10th WORLD AVOCADO CONGRESS

New Zealand 2023

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Aotea Centre
Auckland, New Zealand

Predicting irregular bearing of avocado crops using Sentinel 2 time series data

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Outline

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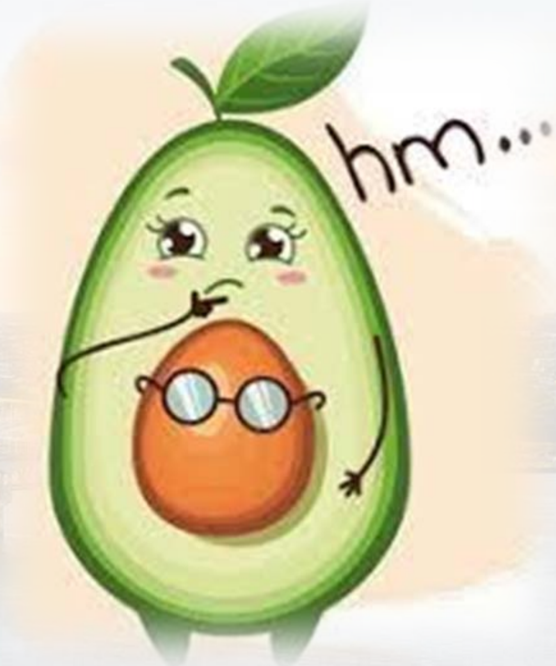
- What is Irregular Bearing
- The research has been done until now
- Research questions
- Methodology
- Results
- Conclusion and Future work

Background Information

- What is Irregular or Alternate Bearing???
- What causes Irregular Bearing??
  - Extreme weather events
  - Water deficit stress
  - Diseases and pests
  - Excessive fruit set
  - Excessive fruit retention



Background Information

- Why understanding of Irregular bearing is important?
  - Improved crop management practices.
  - Accurate prediction of crops.
  - Better logistical planning of field operations.
  - Supports post-harvest decisions

Research on Irregular Bearing

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- Find the causes of irregular bearing
- Control Measures to reduce irregular bearing:
  - Develop new varieties/cultivars
  - Proper management to improve crop nutrition
  - Application of hormones
  - Pruning
  - Pollination

However, no attempt has been made to understand irregular bearing using remote sensing technique and how we can predict this.

Research on Avocado by AARSC

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- Rahman, M.M.; Robson, A.; Brinkhoff, J. Potential of Time-Series Sentinel 2 Data for Monitoring Avocado Crop Phenology. *Remote Sens.* **2022**, *14*, 5942. https://doi.org/10.3390/rs14235942

- Robson, A.; Rahman, M.M.; Muir, J. Using Worldview Satellite Imagery to Map Yield in Avocado (*Persea americana*): A Case Study in Bundaberg, Australia. *Remote Sens.* **2017**, *9*, 1223. https://doi.org/10.3390/rs9121223

- Satellite remote sensing based time series model for yield prediction of avocado crops. (Not yet published)

Research Questions

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- Is it possible to understand irregular bearing using satellite remote sensing data?
- How to predict ‘On’ or ‘Off’ crops using remote sensing time series data for Avocado?

Study Location

- Queensland – 3 farms
- South Australia – 1 farm
- Western Australia – 1 farm

- Total 40 blocks from 5 farms
- From 2017 to 2021 data
- Varieties – Hass and Shepard

