Applications of UAV imaging techniques for characterization of plantation crops

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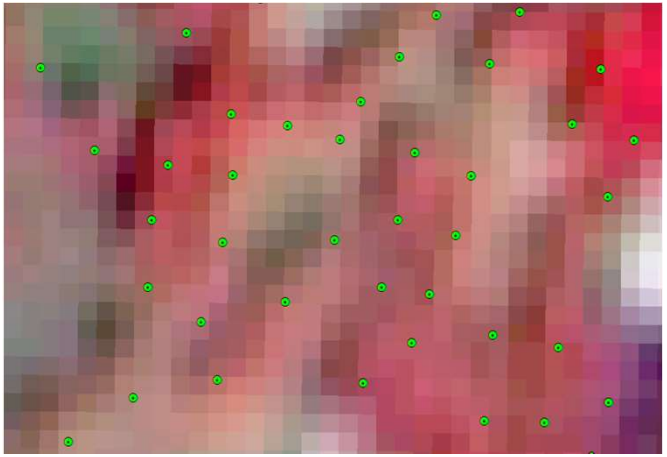
Need for very high resolution images

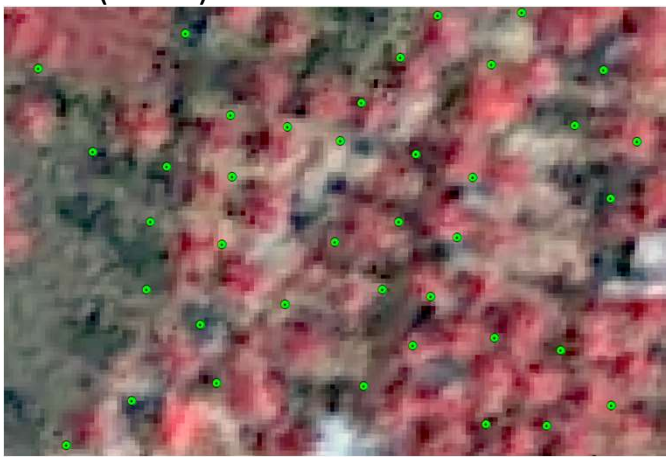
Coconut trees in different Spatial resolutions

L-4+C-1 (2.5m)

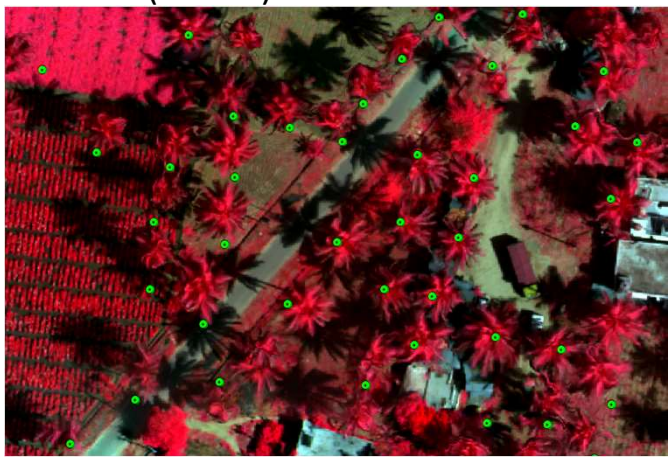


C-2E (1.6m)

C-2E (60cm)



UAV MX (0.15m)



UAV RGB (0.05m)

