Addis Ababa University
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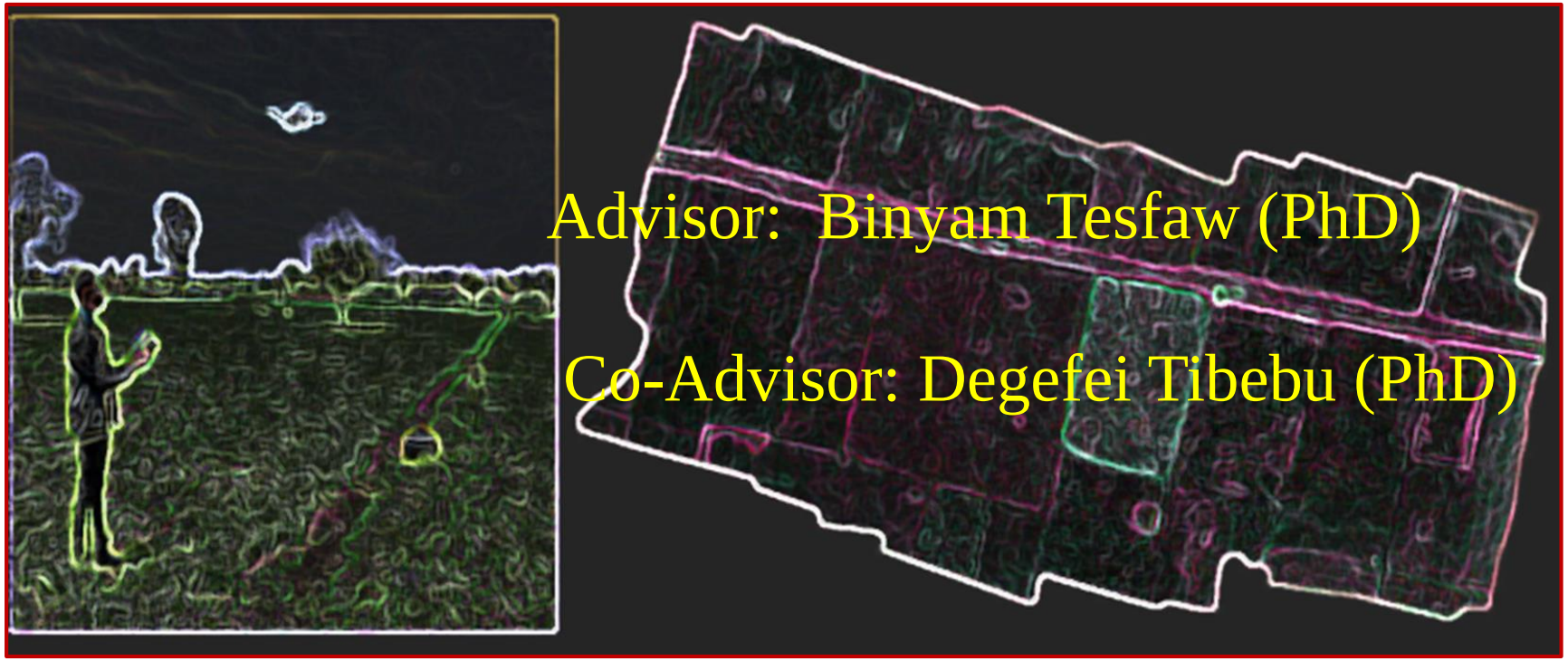
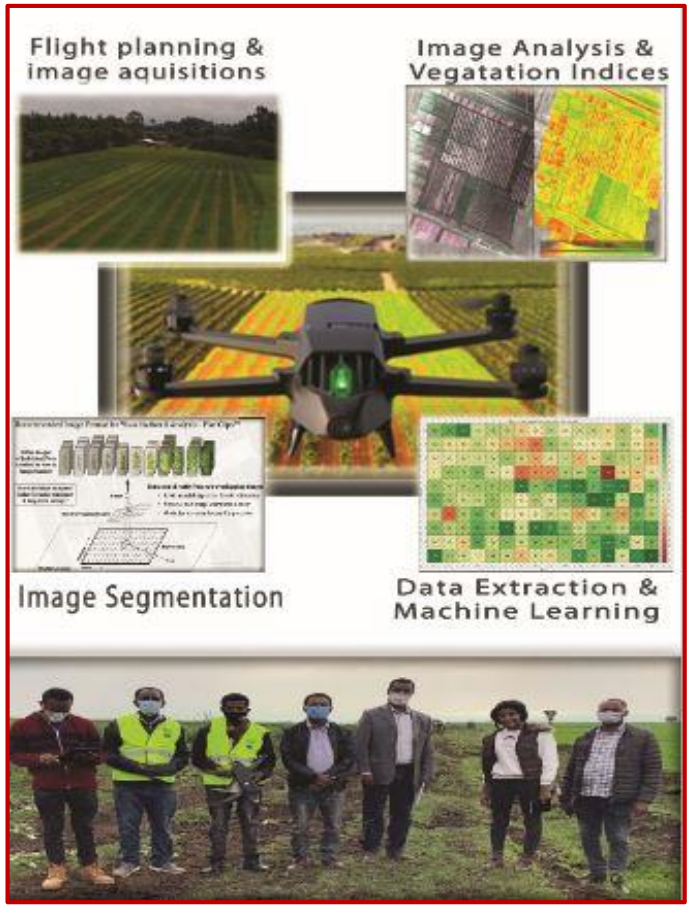
SEEK WISDOM, ELEVATE YOUR INTELLECT AND SERVE HUMANITY !

COLLEGE OF NATURAL AND COMPUTATIONAL SCIENCES
SCHOOL OF EARTH SCIENCES
Remote sensing and Geo-informatics

Title: Crop Field Classification using blending of Unmanned Aerial Vehicle (UAV) and Sentinel 2A satellite data: the case of Oda Dhawata Kebele Cluster farmland, Oromia Region, Ethiopia





By
Melkamu Demelash

Background

Introduction

- In recent years, Remote sensing technology has a major role in dynamic data extraction of crop information and crop distribution mapping (Zhang Jiankang et al, 2012a). and based on interaction of electromagnetic radiation with surface features
- It assesses the amount of sunshine reflected from surface features like **soil, water** and **vegetation.** The application of remote sensing in agriculture has been applied since 1950s (Colewell, 1956).
- The image provided by satellite is of low/medium-spatial and temporal resolutions as compared to UAV image is simply too insignificant result comparatively.

Cont……..

- **Now a days**, UAV-based approach gains **popularity** not just for its high spatial and temporal resolution; however for its ability to get spectral band spatial data at the same time (Licheng Zhao, 2019).

- At low, medium and high resolution, **UAV** will play a great role and might generate additional **feasible crop distribution** information that could be significant to the development and application of crop monitoring technology.

- Mapping of crop type using satellite image is challenging task due to complexities within cluster farmland field, and having similar spectral properties of different crop type.

Cont……

- **Recently** sentinel satellite data launched with high resolution (**10, 20 and 60**), 13 spectral bands, and fast revisit time.
- UAV-technology is good choice for crop type mapping since its running comprises four spectral bands by these two systems.
- Crop classification makes it possible to obtain the spatial distribution and planting area information of crops. A multiple crop mapping helps to show the dynamics of agricultural fields and may serve as the basis of crop structure
- UAV has image composition with **high resolution**, **simple operation**, **quick data acquisition** and **low cost**.

Cont……

- UAS are changing the game in application of remote sensing and innovative digital technology in the agricultural sector by making :-

✓ data capture more affordable and timely accessible for applications for crop type identification and mapping, understanding the plant health monitoring.

✓The need to know about farm plot/field plays a major role in piloting and implementing drone-based services

✓Use of UAV in precision agriculture is increasing day by day (Bansod, et.al, 2017).

✓UAV in agriculture are becoming important systems to collect data ,sustain and improve agricultural productions, efficiency and productivity of the agricultural practices

Statement problem

- So far, there has been lack of a feasible and affordable **data acquisition** means at farm level for agricultural sector for decision making, agricultural practices and technology scaling.

❖To properly and accurately map the agricultural landscape crops in the area, it is necessary to use the satellite technology.

- Agricultural fields are highly complex for mapping crop types that is a problem to accurately detect and discriminate between crop type and also classification mapping
- UAV is the best approach for such mixed crop complexity and classification mapping

Objectives

General Objective

- To evaluate the potential of blending Unmanned Aerial Vehicle (UAV) images and Sentinel 2A imageries for crop field classification from Ethiopia.

Cont……..

Specific objectives

- Evaluating the UAV data for crop classification and mapping
- Mapping of farmland using Sentinel 2A satellite image
- To understand the potential of blending of UAV and Sentinel 2A images for Crop classification.

Significance of the study

- Ethiopian Agricultural practices is complex and also fragmented land , many farmers grow multiple crops with similar plant cycles and inter-cropping is a common practice .
- Satellite images cannot adequately capture in such complex agricultural landscapes and farming systems of Ethiopia ,**so:-**
  - medium resolution data of sentinel 2A captured
  - High resolution data of UAV captured
  - Ground truth data

➡ The fusion approach proceeded to improve the lower resolution and then classify crop types

3.Data and methodology

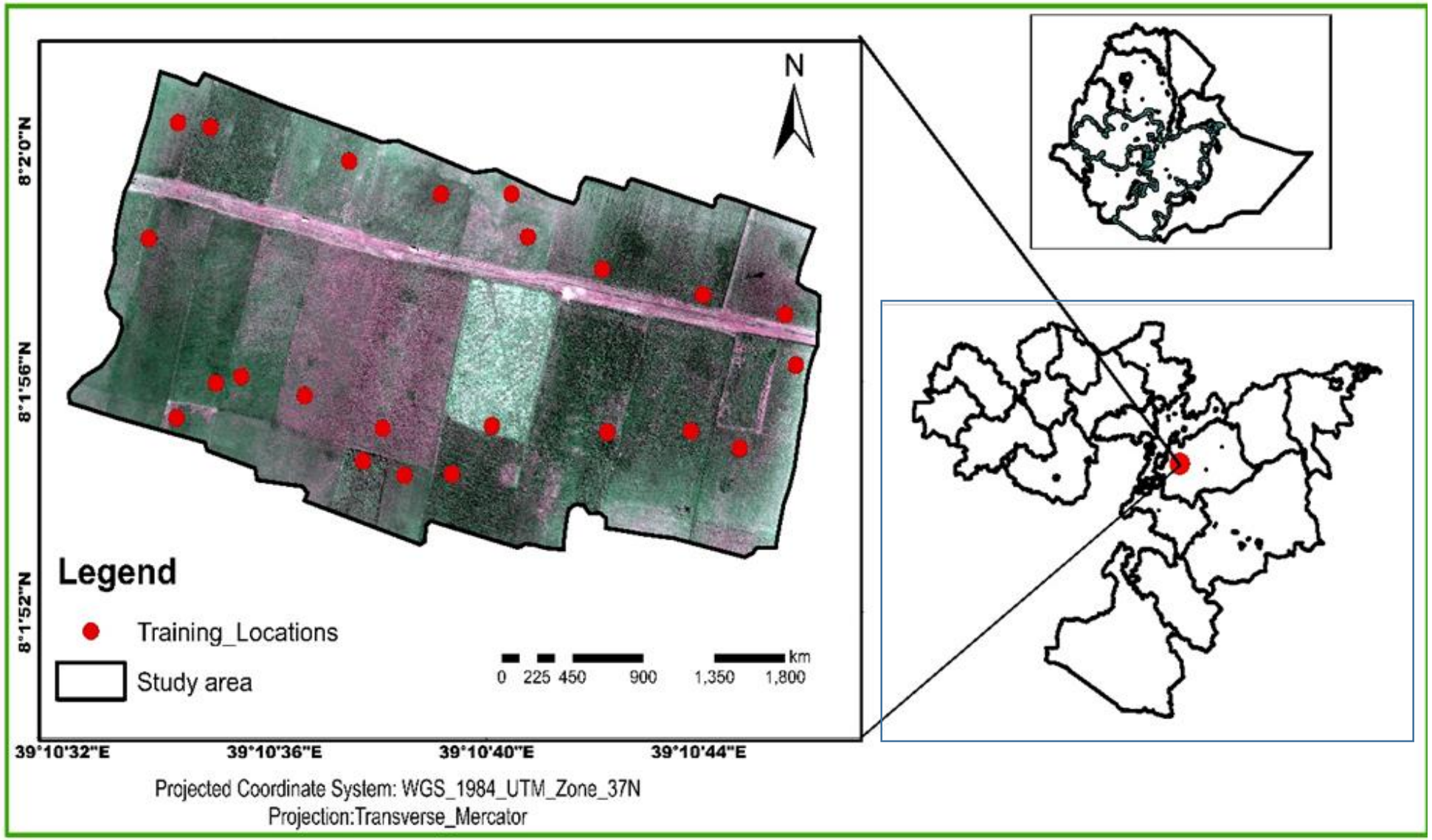
Study area

The study area is located in Arsi zone, which is called Oda Dhawata Kebele, known for Agricultural land with 8^0 1'57.05" N and 39^0 10'39" E and area covering of 7.55ha

The average temperature ranges 10-25 ^{0}c and the altitude over all Arsi zone ranges from from 500 to 3000 mean sea level.