Data Collection

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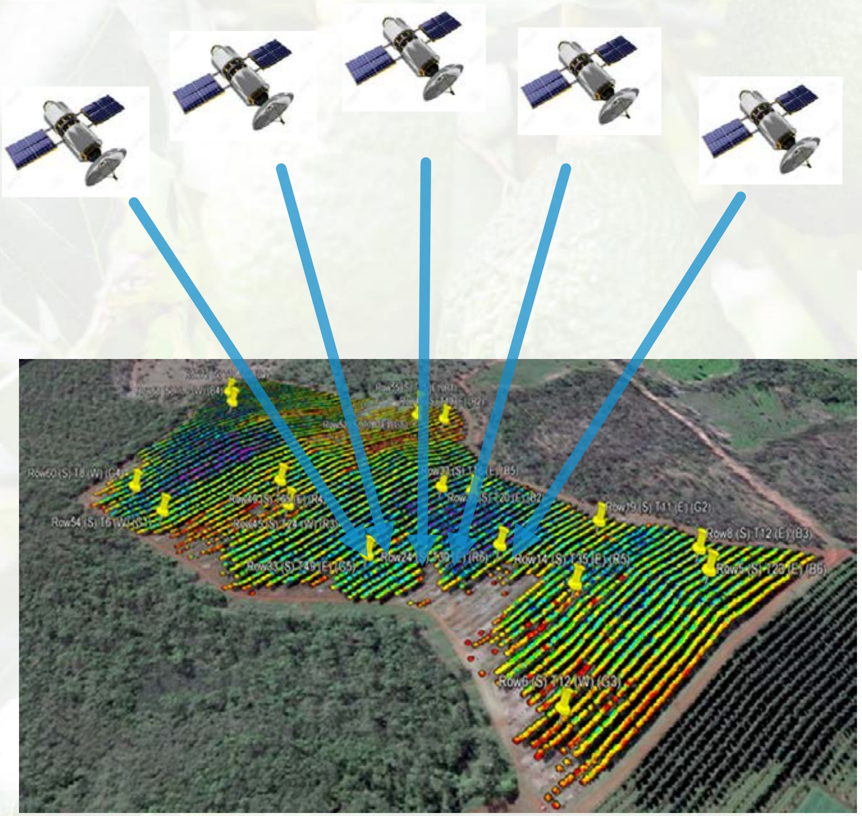
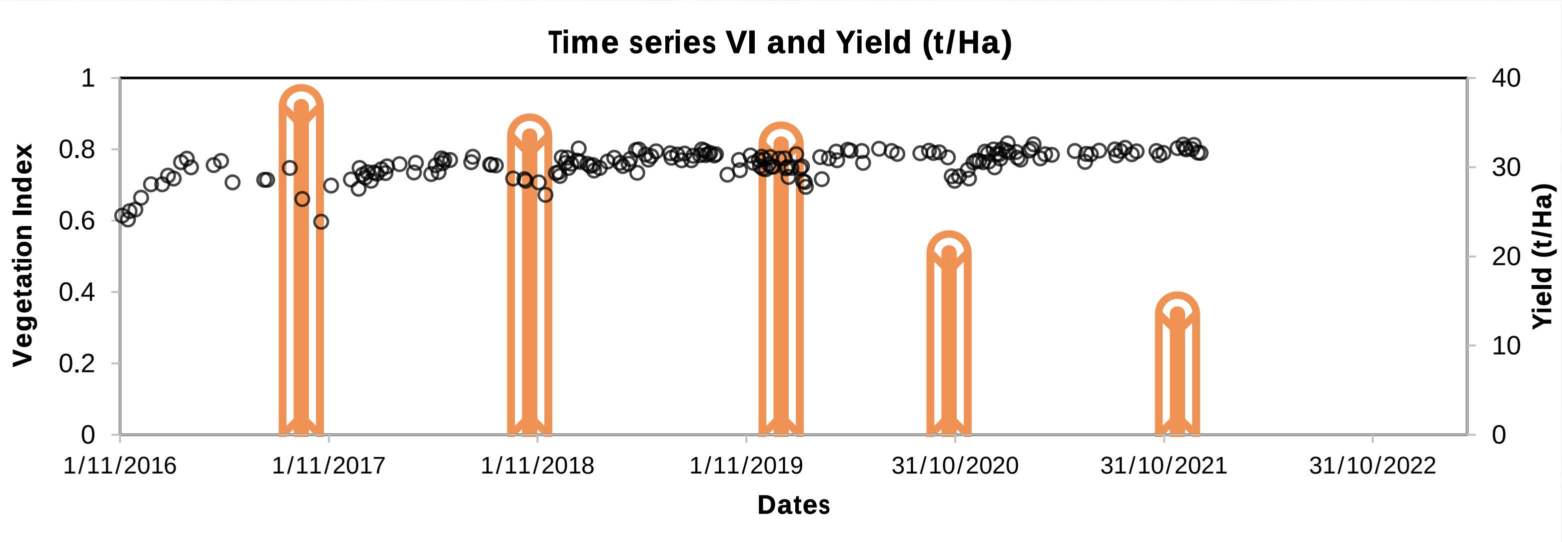


Vegetation Index (VI) = band ratio combination = crop reflectance



Sentinel 2 derived vegetation index (crop reflectance) and historical yield data from 2017 to 2021 for one block