Remote Sensing Platforms and Applications in Agriculture

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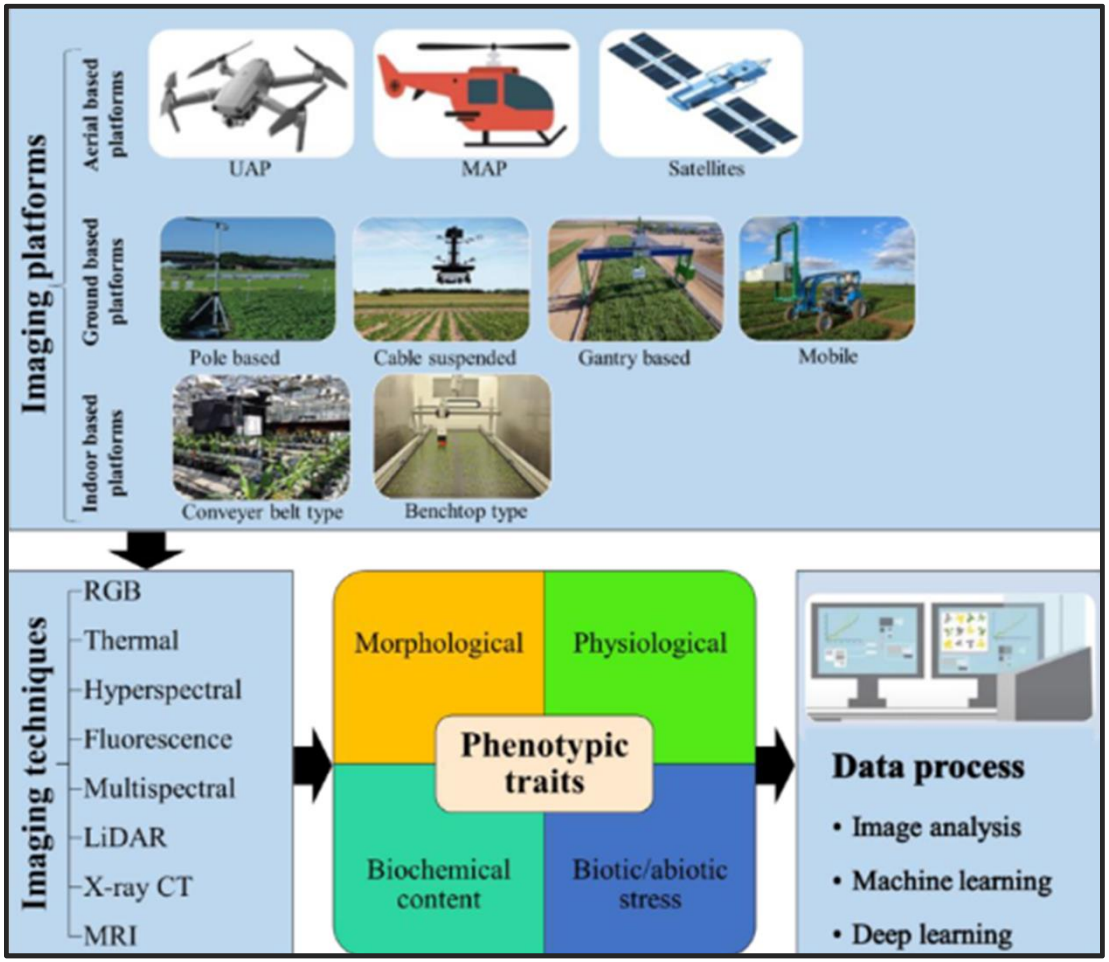
Remote Sensing Instruments & Platforms



Applications

- ❖ Crop Mapping and area estimation
- ❖ Crop Health & Yield Assessment
- ❖ Damage Assessment
- ❖ Detection of Trees & Species Identification
- ❖ Assessment of Agroforestry Land Use
- ❖ Above Ground Biomass & C Sequestration
- ❖ Mapping of Soil Resources

Crop Improvement programmes

- ➢ Crop Growth Monitoring
- ➢ Crop Stress Detection and its Severity
- ➢ Crop phenotyping: Physiology & Biochemistry
- ➢ Plant breeding : Selection of better genotypes
- ➢ Post-harvest: Quality, grading, sorting

❖UAS plays an important role in near-real time field data collection & validation of satellite derived products

