

My learning journey as SERVIR SCO Intern...

FARM BOUNDARY EXTRACTION USING EO DATA AND SEGMENTATION

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THANKS TO

Mentors:

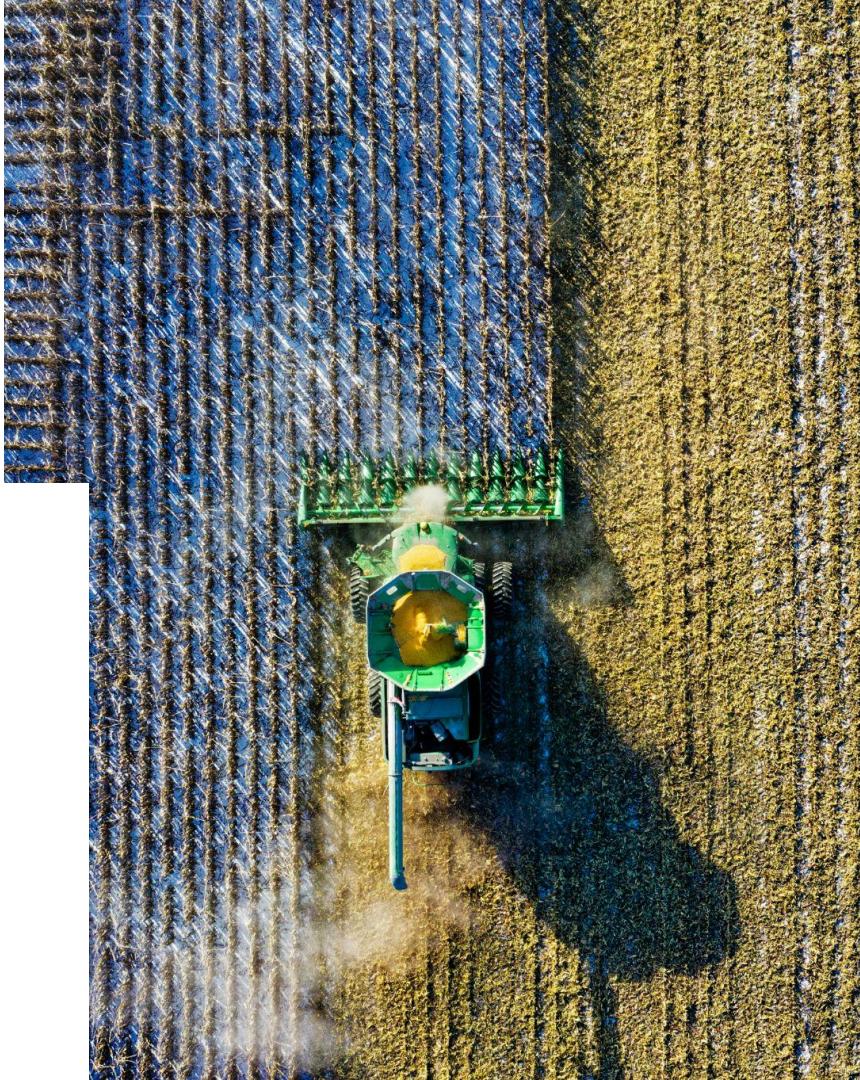
Dr. Aparna R. Phalke
Biplov Bhandari

ITC Supervisor:

Prof.Dr.Ir. Claudio Persello

Problem Background

- **Spatial field data is essential** to provide actionable information for agricultural management.
- Conventional methods of manually digitizing the farm boundary are **not effective and costly**.
- There is a need to provide **automatic farm boundary extraction model** using satellite imagery data.



DL FOR EO?

Deep Learning (DL) have been applied for various application in Earth Observation (EO) technologies.

DL approach provides more accuracy in handling complex classification problems on EO data.

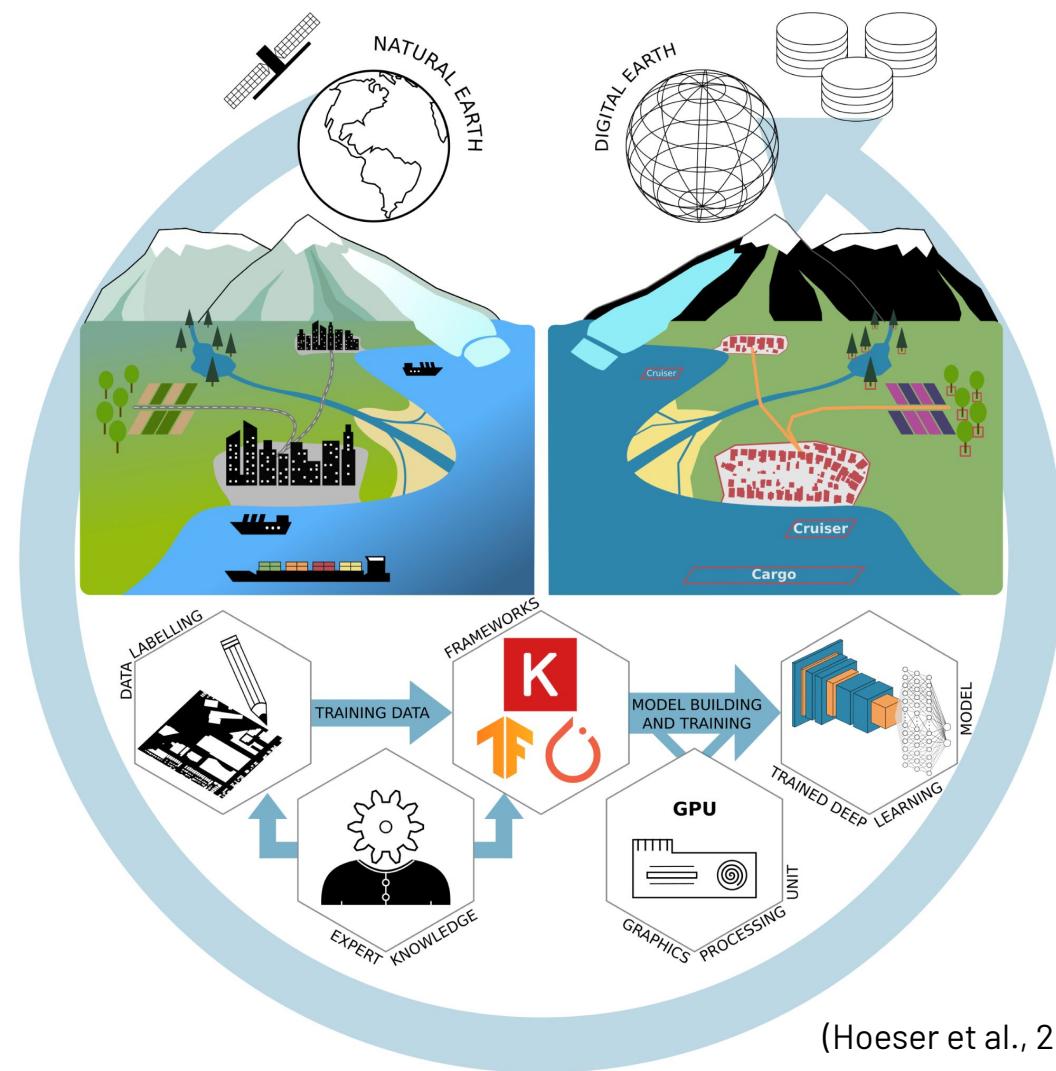




Image source: Spacenus

OBJECTIVE

Provide workflow on how to develop deep learning based farm boundary extraction model using earth observation data.

