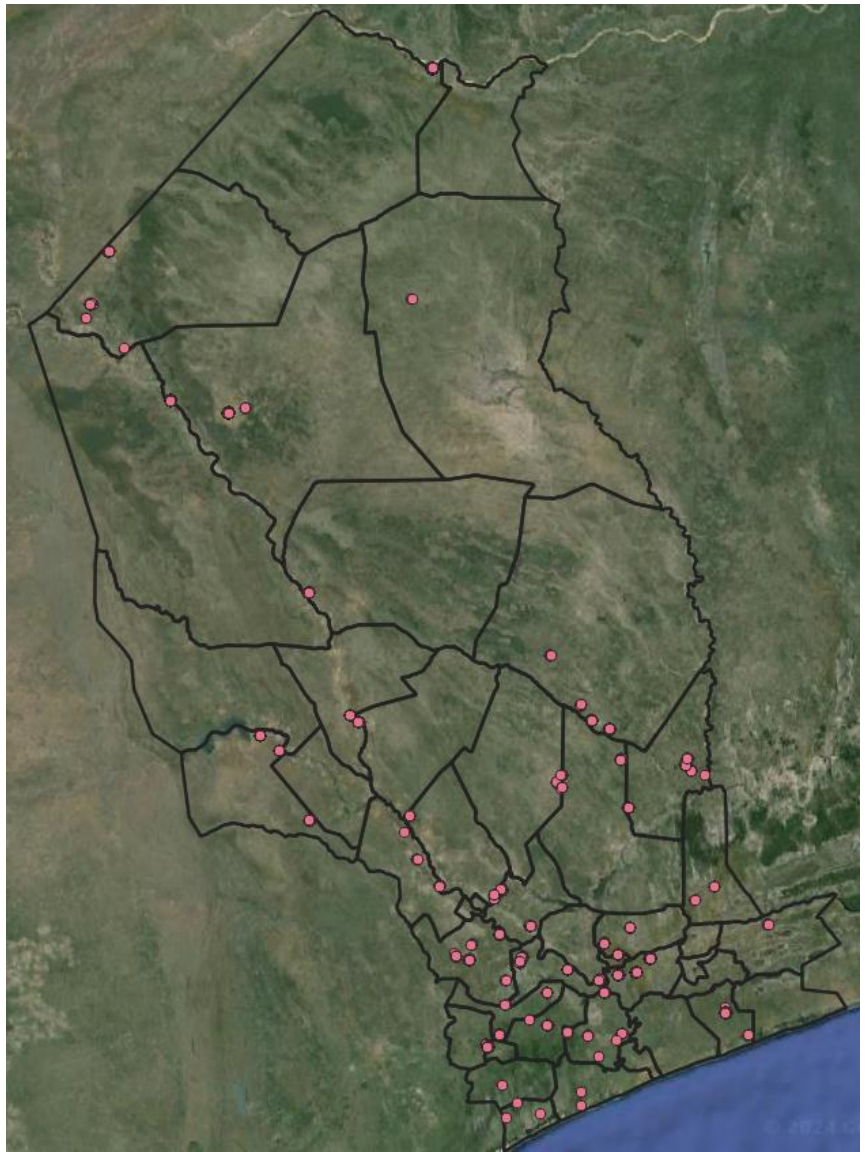
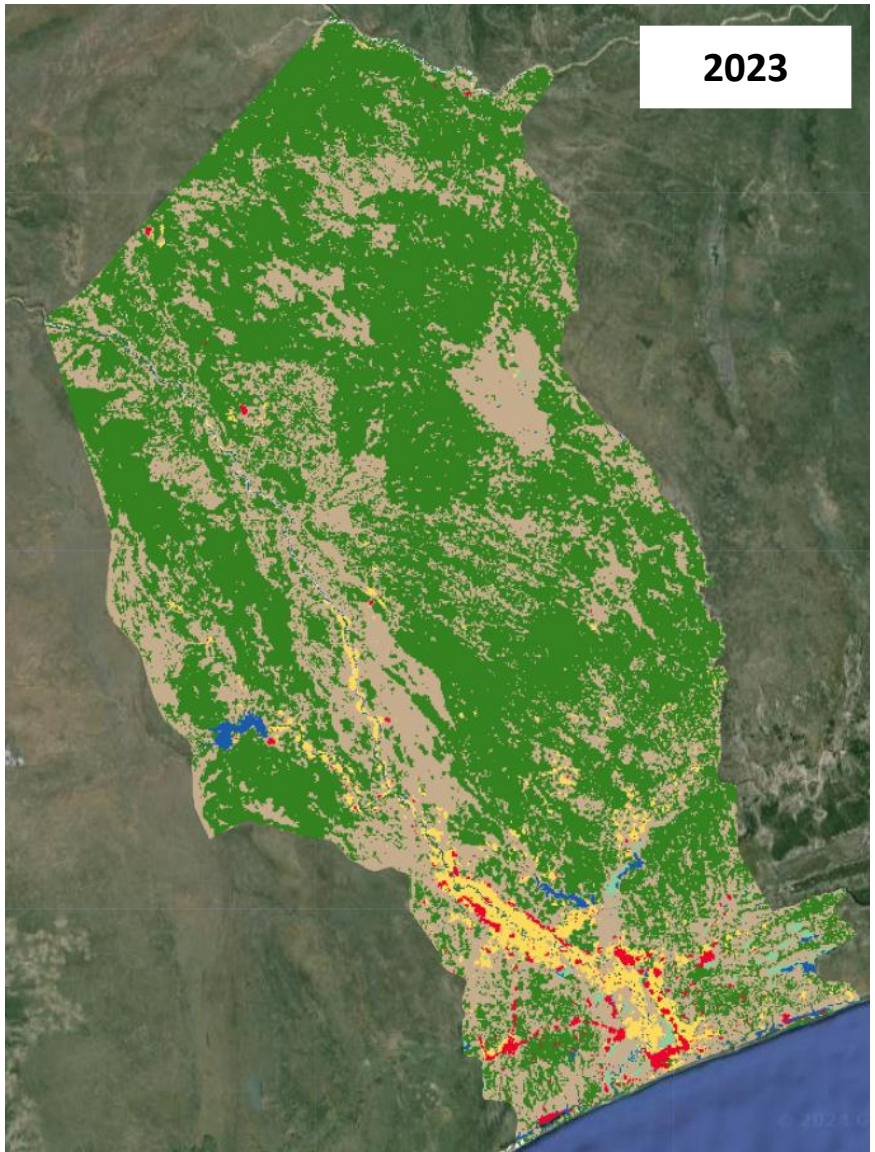
Extra Reference Data





- Water
- Trees
- Flooded Vegetation
- Crops
- Built Area
- Bare Ground
- Clouds
- Rangeland

2023 ESRI LC Map

https://gee-community-catalog.org/projects/S2TSLULC/

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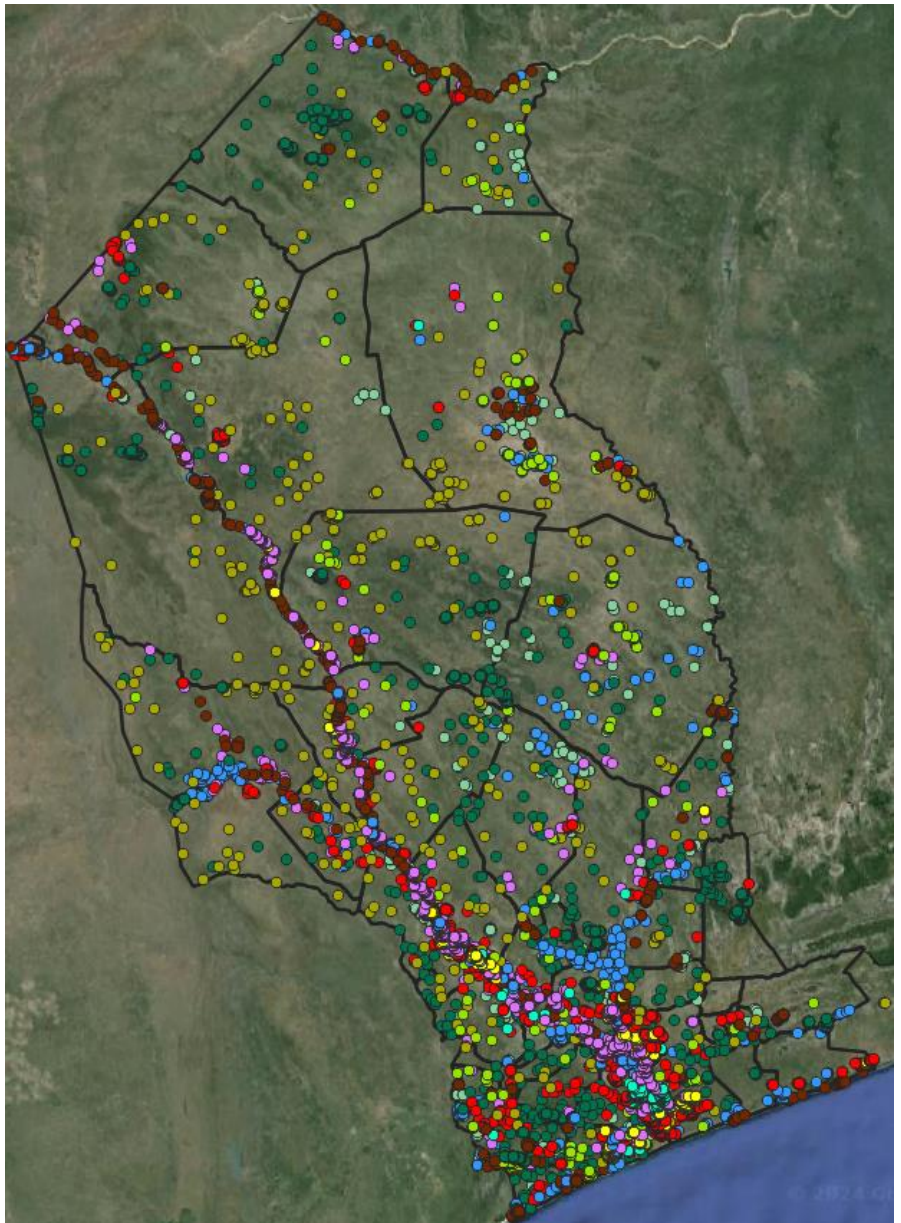
Extra Reference Data

	n. points
Water	856
Maize	822
Flooded Veg.	899
Mixed fields	395
Built up	845
Shurb	537
Trees	1272
Bare	1092
Grass	289
Rice	149
TOTAL	7156

Rice

Mixed

Maize



Remote sensing for crop type mapping

RS data

Feature Extraction

LC Classification

Sentinel-2

Sentinel-1

DEM

Indexes

Textural

Topog.