Advantages and disadvantages Imaging platforms

	Platform	Advantage	Disadvantage
1	Satellite	Stable platform, Covers large area in short time, Reasonable good spatial, spectral and temporal resolutions. Availability of historical data	Very tilt angle. Difficult to obtain VHRS data of uniform acquisition period.
2	Aerial	Stable platform, Covers relatively large area, Need based data acquisition with in Short period, Capable of carrying large payload	Expensive, Strict guidelines, Lack of historical data, big data requiring.
3	UAV	Very convenient, Need based acquisition in short time, Very good plat from for detailed studies at micro level	Lack of long endurance, Platform instability due to wind, Processing related issues, Need Radiometric normalization
4	Ground	Controlled environment, Good repeatability, Very accurate	Expensive, Tedious and time consuming

Synergistic use of Ground, UAV and Satellite based information has immense benefits for near real-time monitoring of vegetation for planning at micro level

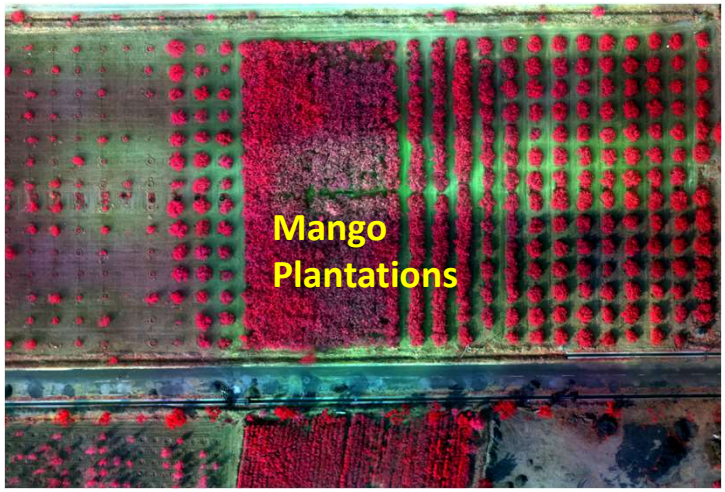
Imaging Sensors Used for Agriculture

S. N	Instruments	Applications
1	RGB	Detailed LULC mapping, Projected leaf area, 3D model, Volume, Geometry, pests & diseases, detailed soil mapping
2	Multispectral	Crop acreage, Crop growth monitoring, Density, Leaf Area Index, Green biomass, yield, soil mapping, soil nutrients
3	Hyperspectral	Physiology and biochemistry, Nutrition, Insect & Pests, Phenotyping
4	Thermal	Canopy temperature, Evapo-transpiration, insect & pests, crop yield estimation
5	LiDAR	Plant height, 3-D model, canopy architecture, Volume, Leaf angle, Biomass
6	Fluorescence	Photosynthetic rate, quantum yield, leaf health, Chlorophyll status

Assessment of Inter and Intra field Variability

RGB Image

Assessment of Inter and Intra-field soil & crop variability for improved farm management



