Application of AI and Multispectral imagery for crop health monitoring

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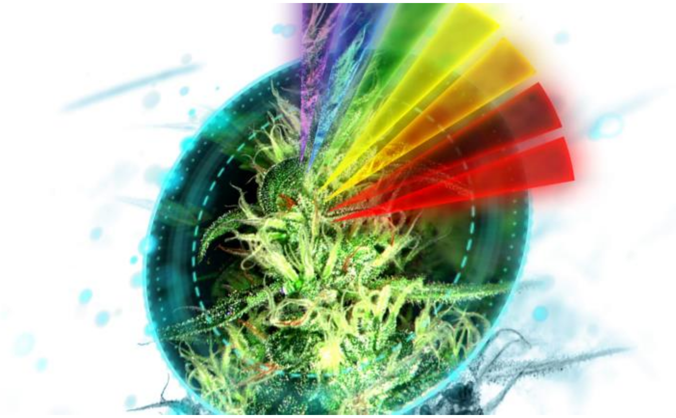


Outline

- Introduction
- Multispectral Imagery
- Proposed Solution
- Vegetation Indices and Application
- AI in health monitoring

Introduction

- Healthy, sustainable and inclusive food systems are critical to achieve the world's development goals.
- Agricultural development is one of the most powerful tools to end extreme poverty, boost shared prosperity, and feed a projected **9.7 billion people by 2050**. Growth in the agriculture sector is **two to four times more effective** in raising incomes among the poorest compared to other sectors.
- Agriculture is also crucial to economic growth: accounting for 4% of global gross domestic product (GDP) and in some least developing countries, **it can account for more than 25% of GDP**.

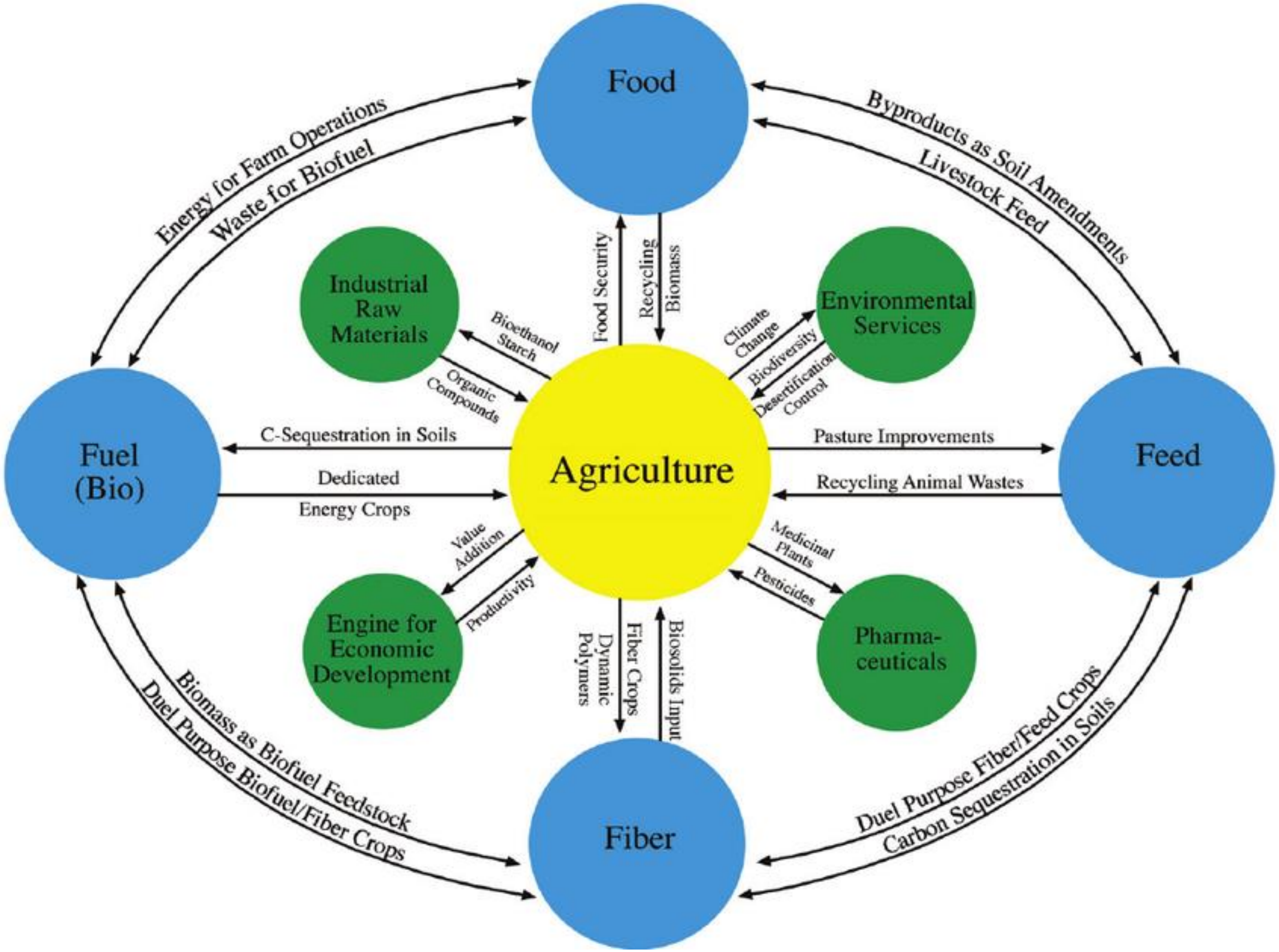


Fig 1: Agriculture Cycle

Crop pests and Diseases

Crop Pest:

- Pakistan has most diverse number of pests in the region. Because of climate and humidity conditions of the region, these pests effect crops badly and disease impact is severe.
- More than 50 insects and mites are found damaging the cotton crop in Pakistan.
- The most notorious pests are Aphid, Whitefly, Jassid, Thrips, Army Worm, American Boll Worm, Spotted Boll Worm and Pink Boll Worm.