Esri

Reference Data Collection

Supervised Classification

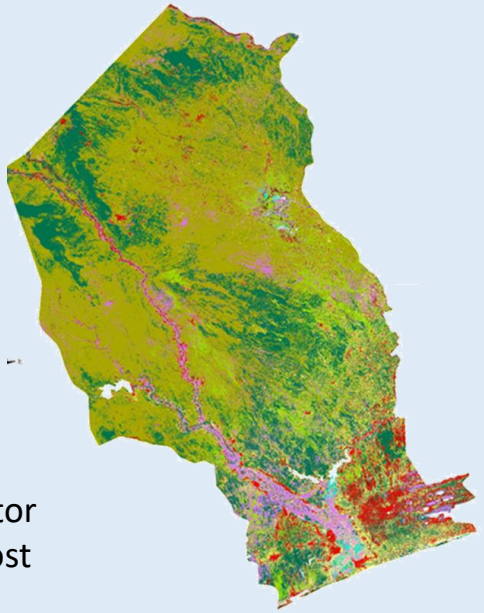
Random Forest, Support Vector Machine, TreeBagger, XGBoost

Yearly Land Cover Mapping

Accuracy Assessment

Crop/NoCrop Map

Crop Type Map



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Sentinel-2 data

Rain Season Composite

First Vegetation Peak
01/01/2023 – 20/03/2023

Dry Season 1 Composite

Later Vegetation Peak
01/05/2023 – 30/06/2023

Dry Season 2 Composite

Dry Vegetation Peak
01/09/2023 – 30/09/2023

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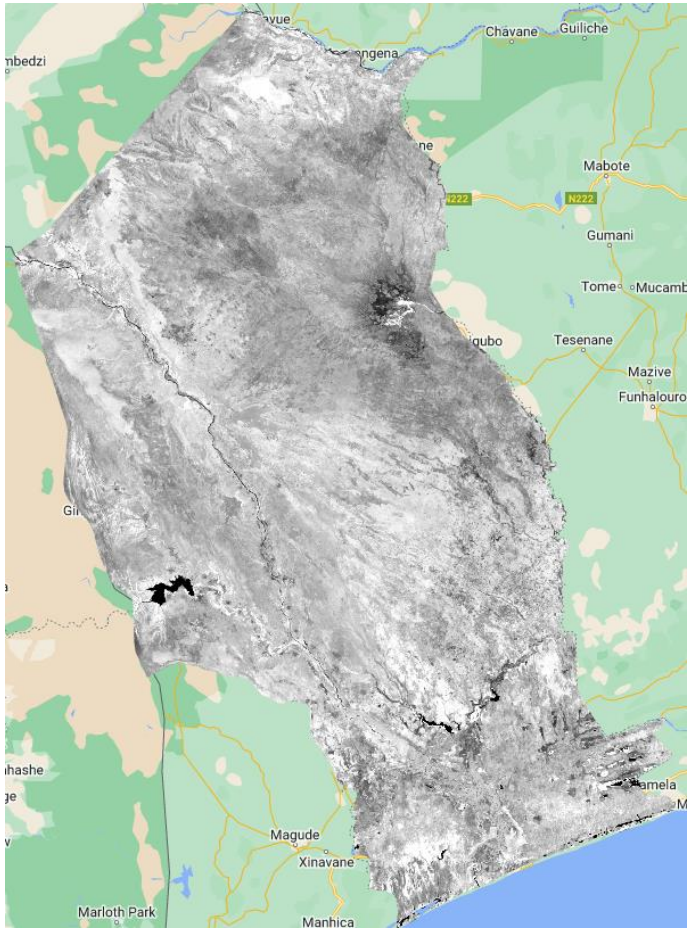
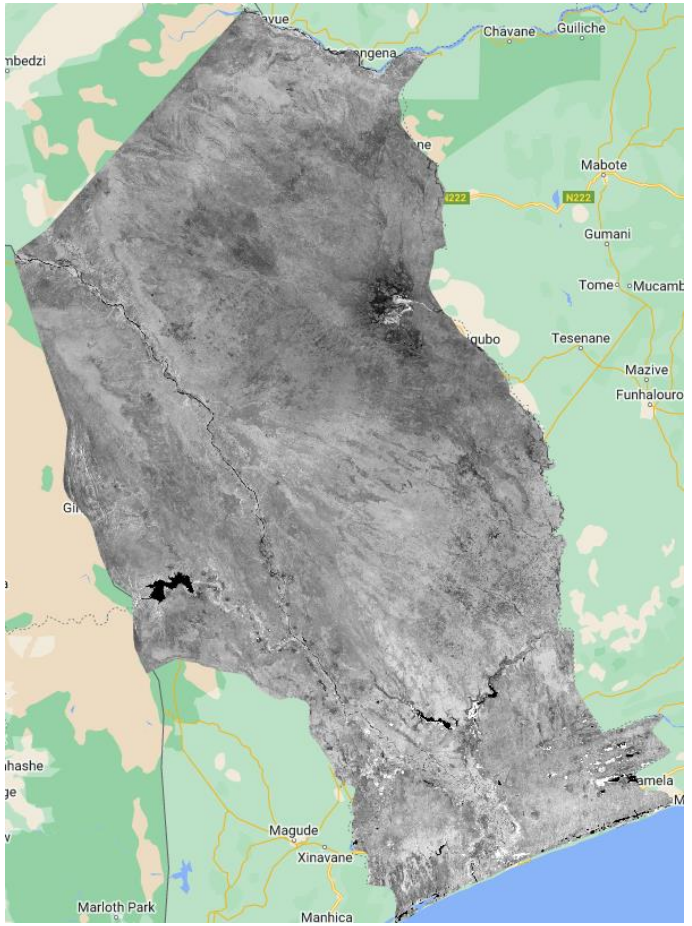
Sentinel-1 data

Rain Season Composite



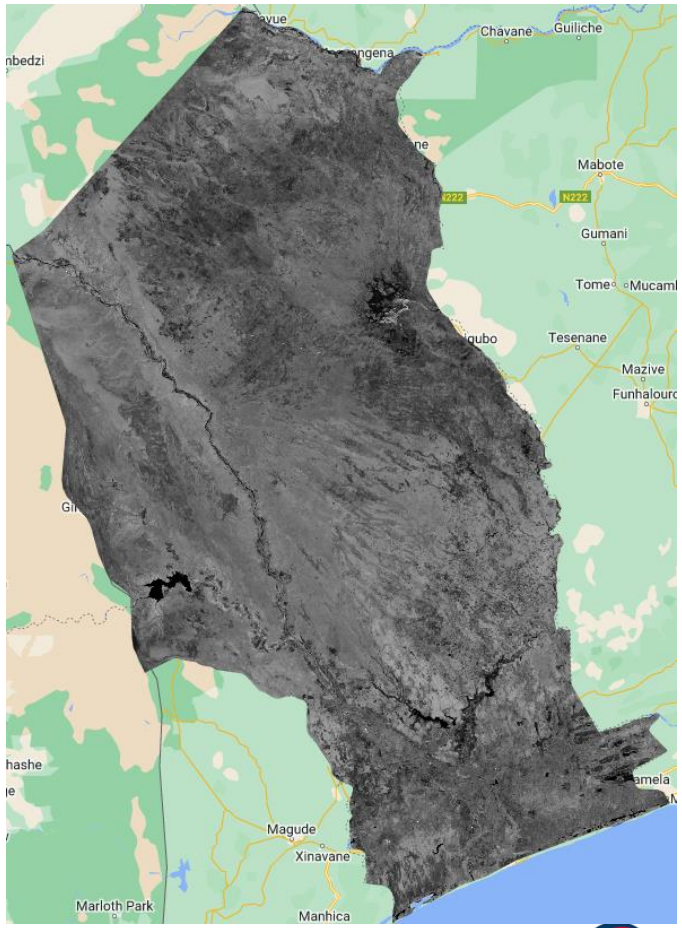
First Vegetation Peak
01/01/2023 – 20/03/2023

