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CREATE CHANGE

Lethal Yellowing Disease in Coconuts: A Diagnostic Tool, and the Potential of Satellite- Based Surveillance

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Bogia Coconut Syndrome/lethal yellowing

- Phytoplasma disease
- Present in the Americas, Africa, Asia and Oceania
- Not only in coconut but in other palms



Monitoring: Surveillance & Confirmation

- Monitoring is essential to control and eradicate the disease
- **Surveillance** will identify suspicious trees
- **Confirmation** will confirm/deny disease

Surveillance

- What are we looking for?
 - Sick looking trees
- How do we look for it?
 - From below
 - With our eyes



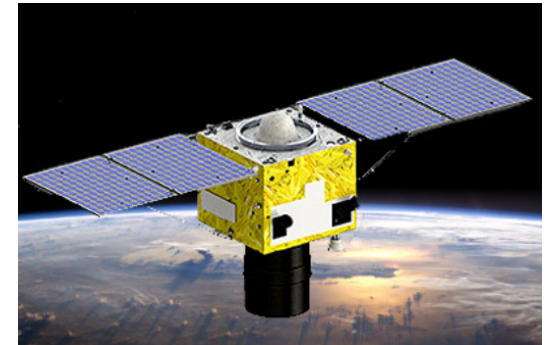
Surveillance

- We can also look from above
- We can use different sets of eyes



Surveillance from above

- Satellites
 - Low resolution: over 60m/pixel
 - Medium resolution: 10 – 30m/pixel
 - High to very high resolution: 30cm – 5m/pixel
- Unmanned aerial vehicles (drones)



Superview-1 0.5m/pxl

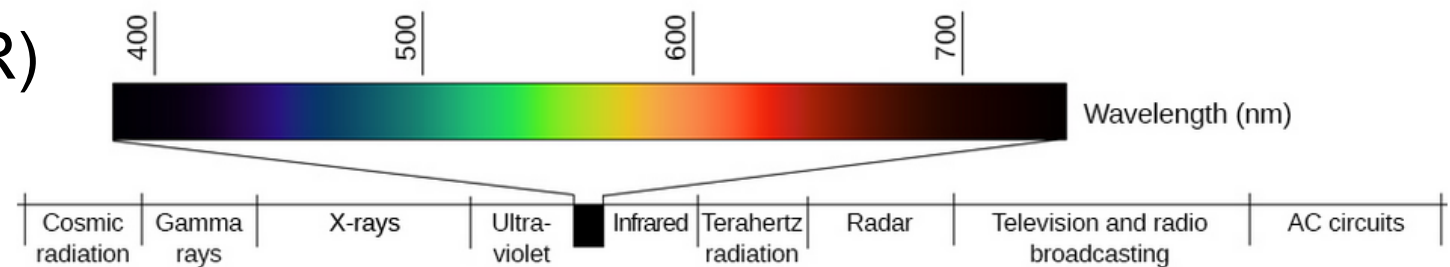


Sentera Double 4K Multispectral NDVI/NDRE
Sensor Upgrade for DJI Phantom 4 Series



There is a lot we cannot see with our eyes

- Visible
- Near Infrared (NIR)
- Fluorescence
- Thermal
- Synthetic Aperture Radar
- Light Detection and Ranging (Lidar) systems



Surveillance: Lethal yellowing symptoms

- Fruits drop
- Trees show yellowing of canopy
- Phytoplasma diseases restrict phloem movement
- Plant is stressed
- Lower photosynthesis

Surveillance Essential Requisite

Find a spectral signature for diseased trees

How can we recognise a diseased tree?

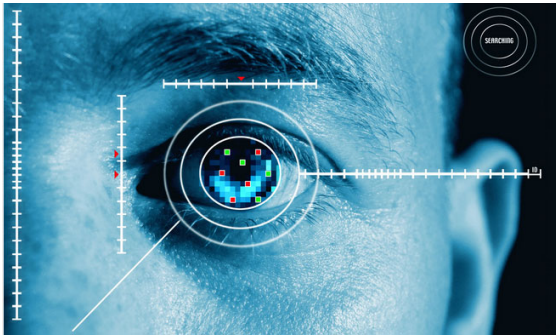
How early can we find it?