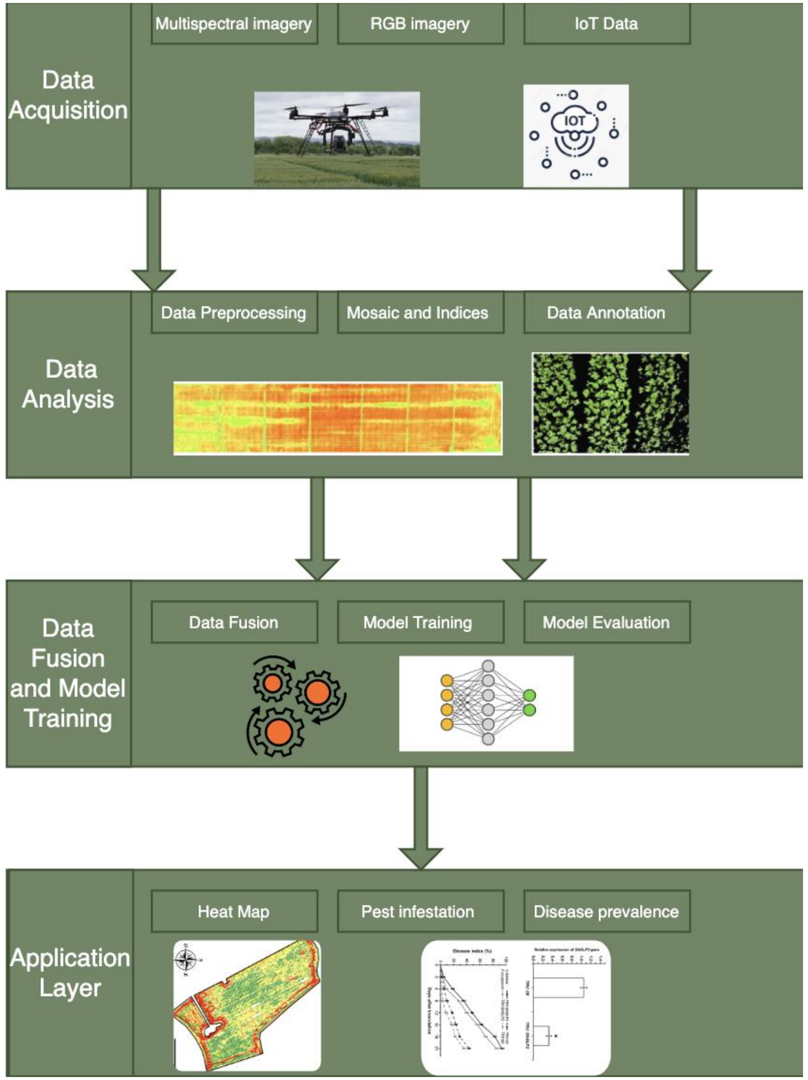
Crop Diseases

- Plant diseases are a severe threat to the entire production. Therefore, it is essential for farmers to effectively deal with them and check them with the help of timely prevention.
- Depending on the agricultural area size, this task can be difficult, especially since the list of harmful crop diseases is quite impressive
- Modern technologies like remote sensing and fusion of IoT with vision is way forward for enhancing yield and growth of crop.

Fig 2: Diseased Leaves

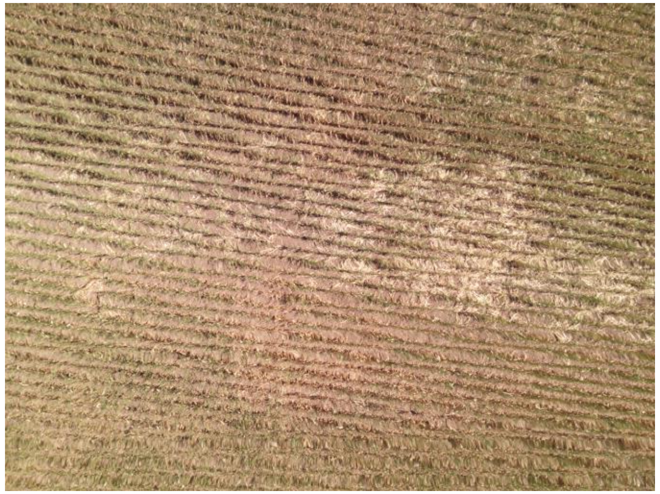
Proposed Solution

Methodology Pipeline:



Data Acquisition:

- The overall prototype development starts with the dataset development. The dataset consists of three streams.
- Data streams are multispectral imagery, RGB imagery and IoT data.
- Multispectral and RGB imagery would be captured through sensors and cameras like Sentera Single NDVI sensor, Parrot SEQUOIA+ Multispectral sensor, etc.



Multispectral Imagery:

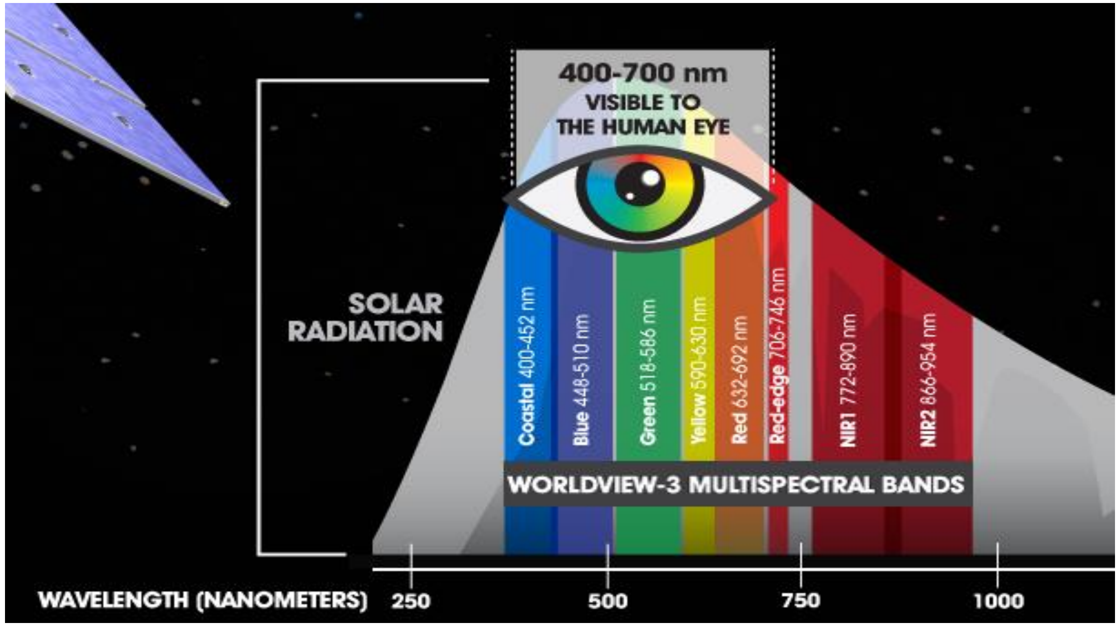


Fig 3: Wavelength Range

- Multispectral imaging captures image data within specific wavelength ranges across the electromagnetic spectrum. It includes light from frequencies beyond visible and light spectrum, i.e., infrared and ultraviolet.
- The primary goal of multispectral imaging in agriculture is to detect variation in plant health before visible symptoms appear.
- Using multispectral imagery, multiple Vegetation Indices can be computed to estimate crop health.

Parrot SEQUOIA+ Multispectral Sensor:

1. Green

   λ=550nm

2. Red

   λ=660nm

3 Red Edge

   λ=735nm

4. Near Infrared (NIR)

   λ=790nm

5. RGB

Fig 4: Sequoia+

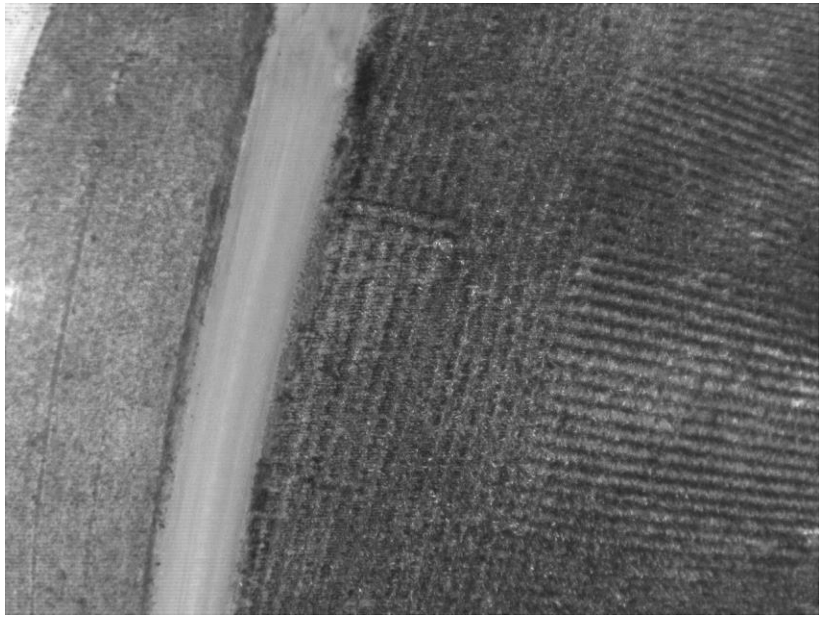


Fig 5a: Green band

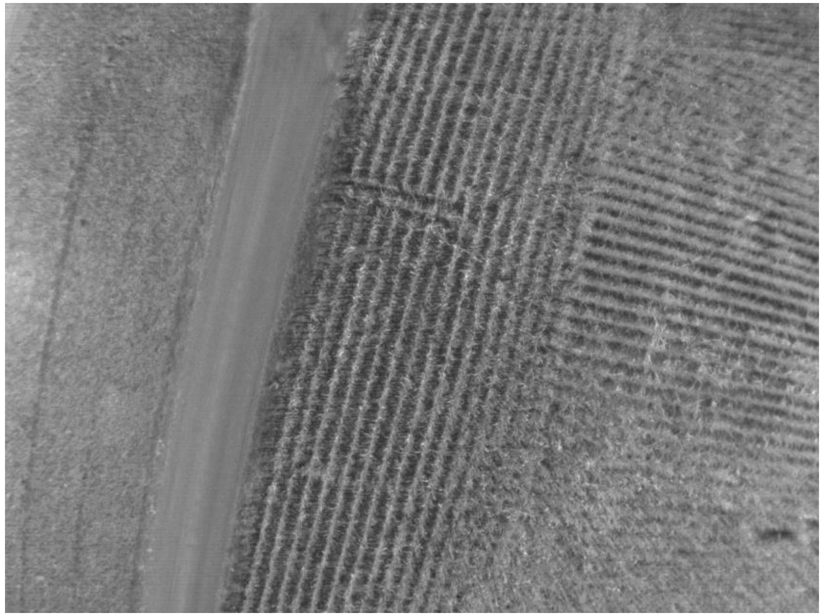


Fig 5b: NIR band

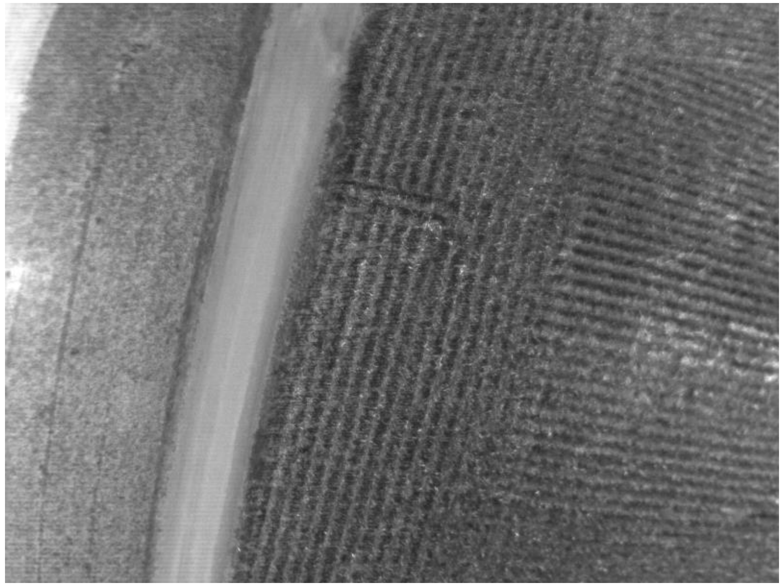


Fig 5c: Red band

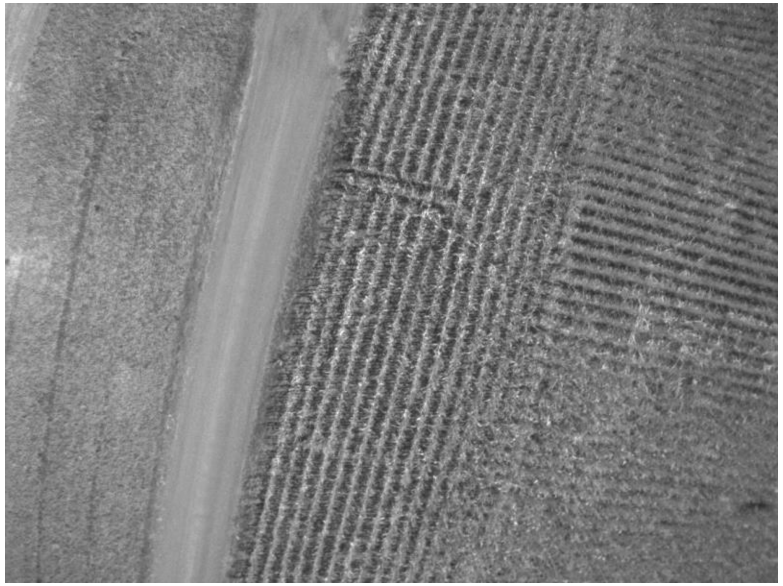


Fig 5d: Red edge band

IoT Data

- IoT data will be computed by using several sensors like temperature, humidity, pH, etc.
- Real time time series data is being computed using SenseCap K-1100 which is compatible with Groove sensors.
- Metrological data will be collected for real time analysis of atmospheric conditions on crop health.