Regional Variation

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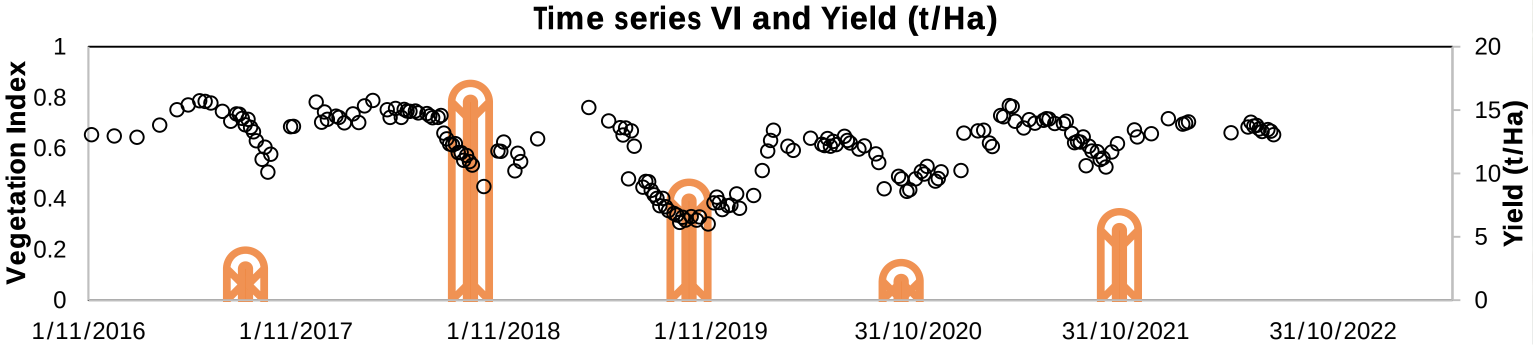
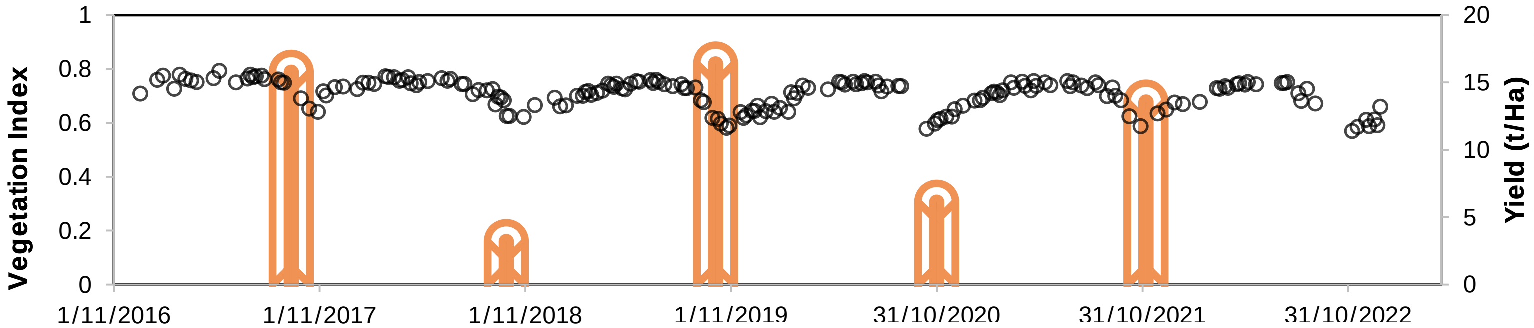
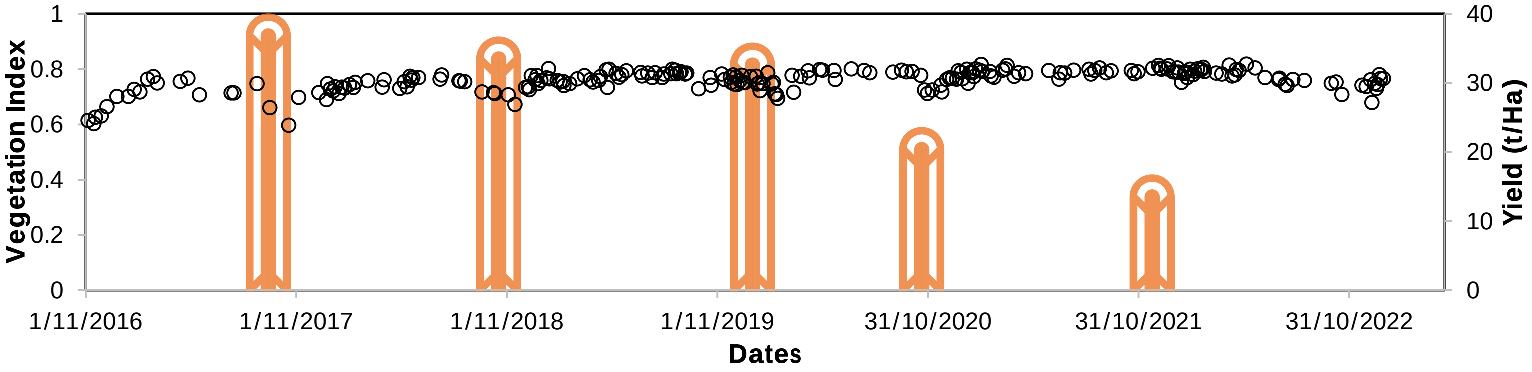


Queensland



South Australia

Western Australia



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Input Variables

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- Lowest VIs values
- Highest VIs values
- Slope between two VIs values
- Bearing index = (yield Y1 – yield Y2)/(yield Y1 + yield Y2)
- Yield achieved in the previous season
- Yield achieved in the season 2 years prior
- Bearing previous year (Whether ‘on’ or ‘off’)
- Other weather or management variables (e.g. drought, floods, pruning etc.)

Machine Learning Model Development

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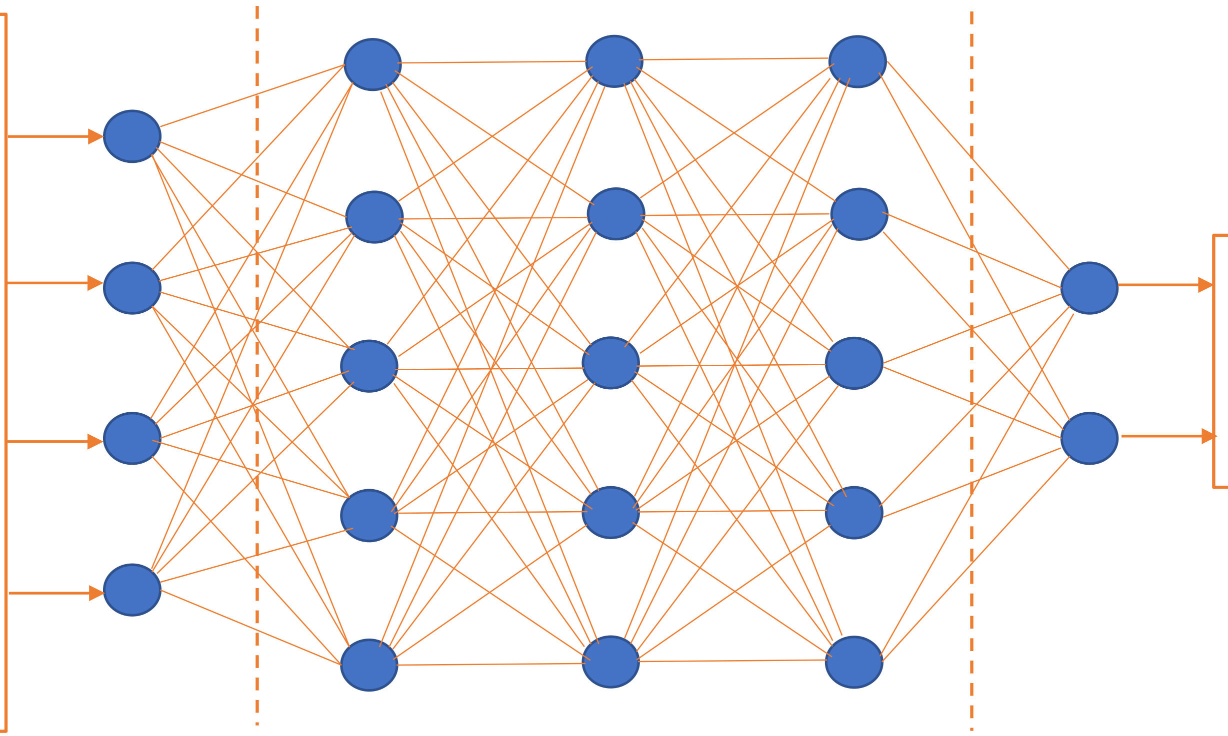
Input Layers