Dry Season 1 Composite



Later Vegetation Peak
01/05/2023 – 30/06/2023

Dry Season 2 Composite



Dry Vegetation Peak
01/09/2023 – 30/09/2023

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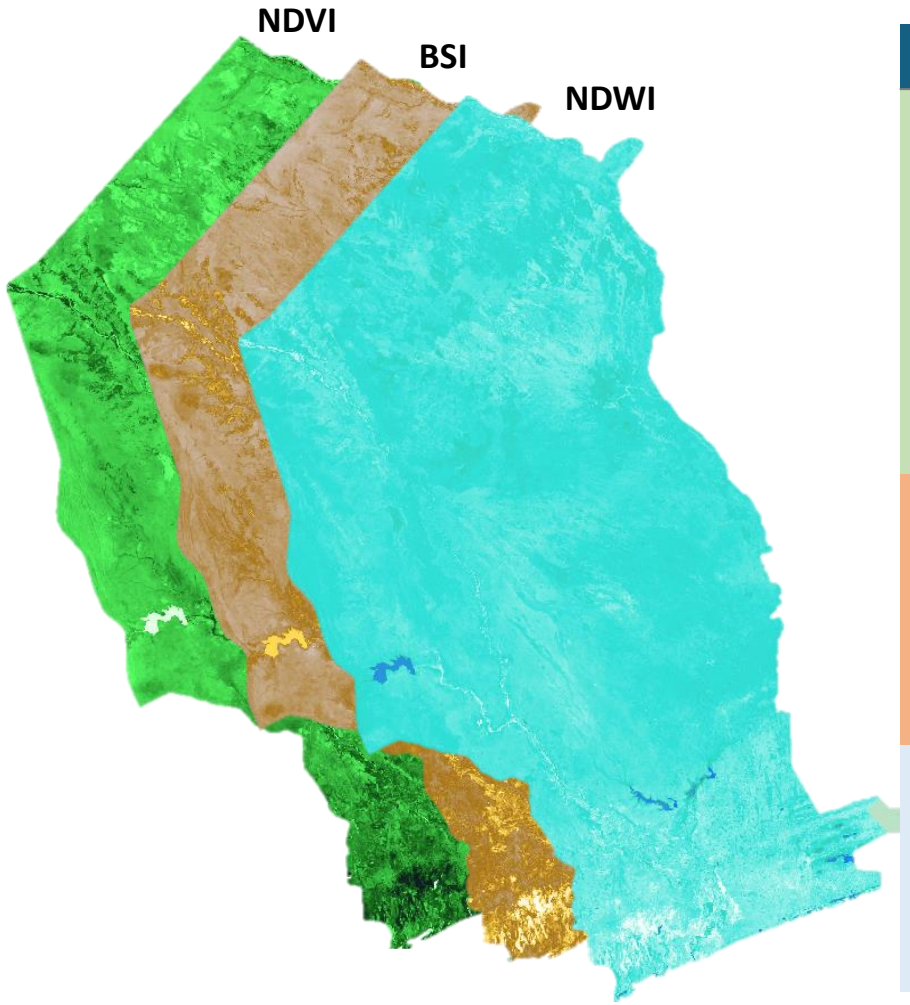
Sentinel-2 data: Spectral Indexes



INDEX	FORMULA	DESCRIPTION
NDVI (normalized difference vegetation index)	(NIR - Red) / (NIR + Red)	Indicates vegetation health and density. High values suggest healthy, dense vegetation.
EVI (enhanced vegetation index)	2.5 * ((NIR - Red) / (NIR + 6 * Red - 7.5 * Blue + 1))	Enhances vegetation signal with improved sensitivity in high biomass regions and better noise reduction.
GNDVI (green normalized difference vegetation index)	(NIR - Green) / (NIR + Green)	Sensitive to chlorophyll content in vegetation, useful for monitoring plant health.
SAVI (soil-adjusted vegetation index)	((NIR - Red) / (NIR + Red + 0.5)) * 1.5	Similar to NDVI but adjusts for soil brightness, improving vegetation detection in areas with less dense canopy.
BSI (bare soil index)	((SWIR + Red) - (NIR + Blue)) / ((SWIR + Red) + (NIR + Blue))	Differentiates bare soil from vegetation and other land covers. Higher values indicate bare soil presence.
NDMI (normalized difference moisture index)	(NIR - SWIR) / (NIR + SWIR)	Indicates moisture content in vegetation and soil. Higher values signify more moisture.
NDWI (normalized difference water index)	(NIR - Green) / (NIR + Green)	Reflects water content in vegetation and soil. Higher values indicate higher water content.

Bofana, J., Zhang, M., Nabil, M., Wu, B., Tian, F., Liu, W., ... & Moyo, C. (2020). Comparison of different cropland classification methods under diversified agroecological conditions in the Zambezi River Basin. Remote Sensing, 12(13), 2096.

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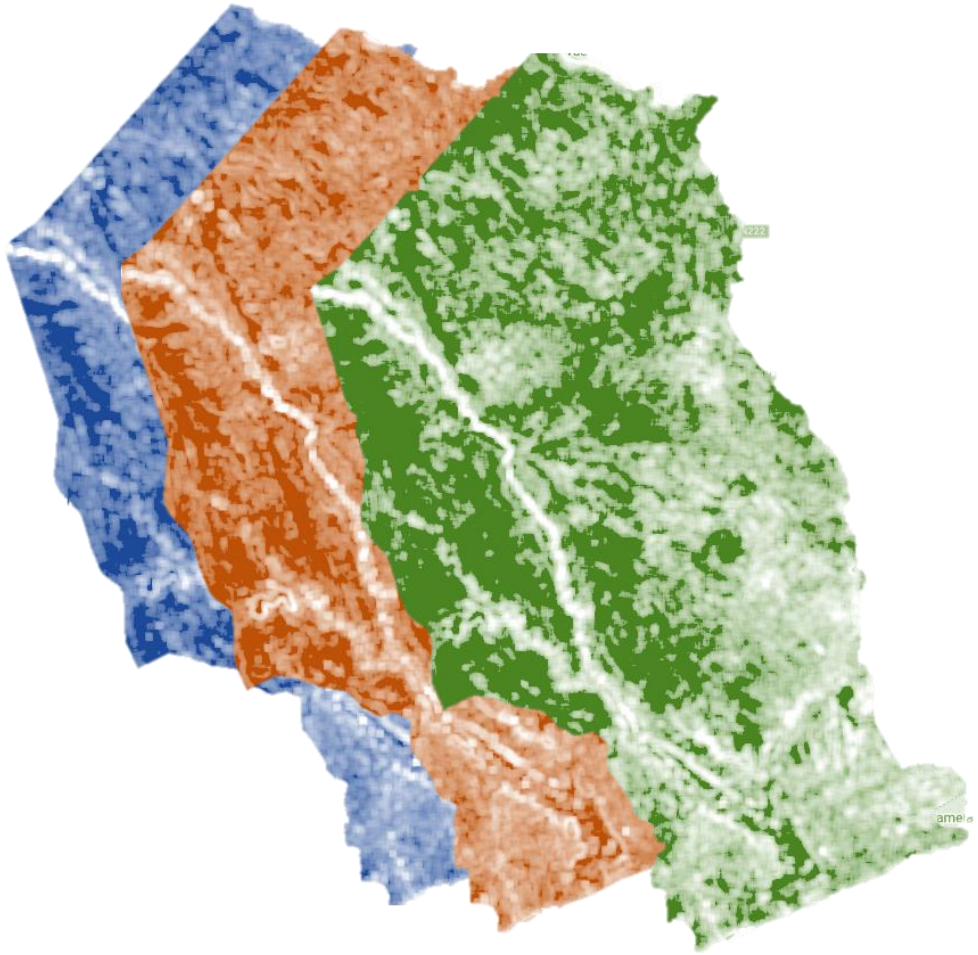
Sentinel-2 data: Textural Features



GCLM	DESCRIPTION
ASM (Angular Second Moment)	Measures the uniformity of the image. When pixels are very similar, the ASM value will be large
CO (Contrast)	Measures of intensity or gray-level variations between the reference pixel and its neighbor
CORR (Correlation)	Measures the correlation between pairs of pixels.
VAR (Variance)	Measure of the dispersion of the values around the mean of combinations of reference and neighbor pixels.
IDF (Inverse Difference Moment)	Measures the local homogeneity of an image. IDM feature obtains the measures of the closeness of the distribution of the GLCM elements to the GLCM diagonal.
ENT (Entropy)	Measures the randomness of a gray-level distribution.
DVAR (Difference variance)	Measures the dispersion of the gray level difference distribution of the image.
DENT (Difference entropy)	Measures the disorder related to the gray level Difference distribution of the image.

Mohammadpour, P., Viegas, D. X., & Viegas, C. (2022). Vegetation mapping with random forest using sentinel 2 and GLCM texture feature—A case study for Lousã region, Portugal. *Remote Sensing*, *14*(18), 4585.