CHALLENGES

Farm:

- Different and complex form of the farm boundaries.

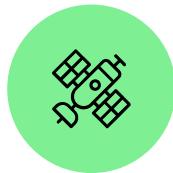
Reference data:

- To train a deep learning model, huge set of reference data of farm boundary is needed.
- Limited/Unavailable **farm boundary reference data**.

EO data:

- High resolution imagery is needed for small-farm boundary delineation.

PROPOSED WORKFLOW



01

Data Collection and
Preparation



02

Model Training



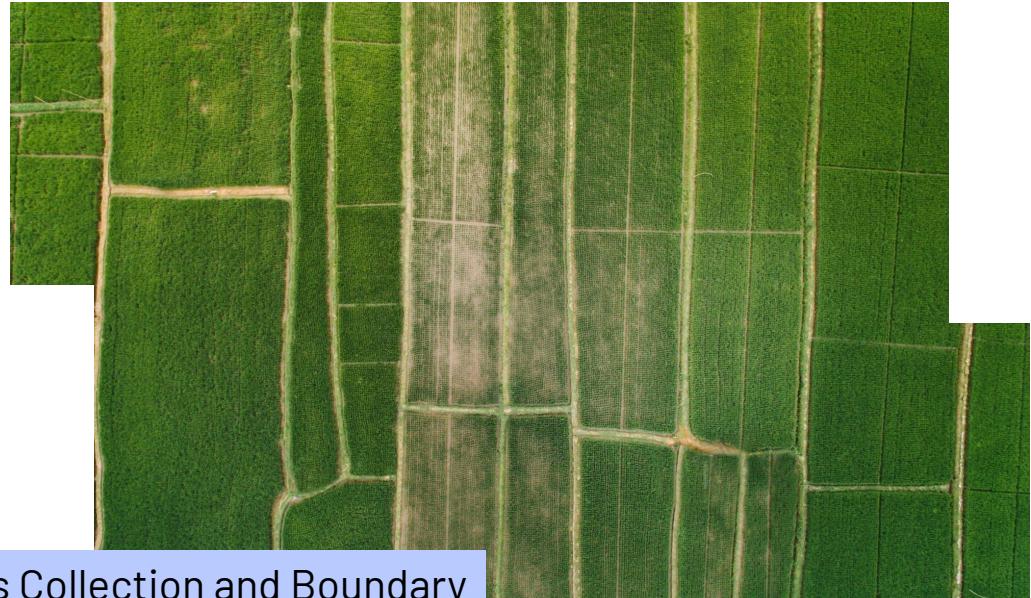
03

Model Fine-tuning

*This workflow can be used as a guide to provide farm boundary extraction model in other study areas.

01.