The major crops in the area are now wheat, Faba bean, barley, sorghum and teff. However, barley is the most dominant in the higher altitude of the zone wide, whereas wheat is the major crop in the middle altitude areas (chilot yirga et al., 1989).

Cont.....


N
8°2'0"N
8°1'56"N
8°1'52"N
39°10'32"E
39°10'36"E
39°10'40"E
39°10'44"E
Legend
Training_Locations
Study area
0 225 450 900 1,350 1,800
km
Projected Coordinate System: WGS_1984_UTM_Zone_37N
Projection:Transverse_Mercator

Materials

UAV- Parrot Blues Grass

Emerging drone technology have the great potential to develop how to monitoring crops and mapping crop type.

- ✓ Parrot blue grass is equipped with multispectral sensors, sequoia capture spectrally accurate high-resolution (fine grain) imagery in visible and near infrared part of electromagnetic spectrum, providing supplement to satellite and aircraft image.
- ✓ Sequoia has **16mp RGB** camera and internal memory of capacity of 64GB.

Cont…….

The parrot sequoia collects data of features in four spectral band in different wavelengths

Band name	Wavelengths(nm)
Green	550
Red	660
Red edge	735
Near infrared	790

Calibrating Sequoia

Before using sequoia the calibration is needed.

The two sensors (multispectral and sunshine sensor) should be properly connected to the drone.

It is recommended that calibration of these sensors is possible at the same time, also calibrate each separately but sunshine sensor must be connected the Multispectral sensor to be calibrated.

Checklists of parrot blue grass before flight

On the field

- Make sure you have 10 m of diameter of free space for takeoff and landing
- Check that the flight area has no obstacles
- Make sur the Sequoia lenses are clean
- Connect the battery
- Connect your smartphone or tablet to the sky controller
- Turn on the drone
- Make sure the GPS is detected on Free flight Pro or Pix4DCapture
- Calibrate the drone and sequoia
- Make sure the SD card of the Sequoia is empty
- Make sure the front camera of the drone is clean

Parrot blue grass pre-flight

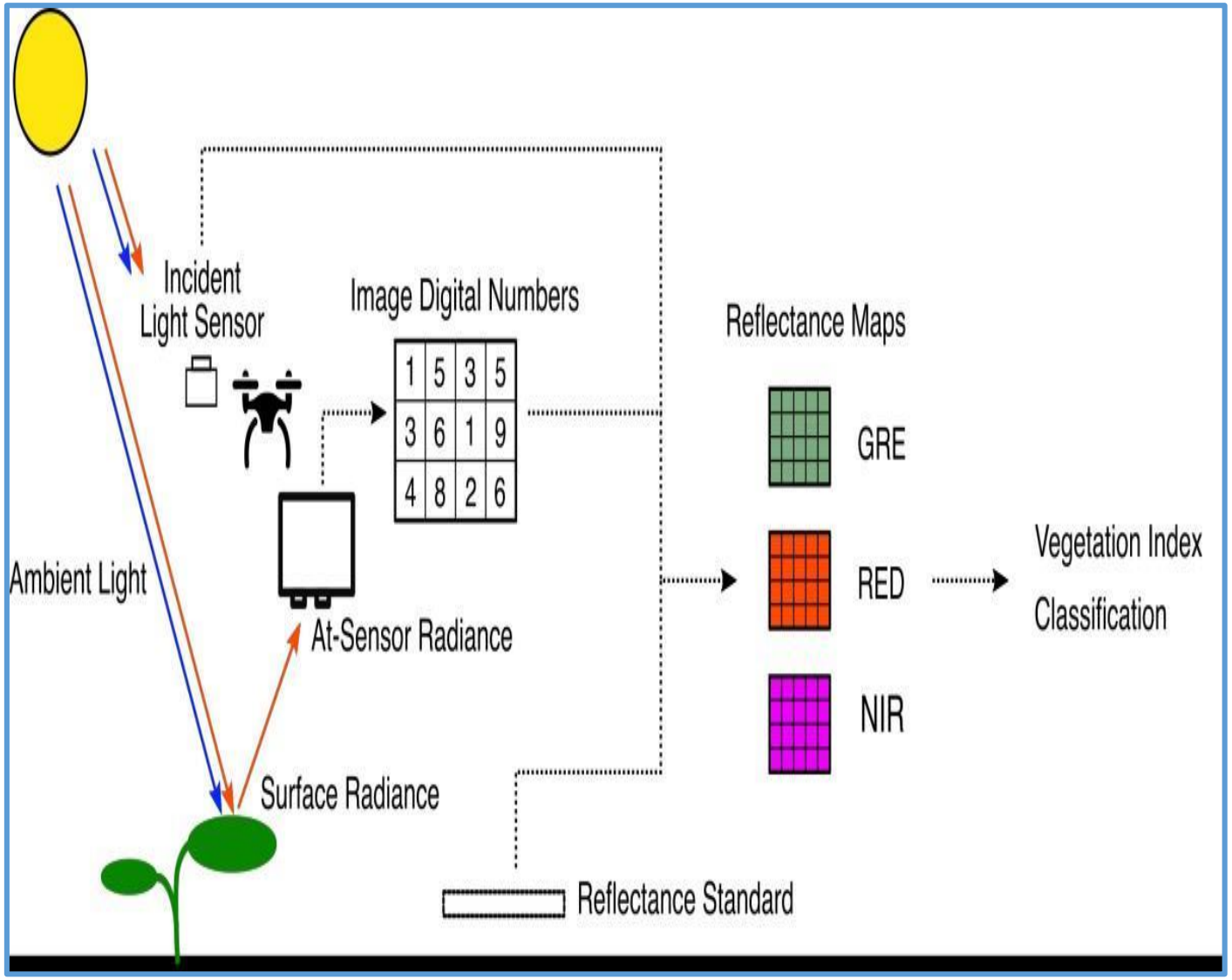
UAV Data acquisition and Orthomosaic generation

In this study, 1862 separate images acquired, at an altitude flight of 40m within -flight mission time to cover an area of the field. Before starting the flight mission, the design of the flight path covering the area of interest was performed by the pilot of the drone.

- The flight controlled both manually and automatically in the study for crop mapping. The approach was applied 80%automatically when capturing images and 20% manually when landing.

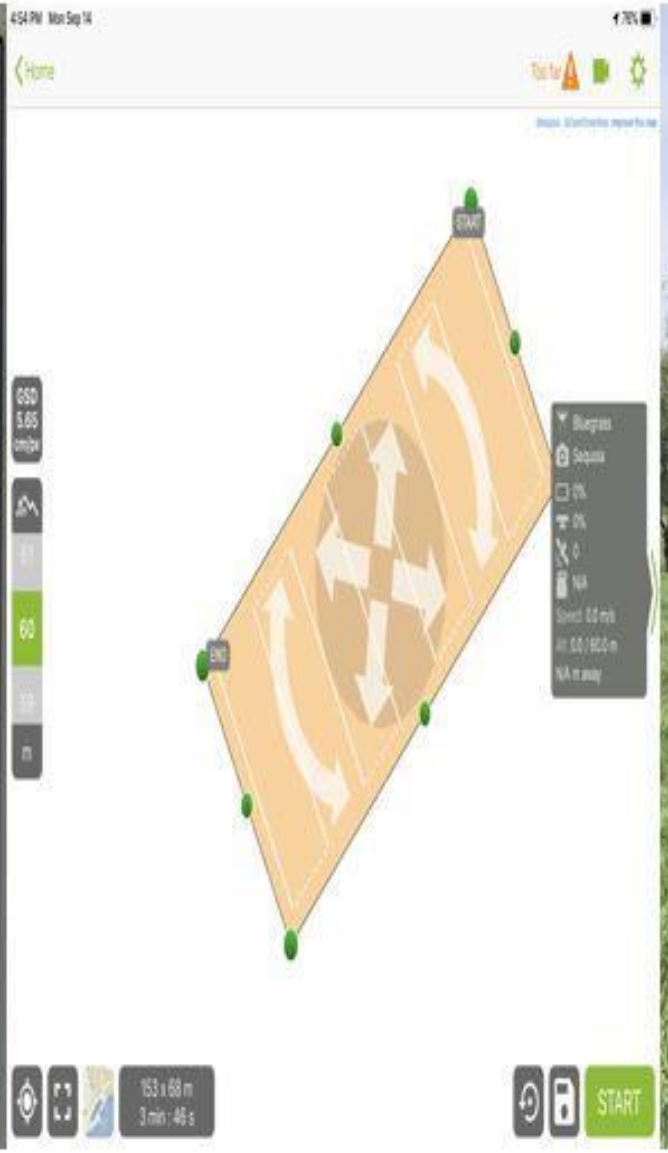
UAV Data acquisition and Orthomosaic generation

Multispectral drone sensors are used to **measure the surface reflectance** across space for two or more specific bands of wavelengths (e.g., the Red band and Near-infrared band) which is used as a base for calculating vegetation Index like NDVI or to form surface over classifications.



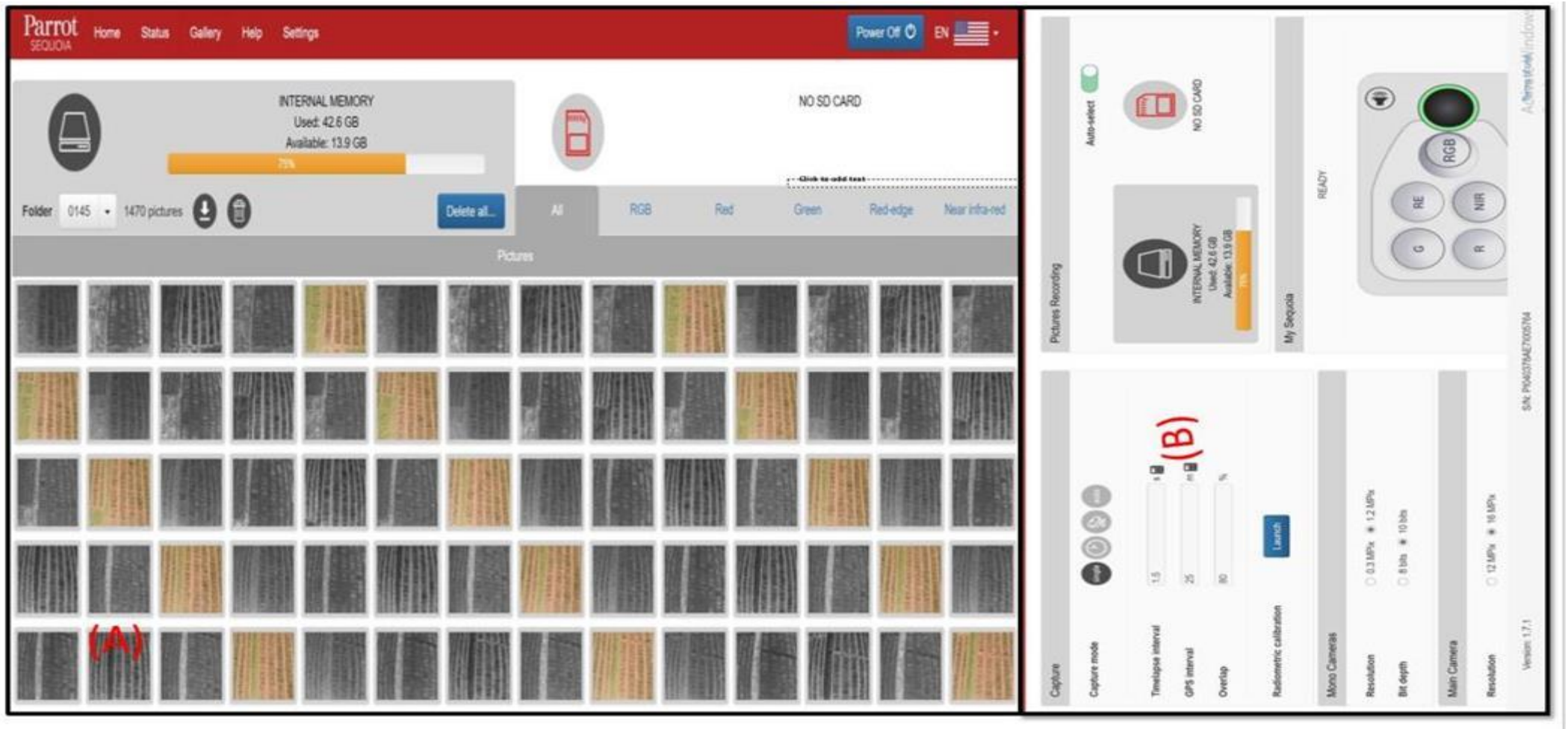
Cont....