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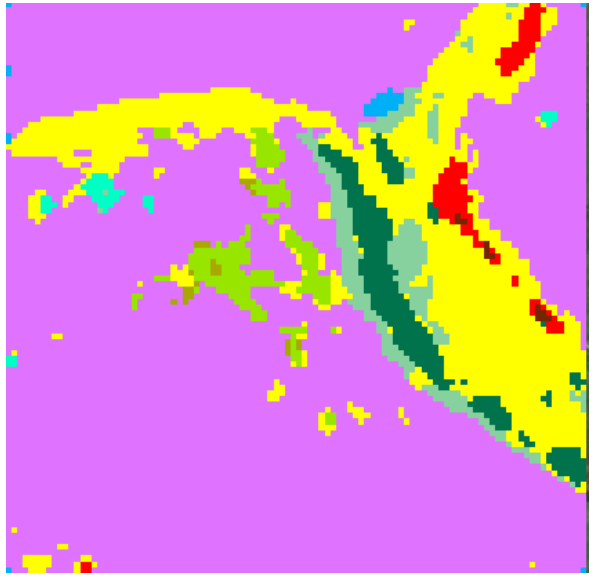
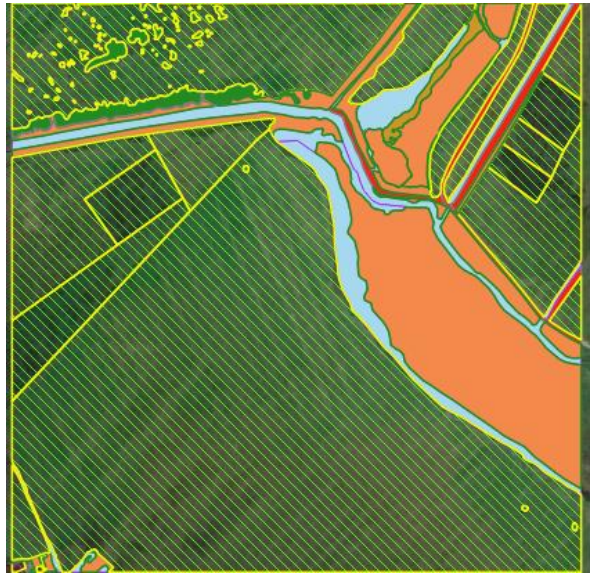
Results

PM



- water
- maize
- Flooded Vegetation
- mixed fields
- built up
- shurb
- Trees
- bare
- grass
- rice

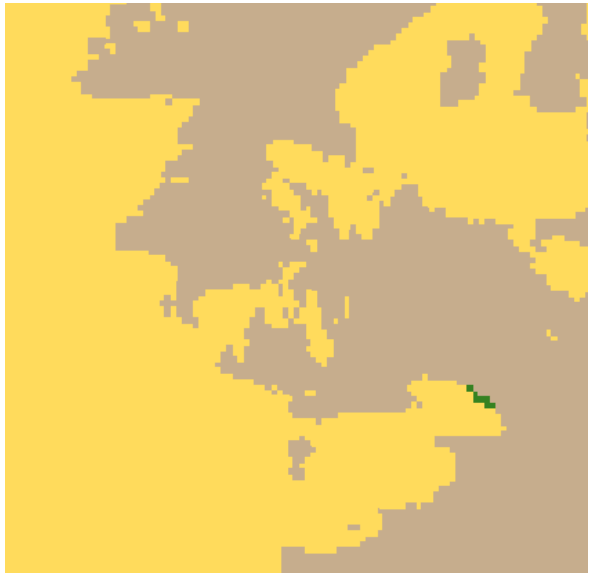
Reference



- kitchen garden
- cultivated other
- surface water
- shore
- marsh
- uncultivated grassland
- forest
- open woodland
- barren (rock, sand)
- uncultivated other
- building object
- tree object in homestead or cultivated field
- plot entry point
- other object
- path, road, track, cattle track
- homestead
- dyke object
- farm field or paddy
- cultivated grassland
- vineyard or orchard

VHR data

2023 ESRI



- Built Area
- Bare Ground
- Clouds
- Rangeland
- Water
- Trees
- Flooded Vegetation
- Crops

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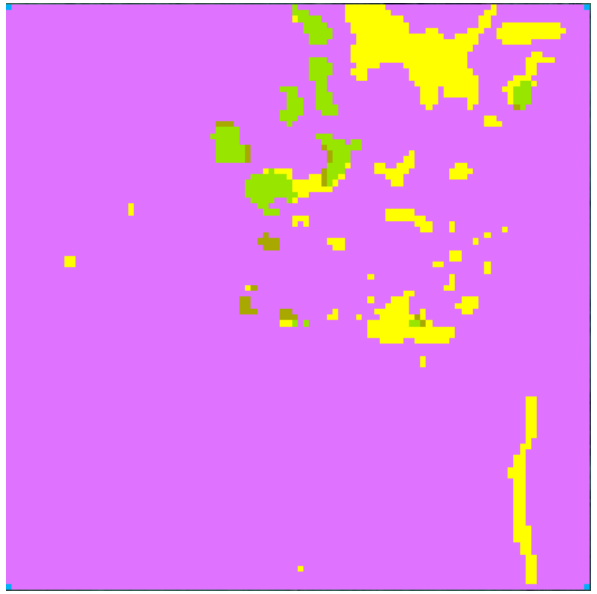
Results

PM



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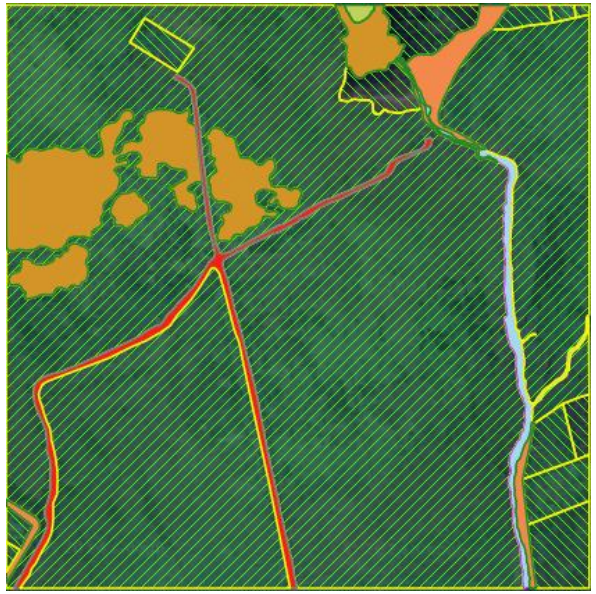
Reference



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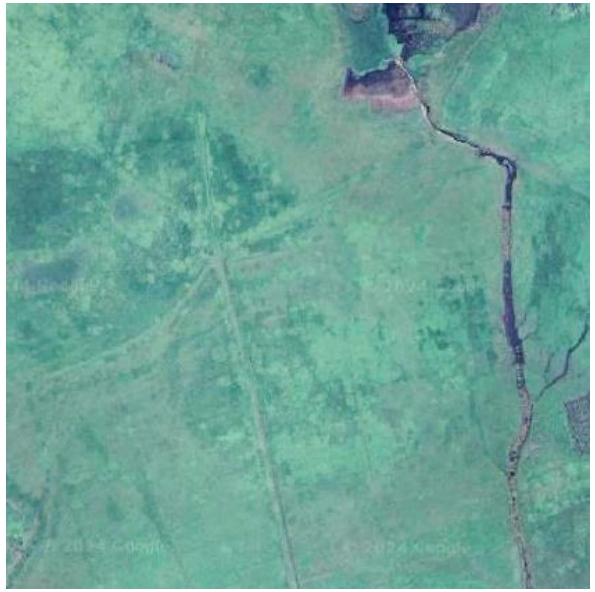

2023 ESRI

- Built Area
- Bare Ground
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- Trees
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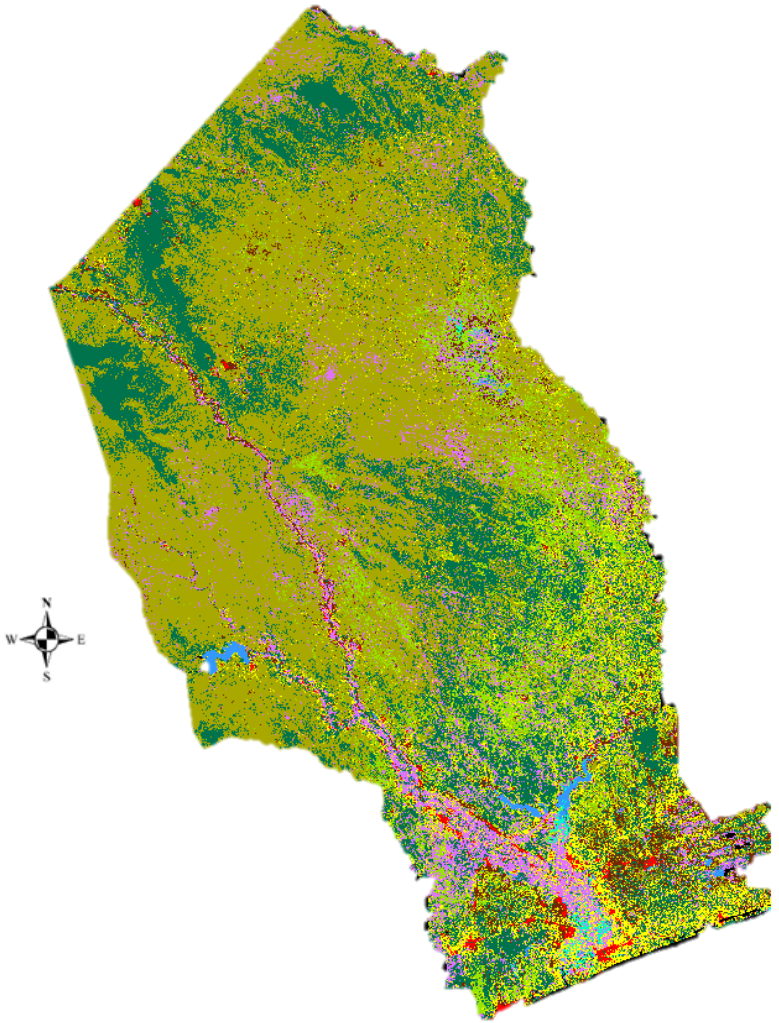
Results



	SVM											
water	48	0	2	0	0	0	0	4	0	0	54	88.89
maize	0	166	1	38	1	2	0	1	4	5	218	76.15
Flooded Vegetation	3	1	52	0	0	0	0	0	0	2	58	89.66
mixed fields	1	14	0	62	1	0	2	2	1	2	85	72.94
built up	0	1	0	1	96	1	2	9	1	0	111	86.49
shurb	0	3	0	0	0	69	3	1	6	0	82	84.15
Trees	1	2	3	6	2	10	344	3	1	0	372	92.47
bare	2	3	0	1	6	3	0	182	6	0	203	89.66
grass	0	1	0	3	0	10	0	6	44	0	64	68.75
rice	0	2	1	1	0	0	0	0	0	23	27	85.19
	55	193	59	112	106	95	351	208	63	32		
	87.27	86.01	88.14	55.36	90.57	72.63	98.01	87.50	69.84	71.88		85.24