Data Collection & Preparation



Sentinel-2 Images Collection and Boundary
Reference Data Preparation

DATA COLLECTION



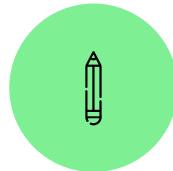
01

Focus study area selection
and 256x256 pixels grid
division



02

Sentinel-2 Images
download via GEE



03

Farm Boundary Mask:
Manual Digitation

*Grid/tiles will be used as training, validation, and test data

STUDY CASE: FARM BOUNDARY IN KENYA



ESRI Satellite World Imagery

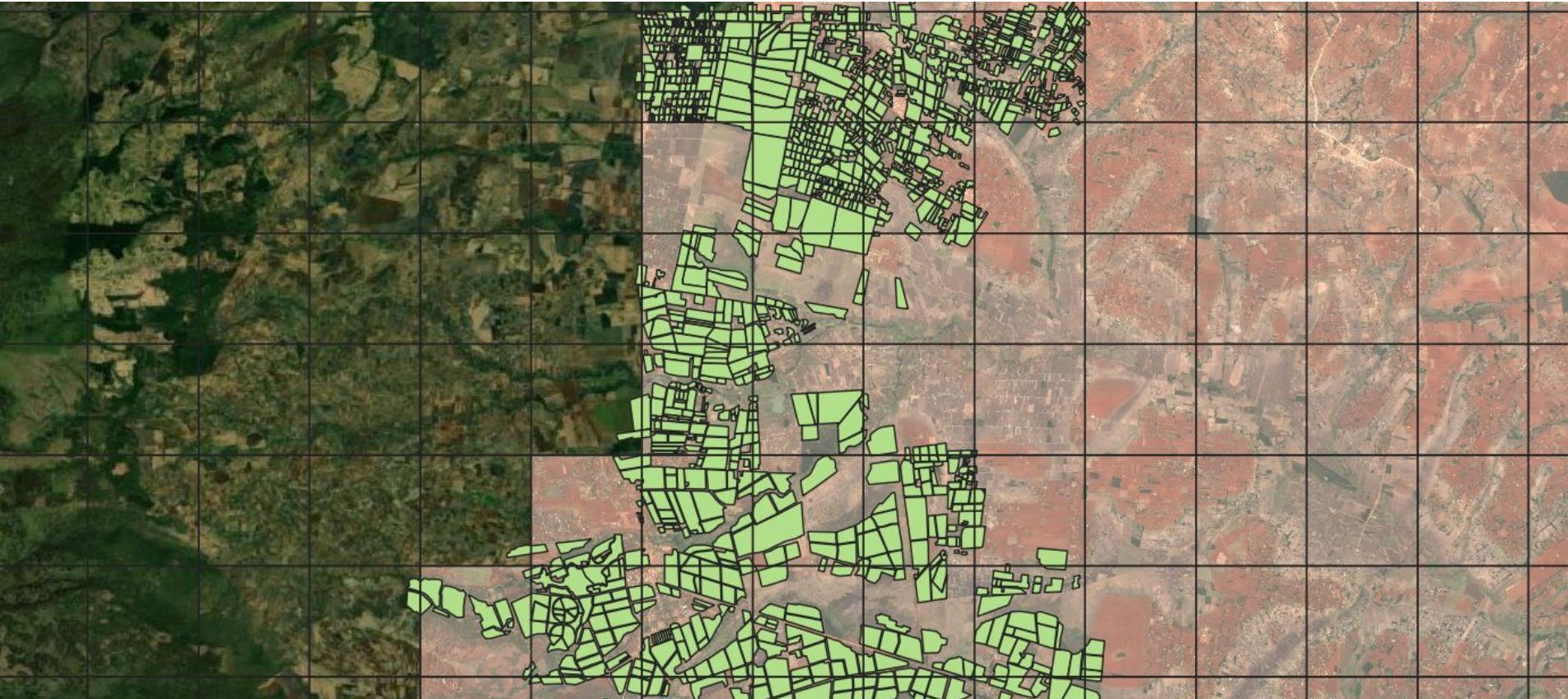
256x256 Tiles

Downloaded using geemap library



Mask Layer

Farm boundary manual digitation



Mask Layer

Rasterize: convert vector to raster files



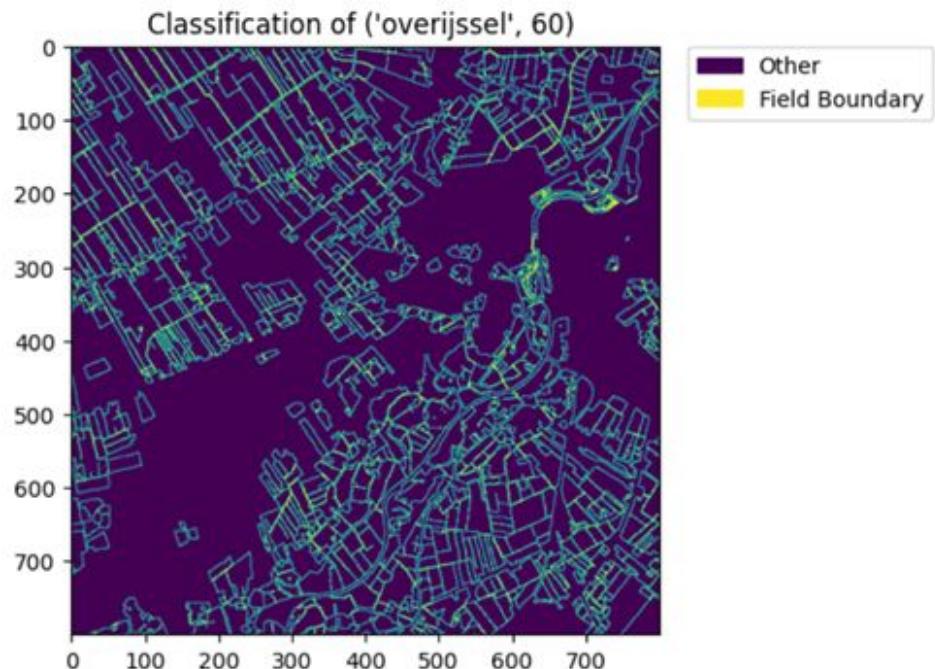
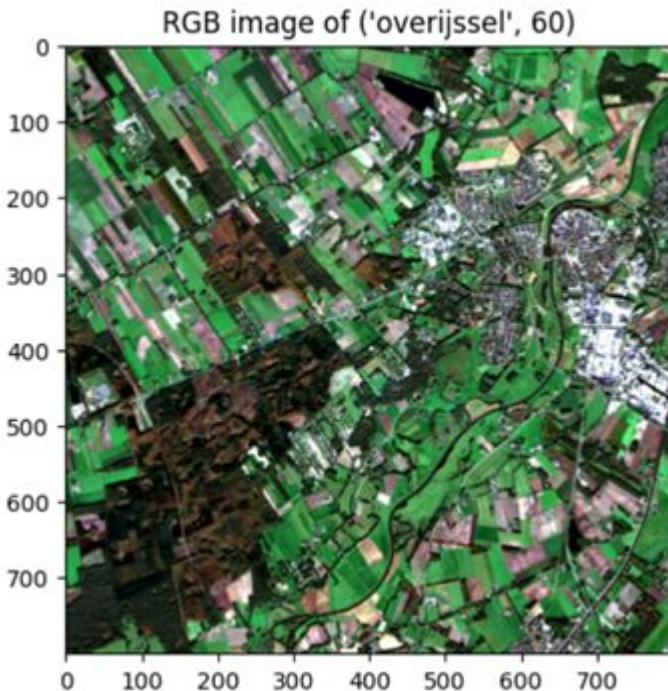
02.

U-Net Model Training



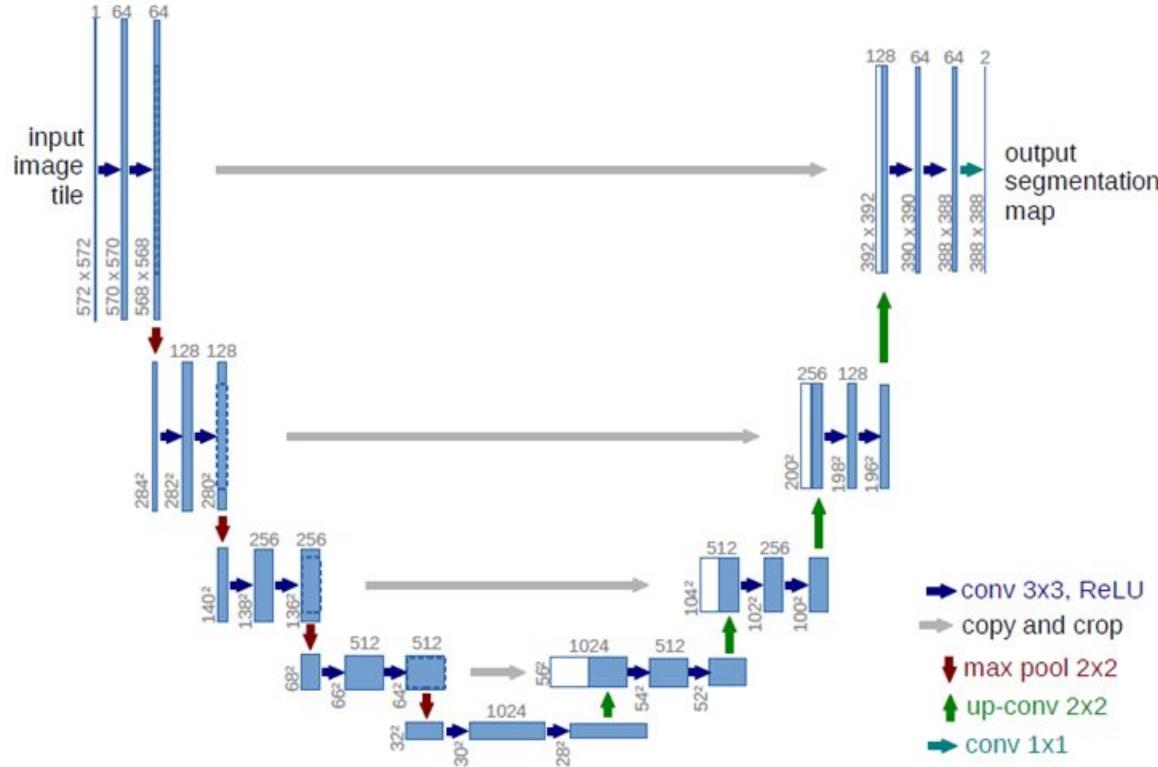
Training on the Netherlands Farm Boundary
Dataset to provide pre-trained weight

Why using Netherlands data? ---



NL data provide a total of 122 Sentinel-2 images with the corresponding farm boundary masks (with the size of 800x800 pixels)

Why using U-Net model?



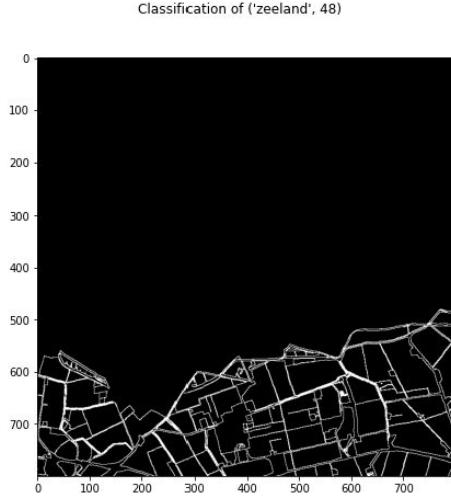
(Weng & Zhu, 2015)

Model Development Reference

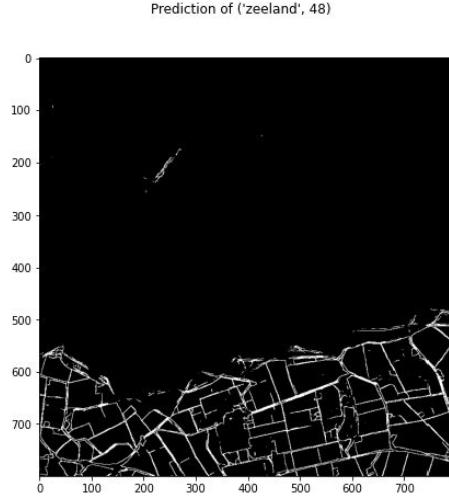
Resing et al. (2021) successfully developed a U-Net-based model for the Netherlands farm boundary delineation. The model is trained on a total of 109 training images and 13 test images. The U-Net model obtained 58% of the F1 score in delineating the farm boundaries.