Low VIs
High VIs
Slope VIs
Bearing Index
Yield Y-1
Yield Y-2
Bearing Y-1
Others

Hidden Layers



Output Layers

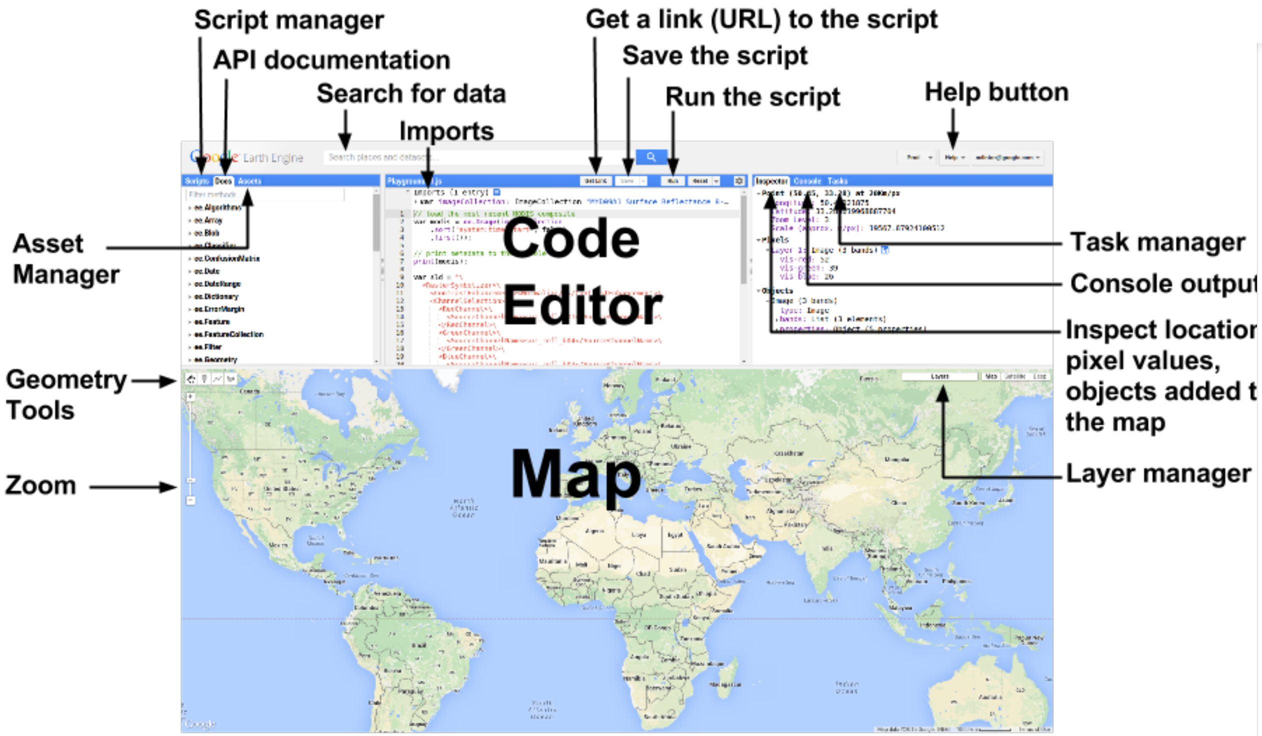
'On Season'
'Off season'