	SVM		
	PA	UA	F1
water	87.27	88.89	88.07
maize	86.01	76.15	80.78
Flooded Vegetation	88.14	89.66	88.89
mixed fields	55.36	72.94	62.94
built up	90.57	86.49	88.48
shurb	72.63	84.15	77.97
Trees	98.01	92.47	95.16
bare	87.50	89.66	88.56
grass	69.84	68.75	69.29
rice	71.88	85.19	77.97
		85.19	

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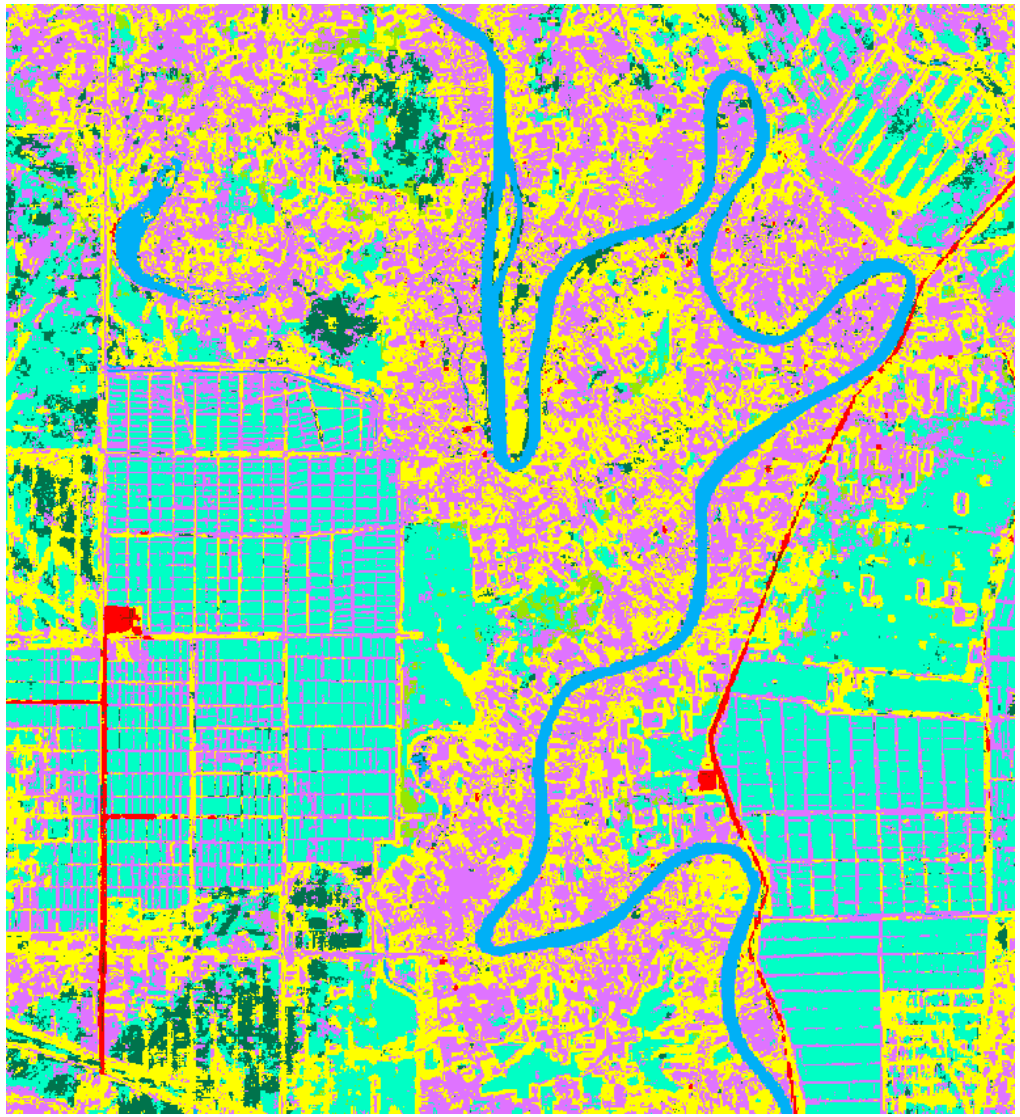
Results



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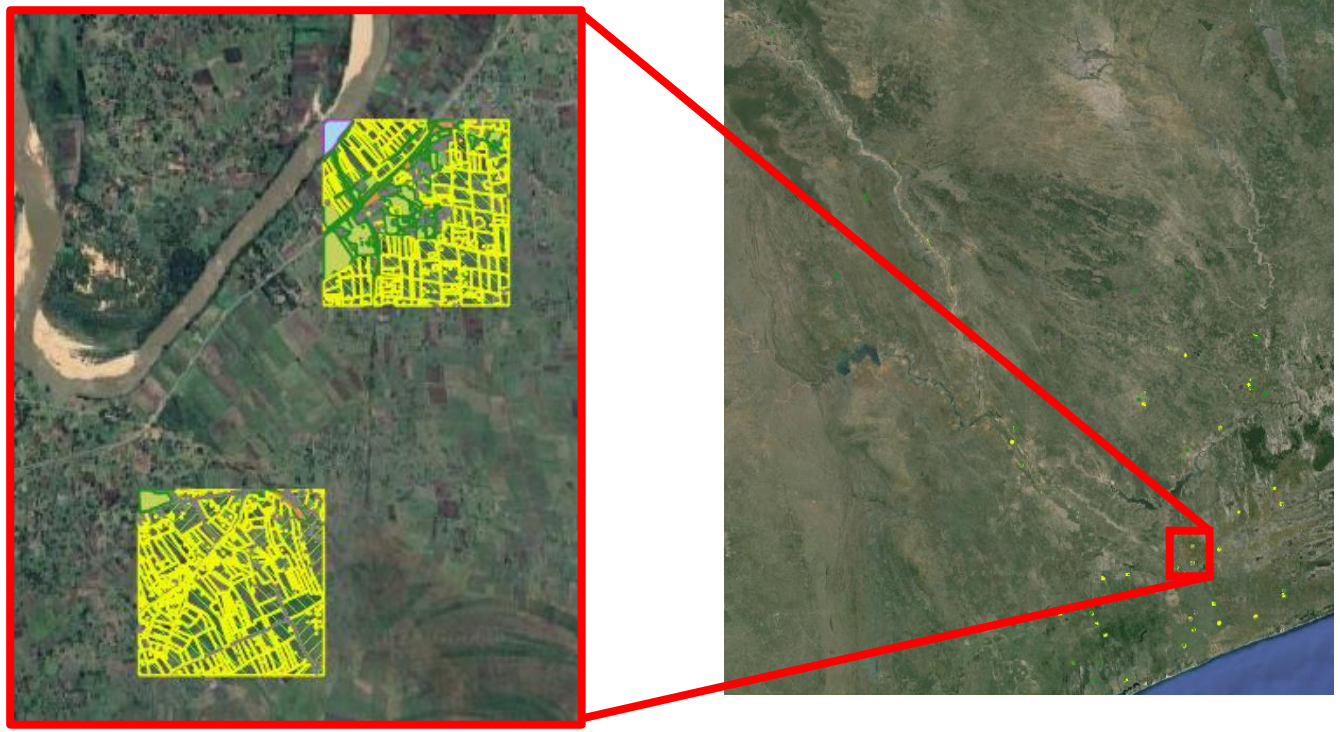
Cultivated vs Non Cultivated

	F1%	
	Esri 2023	PM 2023
uncultived	85.73	87.54
cultivated	46.86	72.40
	78.10	81.73



PM 2023

	uncultived	cultivated		
uncultived	248794	44859	293653	84.72
cultivated	25974	68118	94092	72.40
	274768	112977	387745	
	90.55	39.71		81.73

Esri 2023

	uncultived	cultivated		
uncultived	255091	38562	293653	86.87
cultivated	46354	47738	94092	49.26
	301445	86300	387745	
	84.62	44.68		78.10