(a) Original



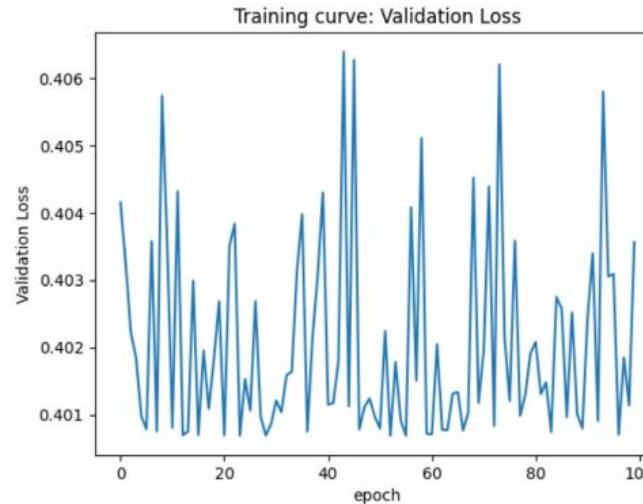
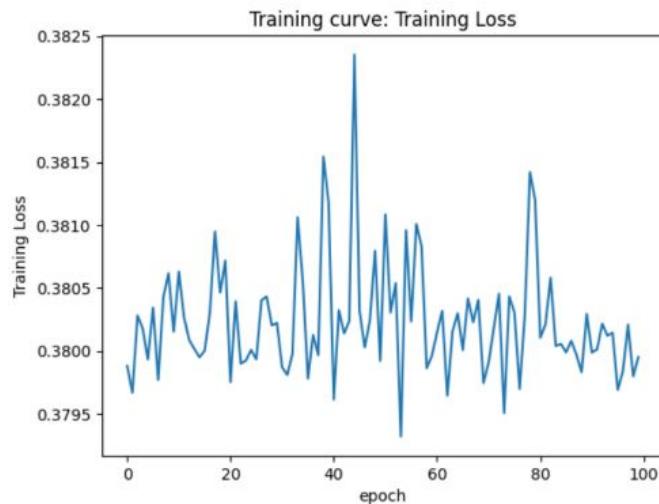
(b) Reference



(c) Prediction

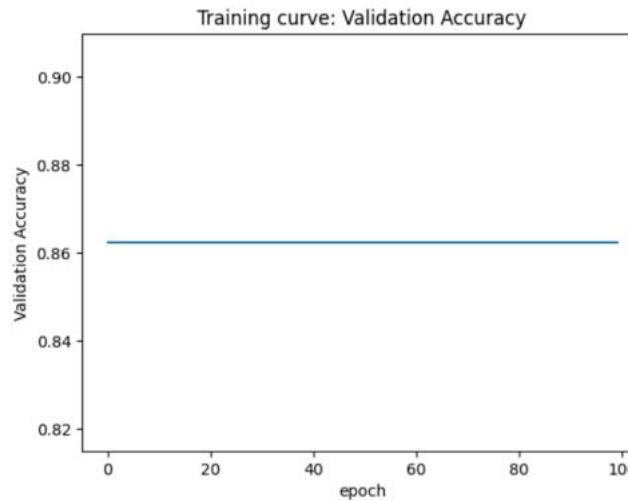
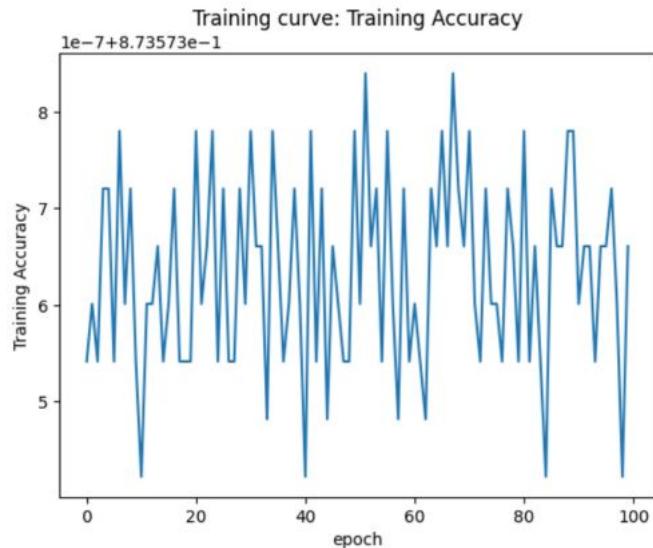
Trials based on Resing et al. (2021) ---

Tried to replicate the works by Resing et al. (2021) by following the documentation, but **obtained different results.**