Machine Learning Models

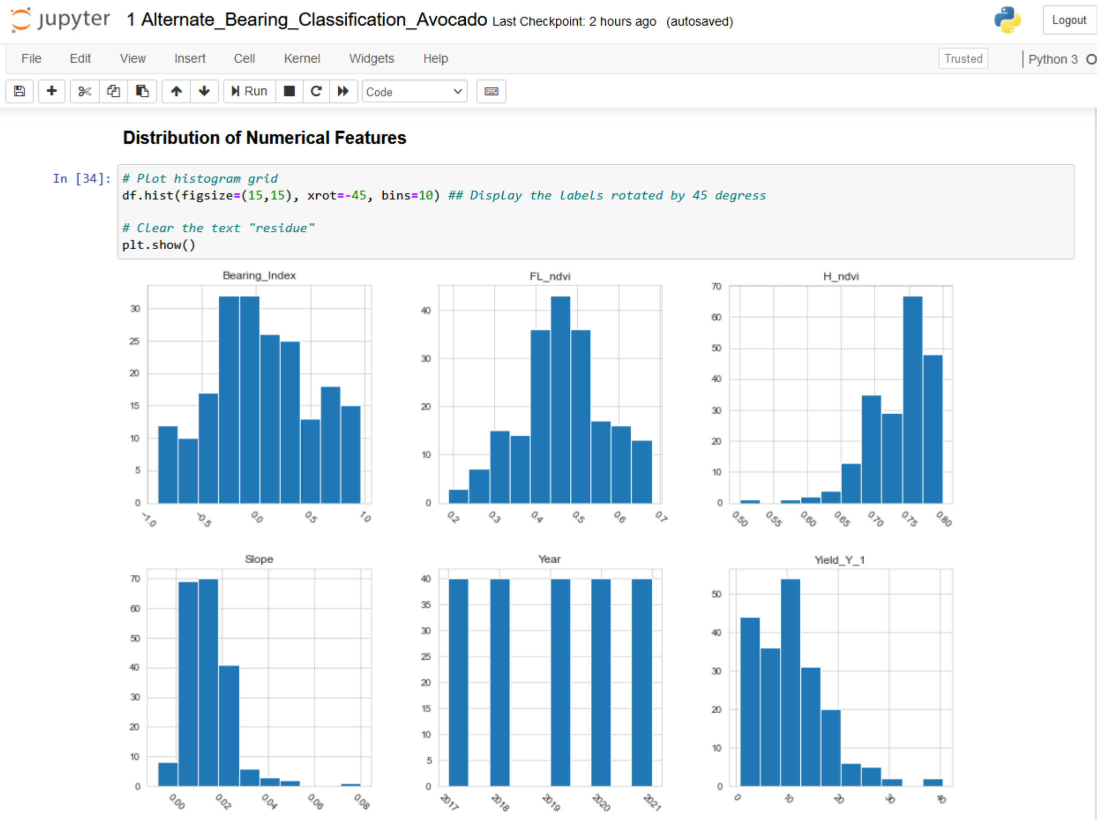
Machine Learning Models used for classification of ‘On’ or ‘Off’ season:

- Logistic Regression
- Random Forest Classification
- XGBoost Classification
- KNN Classification
- Decision Trees
- Support Vector Classification
- Gradient Boosting

Model Development Platforms



Google Earth Engine Code Editor



Python 3 in Jupyter Notebook

Alternate Bearing in 5 years

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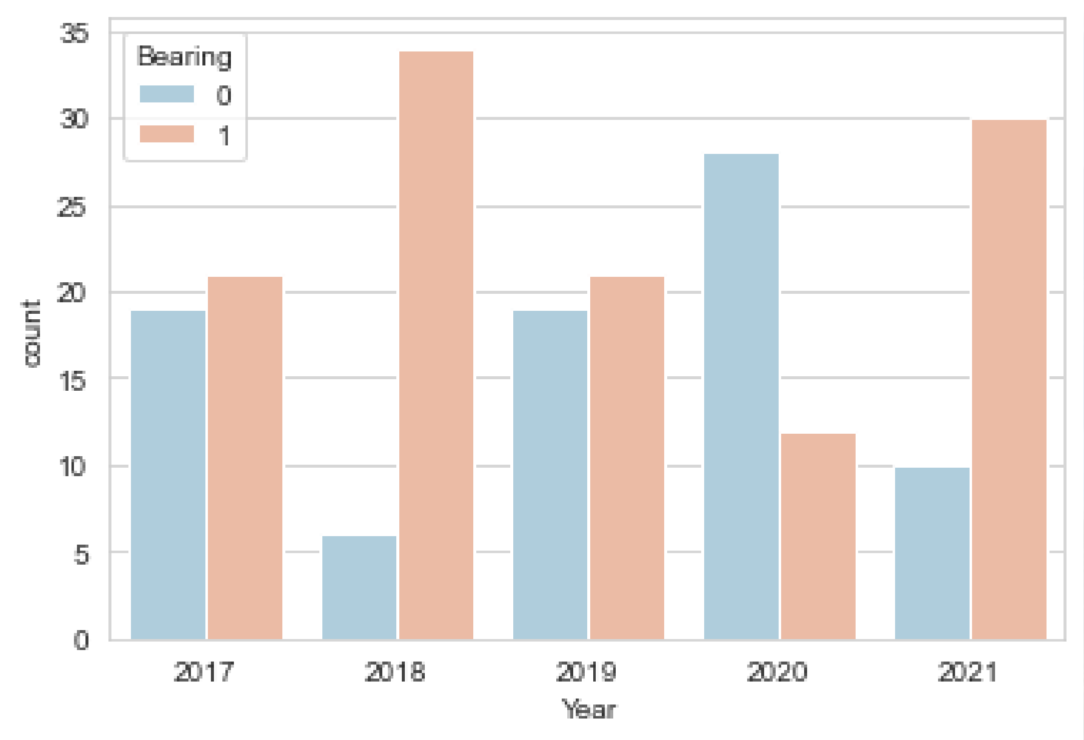
Yearly 'On' or 'Off' season data from 40 blocks over 5 years



Yearly 'On' and 'Off' season in 40 blocks
(Total data 200 from 5 years)