Multi-spectral Image

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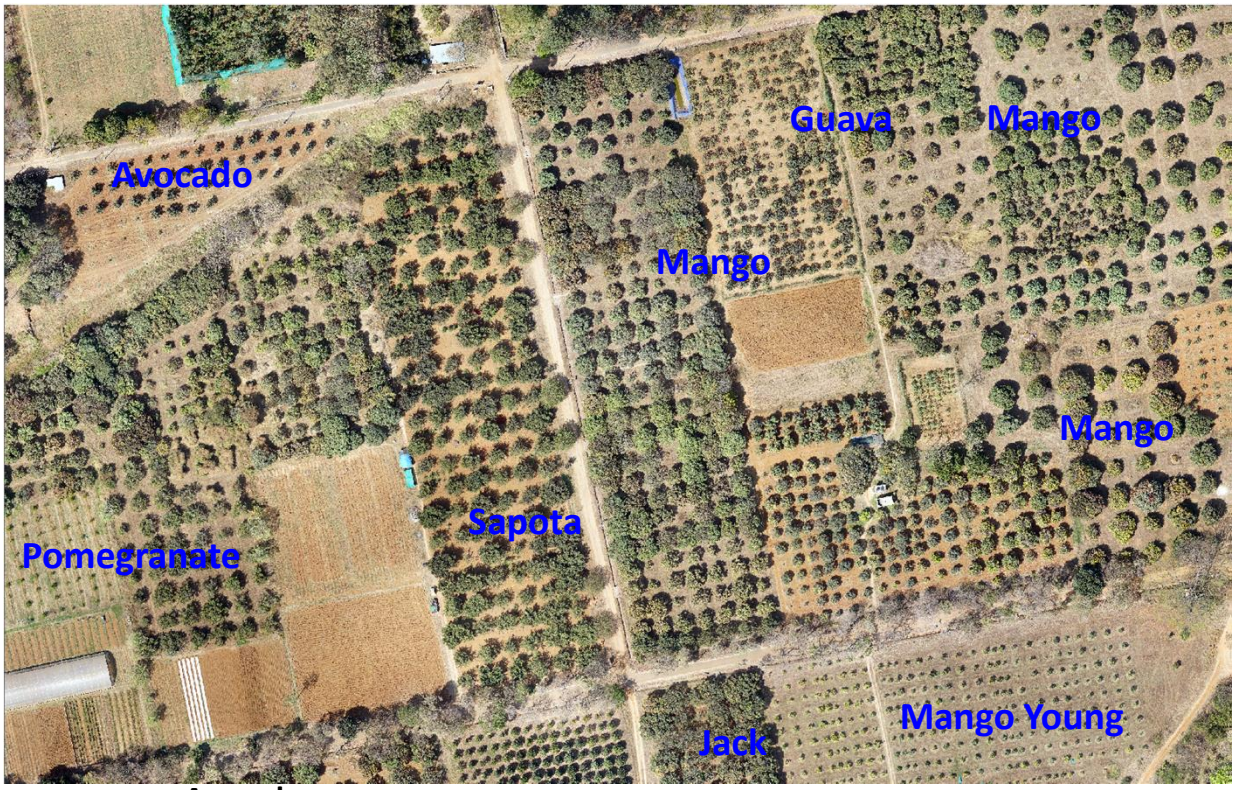
Different types of Horticulture crops in IIHR Campus



Jack Fruit

Mango

Sapota

Avacado

Pomegranate

Guava

Different types of Horticulture crops in IIHR Campus

Jack Fruit

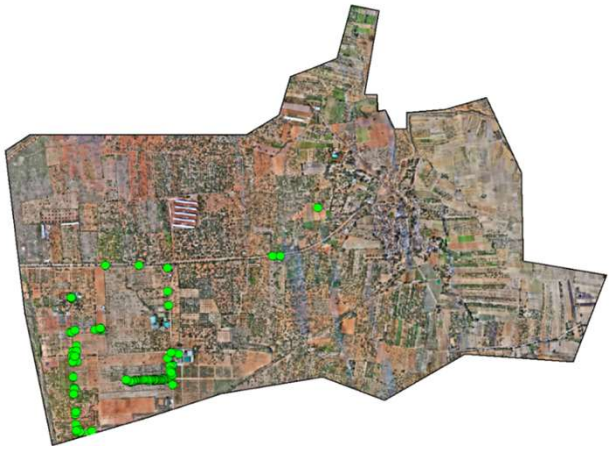
Mango

Sapota

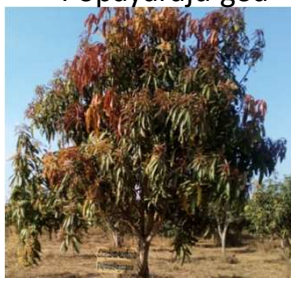
Guav
a

Hogalagere Horticulture Farm, Srinivaspura Taluk , Kolar District

INDO-ISRAEL center for Excellence for Mango –MDC (64 Verities of Mango)



Bombay Green | Vanraj | Popayaraju goa | Bennet Alphonso | Bada Gulab | Gopal Bhog | Navneet