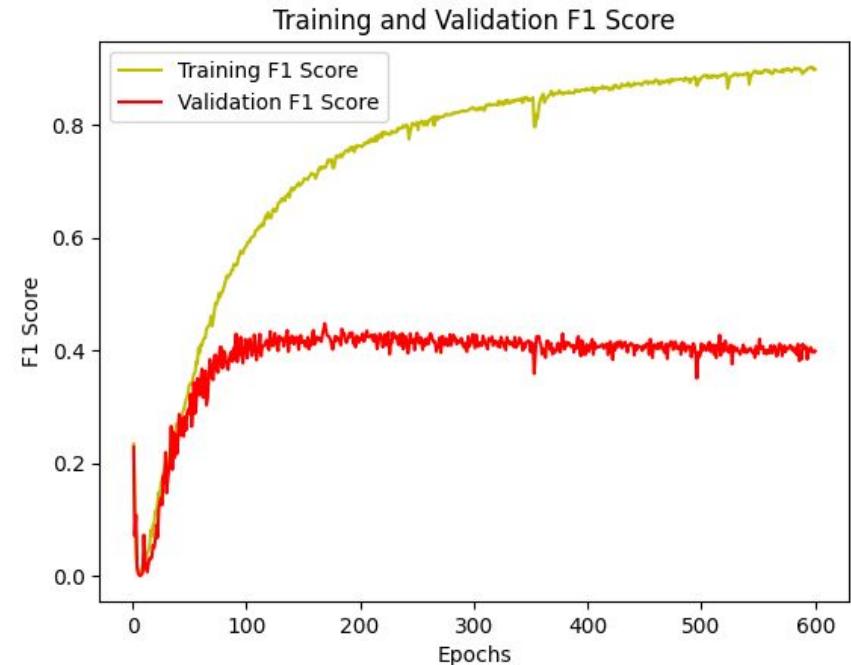
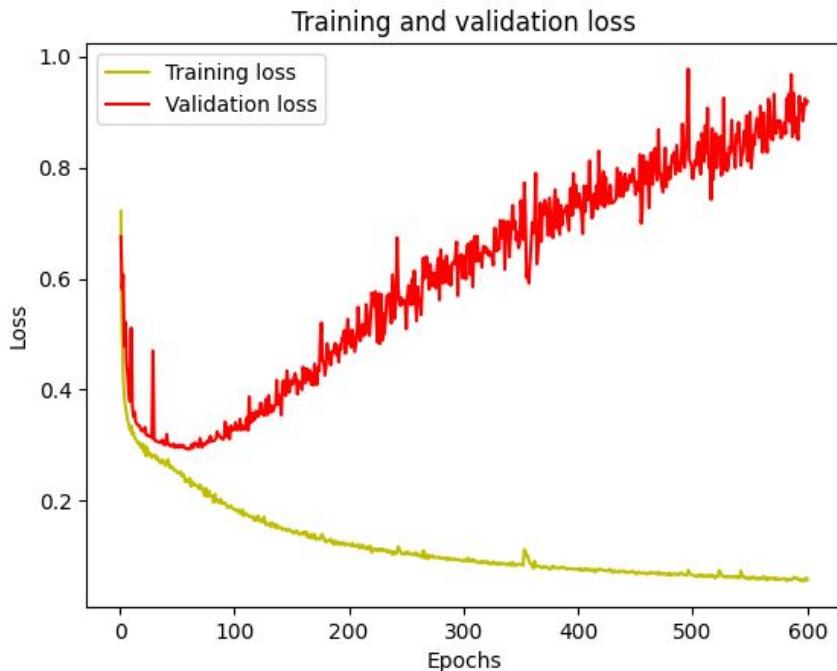
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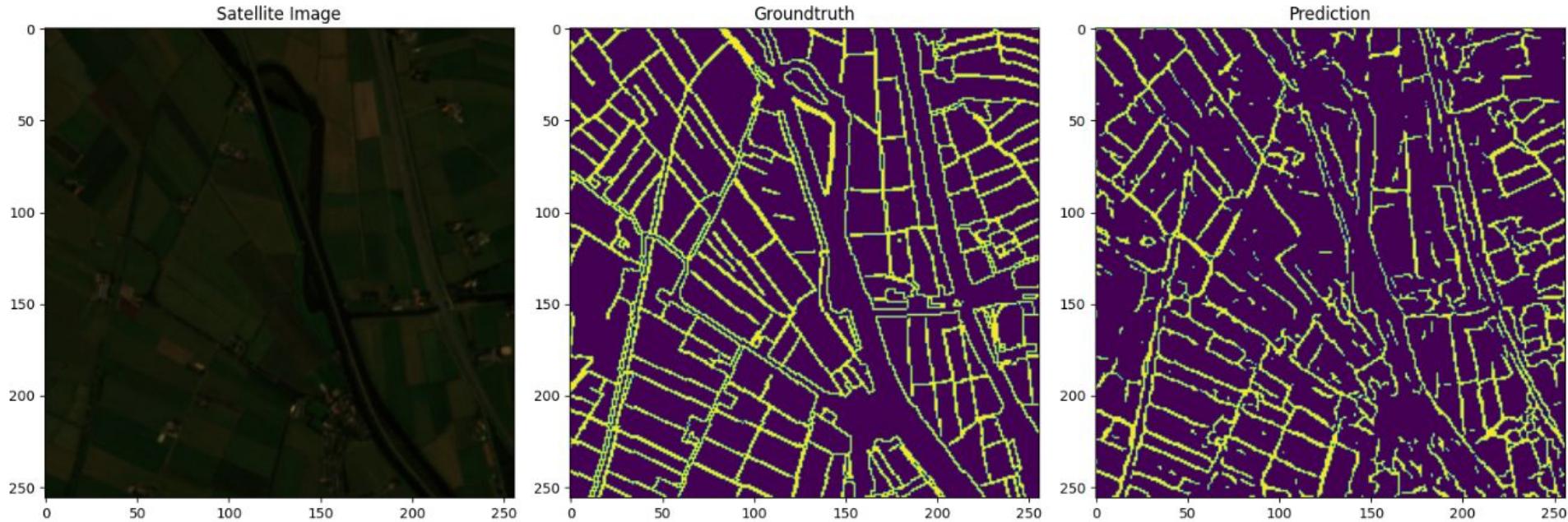
Trials using another U-Net model

Used U-Net model from segmentation_models library by Qubvel ([Github](#))



Trials using another U-Net model

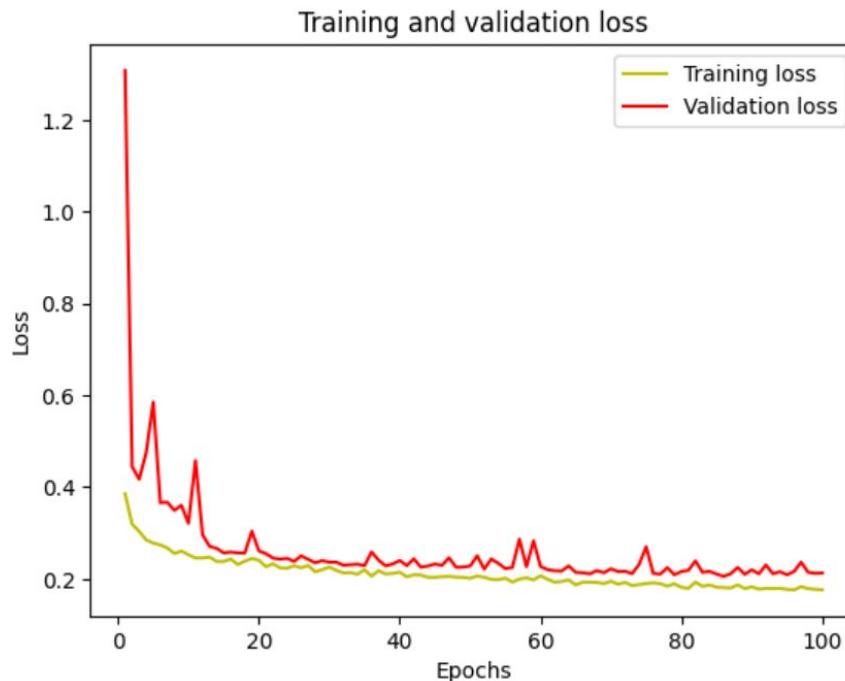
Used U-Net model from segmentation_models library by Qubvel ([Github](#))



**Finally... found the better U-Net
model configuration**

U-Net model trained on NL data

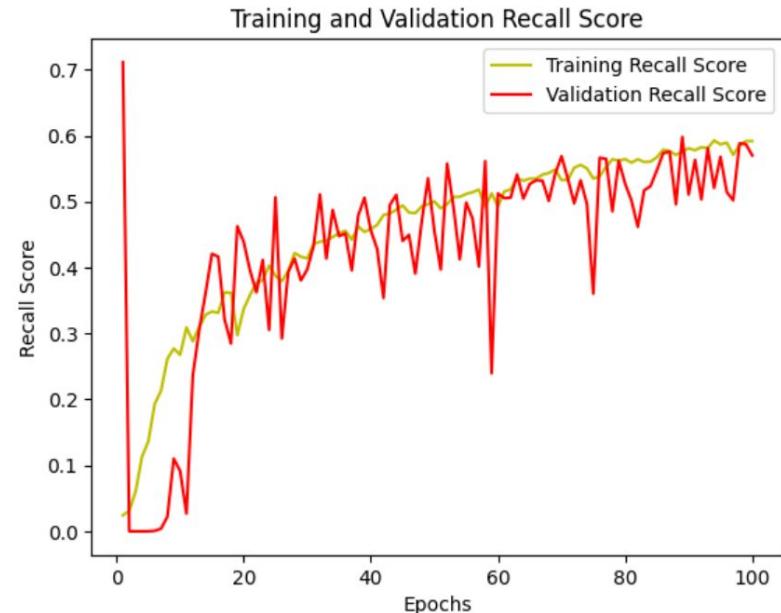
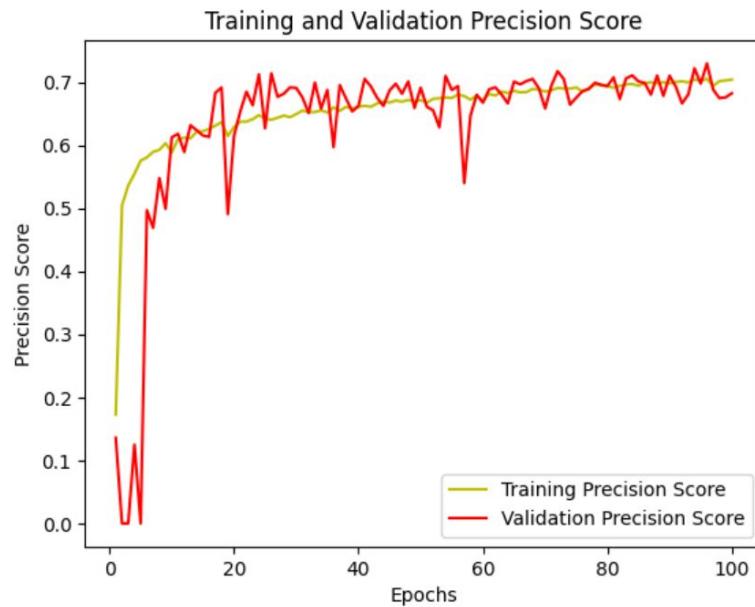
Training and validation loss graph for every epoch