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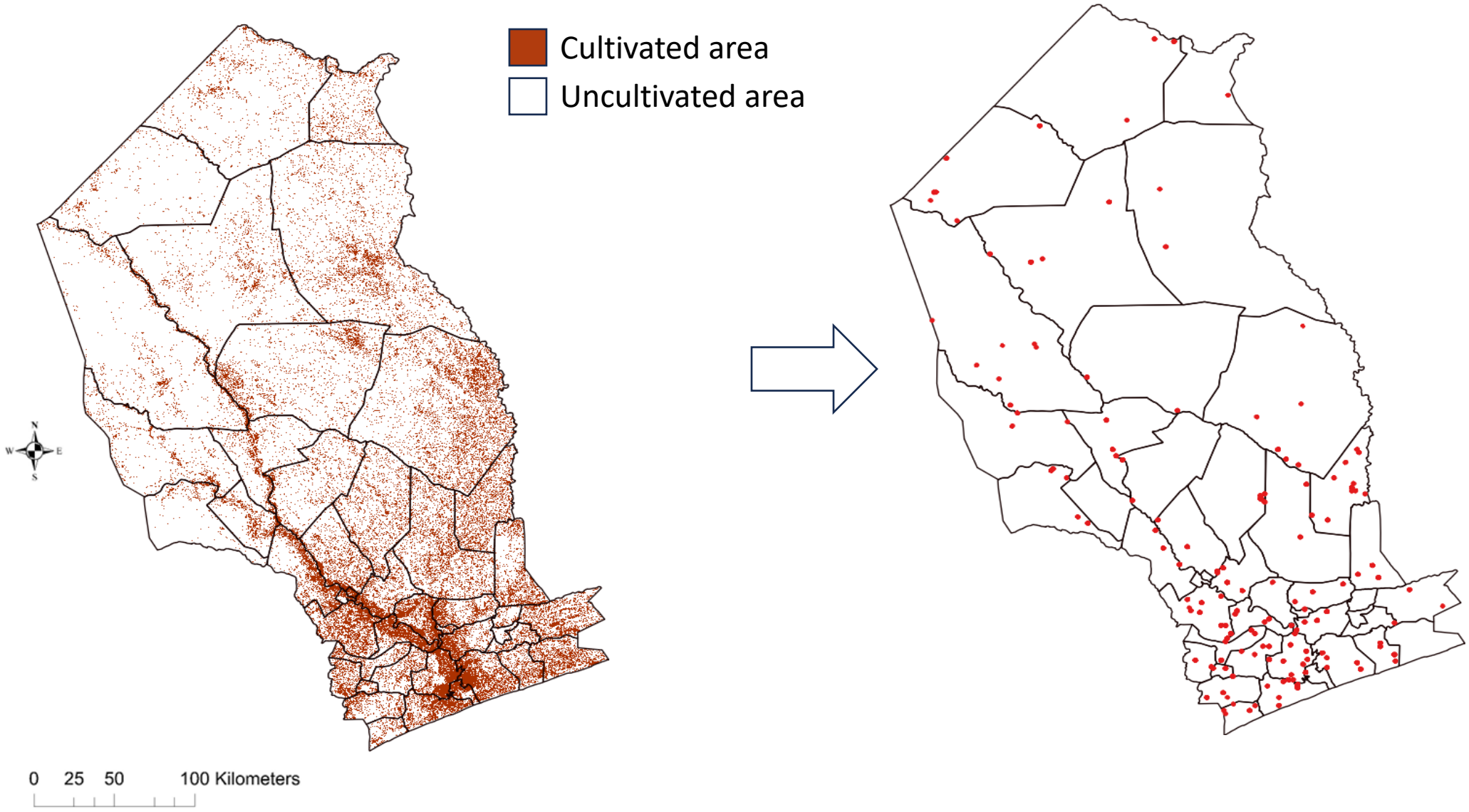
Results



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Using UAVs/drones to map SAs

Mapping the Sampling Area (SA)s with a UAV/drone:

- Speed up the field data collection:
  - Reference data for the manual enumeration with the app;
  - Both data sets are complementary and represent an ideal data mix.
- High-resolution reference data for satellite data analysis;
- Derive quantitative data on:
  - Crop types cultivated;
  - Crop availability in the segments;
  - Crop health and stress status.

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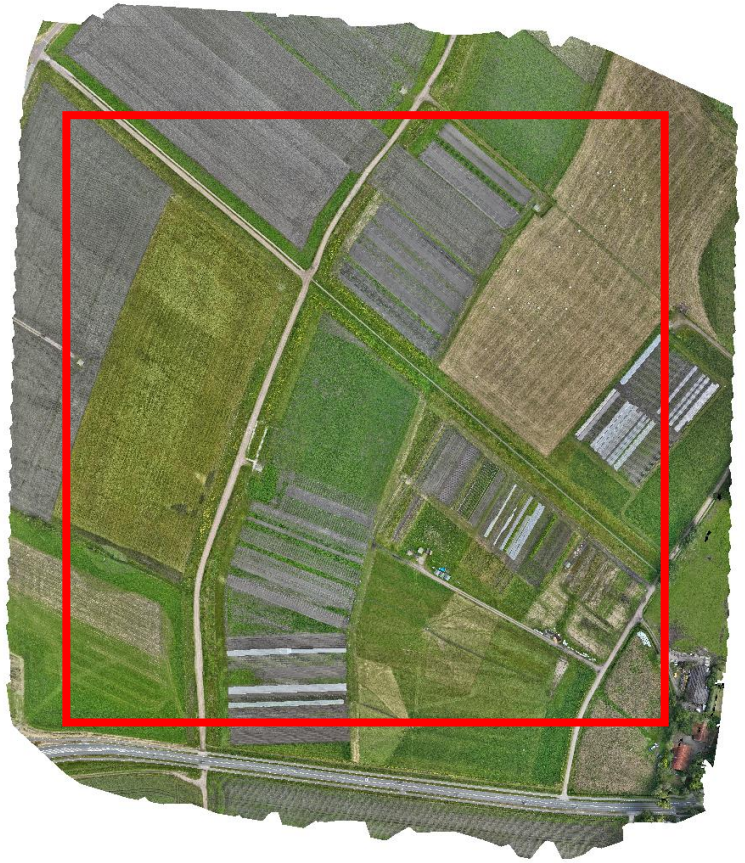
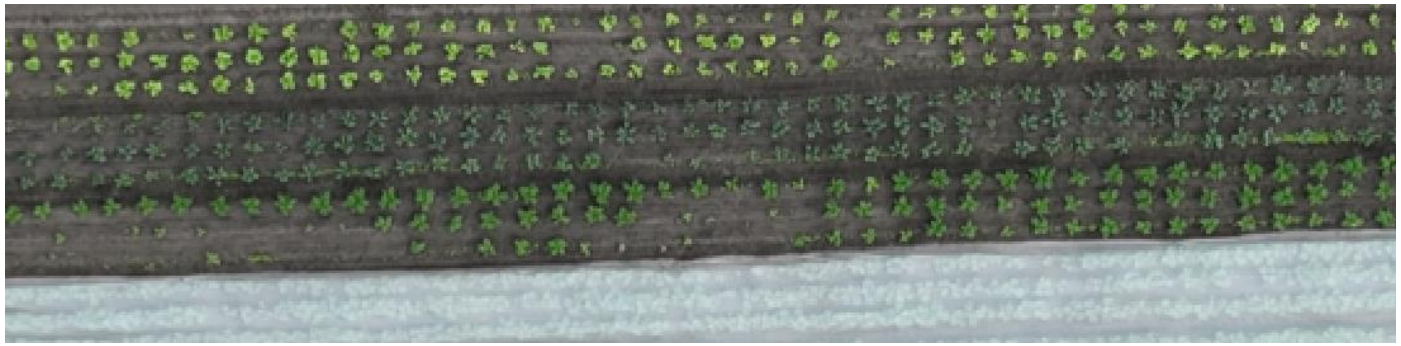
Using UAVs/drones to map SAs

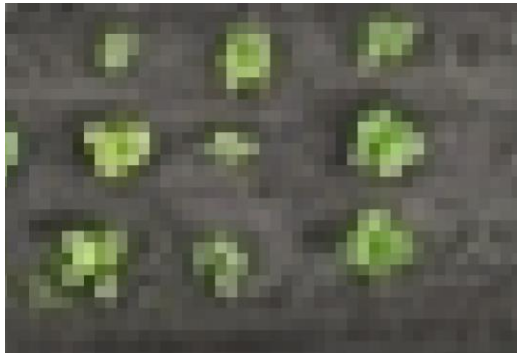
We did a test and here are the results:



- Individual crops are distinguishable:



- Several pixels (<5cm) per crop allow crop health assessment:



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Using UAVs/drones to map SAs

- 45 minutes required for mapping an SA (500x500m)
  - 15 min pre flight preparation;
  - 15 min flight time;
  - 15 min post flight preparation.
- UAV gathers RGB data and different spectral bands:
  - RGB orthomosaic (on the right) <5cm pixel size;
  - Digital surface model <5cm pixel size;
  - Green, red, red-edge and near infrared band ; orthomosaics <5cm pixel size;
  - 3D-point cloud;
  - NDVI and EVI index.