Does it changes with disease progression?

Can we use Artificial Intelligence/Machine Learning to recognise symptoms?

Surveillance

1. Image acquisition



2. Image analysis



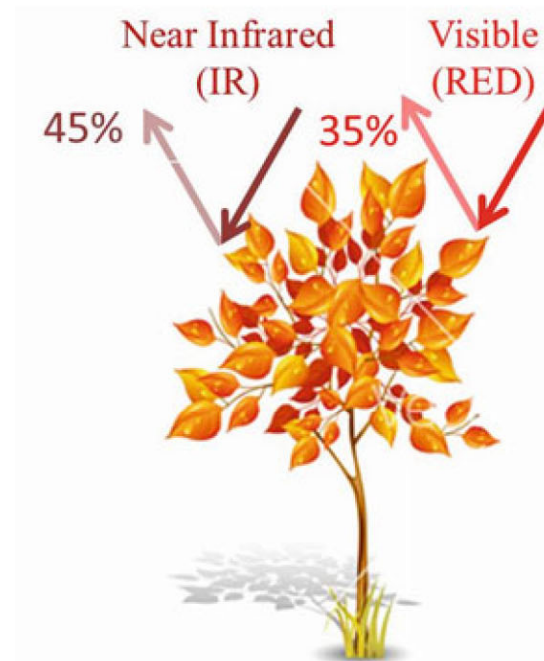
Surveillance: Image acquisition

- Drones are good local surveillance
 - Small scale
 - High resolution
 - Fast
 - Cheap
- Satellites are good for large/national programs
 - Large scale
 - Lower resolution
 - More expensive

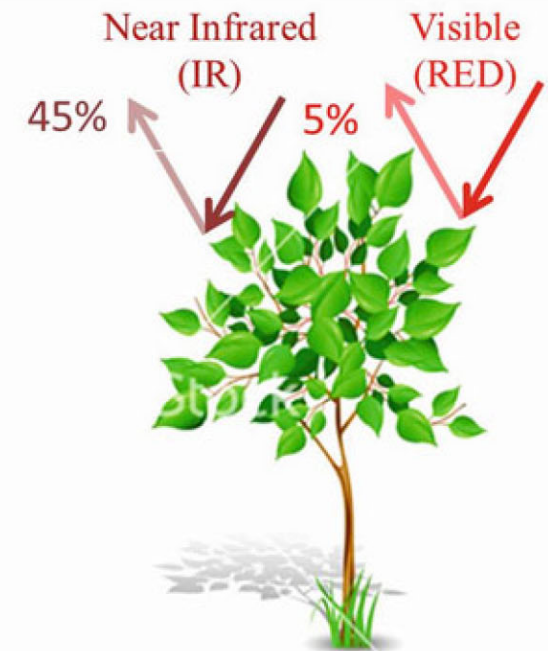
Surveillance: Image analysis

Is not only what you detect, it is how you analyze it

- Normalized Difference Vegetation Index (NDVI)
- $NDVI = \frac{(NIR - VIS)}{(NIR + VIS)}$