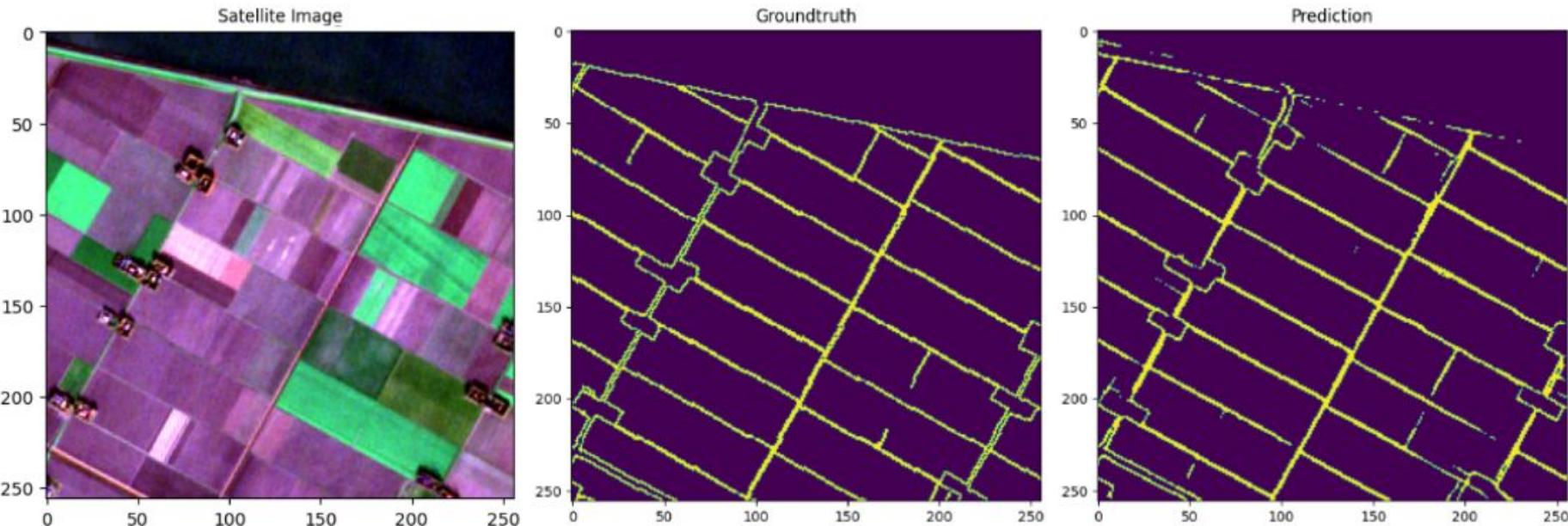
Training Settings:

- Batch Size: 16
- Number of Epoch: 100
- Optimizer: ADAM
- Loss Function: Binary Cross-Entropy
- Learning Rate: 0.0001

U-Net model trained on NL data



Prediction Result on Test Data



This model obtained a **0.65 F1 score** tested on the test data (not included in the training process).

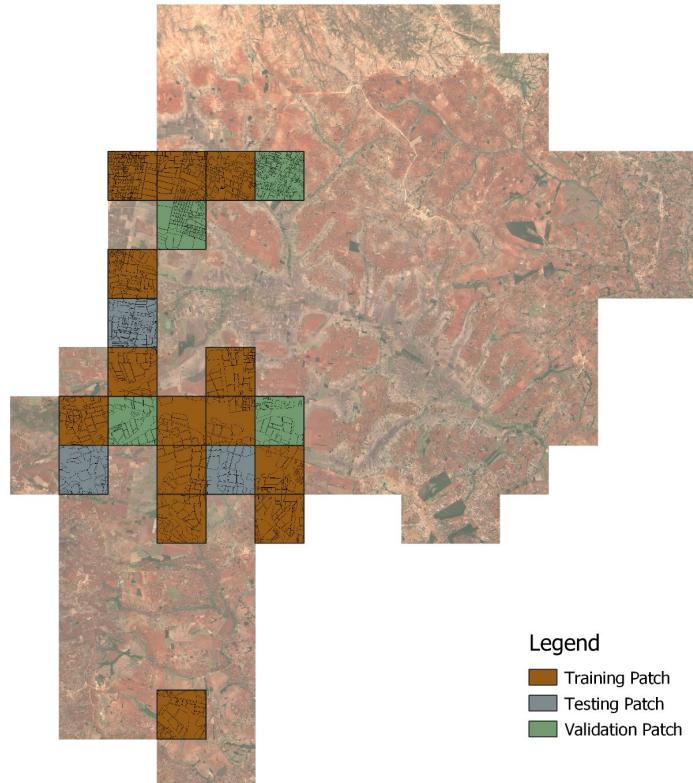
03.