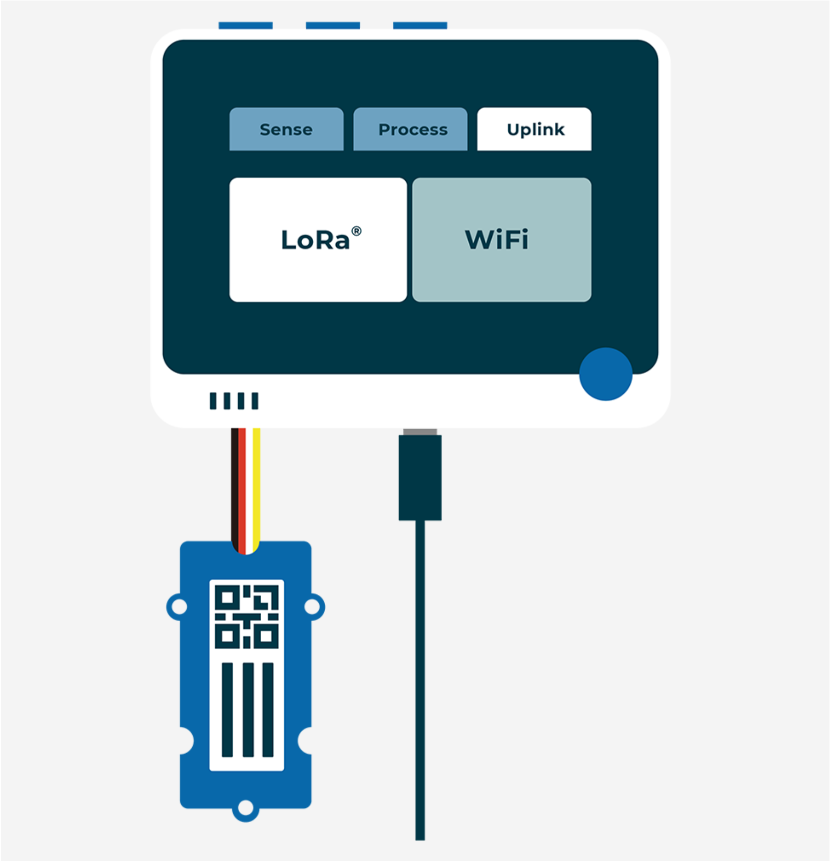


Fig 6: Wio Terminal

Time series data

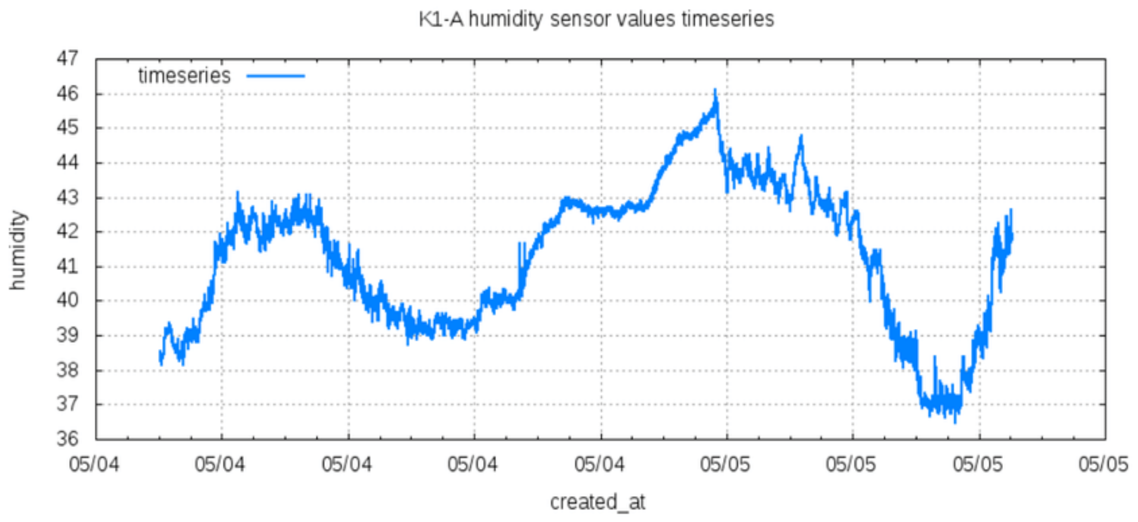


Fig 7a: Humidity Sensor

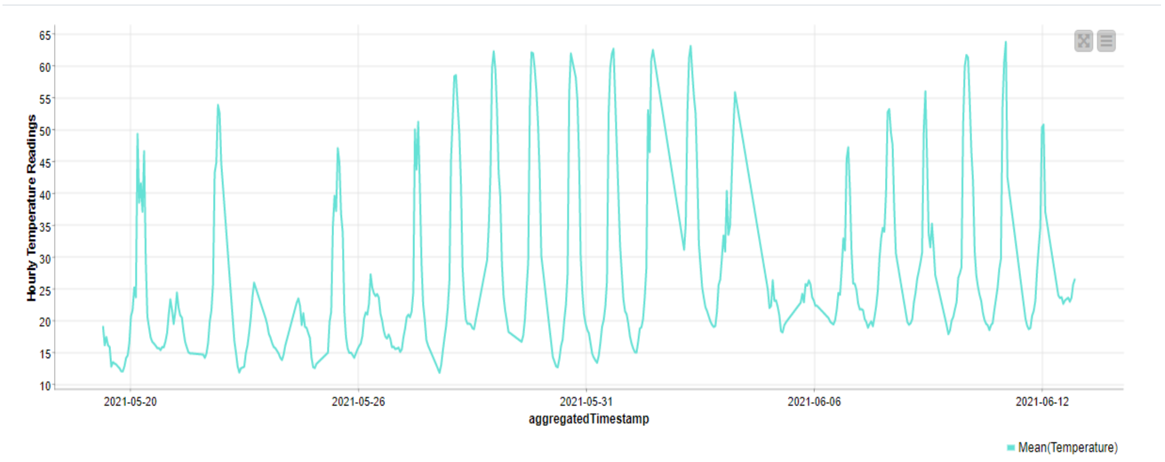
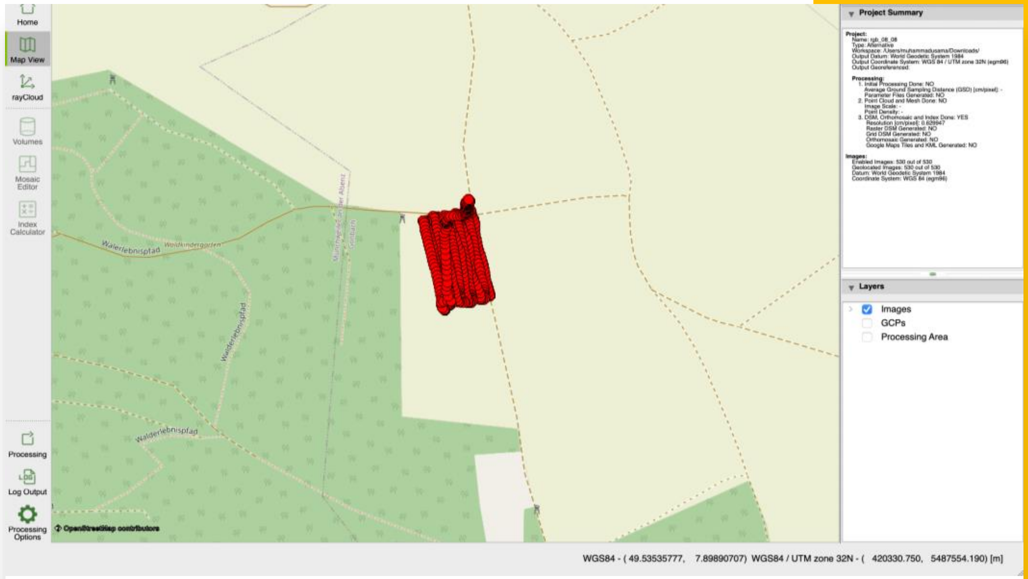


Fig 7b: Temperature Sensor

Data analysis and Preprocessing

- Data stitching and orthomosic compilation is being done using several stitching software like Pix4Dmapper, Pix4dfields, WebODM, etc.
- While collecting data, picture overlap is fixed at 80% which helps in accurate geo referencing of images.