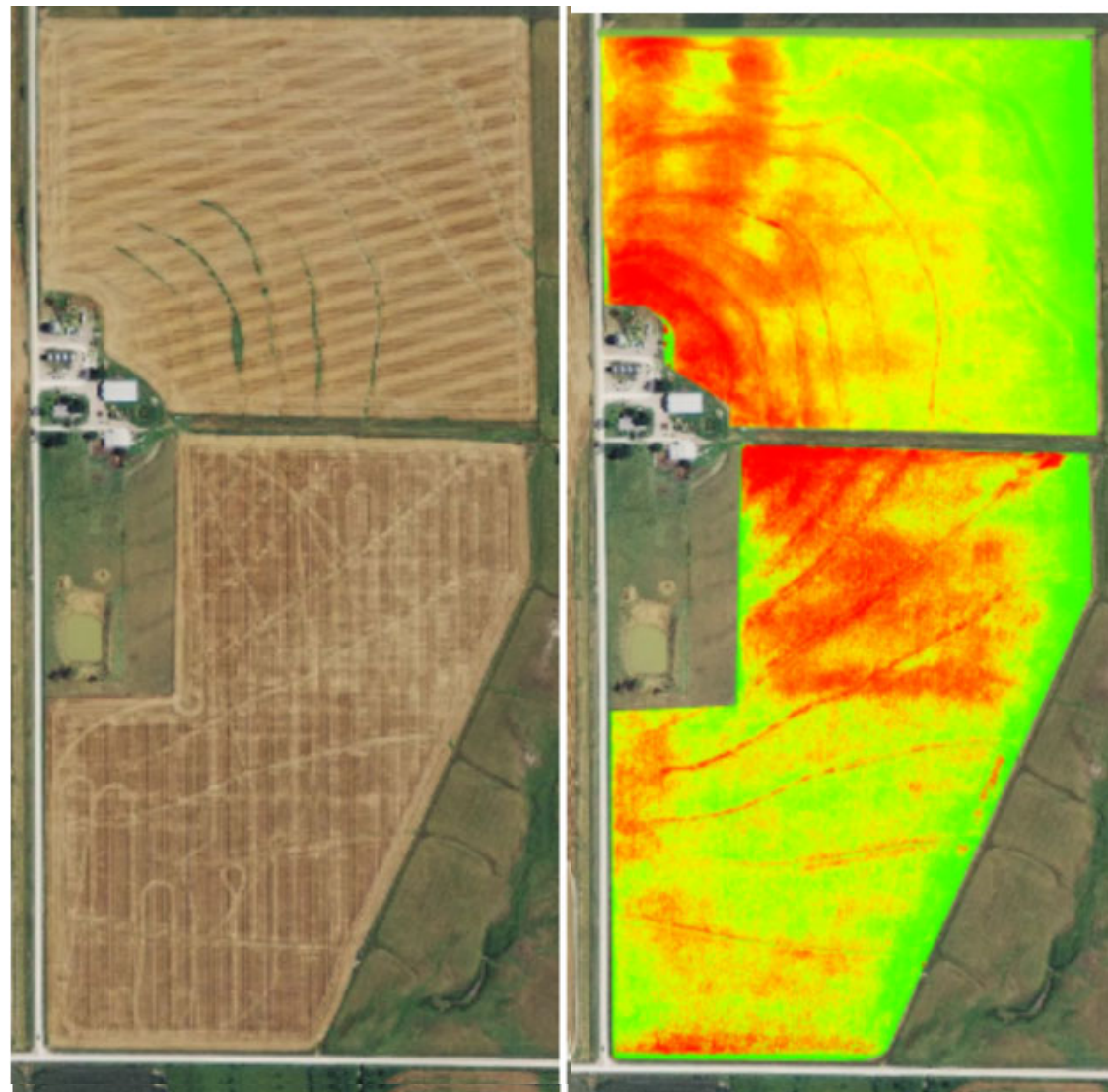
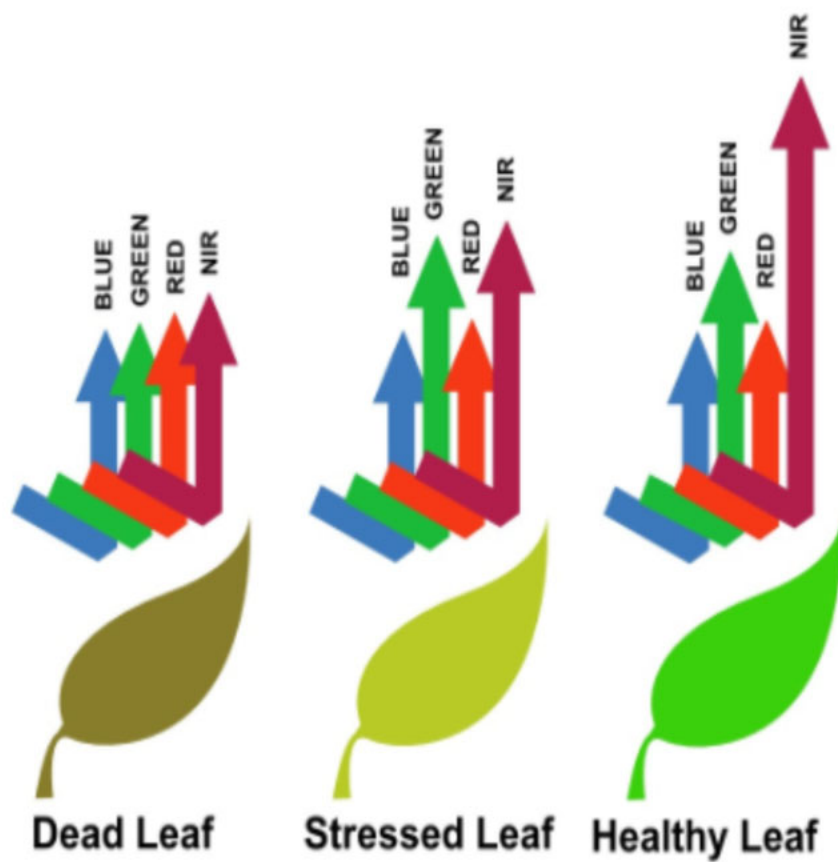