U-Net Model Fine-tuning



Fine-tune on Kenya dataset using
pre-trained weight

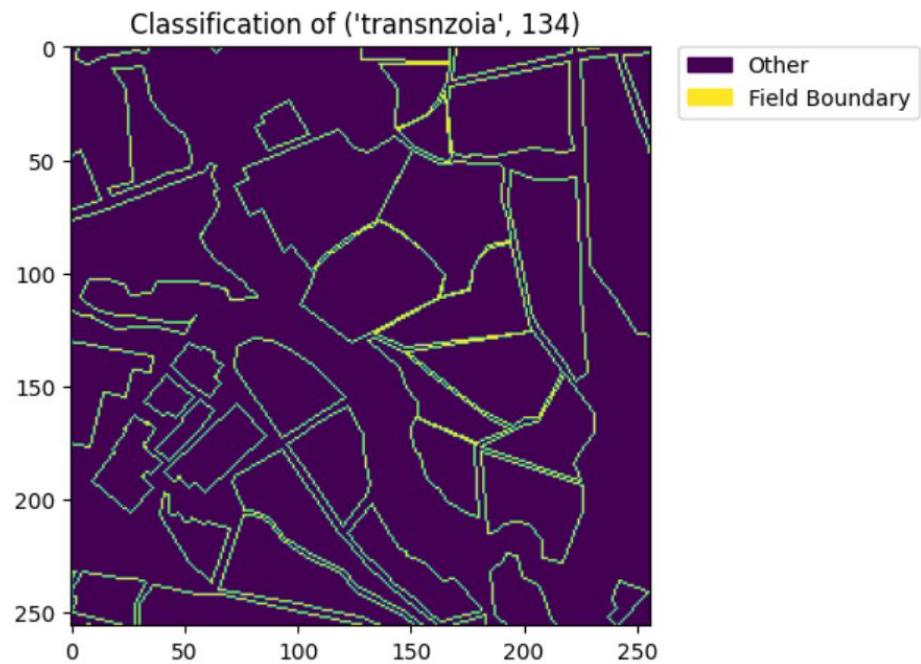
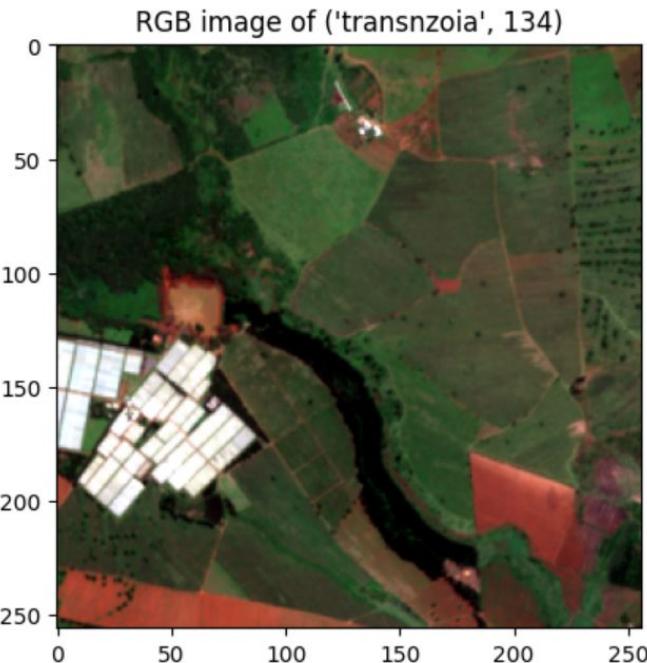
Kenya Data Division



From the manual digitation process, a total of 21 patches were obtained. Divided into:

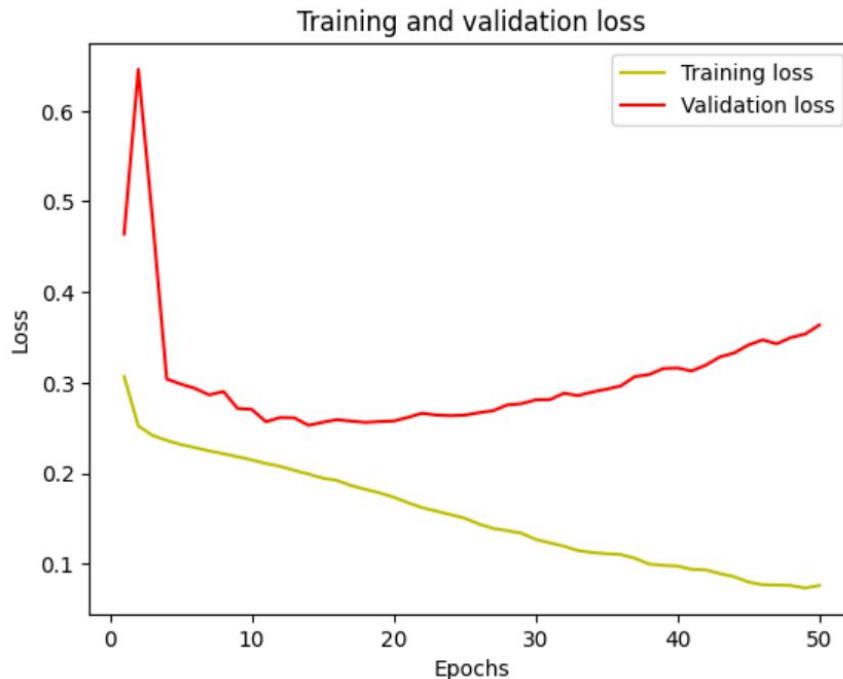
- 14 patches for training
- 4 patches for validation
- 3 patches for testing

Kenya Data Loader



U-Net model trained on KE data

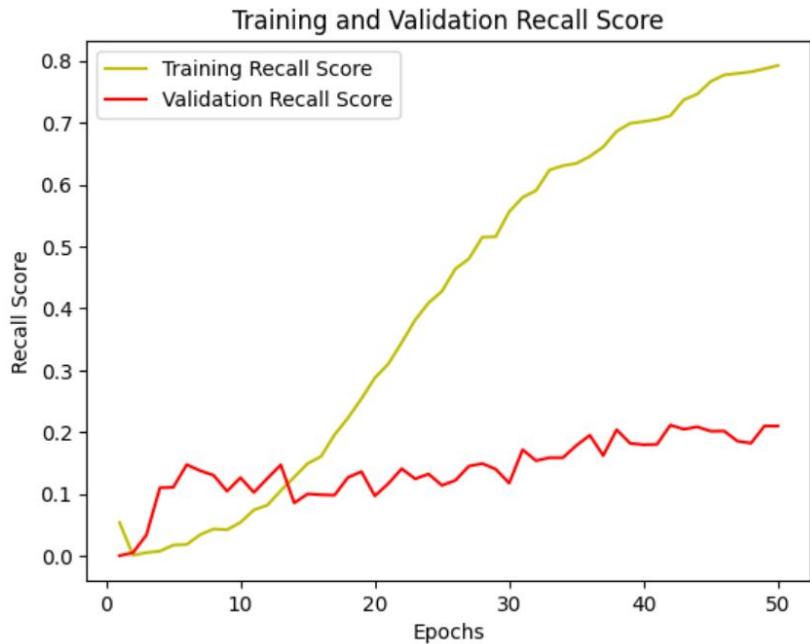
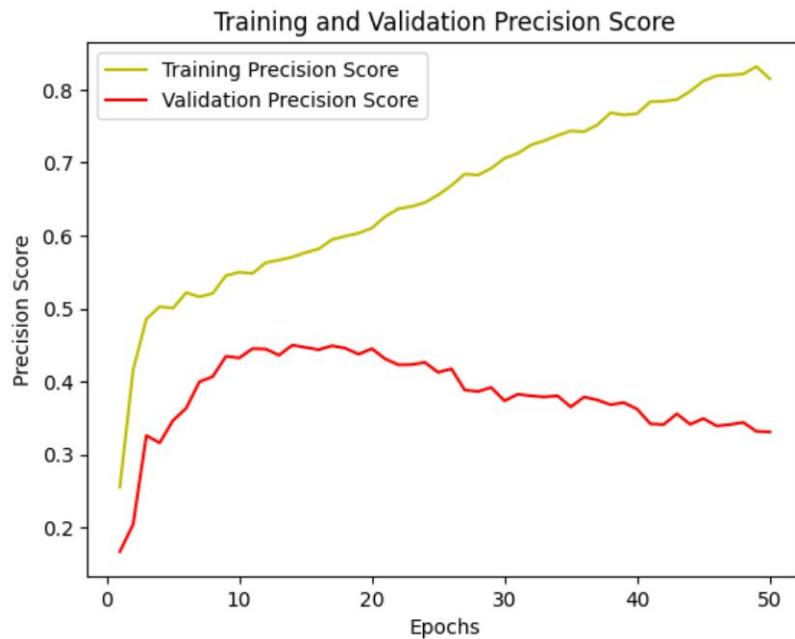
Training and validation loss graph for every epoch