RGB Mosaic

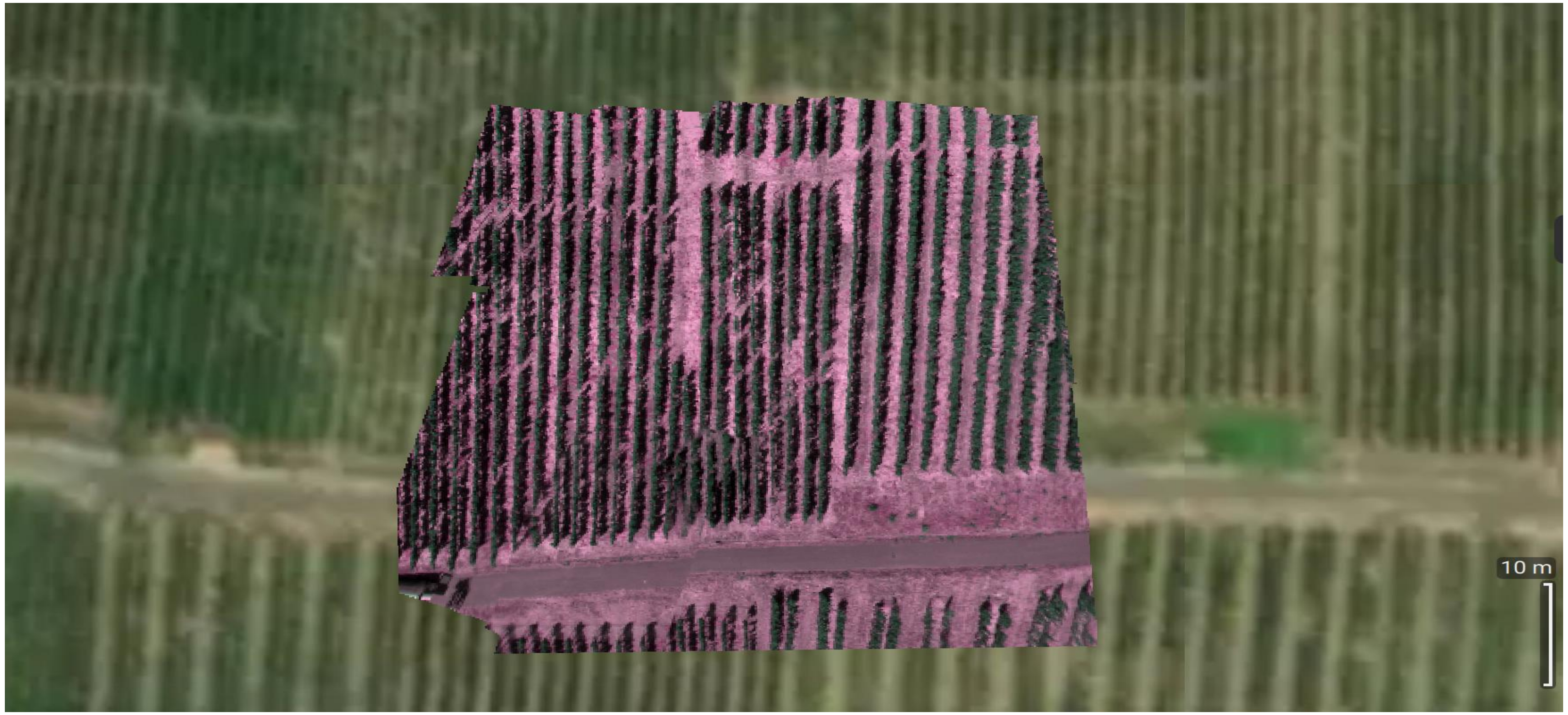
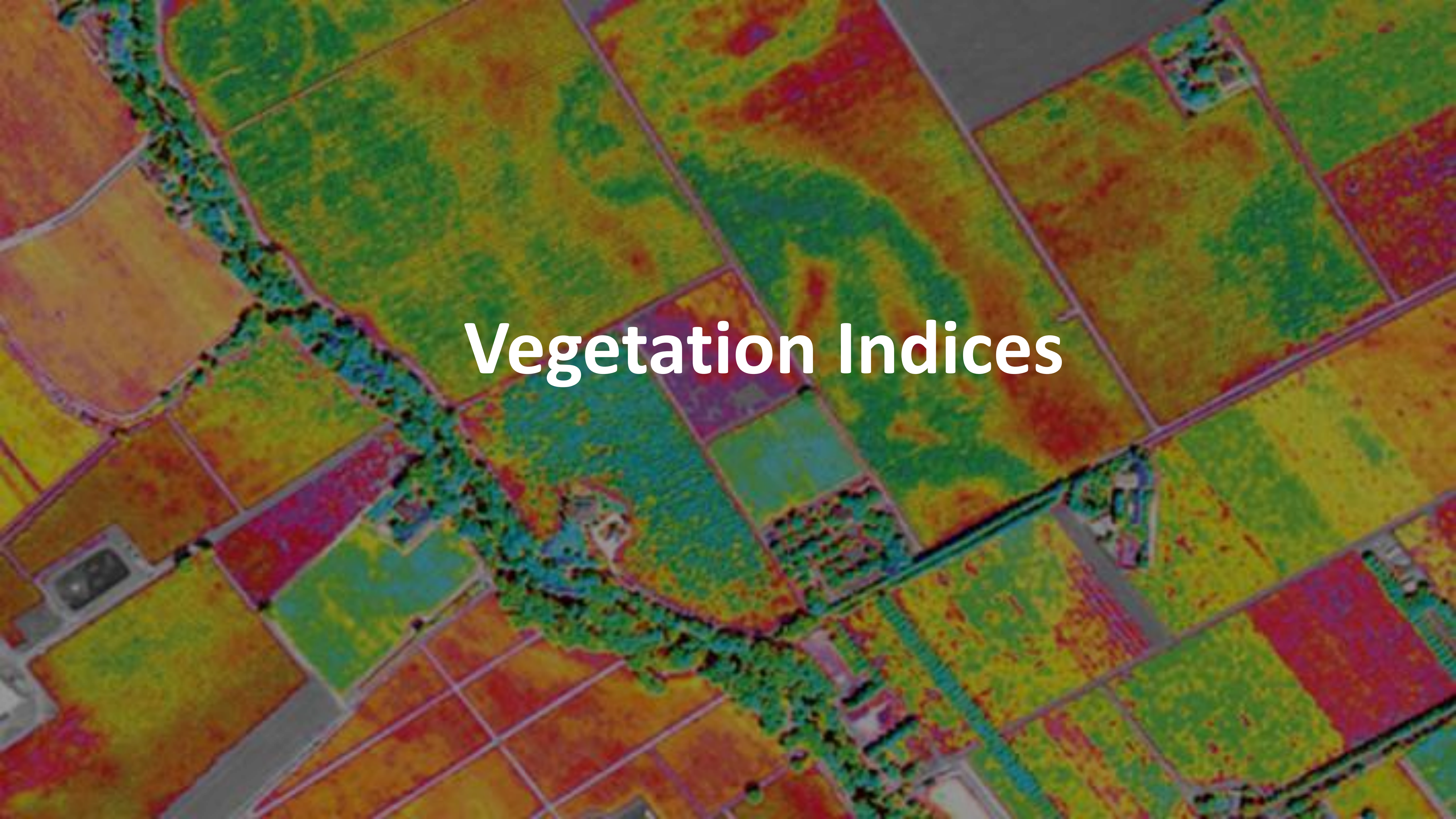