$$NDVI = \frac{(NIR - RED)}{(NIR + RED)} = \frac{(45\% - 35\%)}{(45\% + 35\%)} = 0.125$$



$$NDVI = \frac{(NIR - RED)}{(NIR + RED)} = \frac{(45\% - 5\%)}{(45\% + 5\%)} = 0.8$$

NDVI




```

graph LR
    subgraph Pre-processing
        Input[Input image] --> CalcVIs[Calculate VIs]
        CalcVIs --> G_R[G-R]
        G_R --> Thresholding[Thresholding]
        Thresholding --> Mask[Mask building and soil]
    end

    Mask --> SelectVIs[Select better VIs]
    SelectVIs --> Bands[Bands]
    SelectVIs --> VIs[VIs]
    Bands --> PCA[PCA]

    subgraph Features_extraction
        Micascense[Micascense and WV-2]
        Banana1[Banana]
        Other1[Other]
        Tree1[Tree]
        PS_S2[PS and S2]
        Banana2[Banana]
        NoBanana[No banana]
    end

    PCA --> Features_extraction

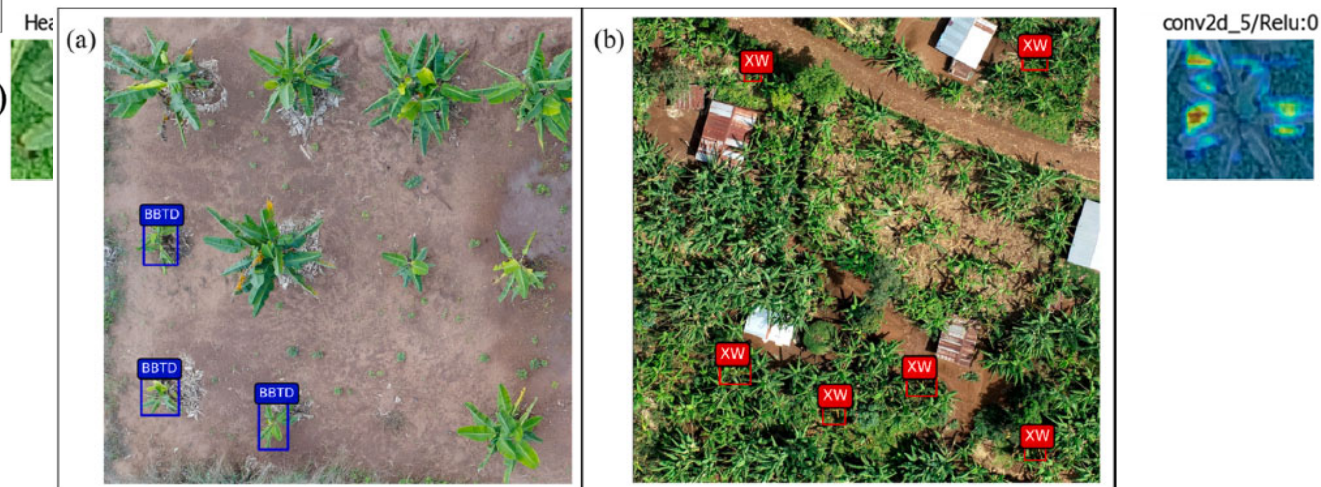
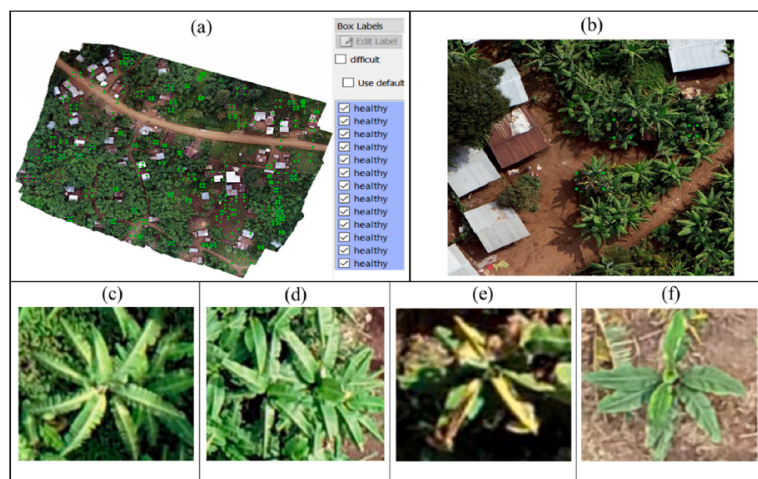
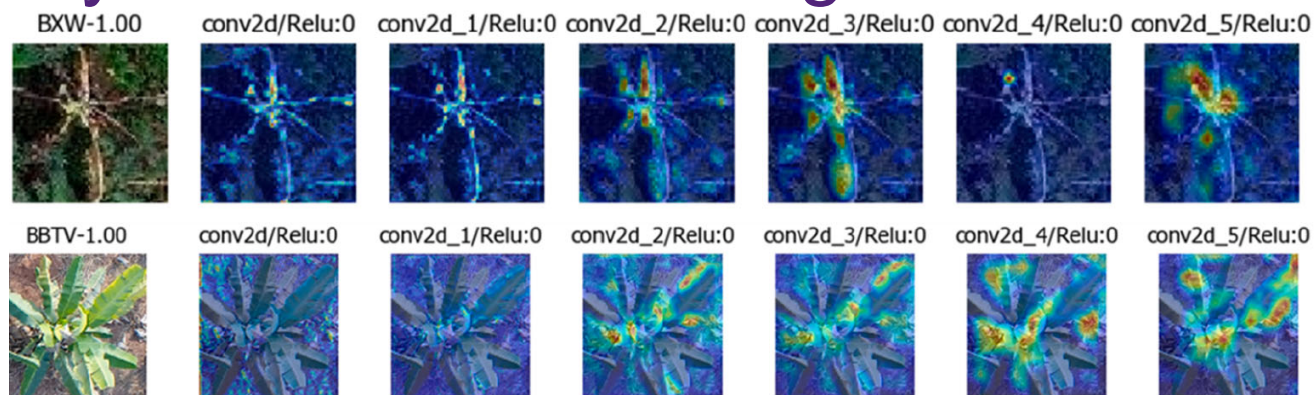
    Features_extraction -- 70% --> Training[Training data]
    Features_extraction -- 30% --> Testing[Testing data]

    Training --> Model[Model: Random forest and SVM]
    Model --> Bands2[Bands]
    Model --> Bands_VIs[Bands + VIs]
    Model --> PCA2[PCA]
    Model --> Bands_VIs_PCA[Bands + VIs + PCA]

    Testing --> Prediction[Prediction]
    Prediction --> Micascense2[Micascense and WV-2]
    Prediction --> Banana3[Banana]
    Prediction --> Other2[Other]
    Prediction --> Tree2[Tree]
    Prediction --> PS_S22[PS and S2]
    Prediction --> Banana4[Banana]
    Prediction --> NoBanana2[No banana]

    Prediction --> Accuracy[Accuracy]
  