SETTINGS
LOG OUT
Plan new mission
POLYGON
GRID
PROJECT LIST
TUTORIAL/HELP


Home
START
END
GSD
60
153 x 68 m
3 min : 46 s
START

Cont….

Both **Multispectral** image and **RGB** image have been acquired in October 16/2020 and downloaded via server 192.168.42.2 of the drone in each flight mission in the field.



Orthomosaic generation process

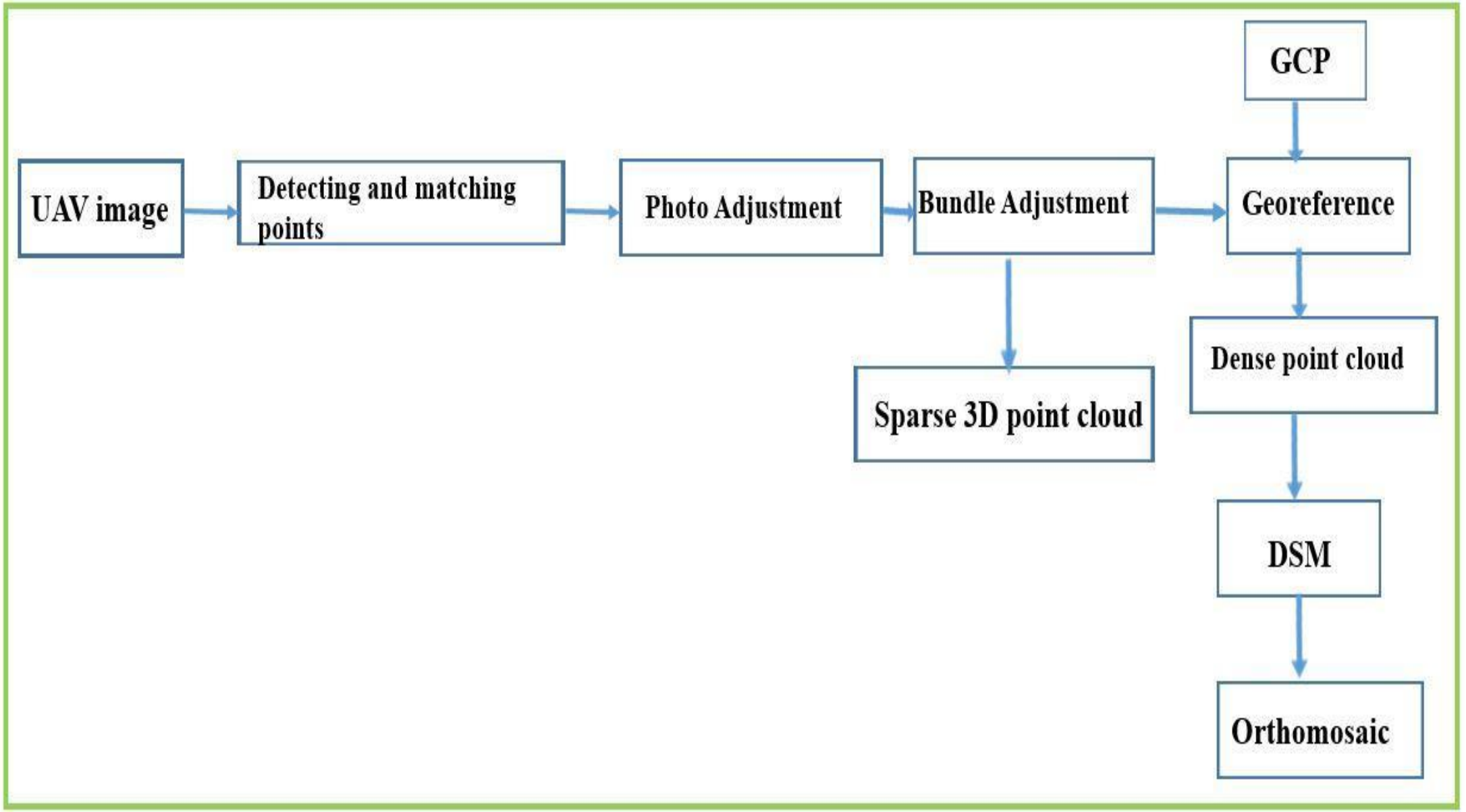
All the images need to be and stitched together to get a **single image** for further analysis.

- The orthomosaic have been done using pix4Dfield that it combines all the individuals and overlapped images.
- Pix4Dfield approach applied to process the drone images and then produce orthomosaic

It allows the structure reconstruction of scene from a number of images with corresponding points, and used to generate orthophoto.

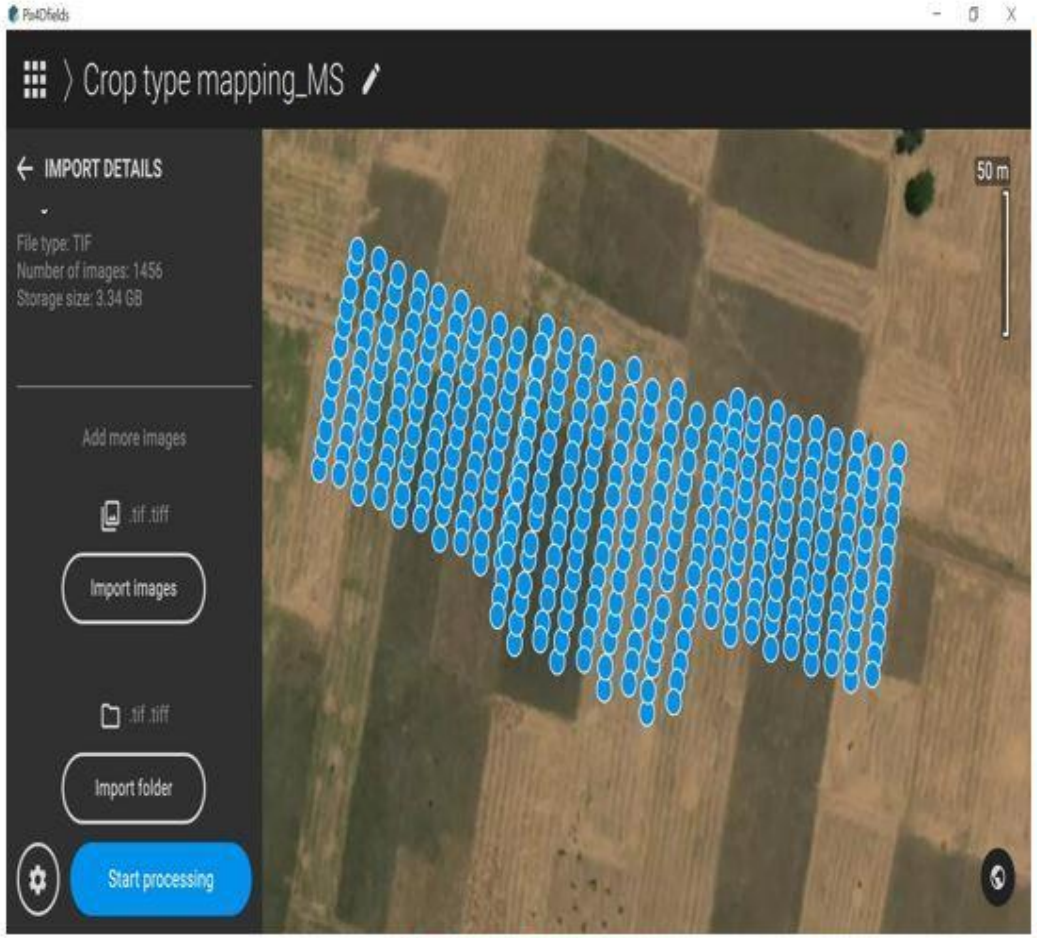
- Another significant of pix4Dfield is feature detection and matching

Cont……..

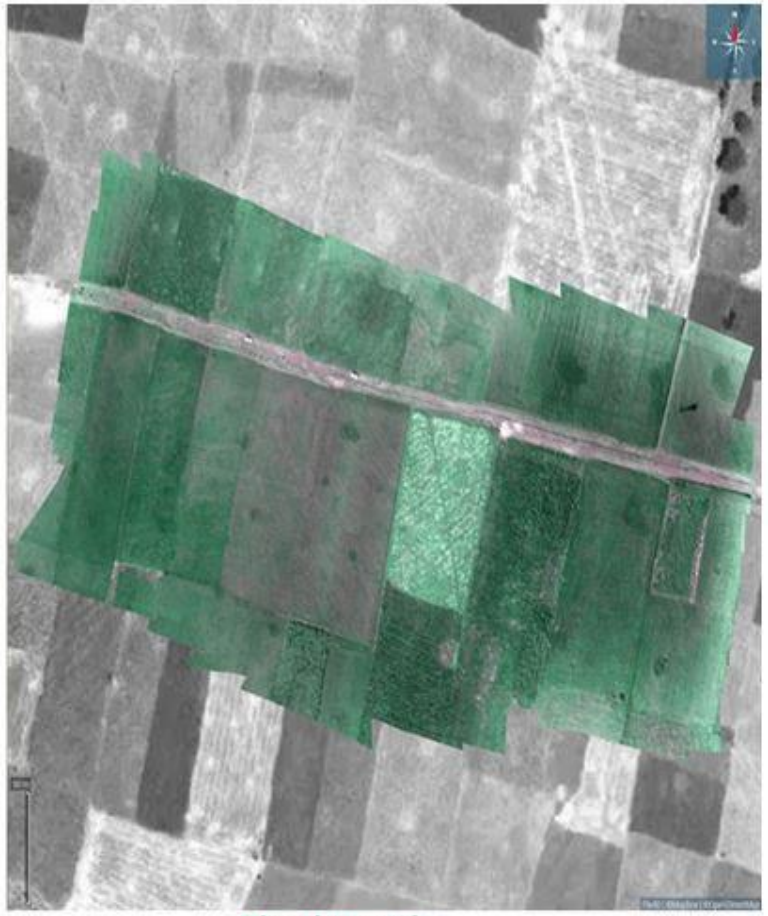

GCP
UAV image
Detecting and matching points
Photo Adjustment
Bundle Adjustment
Georeference
Sparse 3D point cloud
Dense point cloud
DSM
Orthomosaic

Cont……..

The final product of Pix4Dfield is orthomosaic , digital surface model (DSM), different vegetation indices can be generated



A) Camera location



B)orthmosaic

Sentinel 2A

The sentinel 2A image has 13 spectral bands in total, in which four bands (Blue, green, red and near infrared) have spatial resolution of 10m.