'0' = 'Off' crops = 82
'1' = 'On' crops = 118

Model development flowchart

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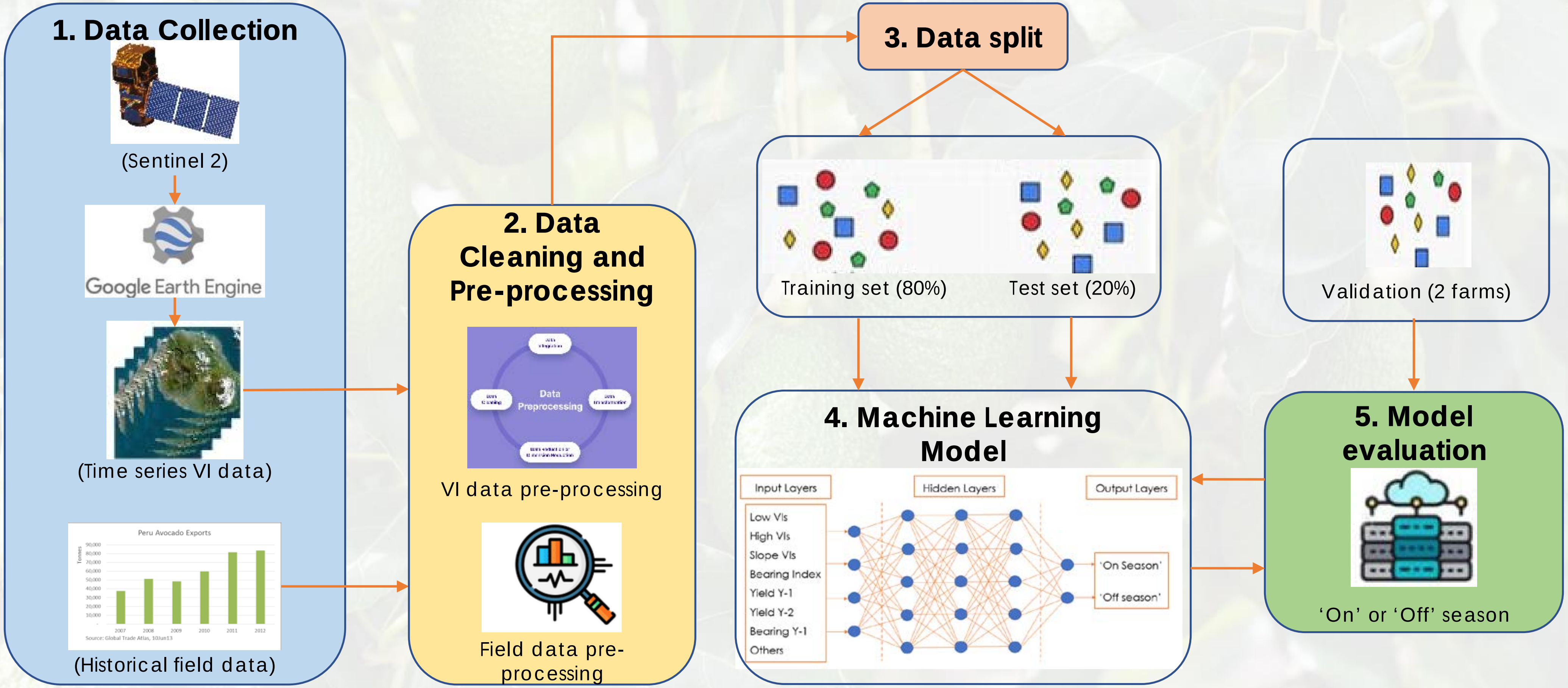
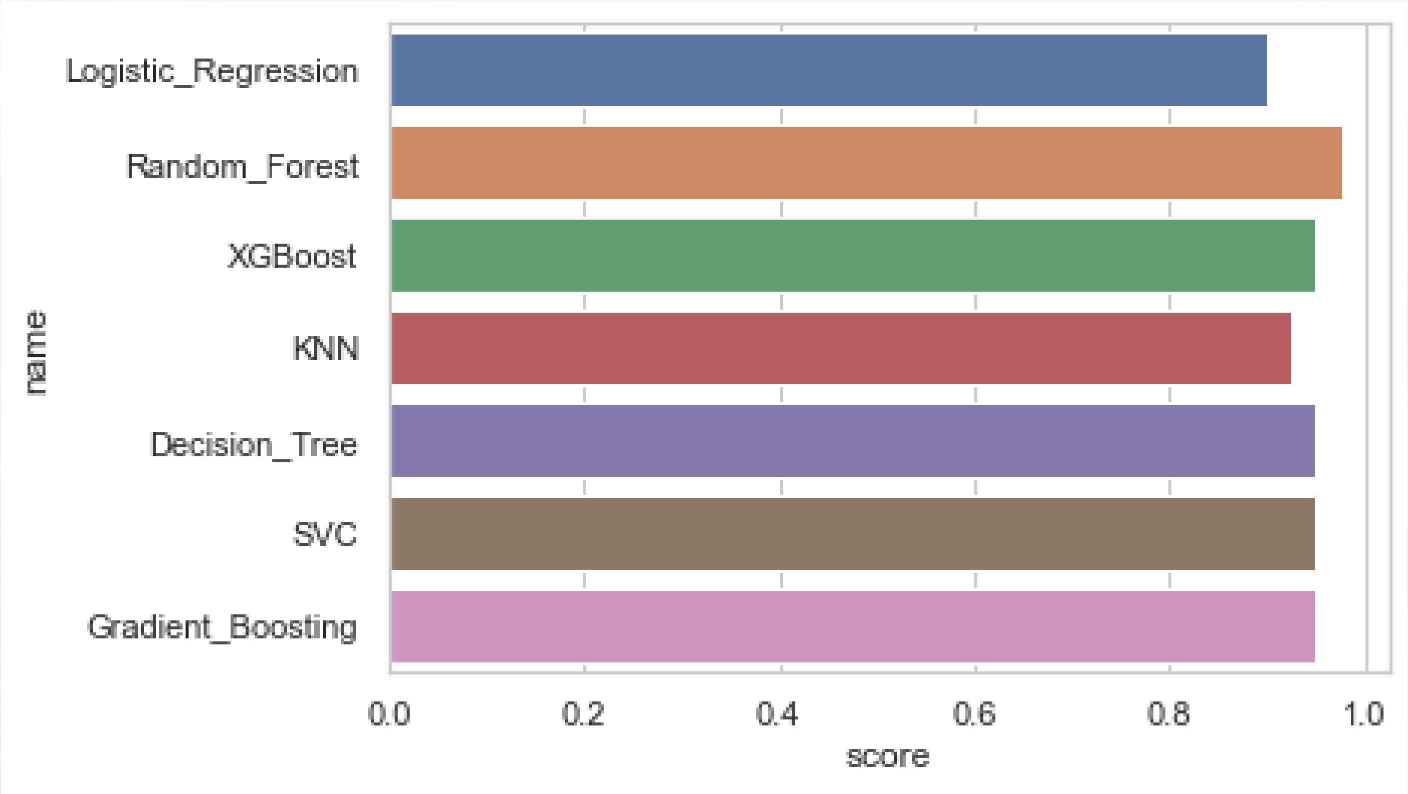