```

Flowchart illustrating the proposed model for banana detection in satellite images. The process starts with **Pre-processing** (Input image, Calculate VIs, G-R, Thresholding, Mask building and soil). This leads to **Features extraction** (Micascense and WV-2, Banana, Other, Tree, PS and S2, Banana, No banana). The data is then split into **Training data** (70%) and **Testing data** (30%). The Training data is used to build a **Model** (Random forest and SVM) which outputs Bands, Bands + VIs, PCA, and Bands + VIs + PCA. The Testing data is used for **Prediction** (Micascense and WV-2, Banana, Other, Tree, PS and S2, Banana, No banana). The final output is **Accuracy**.



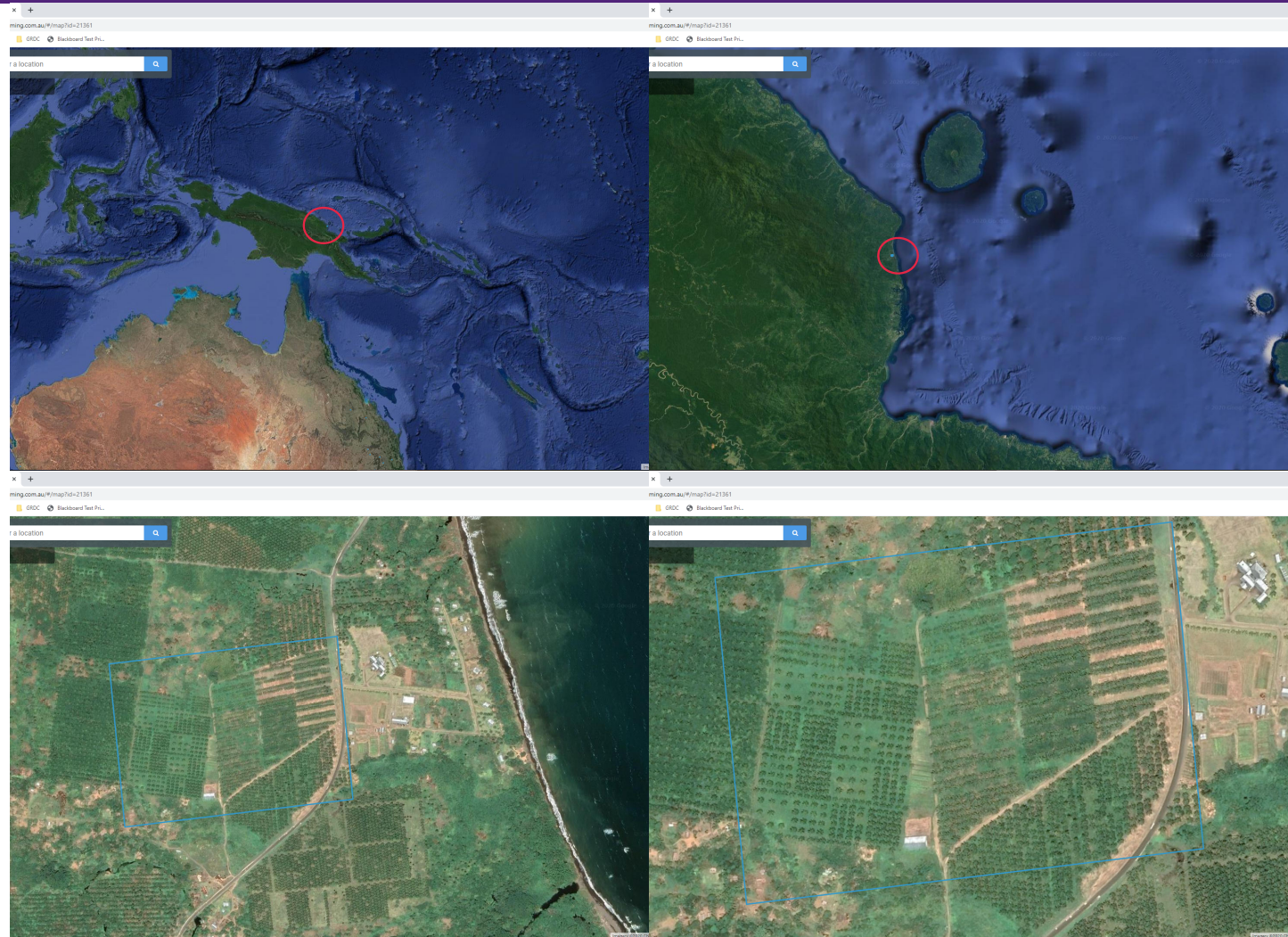