- Using Drone capturing data under cloud is possible and fine but not for satellite (Sentinel 2A) product. Thus, the only free cloud coverage image on 20 October 2020 was downloaded and preprocessed.

Cont.….

wavelengths b/n UAV &S2A

Sensor	Blue	Green	red	Red edge	NIR
parrot	-	550	660	735	790
S2A(10m)	492.4	559.8	664.6	-	864.7

Methodology

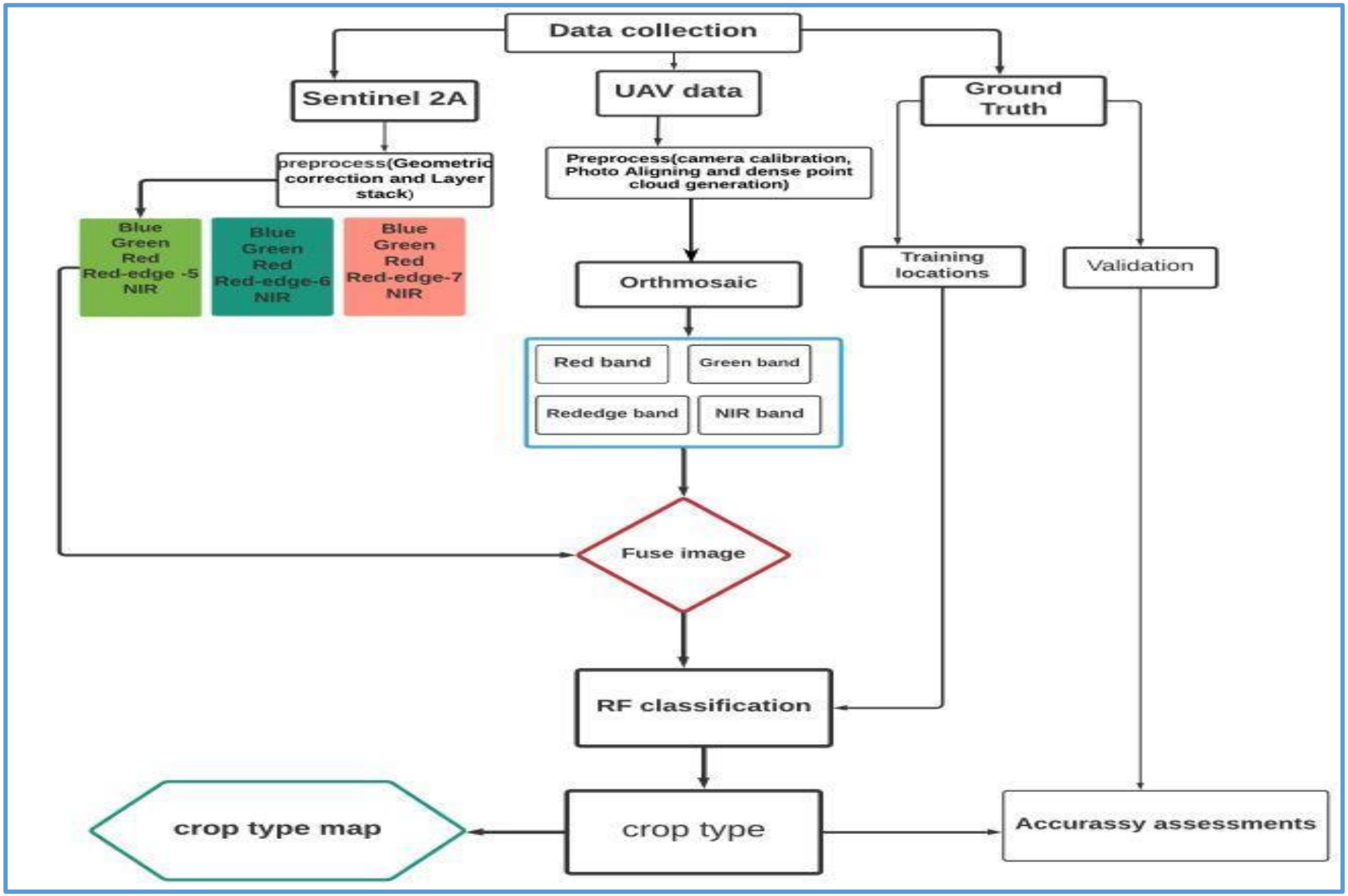


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Image fusion using Gram Schmidt Approach

Image fusion is the combination of spectral characteristics of a low-resolution image and spatial feature of higher resolution image to produce the spatially enhanced image.

- ❖Gram-Schmidt pan sharpening is to pan sharpen multispectral data using high spatial resolution data.
- ❖During fusion the high spatial resolution represents the information content of the images much more in detail and provides synthetic image close to reality when enhancing the resolution
- ❖The purpose is to improve the medium resolution(S2A) data which was 10m

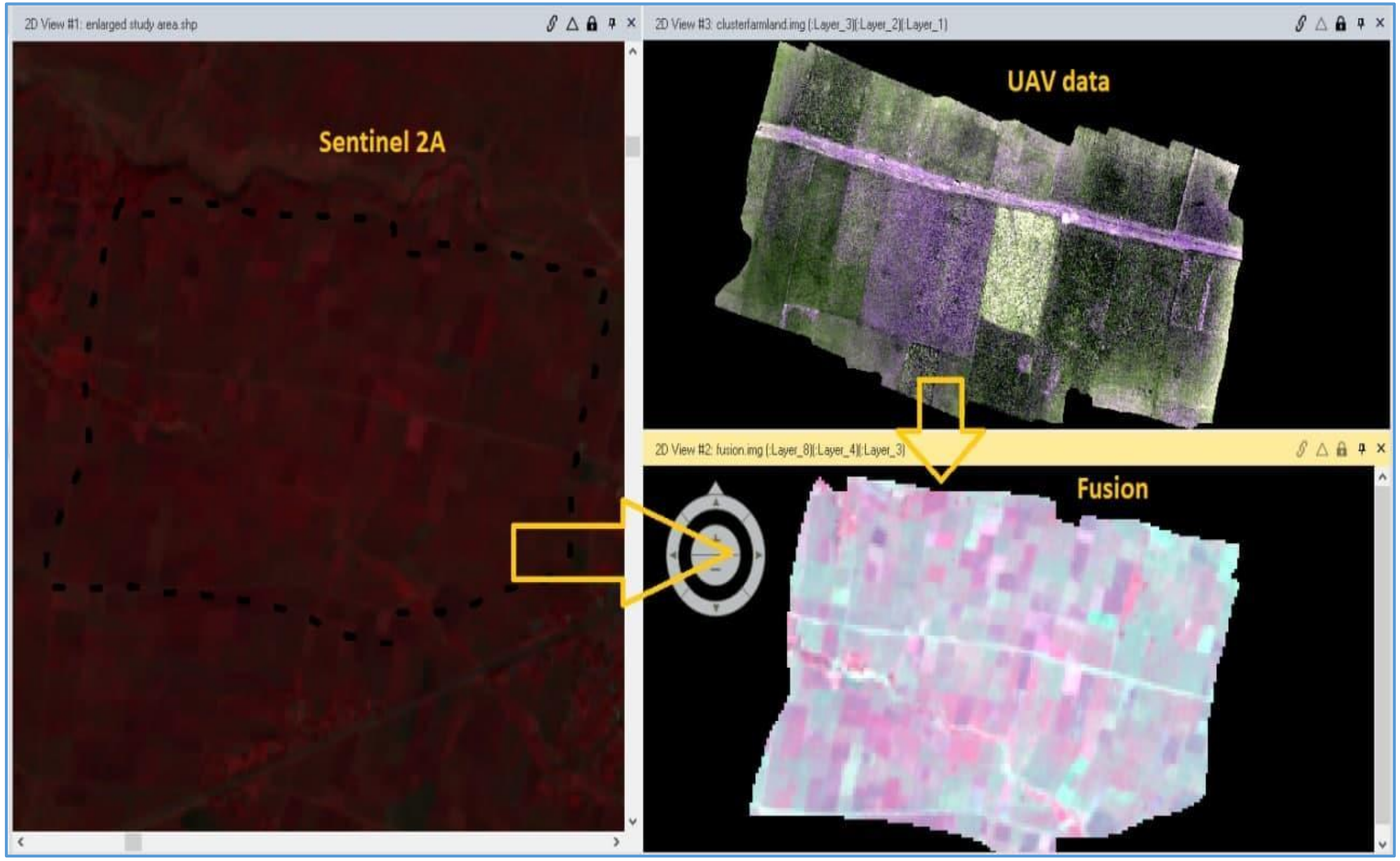
Results

From multispectral Analysis of UAV raw data

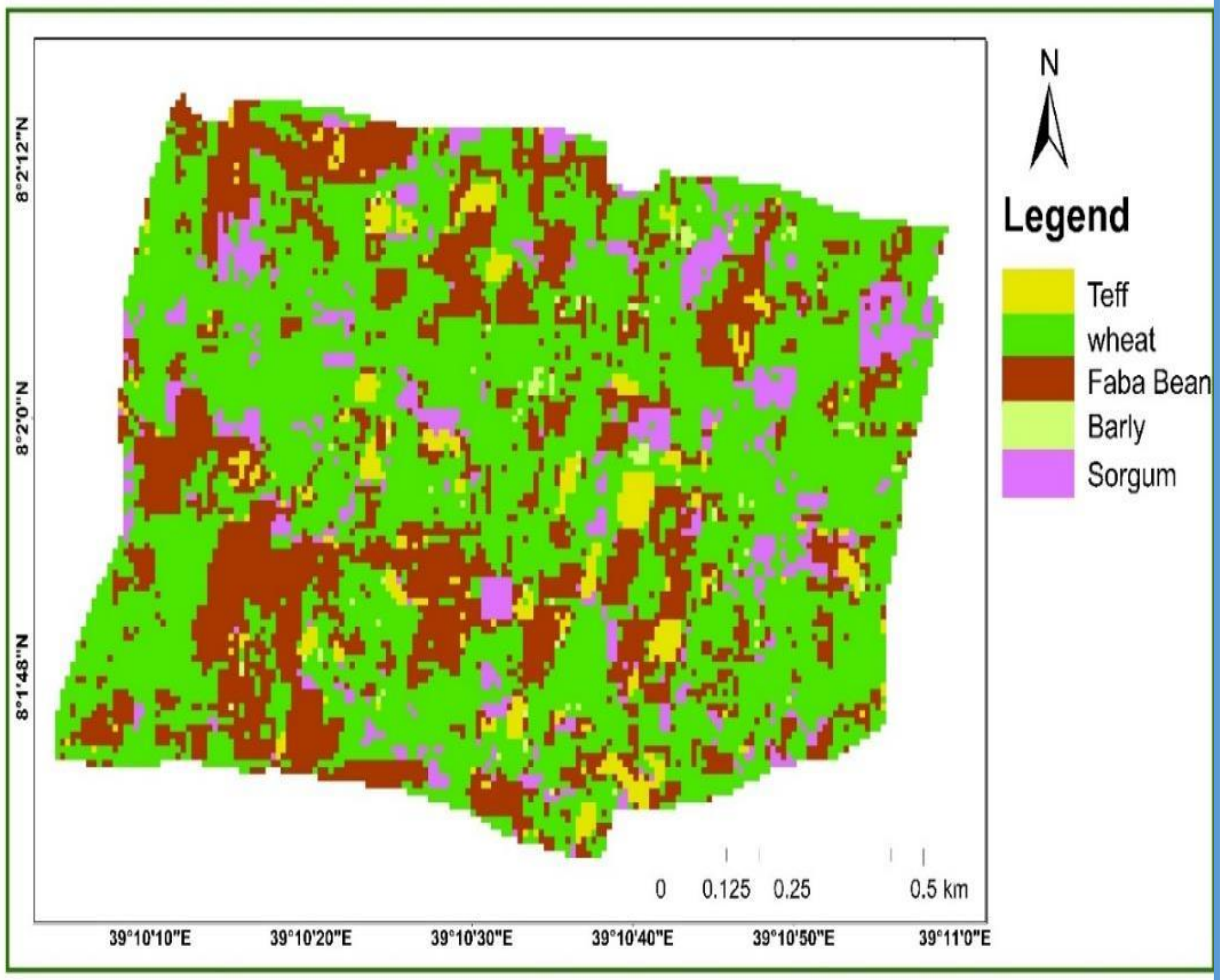
- Number of overlapping images computed
- Orthomosaic and sparse DSM before densification
- Key points and Tie point positions
- Internal camera parameters