Varietal Discrimination of Mango Orchards – IIHR Campus

Alphonso Flowering

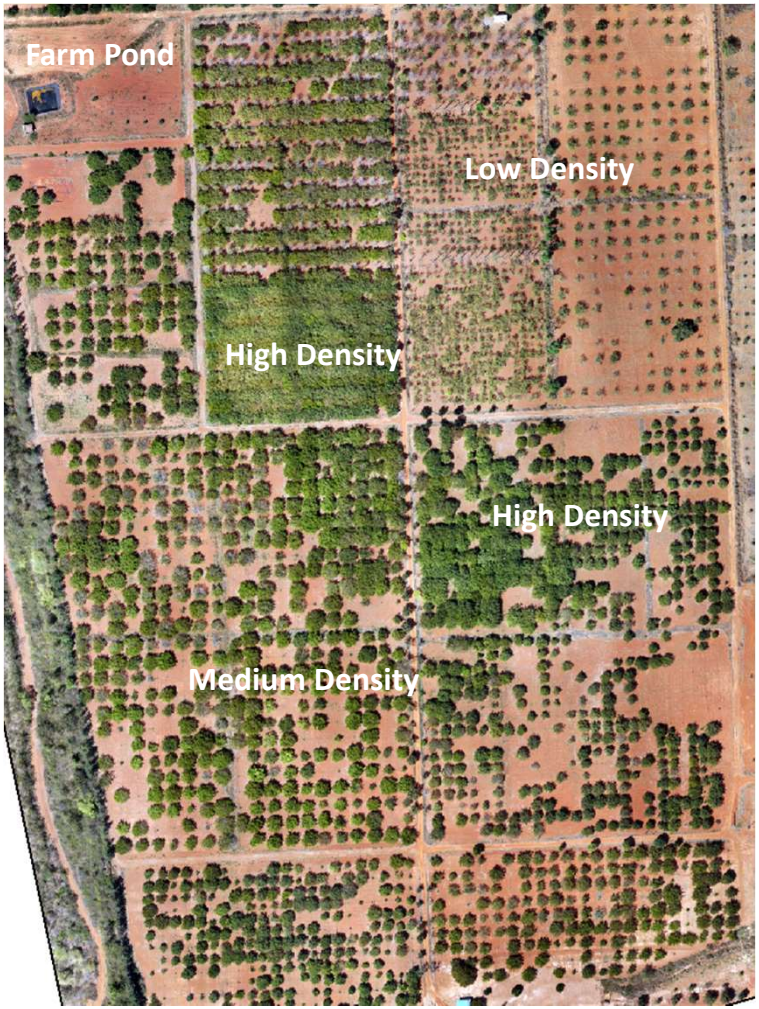
Totapuri Flowering

Alphonso Mango

Thotapuri Mango

Banganapalli Mango