Model development and validation flowchart

Model Performance

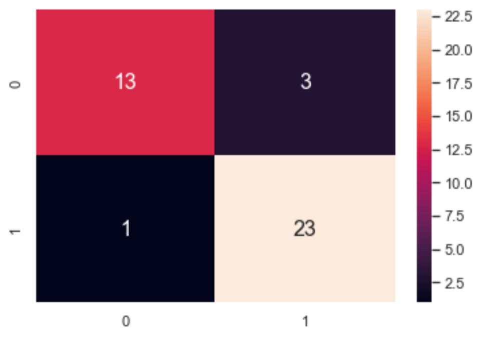


Model performance over test set (40 blocks)

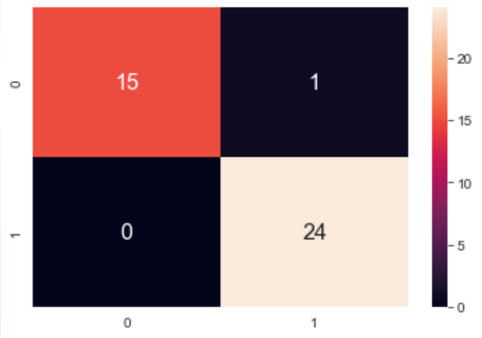
Confusion Matrices

Confusion Matrix

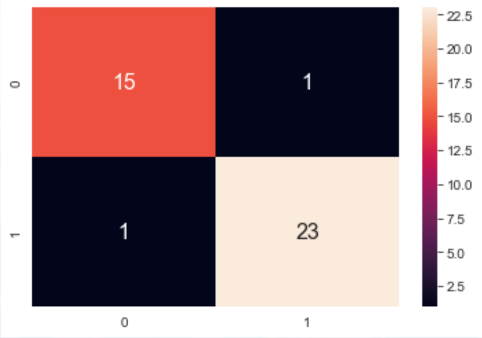
	Actually Negative (0)	Actually Positive (1)
Predicted Negative (0)	True Negatives (TNs)	False Negatives (FNs)
Predicted Positive (1)	False Positives (FPs)	True Positives (TPs)