MS analysis report

The Fusion approach

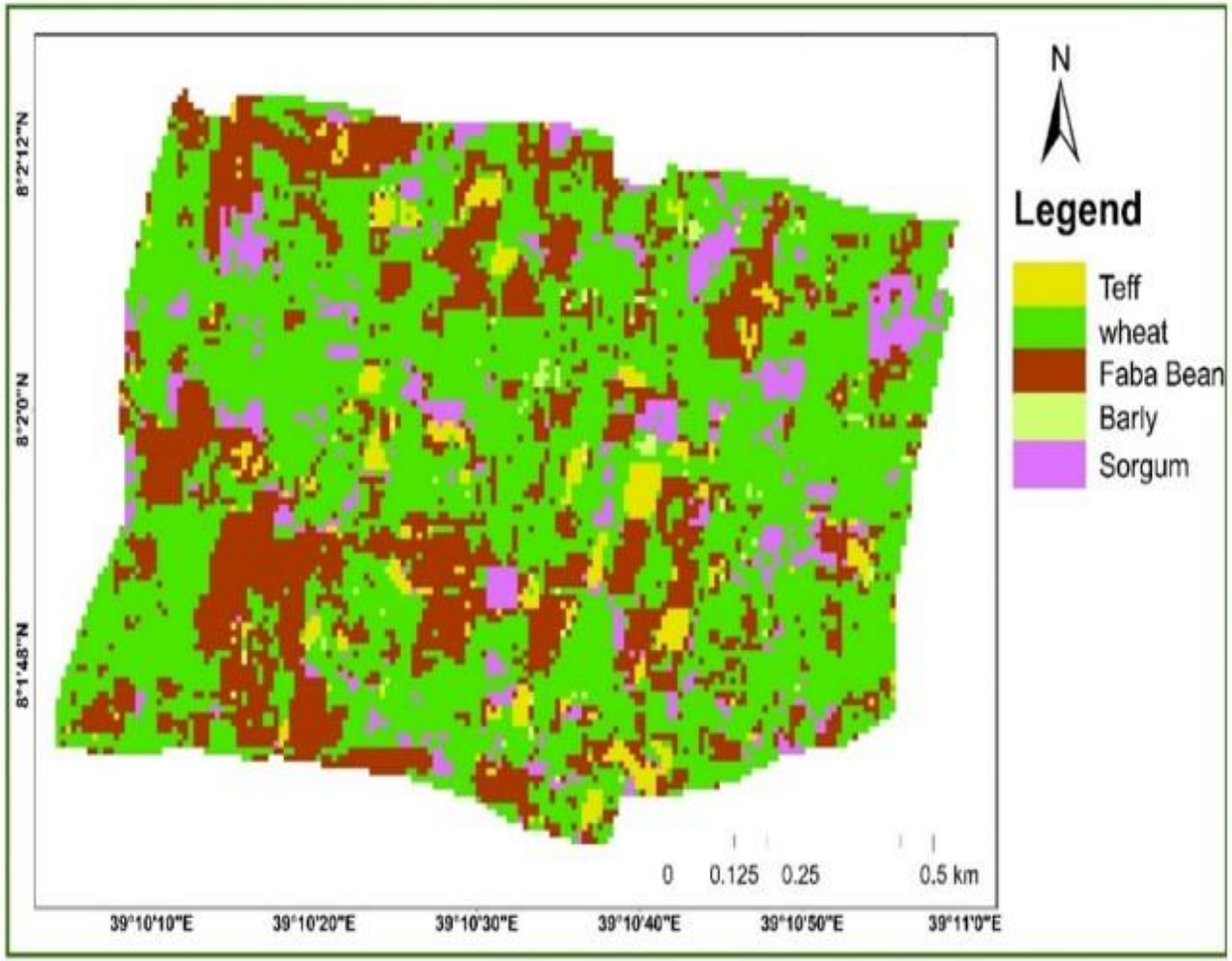


Random Forest classification Approach for fusion



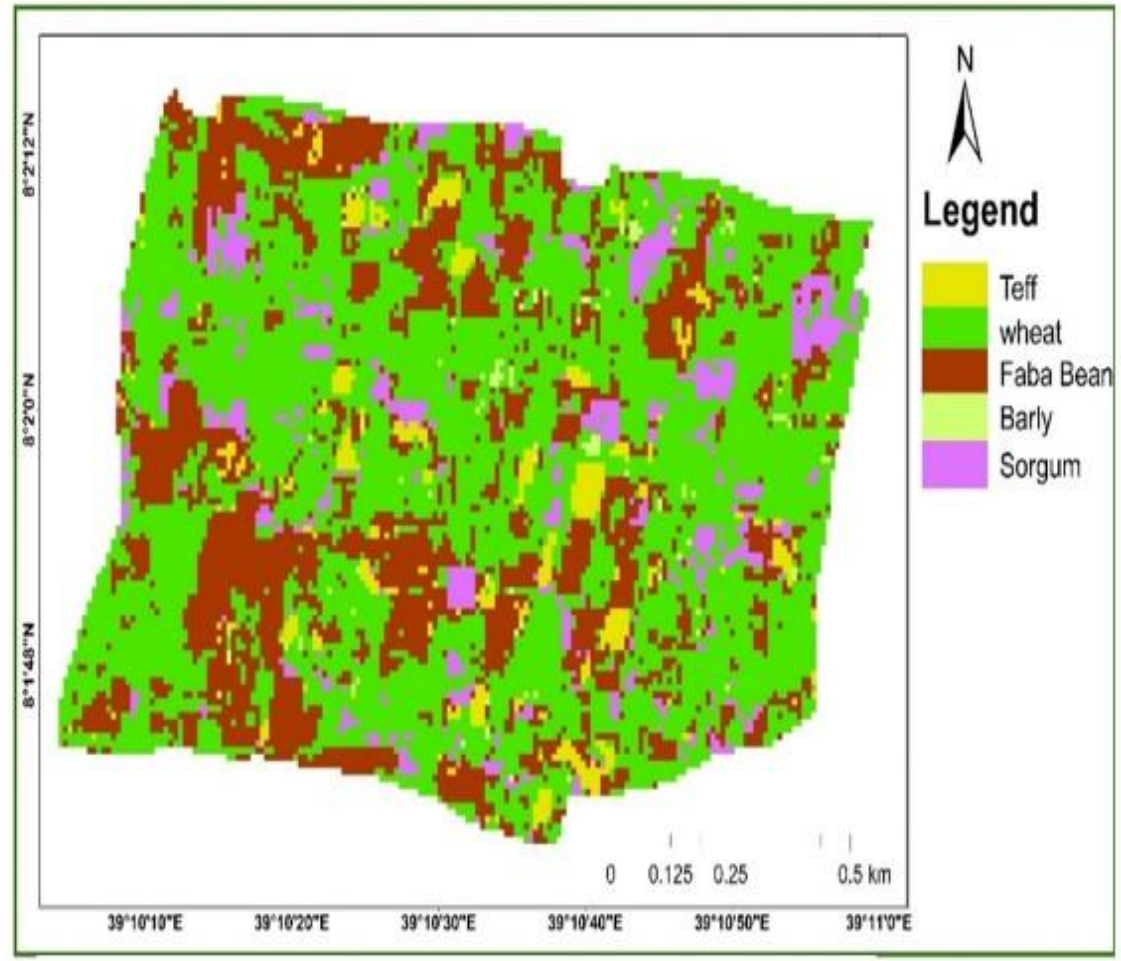
After UAV and Sentinel 2A fused together, it gives accurate accuracy assessment this means that the accuracy result was better than using either UAV or Sentinel data of crop classification separately.

This is done by splitting the Ground truth data in to two categories: training and validation



Fusion classification Using RF

Overall accuracy=94%

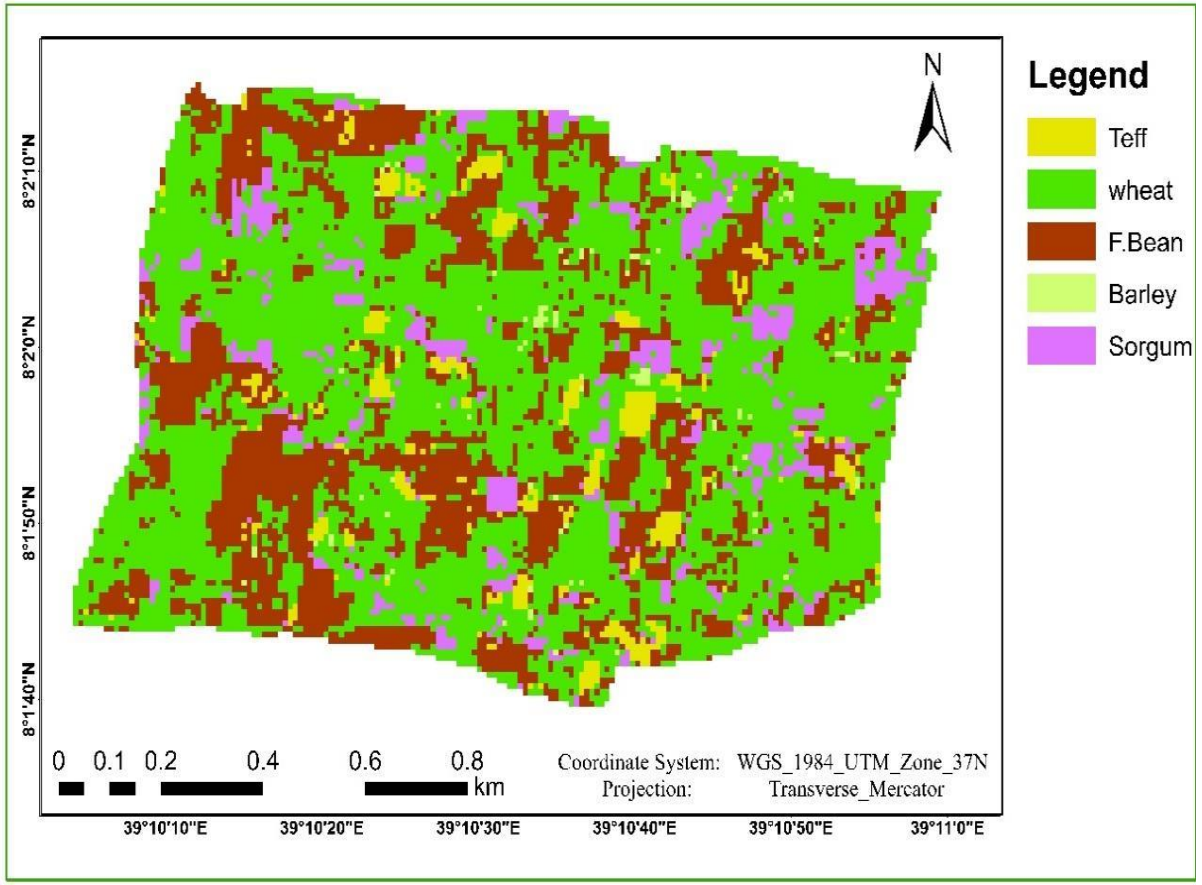


UAV-classification using RF

Overall accuracy=84%

Maximum likelihood classification Approach

- ✓ The study conducted to compare RF approach within the traditional algorithm which is Maximum likelihood classification.
- ✓ Since maximum likelihood has been for a long time and easily implemented.



Accuracy Assessments

Accuracy assessment is a quantification of estimation with aid of remotely sensed data set to classification conditions:-

- ❖ it is useful for evaluation of classification approach.
- ❖ It is also important to determination the error that might involves.