Cashew at HRS – Different Densities, Holagere , Kolar District

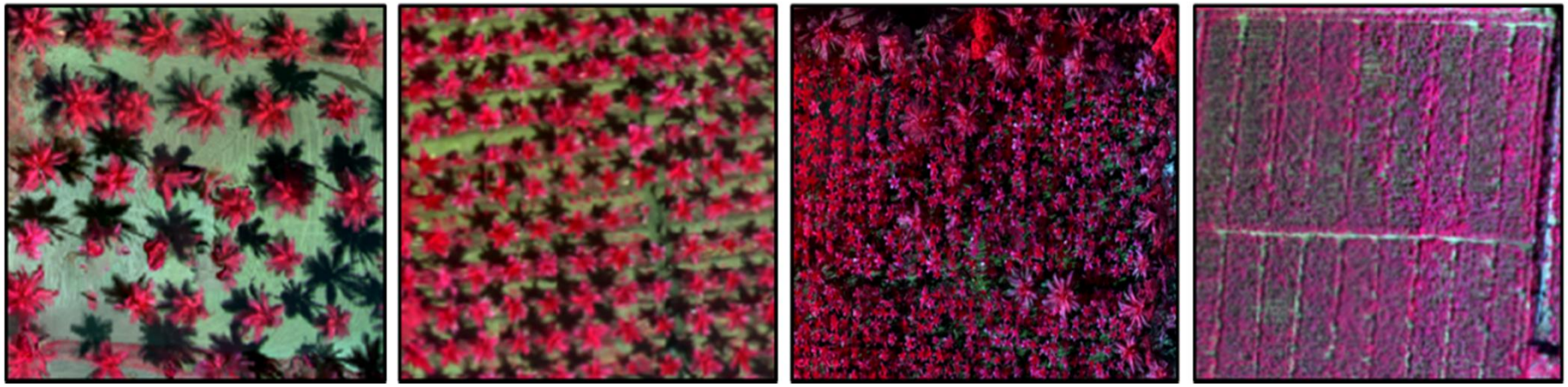


nrsc Spectral and spatial patterns of major plantations in RGB & MX Image

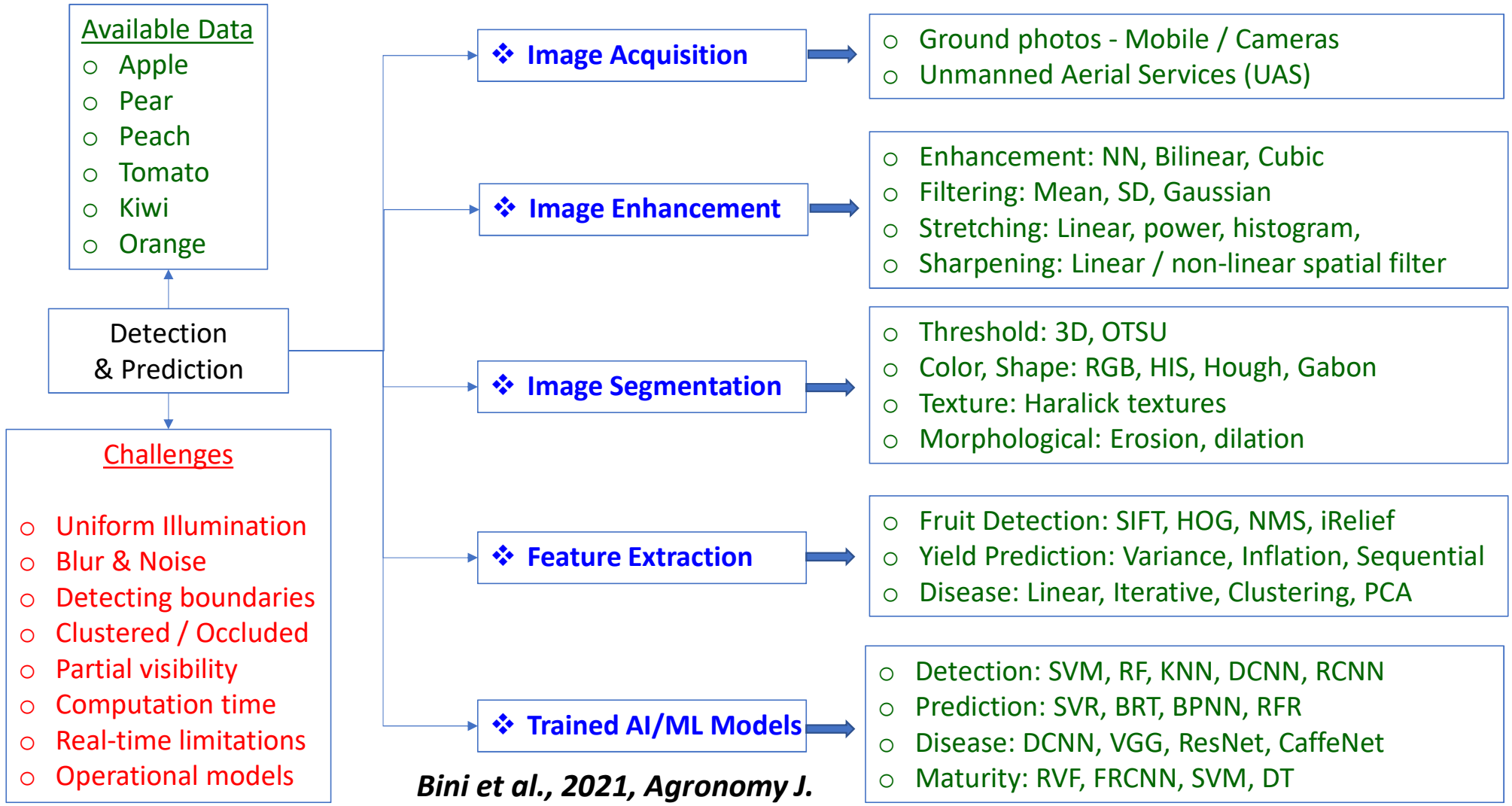
RGB Images (5 cm)