A road map for research

1. Locate trees at different stages of disease
2. Collect image/spectral data with drone
3. Collect satellite images/spectral data
4. Mathematical analysis of data
 - NDVI, thermal, RGB, visible/image analysis
5. Use machine learning/artificial intelligence
6. Create surveillance method for local systems (UAVs)
7. Create surveillance method for wide area systems (satellites)

Madang Stewart Research Station

Airbus Worldview imagery
showing station

Below is example of 0.5m NDVI
image



Madang Stewart Research Station

2019?

Google reference satellite image

RGB @ 0.5m

21 Sep 2020

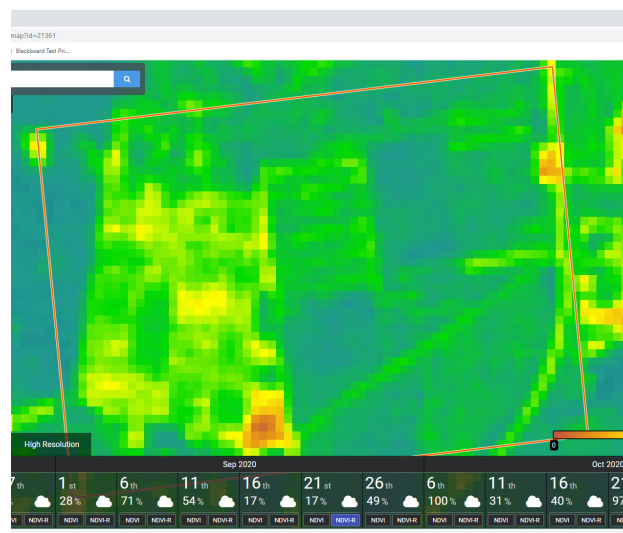
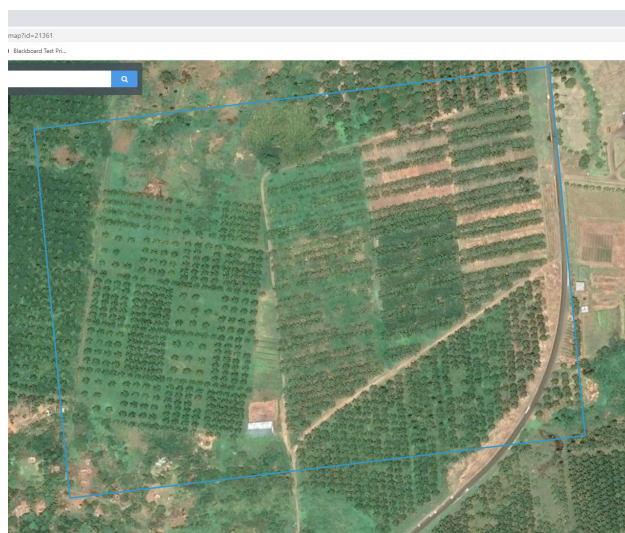
Sentinel-2