Approach	Overall accuracy(%)
Random Forest	94
Maximum Likelihood	90

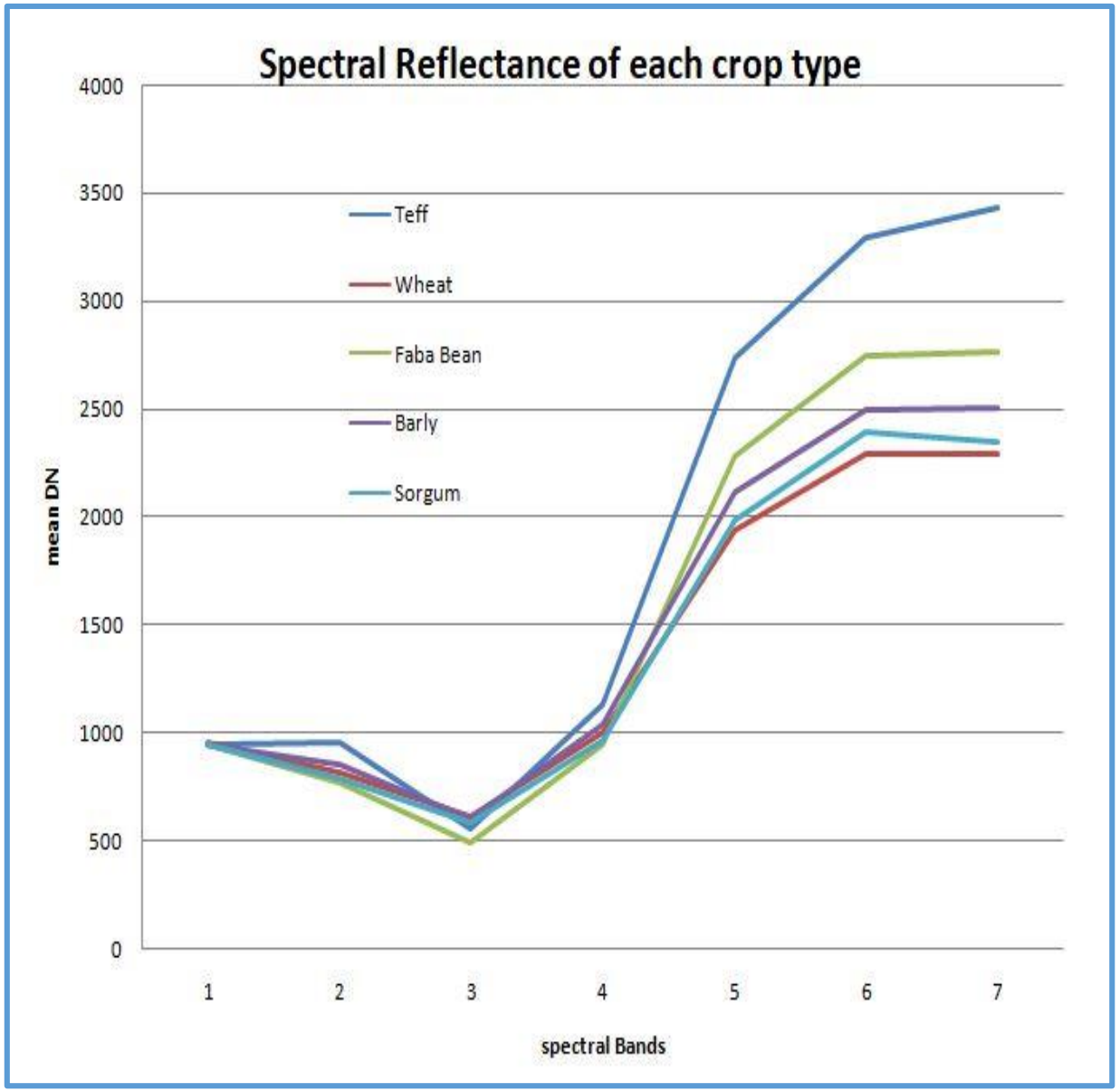
UAV accuracy assessment=84%

Spectral reflectance of crop types

The spectral response of each band is calculated by considering the average response of all pixel values in each crop type in the study area.

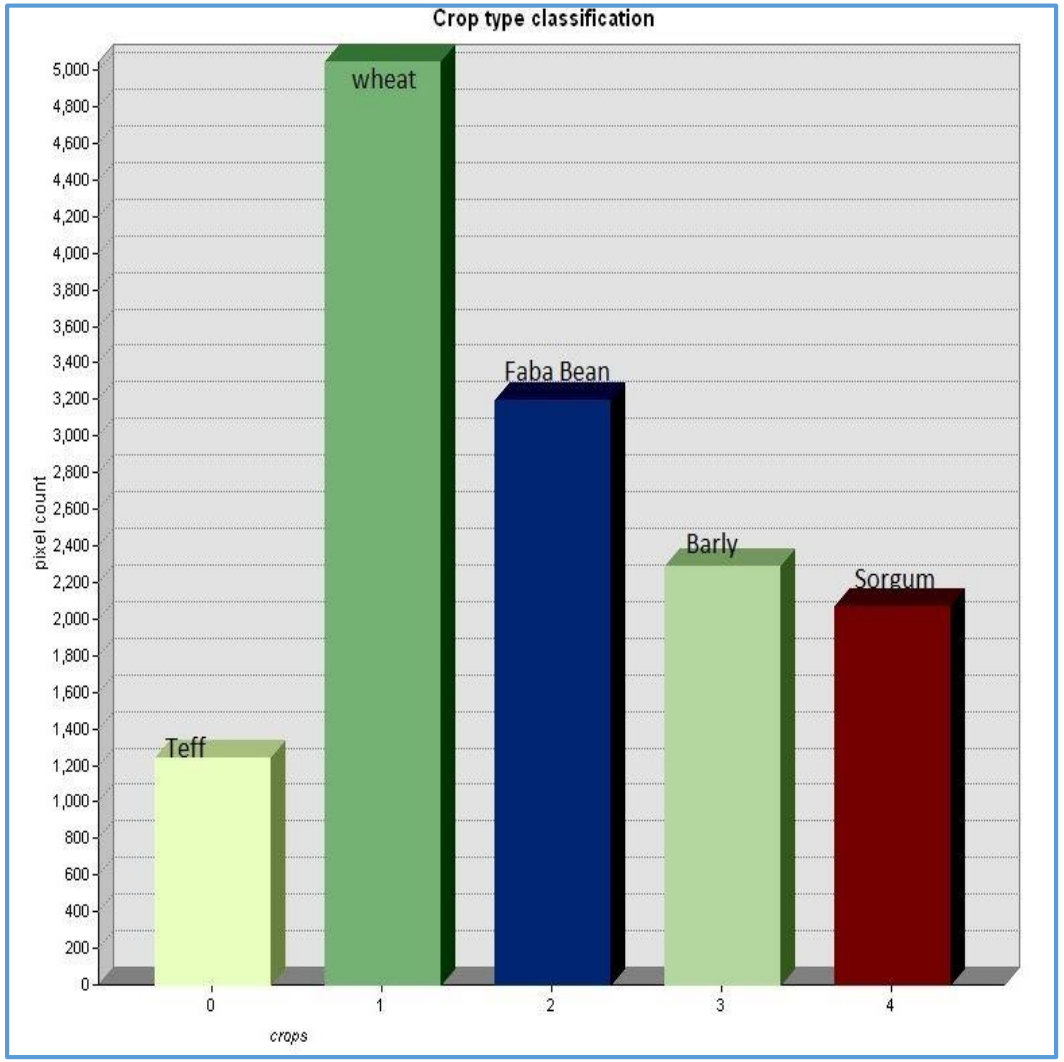
The spectral reflectance curves are created the average value of surface reflectance of spectral bands.

The spectral response of each crops is more distinguishable after band four to last bands range