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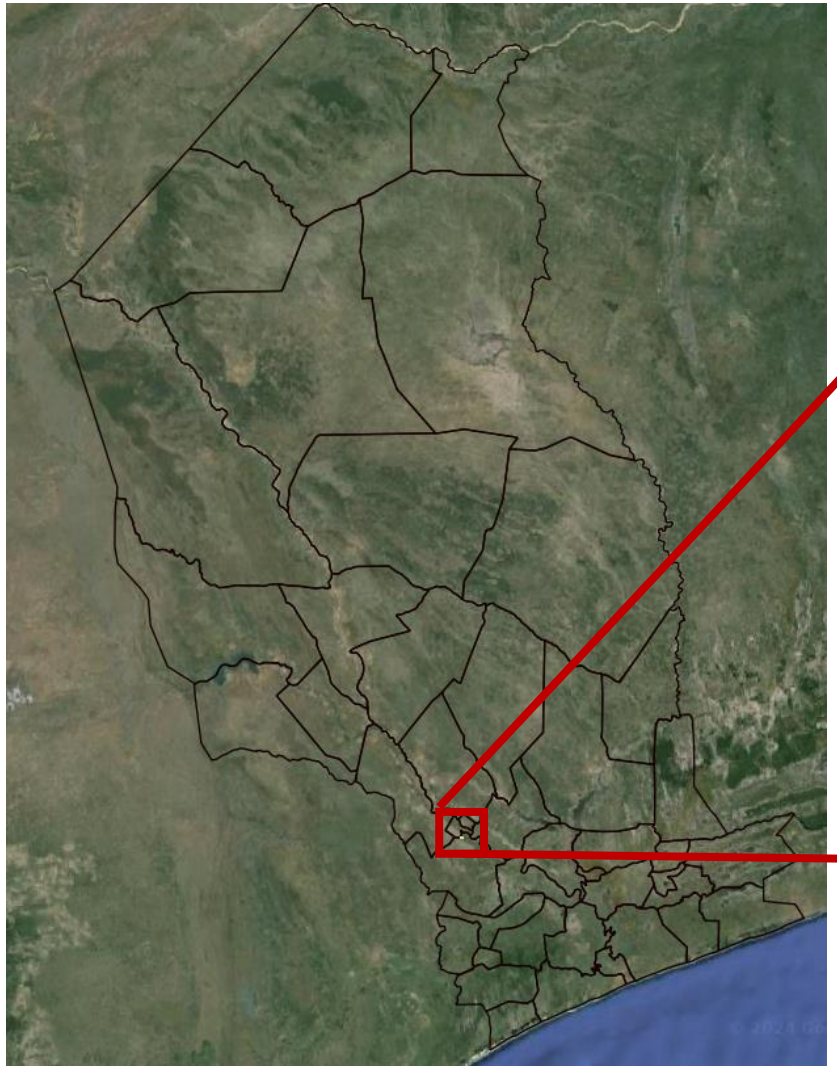
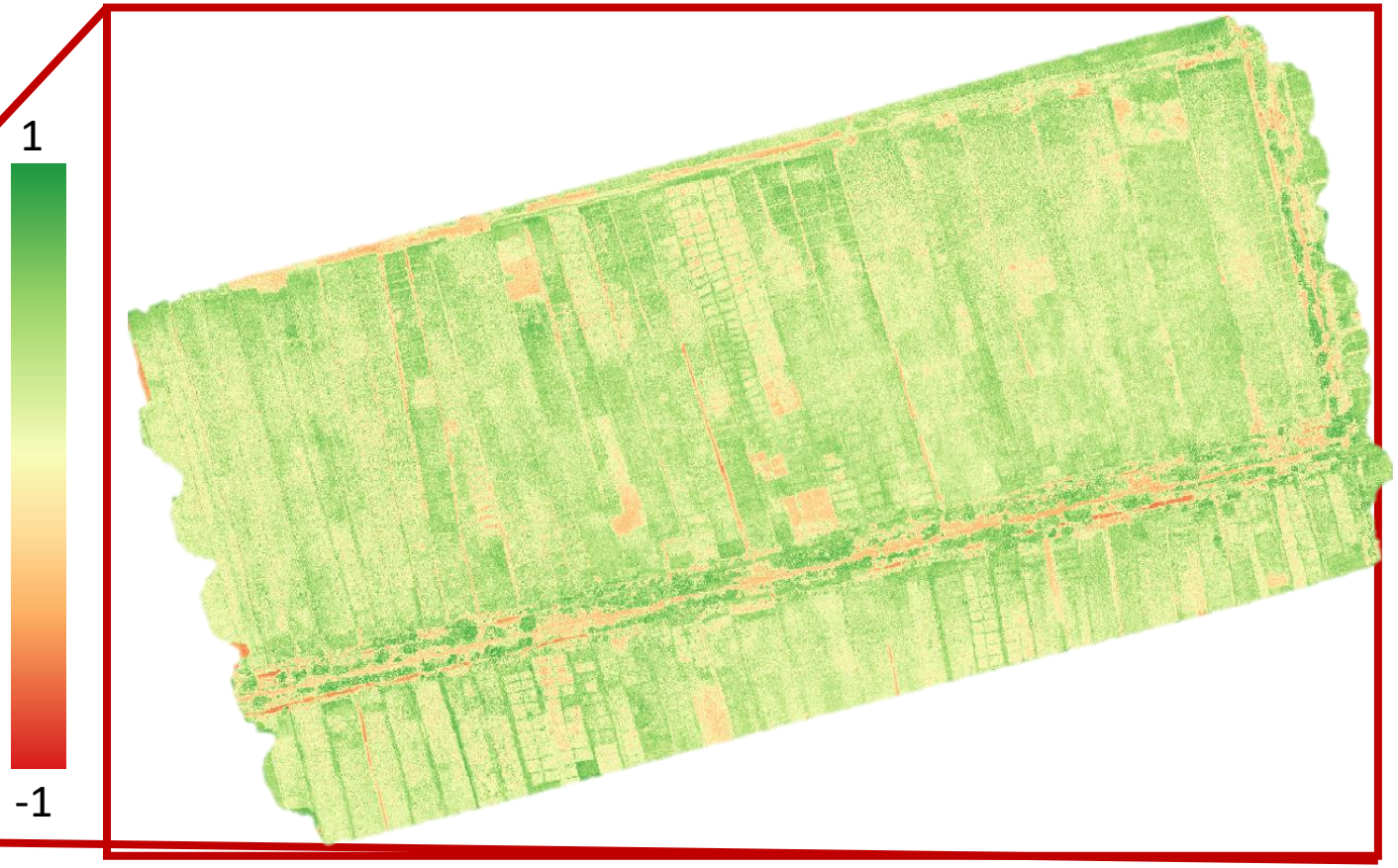
Using UAVs/drones to map SAs