Coconut trees | Arecanut | Coconut + Arecanut mixed | Flowers

Multispectral Images (15 cm)



AI/ML techniques for processing and analysis RGB images



Bini et al., 2021, Agronomy J.

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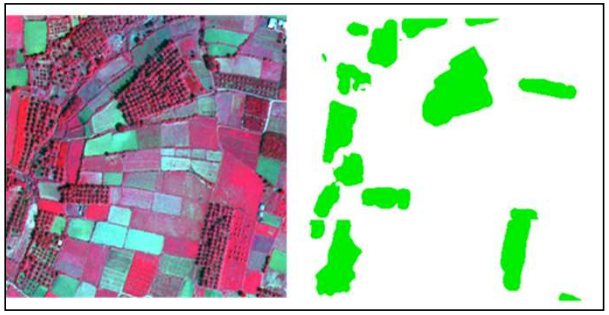
Assessment of coconut plantation using VHRS Image & DL

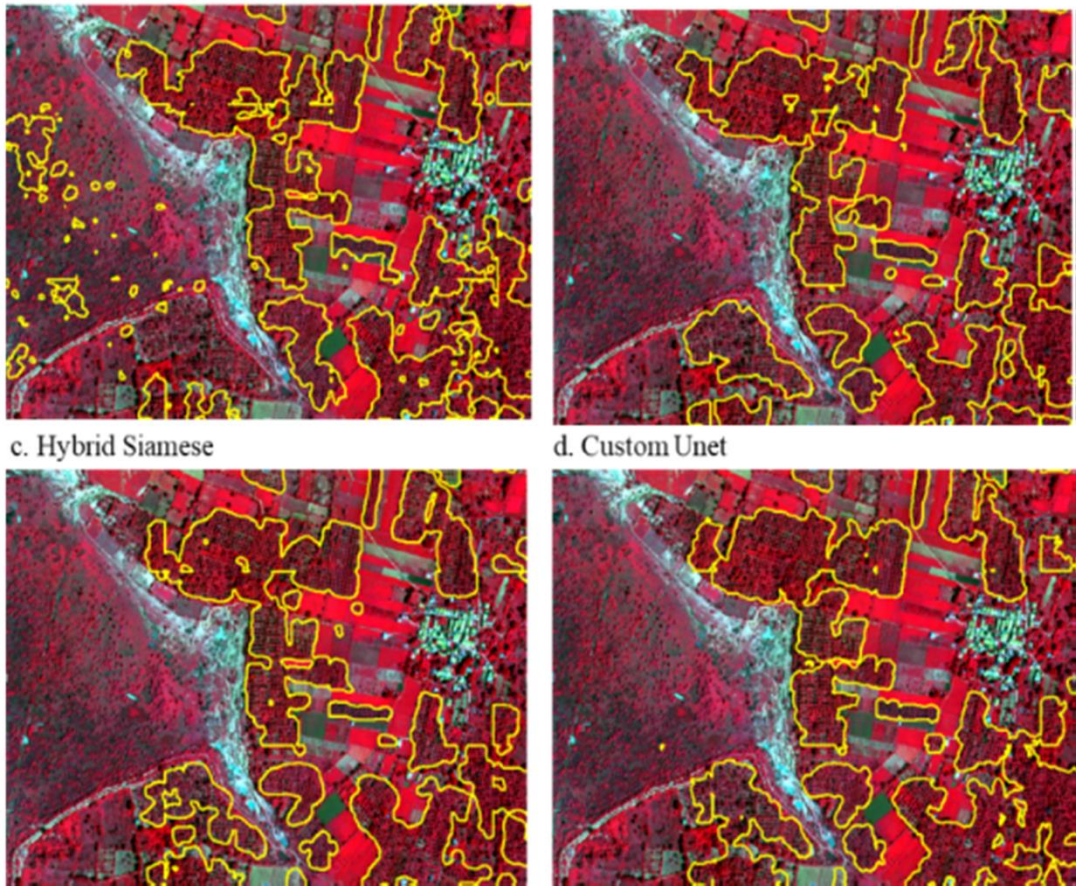
Image Chips **Training Samples**



U-Net Architecture	Accuracy %
MobileNet	83.51
ResNet-152	84.62
VGG-19	86.96
DenseNet-121	87.93
Siamese U-Net	89.17
Custom U-Net	91.88