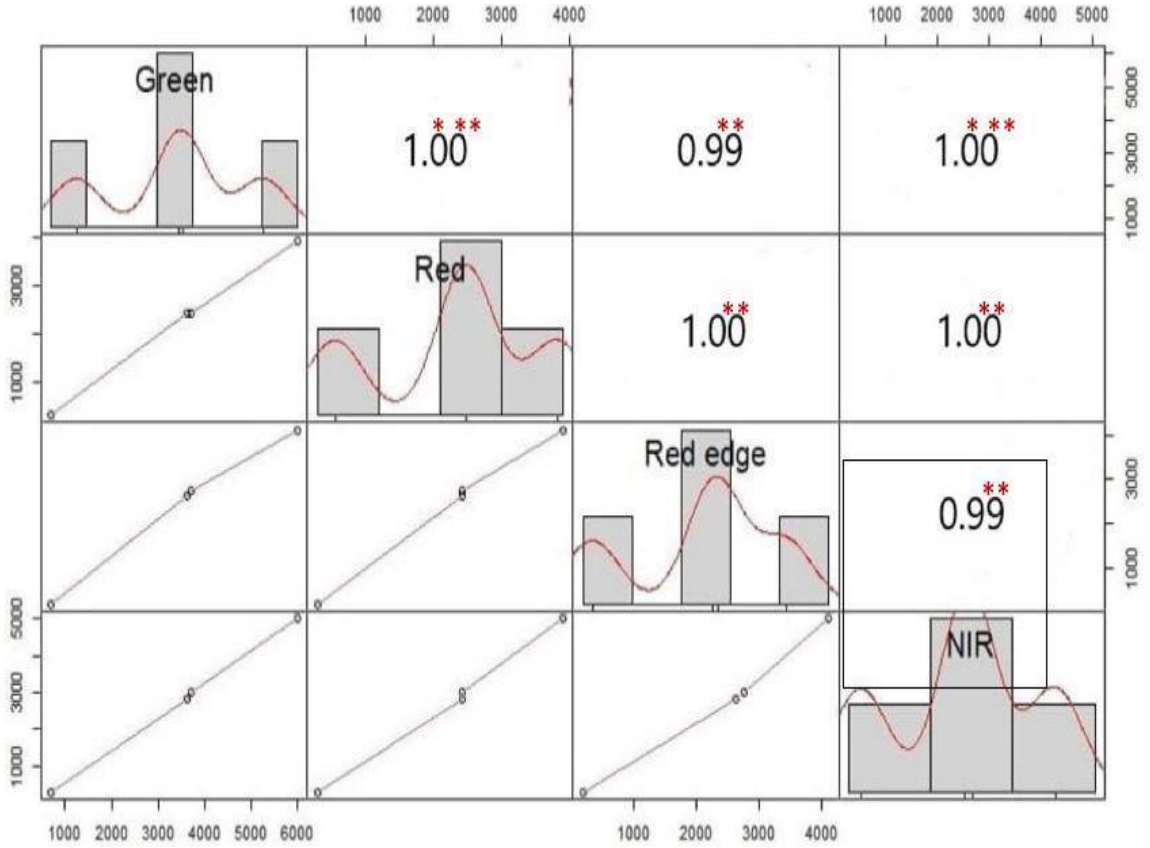
Spectral reflectance of crop types

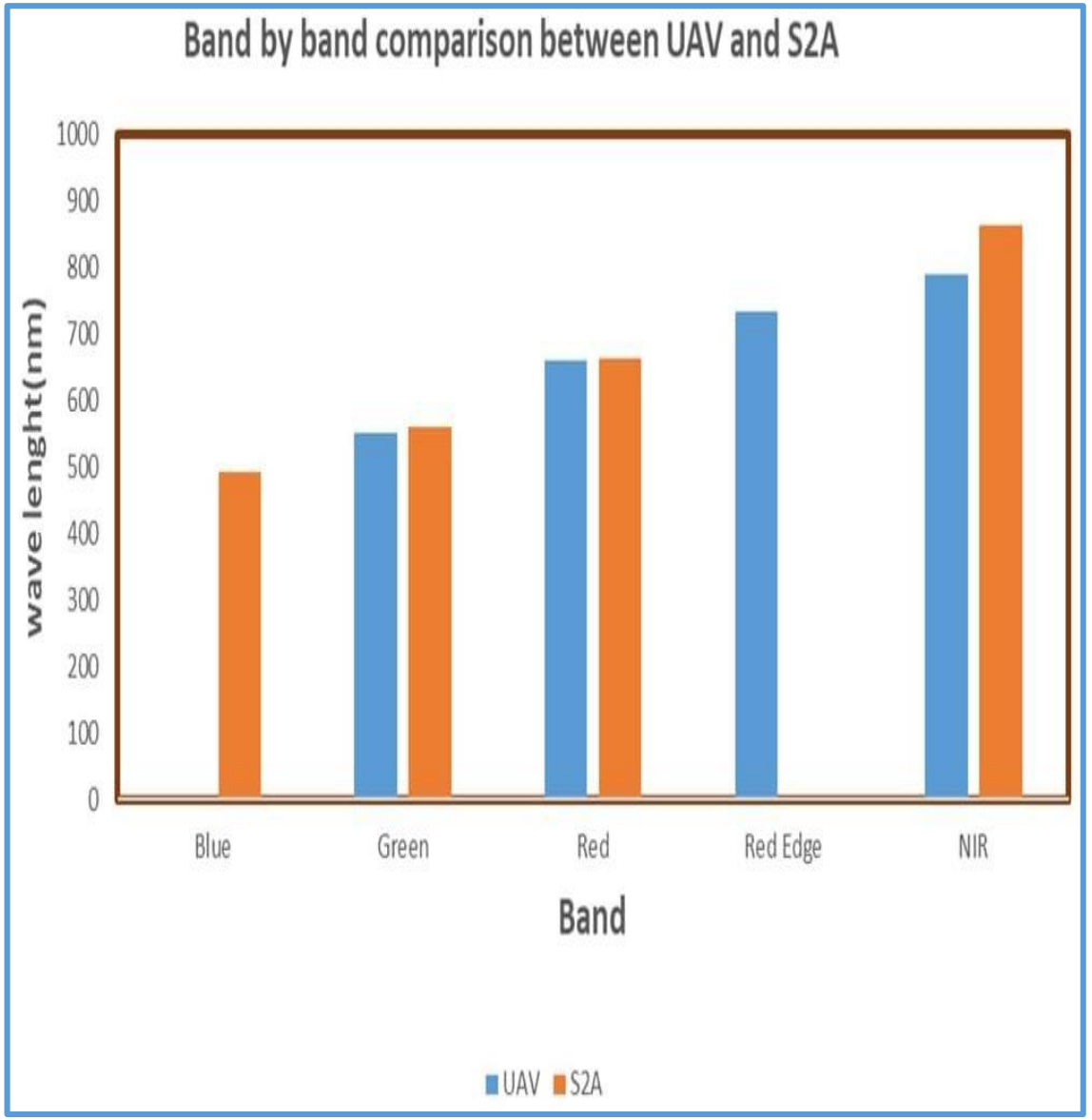
The crop type classification was pixel based digital number (DN) values of reflectance curve of each type evaluated after fusion.



Band comparison b/n UAV and S2A

NIR(Near-infrared) and or Band4 wave length is useful in vegetation and also in Crop identification soil/crop and land/water contrast.



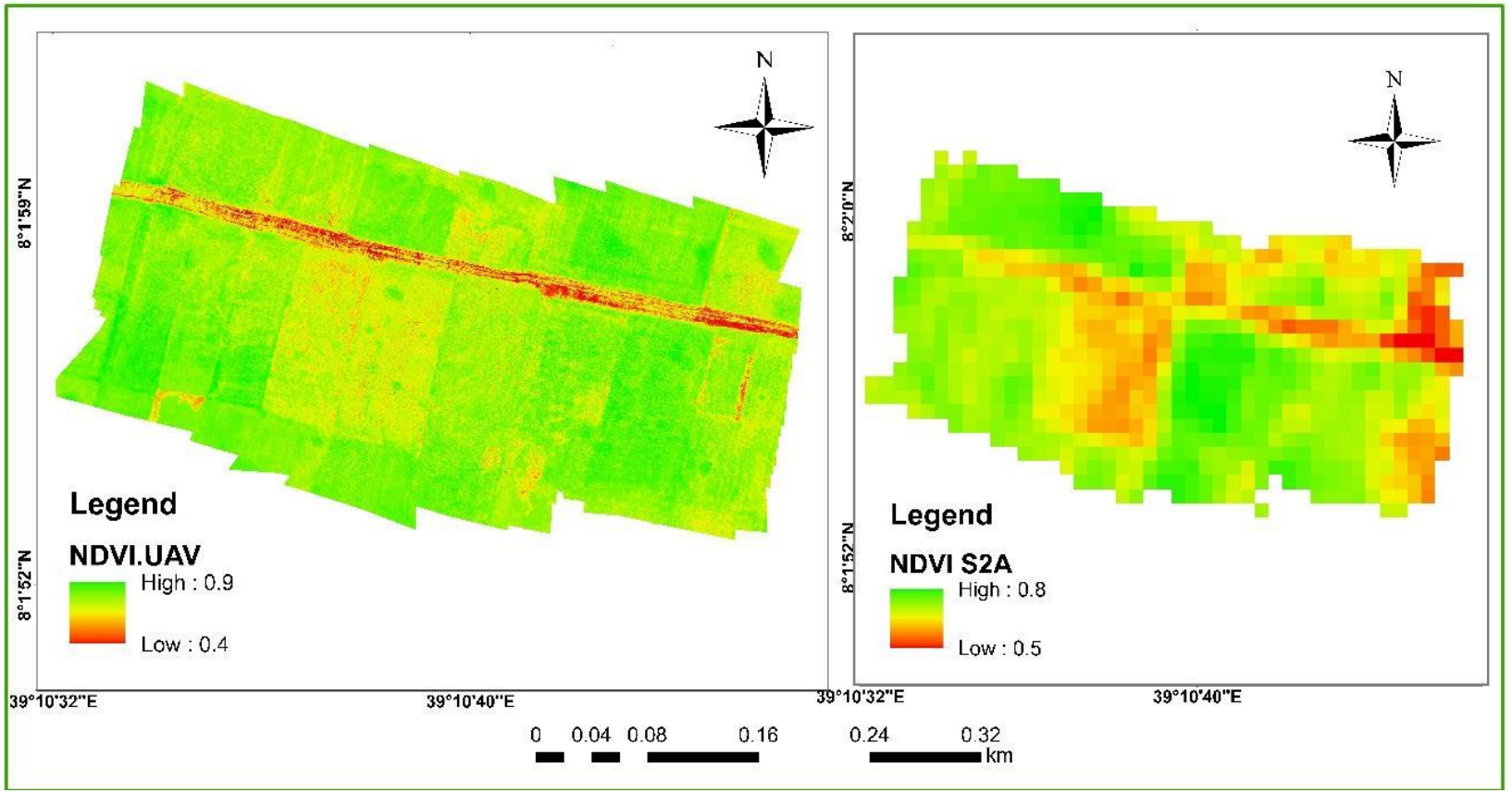


NDVI calculations for UAV &S2A

The **NDVI** shows the Vegetated plot in which:-

- The highest value is the crop type features that its spectral reflectance was almost good at maturation (finer green).
- The lowest value indicates the reflectance of each crop type was least, this is due different parameters of farming practices or any other.

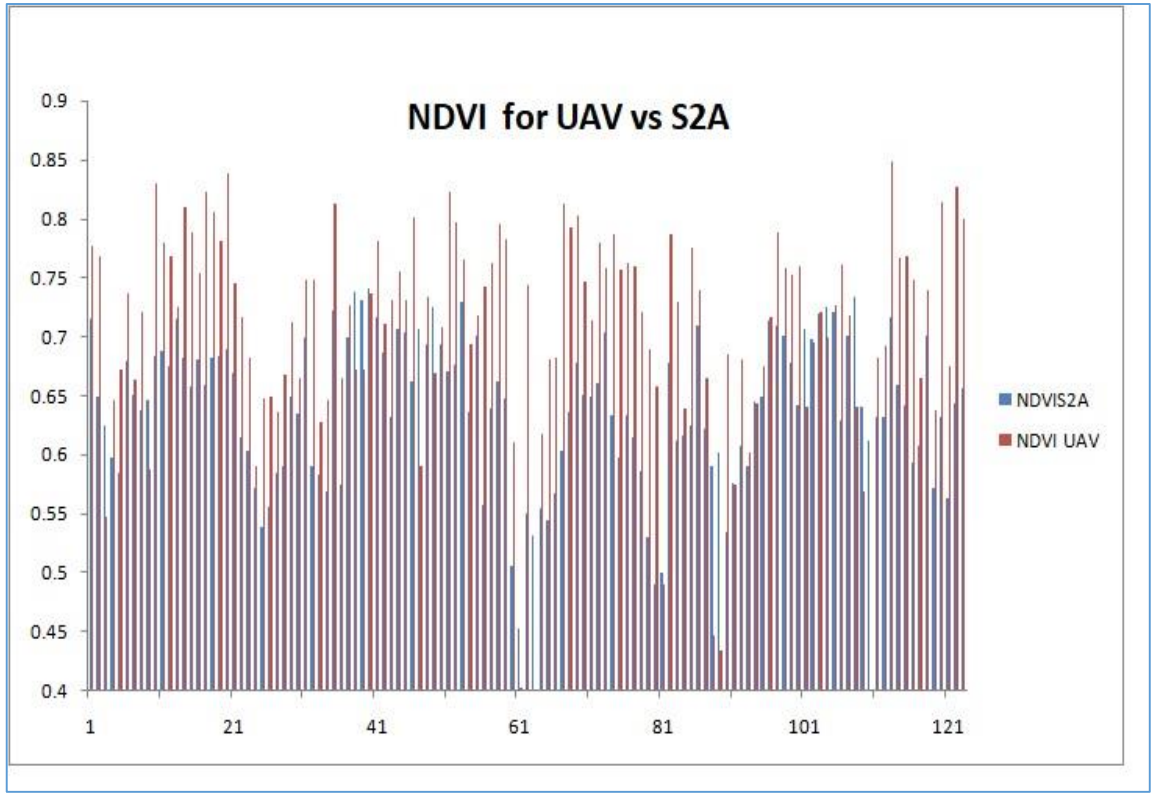
$$NDVI_{UAV} = \frac{NIR(band4) - Red(band2)}{NIR(band4) + Red(band2)}$$