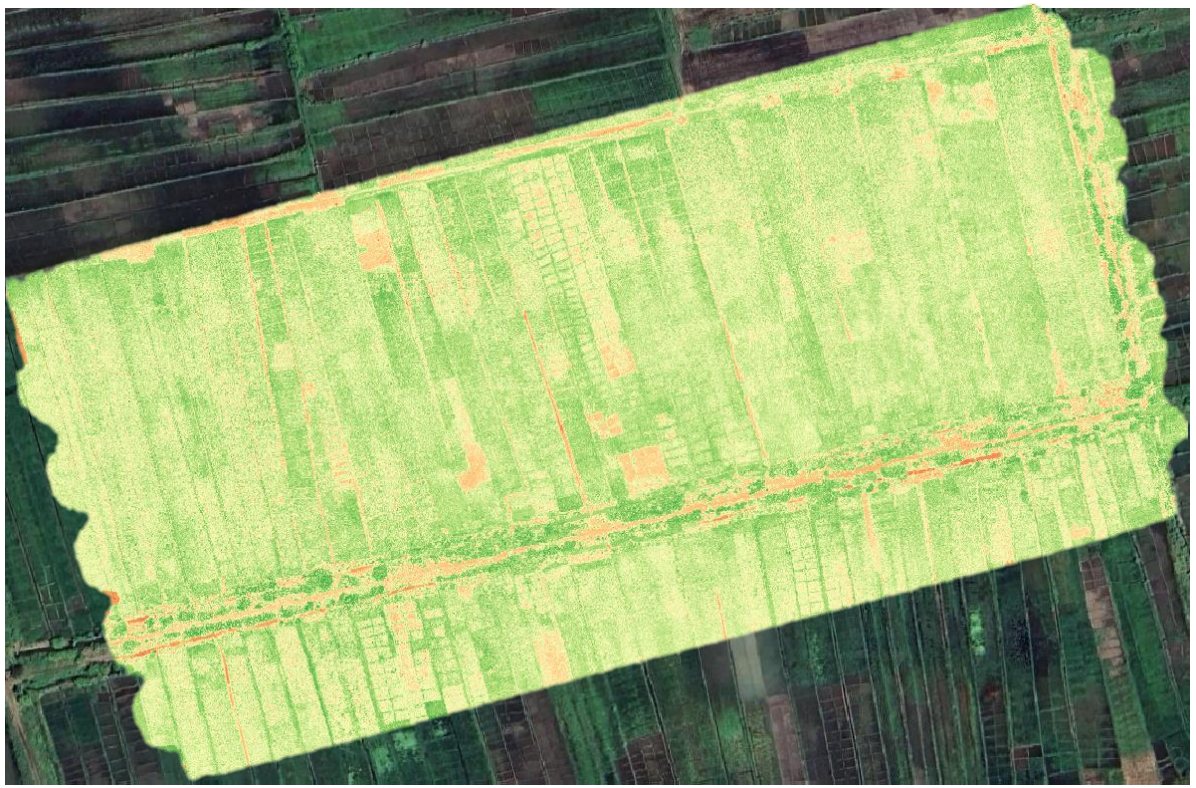
NDVI

UAV data acquired in 2024
Area: Chokwe over Rice fields

Ministry of Agriculture, Food and Rural Affairs
Republic of Korea

Using UAVs/drones to map SAs

50cm



5cm

UAV data acquired in 2024
Area: Chokwe over Rice fields

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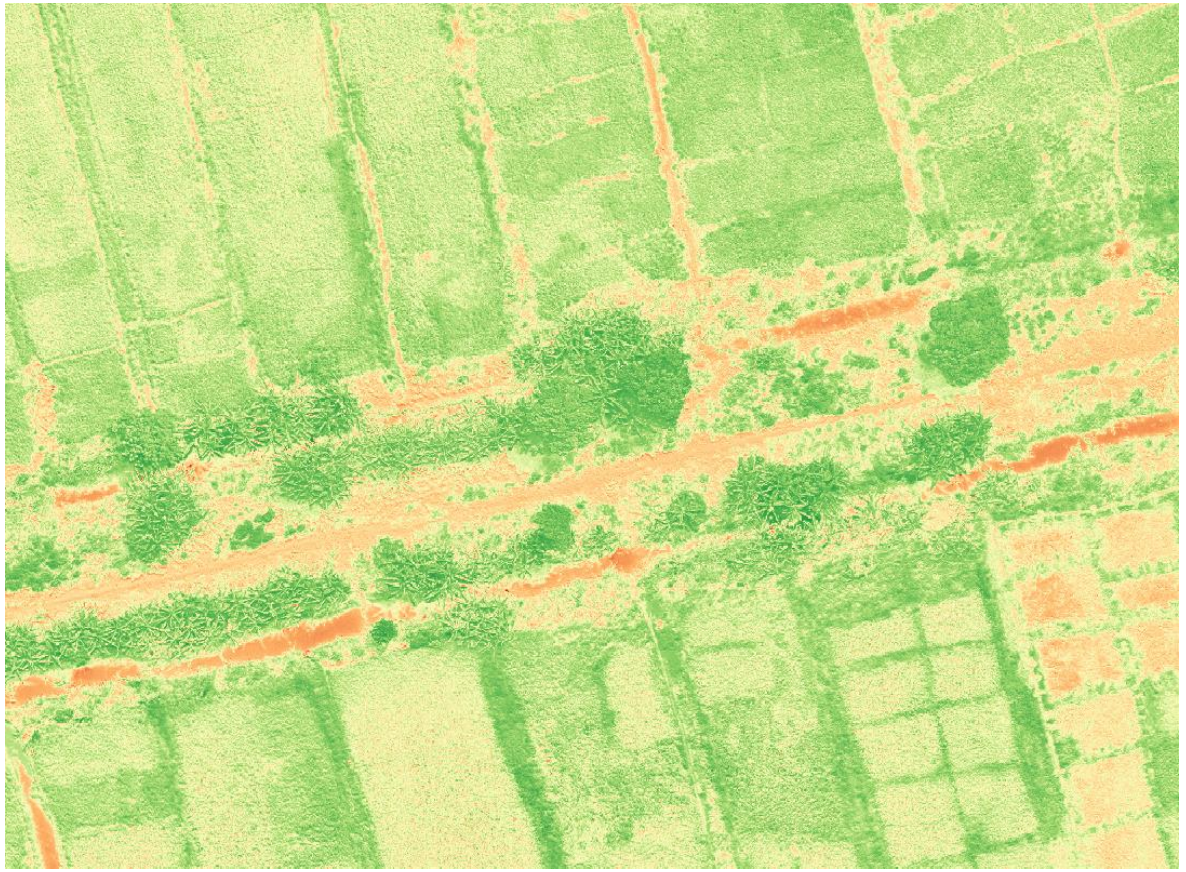
Using UAVs/drones to map SAs

50cm



5cm

UAV data acquired in 2024
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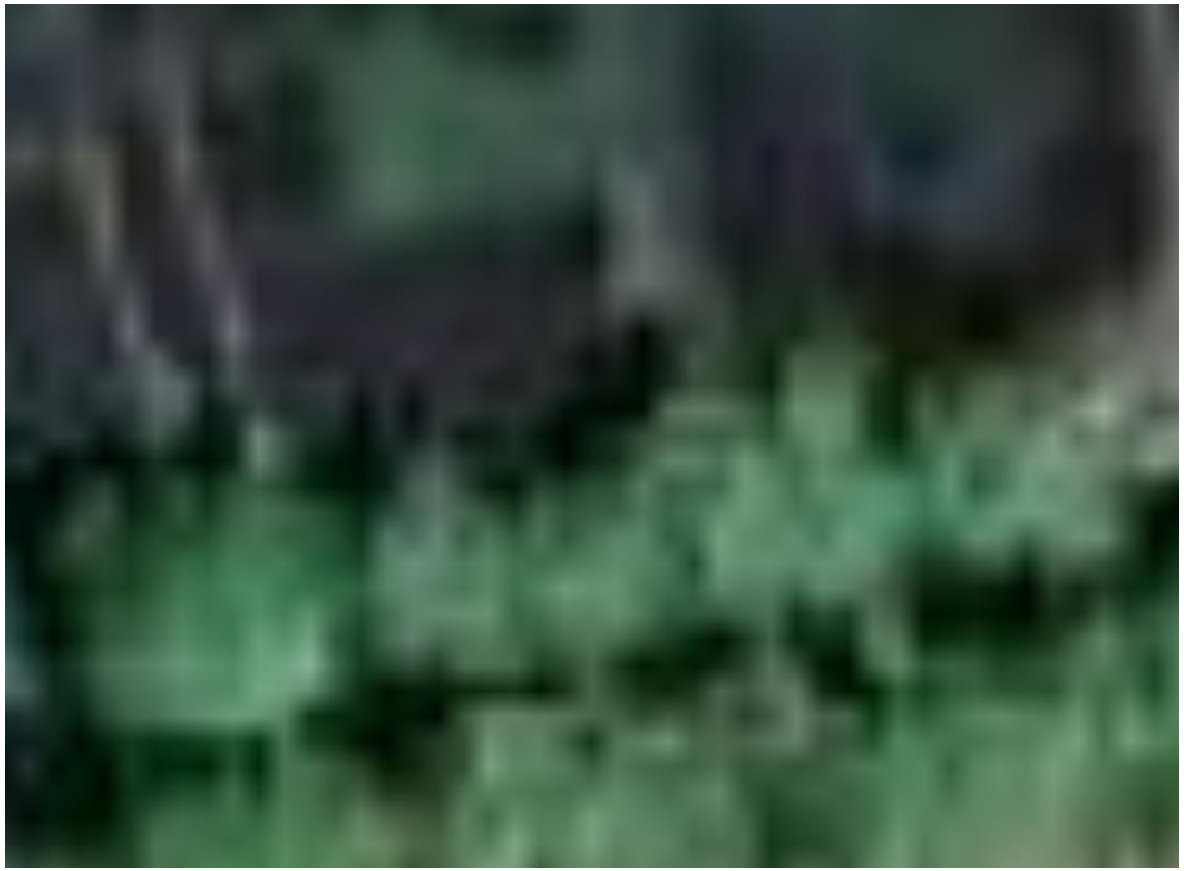
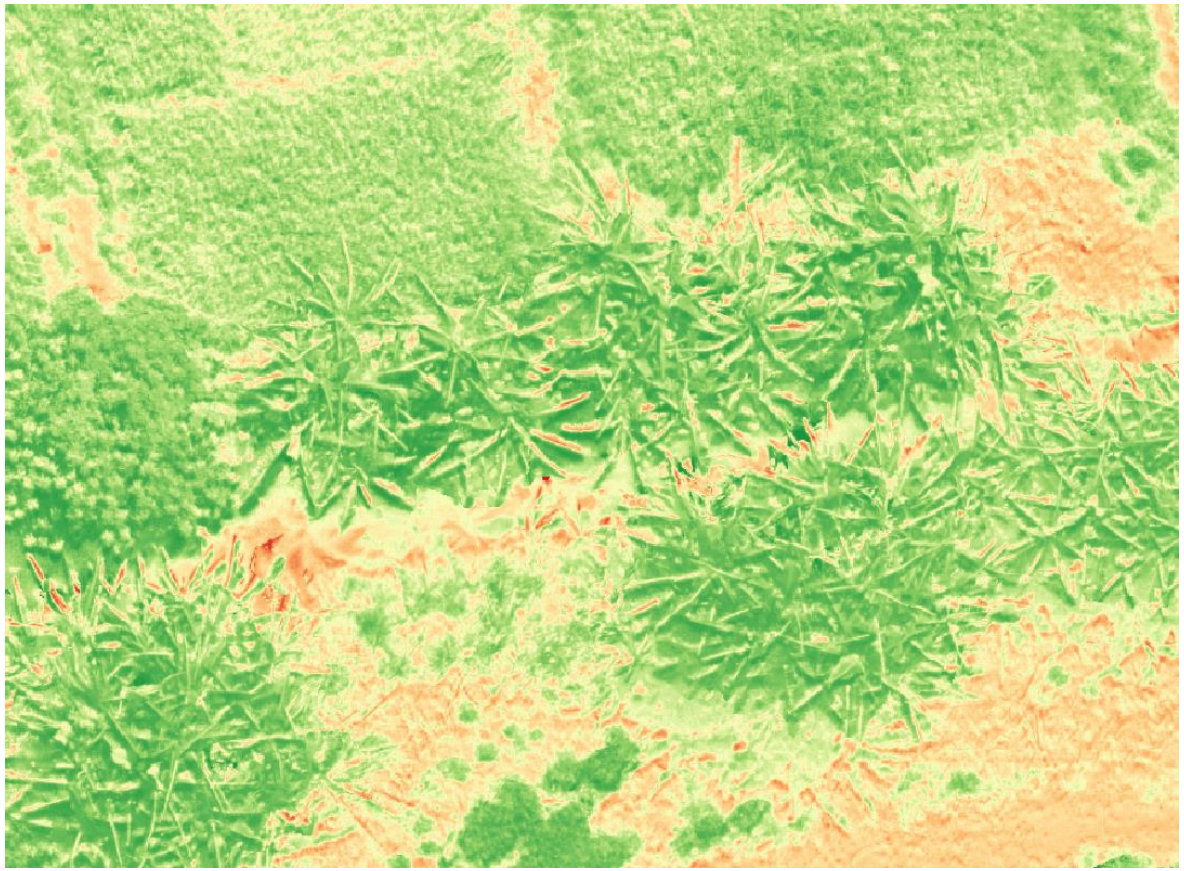


50cm



5cm

UAV data acquired in 2024
Area: Chokwe over Rice fields

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In summary

- Given the promising preliminary results, we can conclude that Sentinel-1 and Sentinel-2 have the potential to map crop types in Mozambique.

- Working at local scale, the preliminary land cover map:
  - captures the location of agricultural areas better than the publicly available ESRI global land cover product;
  - Provides detailed spatial information for the selection of the sampling sites.

- SAs can be mapped in 45 min total time. Data on crop levels can be collected to improve agricultural statistics. UAV/drone data can be used as reference for enumerator collected data.

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