NDVI @ 10m resolution

7 Oct 2020

Airbus Worldview

NDVI @ 0.5m resolution



Madang Stewart Research Station

2019?

Google reference satellite image

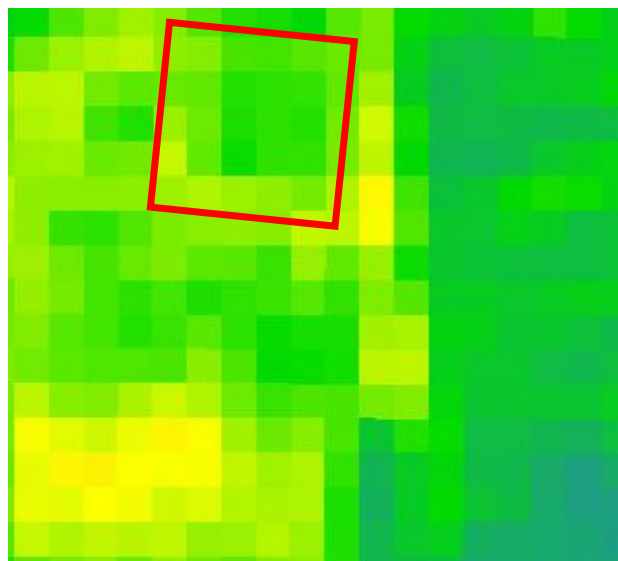
RGB @ 0.5m



21 Sep 2020

Sentinel-2

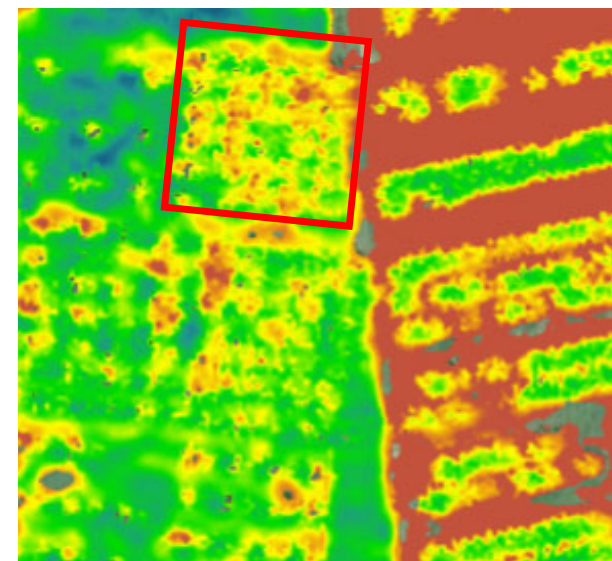
NDVI @ 10m resolution



7 Oct 2020

Airbus Worldview

NDVI @ 0.5m resolution



Reference square ~ 50m x 50m

Monitoring: Confirmation

- After suspicious trees are identified we need to confirm the disease
- Field ready system developed for BCS in PNG
- Awaiting deployment (delayed because of COVID)
 - Transfer of kits
 - Training of personnel

Monitoring: Confirmation