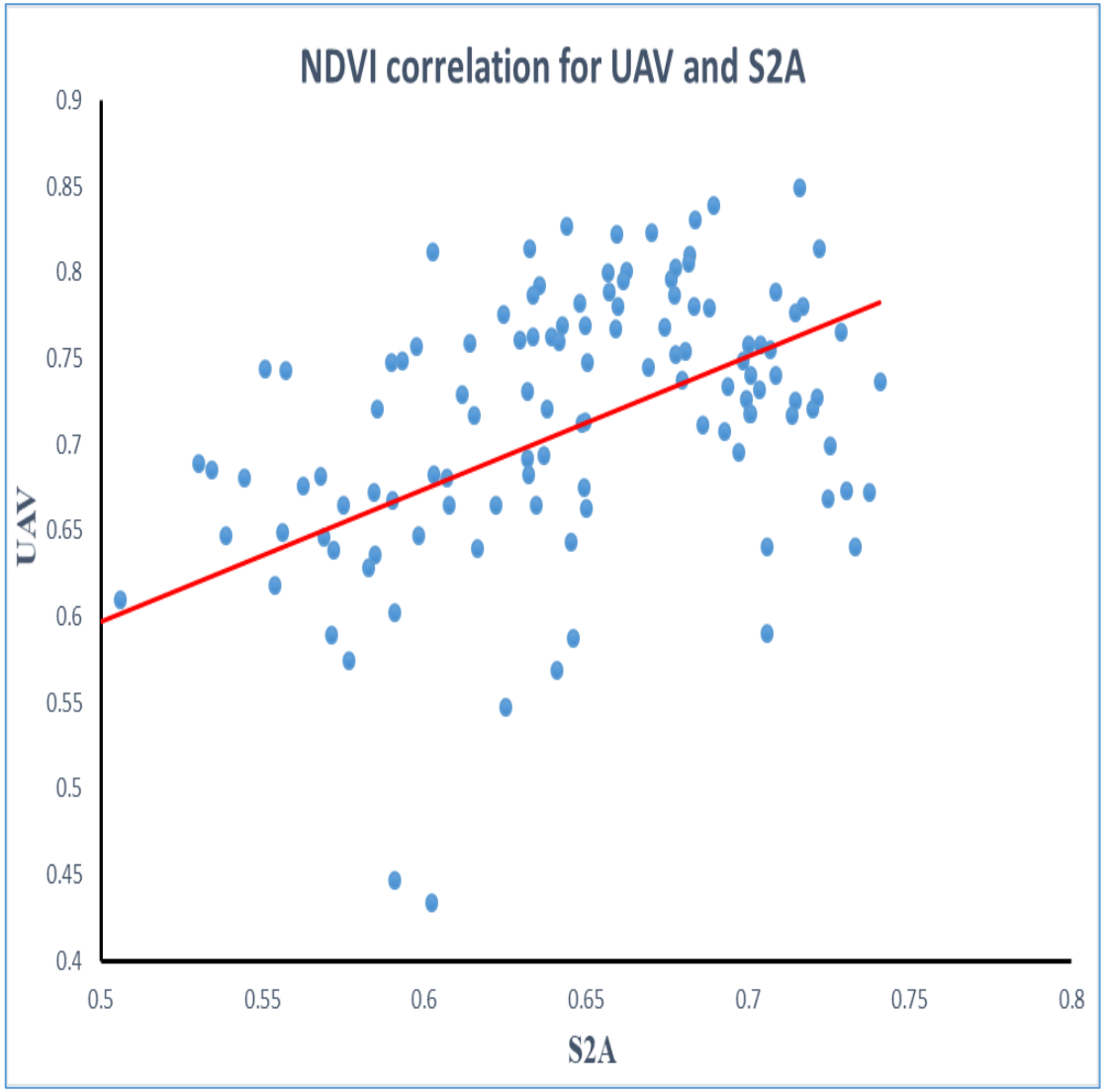


$$NDVI_{S2A} = \frac{NIR(band8) - Red(band4)}{NIR(band8) + Red(band4)}$$

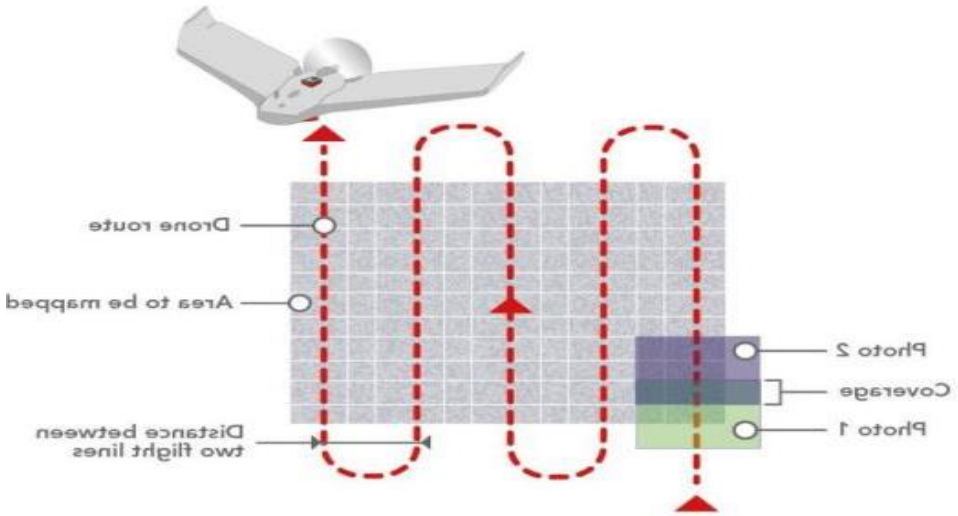
Cont…….

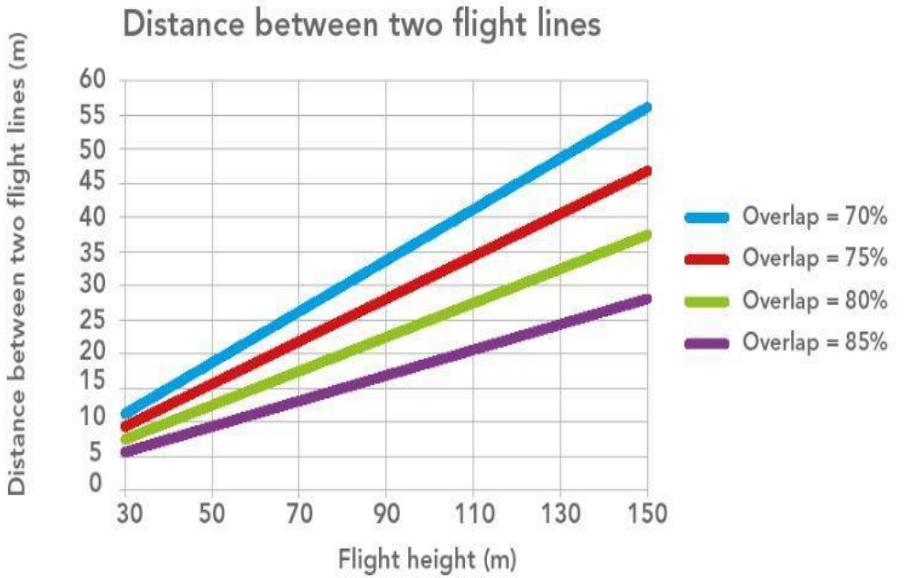
The NDVI correlation value(0.57) shows how much the classification of fused image was strong and a**ppropriate classification** for crop type mapping.

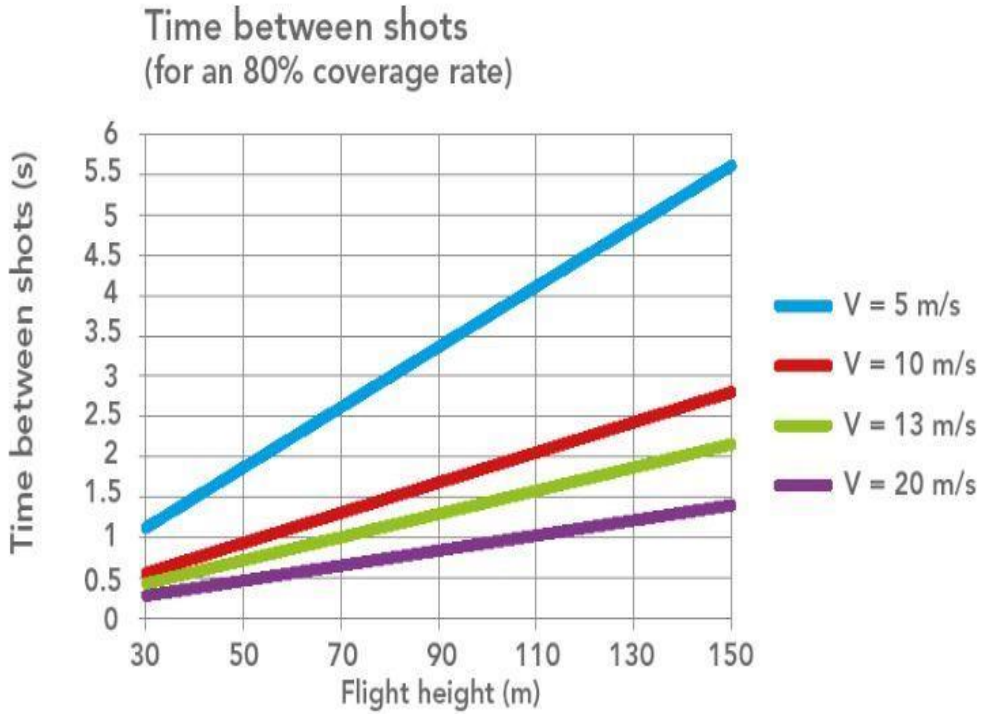


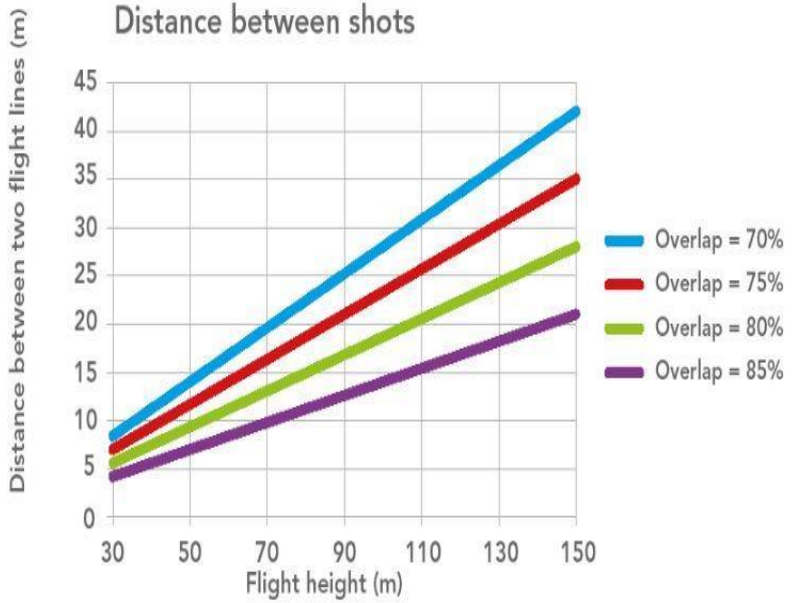


The flight of Parrot blue grass factors









Discussions

- In this study the supervised Random forest and the traditional Maximum likelihood classification have used.
- **RF algorithm is selected** because of its high performance in classifying raster images and fragmented crop type landscape components.
- Sentinel 2A and UAV has been fused together using Gram Schmidt (*GS*) technique for crop type mapping.
- From the fused approach, the Random forest classification algorithm obtained high classification accuracy 94% ,the maximum likelihood classification accuracy was 90 % and UAV 84%.
- The classification was not done only from multispectral image based of the fusion; it *needs ground data*.

Cont.….

- Pix4Dfield preprocess of the raw image have been done and "**zonal prescription** "that it categorizes and /or classify the study area into regional plots of farmlands.

The purpose of categorized area is to know the high spot areas of diseases, stress

Conclusion

The crop type classification of the fused image performed well, with advanced Random forest to **identify and discriminate different crop types** in the cluster farmland and machine learning RF algorithm is promising .

RF algorithm is powerful in classification and **runout huge amount of data** within high accuracy

The overall accuracies from RF approach resulted **94%,** this is because of UAV data played a great role in **improving the low resolution** of sentinel 2A

Recommendations

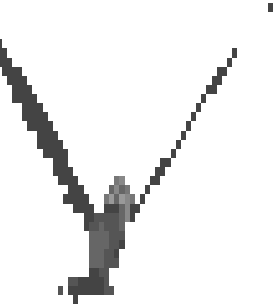
- It is better way if the **area of interest** is enhanced in Ethiopian agricultural practices, detect stress and crop type mapping by using blending of UVA with the **newly launching satellite** of Ethiopia.
- further studies need to develop a technique **capable of accurately analyzing** and **discriminating the crop types** found in small agricultural fields in Ethiopia landscape.
- Furthermore, now a days the **machine learning in** (**Digital agriculture**) is highly running so that the study strongly recommend that the agriculture sector should to interact, select the good approach for crop type mapping and monitoring
- Within integration of high resolution data to detect the weed availability in crop type mapping

Challenges

- Drone battery durability per flight ,obstacles frequent crashing's, distance from pilots
- Mission flight mistakes
- Time of flight ..wind, sun angle, weather(natural problems)
- Need to engage experts with diverse specialization
- Software capability (limited functionality) and license issue
- Computational and storage requirements

Acknowledgements

- Special appreciation goes to my Advisor Dr. Binyam Tesfaw Hailu (PhD) for your guidance, knowledge sharing, critical advices, helpful comments and insight in my study.
- Secondly, my special thank goes to my co-Advisor Dr. Degefei Tibebe (PhD) ,who propose the title of this thesis and gave me modifications from the beginning to the present form of this thesis.
- I am also thankful and recognize my sponsored institution, Ethiopian Institute of Agricultural Research (EIAR), sponsored me for my MSc study, trained me for piloting Unmanned Aerial vehicle and provided me the UAV itself for my primary data collection, encourage me well.




Thank you!!!
Q&A
You have Questions
We have Answers