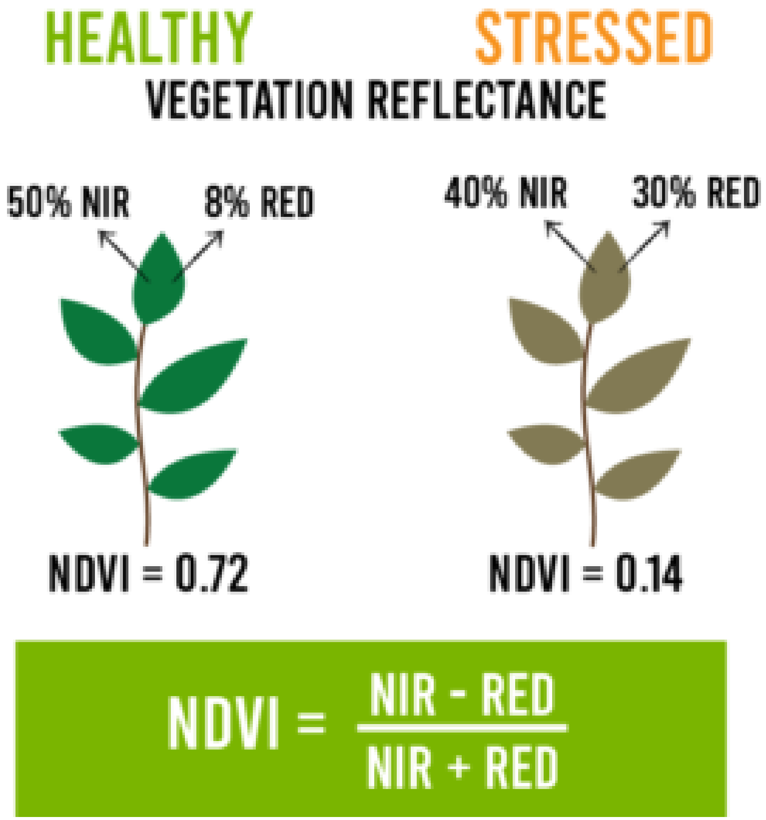
Fig 8: Vineyard fields

Vegetation Indices



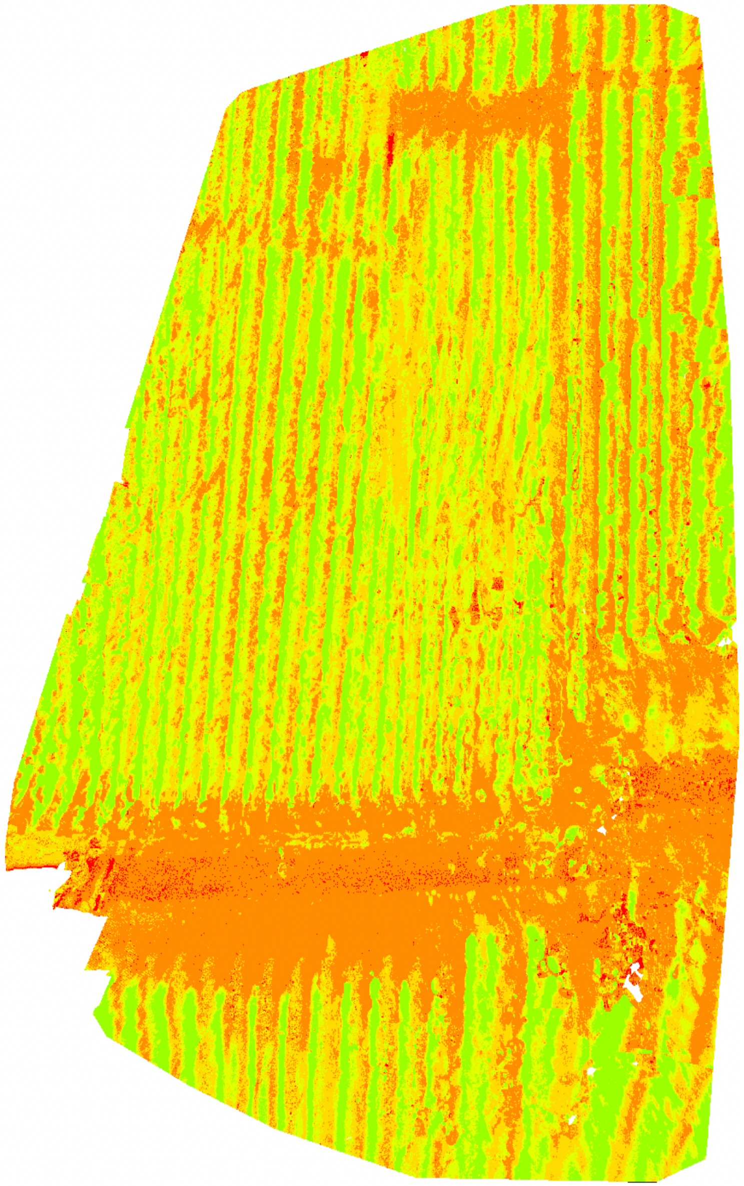
Normalized Difference Vegetation Index:

- NDVI is the ratio of difference between NIR band and red band to that of sum of NIR band and red band.
- It varies between -1 to +1 where -1 indicates no chlorophyll content or dead plant while +1 indicates a high possibility of dense green leave.
- When NDVI is close to zero, there are likely no green leaves and it could even be an urbanized area.



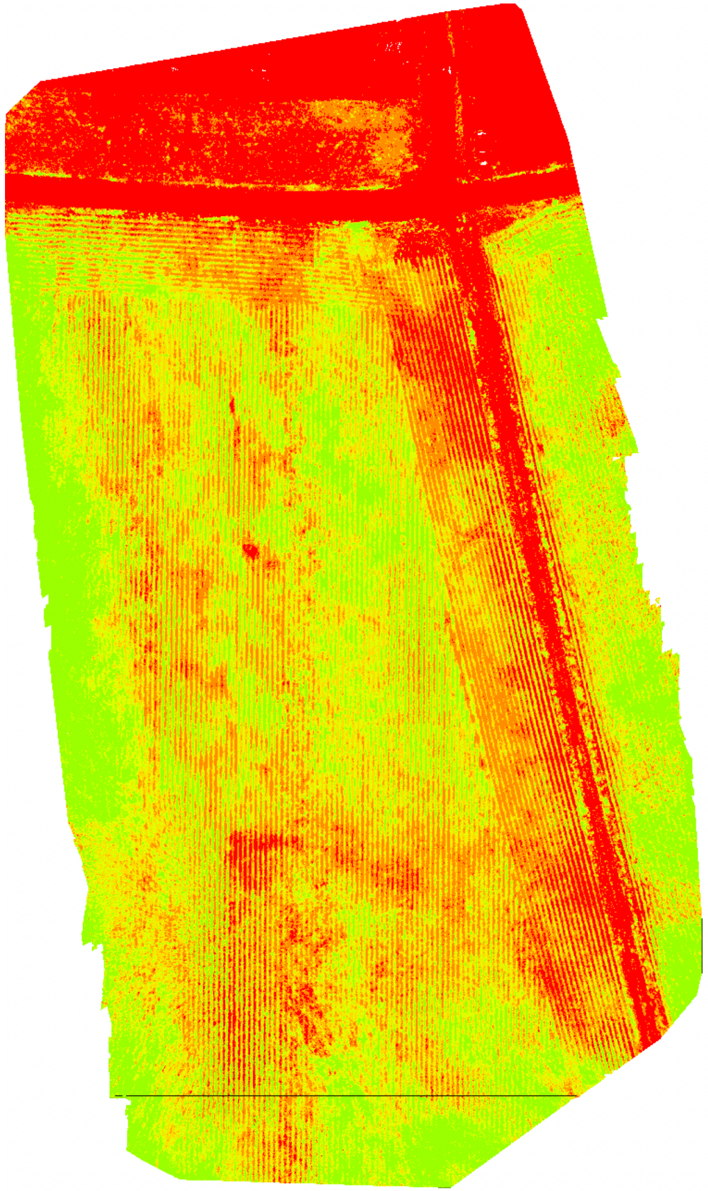
https://un-spider.org/sites/default/files/ISA_wf_41.png

Vineyard field NDVI



Color	Min	Max	Area [ha]	Area [%]
	0.76	0.99	0.06	21.56
	0.59	0.76	0.06	20.77
	0.43	0.59	0.08	26.02
	0.24	0.43	0.09	30.92
	-0.01	0.24	0.00	0.72