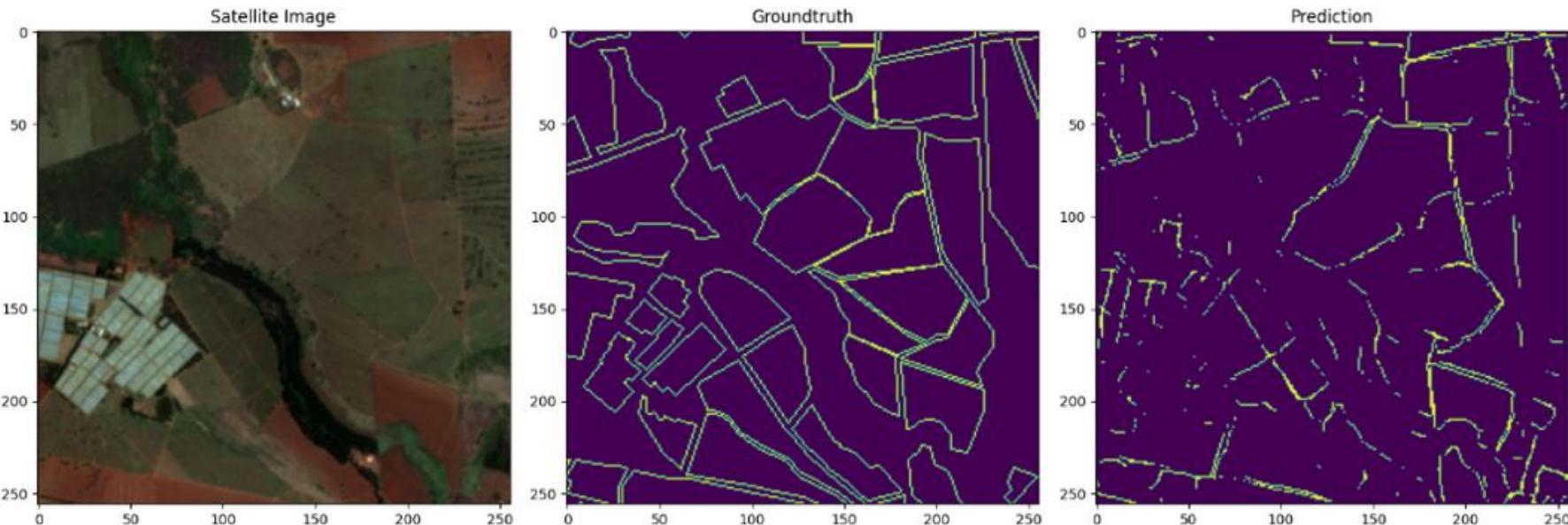
Training Settings:

- Batch Size: 8
- Number of Epoch: 100
- Optimizer: ADAM
- Loss Function: Binary Cross-Entropy
- Learning Rate: 0.0001

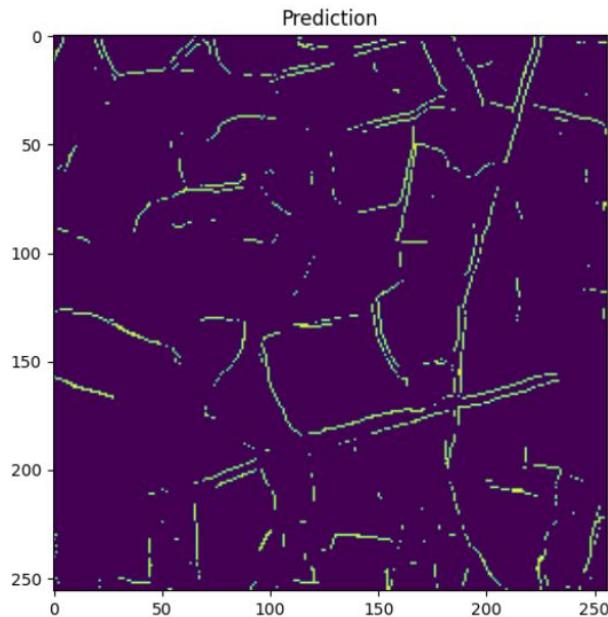
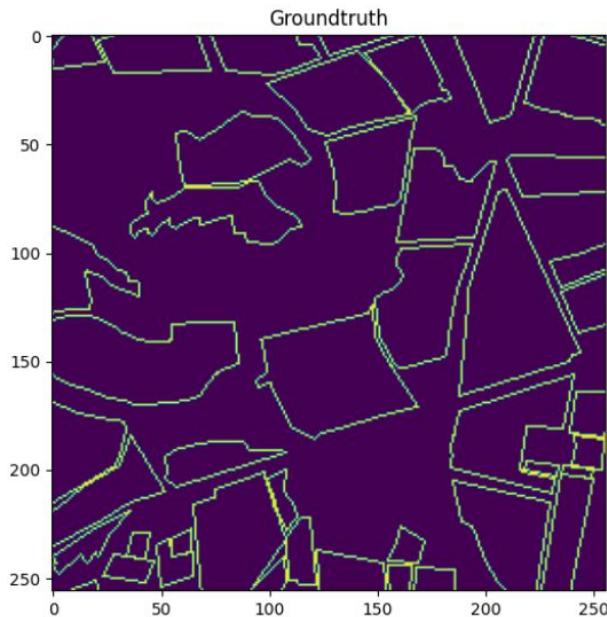
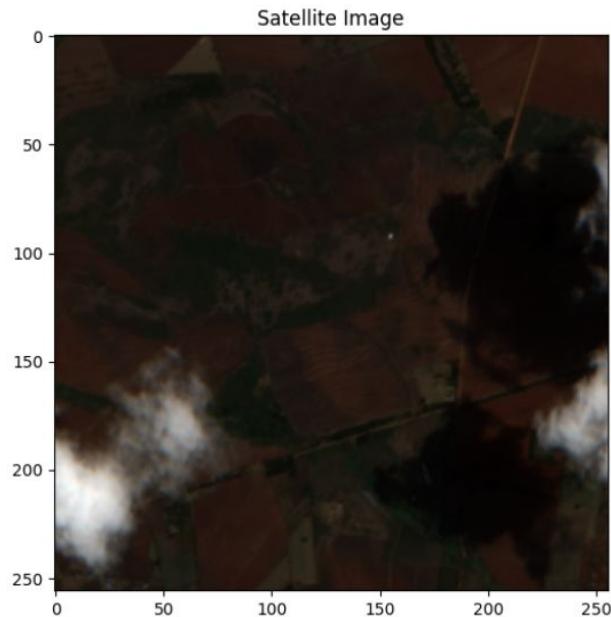
U-Net model trained on KE data



U-Net model trained on KE data



Tried to use time series data



CONCLUSION

1. This works provide the workflow with detailed documentation on how to develop deep learning based farm boundary extraction model using earth observation data.
2. This works show that U-Net model is proven to be able to extract farm boundaries but with enough amount of training data.



ESRI Satellite World Imagery

PROJECT OUTPUTs



01

Data Collection & Preparation
[documentation here](#)



02

Model Training
[documentation here](#)



03

Model Fine-tuning
[documentation here](#)

*This workflow can be used as a guide to provide farm boundary extraction model in other study areas.

RECOMMENDATIONS



FOR FURTHER DEVELOPMENT

The future project development can focus on providing high quality and quantity of farm boundary reference data.



FOR SERVIR SCO

Will be really good if SERVIR have the initiatives/program to provide the data for farm boundary in the SERVIR's focus area.



Connecting Space to Village

Thanks to:

Biplov and Aparna

Claudio

Micky

Belinda

All SERVIR Team

//SERVIR 2023 INTERNSHIP

THANKS!

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