Logistic Regression

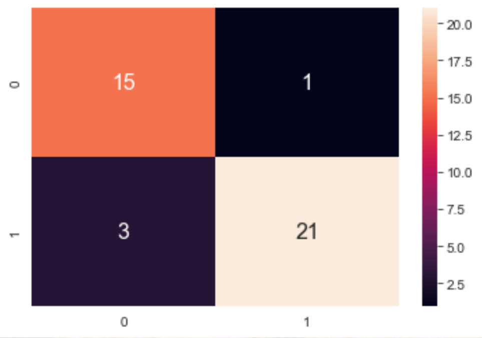


Random Forest

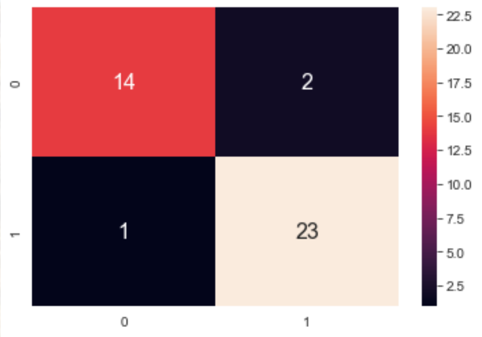


XGBoost

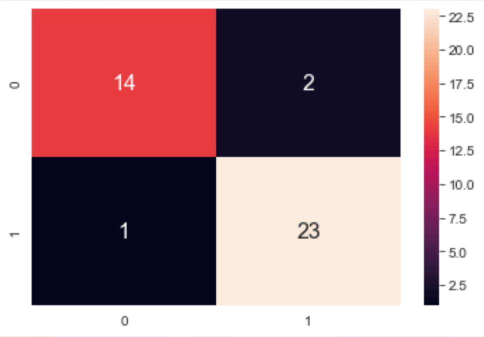
K Nearest Neighbour



Decision Tree



Support Vector



Gradient Boosting

Alternate Bearing in 2022

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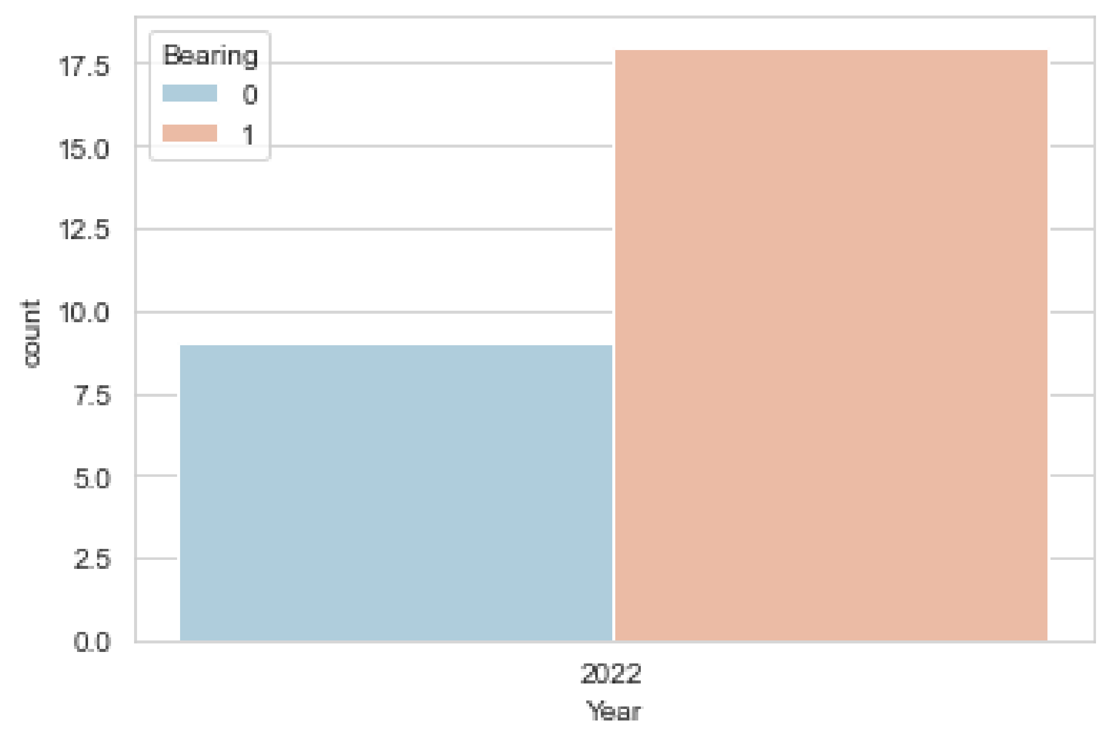
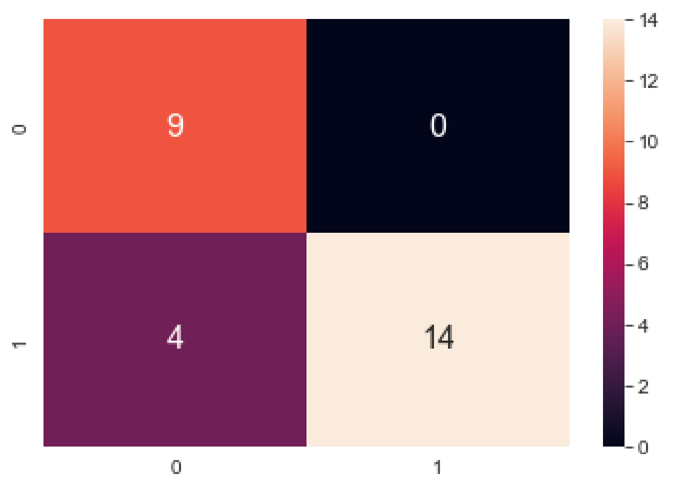
‘On’ or ‘Off’ season data from 27 blocks on 2022 year



‘On’ and ‘Off’ season crop in 2022 in 27 blocks

‘0’ = ‘Off’ crops = 9
‘1’ = ‘On’ crops = 18

Random Forest on 2022



Confusion Matrix

	Actually Negative (0)	Actually Positive (1)
Predicted Negative (0)	True Negatives (TNs)	False Negatives (FNs)
Predicted Positive (1)	False Positives (FPs)	True Positives (TPs)

Accuracy = 0.85

Conclusions

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- Satellite remote sensing has the potential to predict 'On' or 'Off' crops.
- The 'Random Forest' provides better accuracy.
- The developed model can provide information at the early stage of season (4 months prior to harvest).
- This is exciting at this stage, since it supports growers to improve management decisions.

Future Works

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- Acquire more data from growers to improve model accuracy and generalize the model
- Apply at different regions (internationally) with various management practices
- Apply the model as an input to improve yield prediction of Avocado crops

Acknowledgements

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Australian Government
Department of Agriculture and Water Resources

Avocados Australia

Hort Innovation

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Questions

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