Corn field NDVI



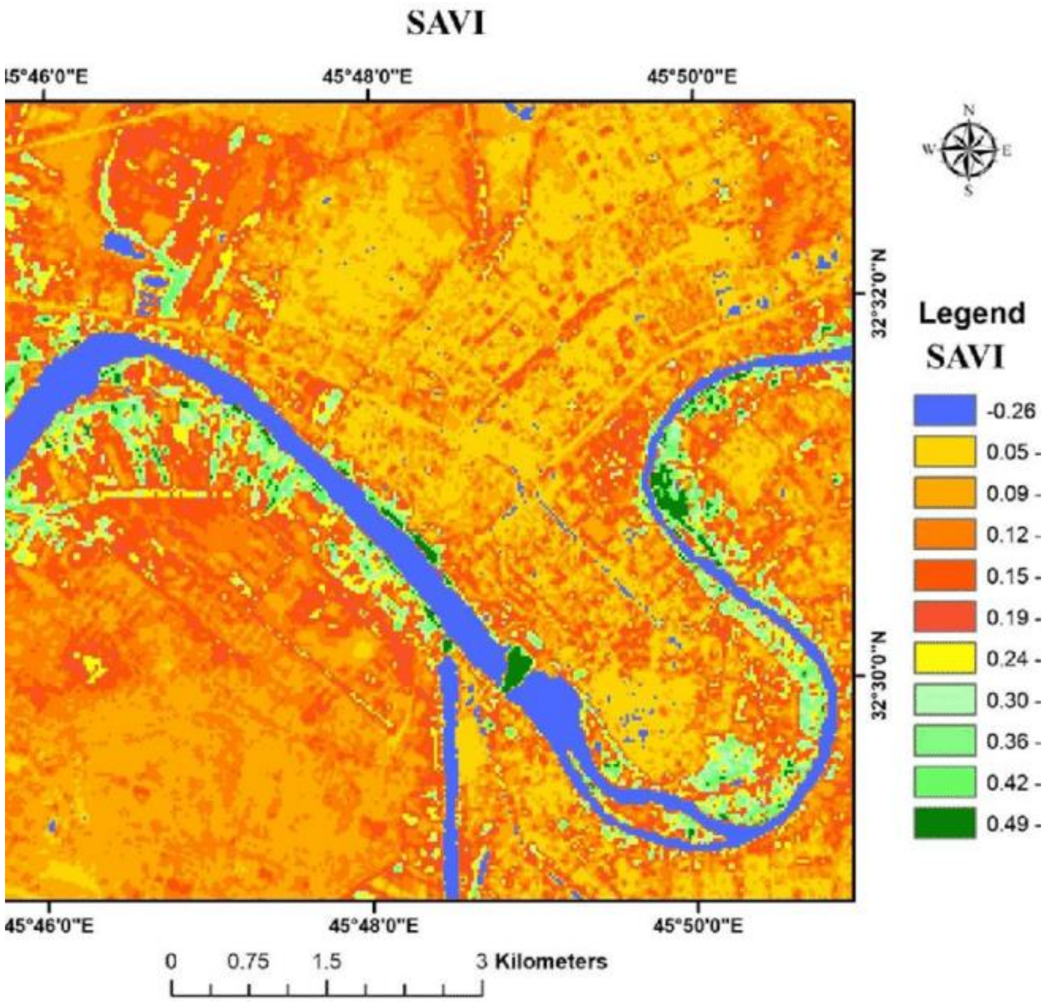
Color	Min	Max	Area [ha]	Area [%]
	0.61	0.87	0.27	19.96
	0.56	0.61	0.27	20.01
	0.50	0.56	0.27	20.01
	0.41	0.50	0.27	20.01
	0.15	0.41	0.27	20.00

Soil-Adjusted Vegetation Index:

- SAVI (Soil-Adjusted Vegetation Index) is used to correct Normalized Difference Vegetation Index (NDVI) for the influence of soil brightness in areas where vegetative cover is low.

- **Formula:**

$$\text{SAVI} = \frac{NIR - Red \times (1+L)}{NIR + Red + L}$$

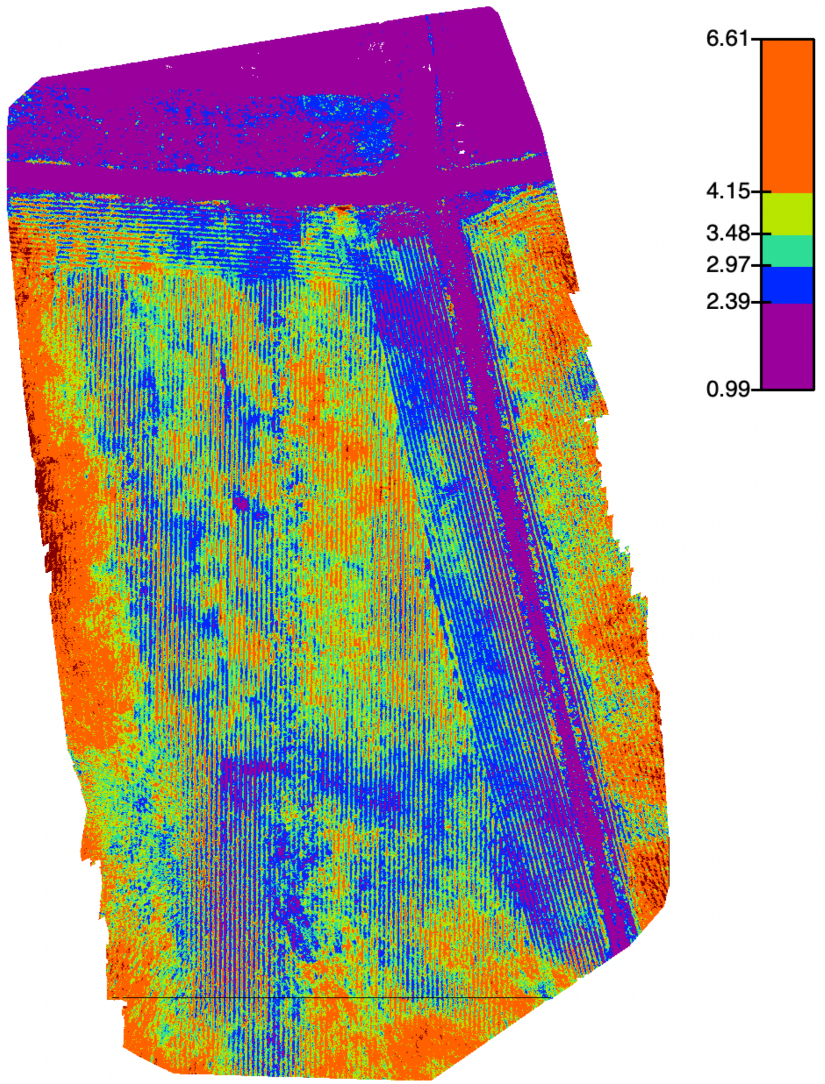


https://www.researchgate.net/figure/a-6-graphs-showing-comparison-of-NDVI-vs-SAVI-at-10-and-30-m-spatial-resolution-using-DN_fig3_299469974

Ratio Vegetation Index:

- Ratio Vegetation Index is the ratio of NIR band to Red band. With the increase in RVI value, the vegetation cover increases.
- The ratio vegetation index RVI **has the potential to indicate the stress level of crops** due to its high correlation with the leaf area, dry biomass and chlorophyll content. The damage degree of a crop by pests is determined by the pest population size and exposure time.
- **Formula**

  RVI = NIR / RED



Locating hotspots:

- Once finding NDVI mosaic, the next step would be to locate hotspots in the whole crop where the crop needs to be taken care of.
- We apply thresholding on the whole mosaic. The 100x100 kernel is applied to the whole map and check for the reagions below specific threshold of NDVI values.
- The model has longitudes and latitudes of only those reagions where spraying drone needs to go and apply pesticides to control disease.

Disease Detection

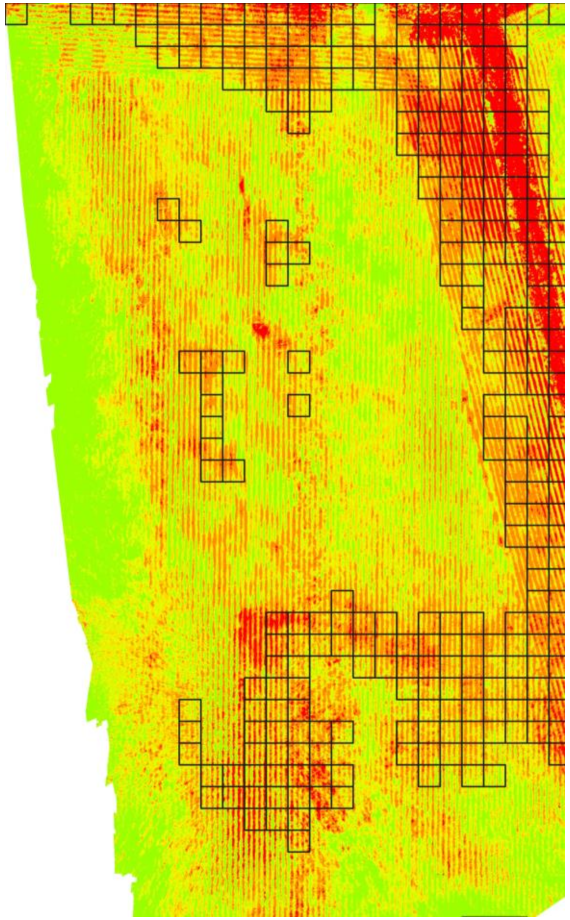
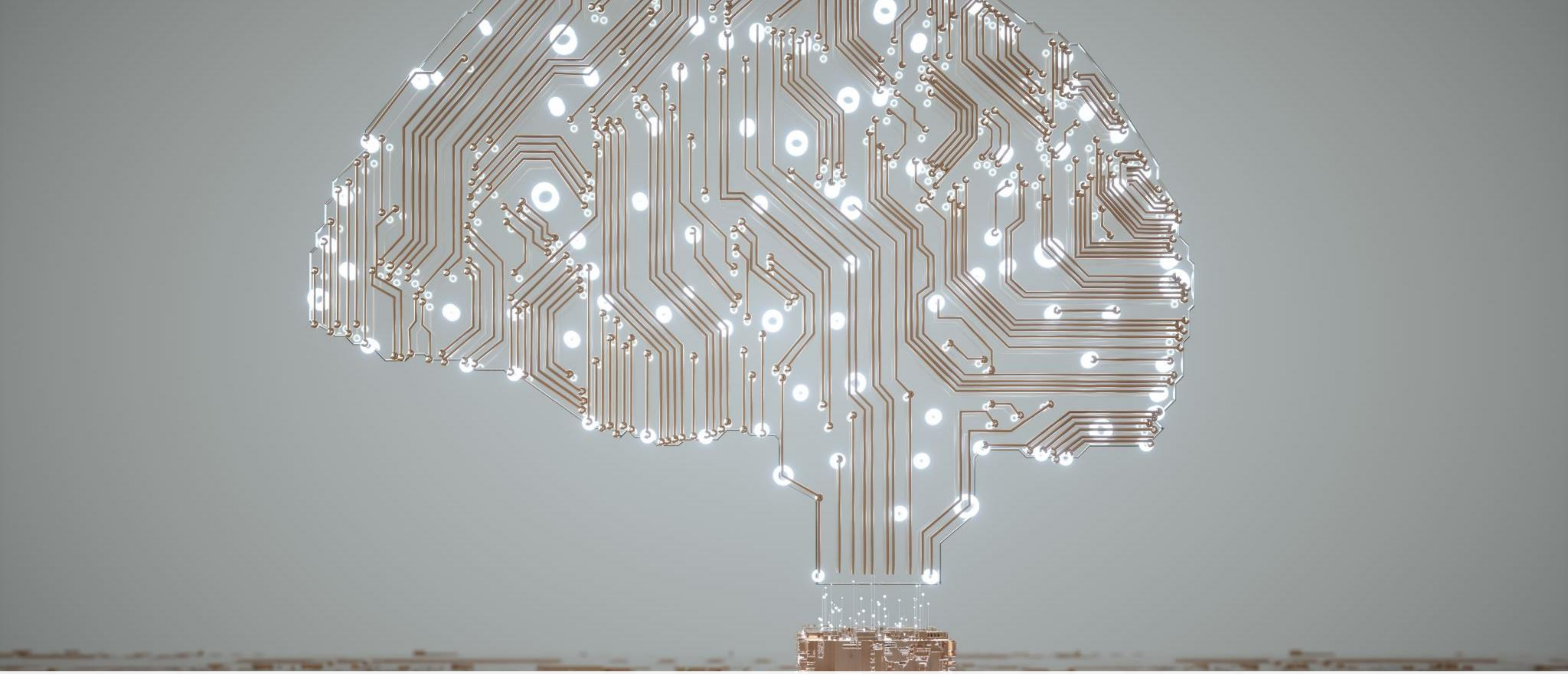


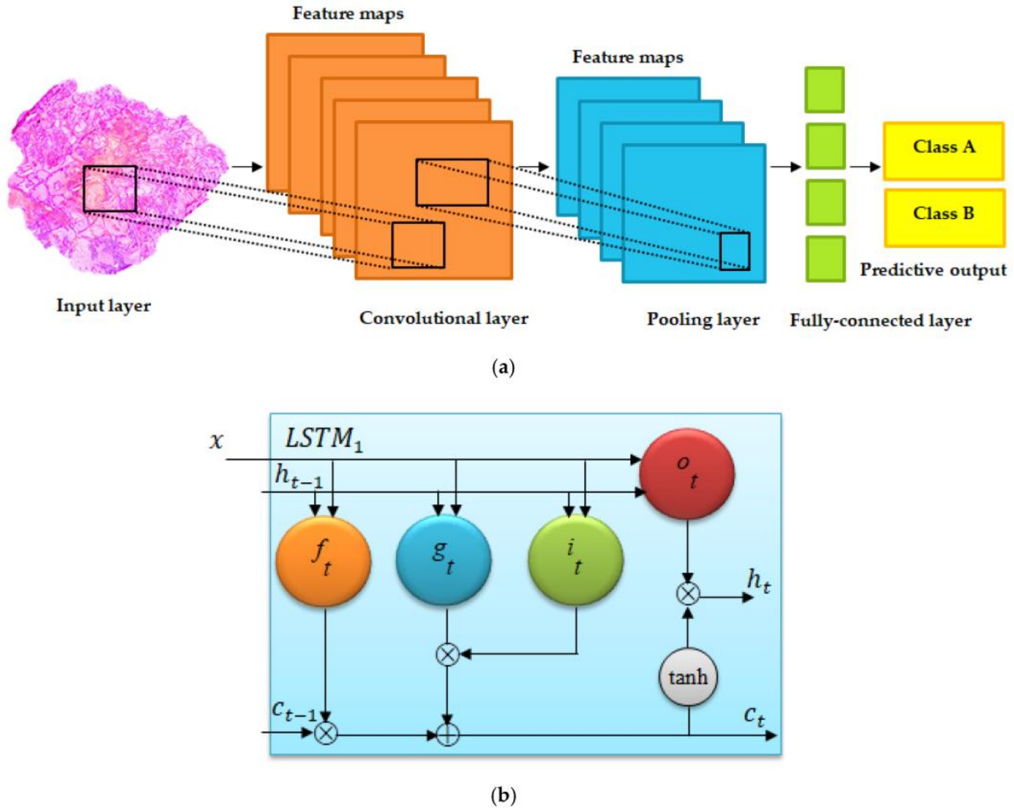
Fig 9: NDVI based Thresholding



Why Artificial Intelligence ?

Multi-Modality

- AI provides multi modality of data. The two main streams of data are Iot and wide wavelength magnetic spectrum.
- Instead of using only vegetation indices for detection of stress on crop, Iot data will provide information about environmental impact on crop health.
- CNN will extract features from imagery that will be fused with RNNs for inclusion of time series IoT data.



Conclusion

- After finding hotspots of stress in the reagion, the model will give longitudes and lattitudes of only those reagions which needs to be taken care of.
- So instead of sprying on whole field, pesticides will be applied to specified reagions which will not only improve yield but also crop quality.
- Hence, precison farming using AI is the only way forward for sustainable and productive agriculture sector.


Question??


Thank You