Semantic Segmentation – coconut plantations

a. Mobilenet b. Densenet



c. Hybrid Siamese d. Custom Unet

IEE InGARSS - 2021

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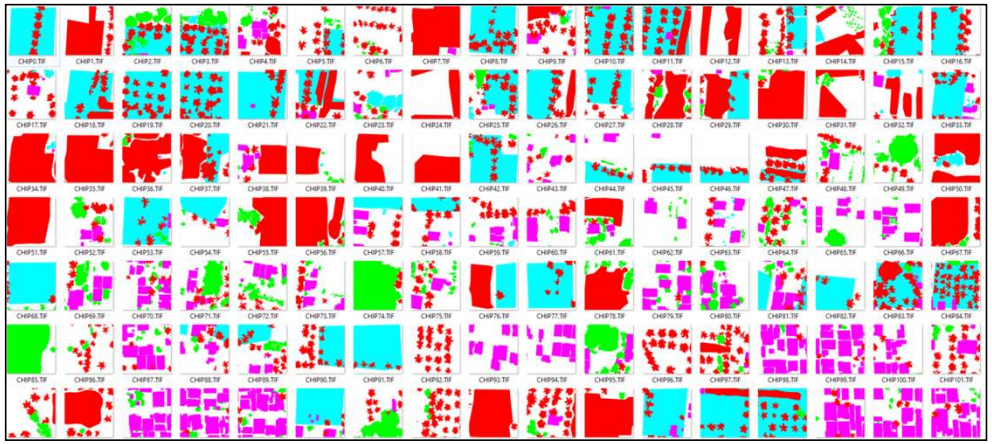
Semantic Segmentation of UAV Images

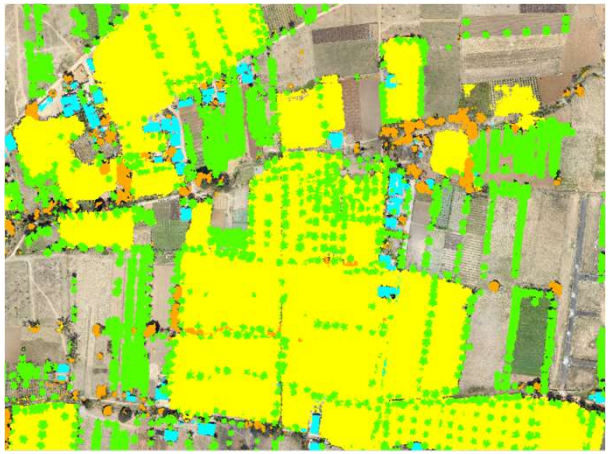
Image Chips (1276 x 1276) - Semantic Segmentation

Annotated chips (1276 x 1276)



Coconut
Arecanut
Trees
Buildings

Plantation crop maps



Arecanut Coconut Trees Buildings

Accuracy ranged from 76.2 % to 90.1 %

Tree Detection in ICAR-IIHR test site using UAV image & DL

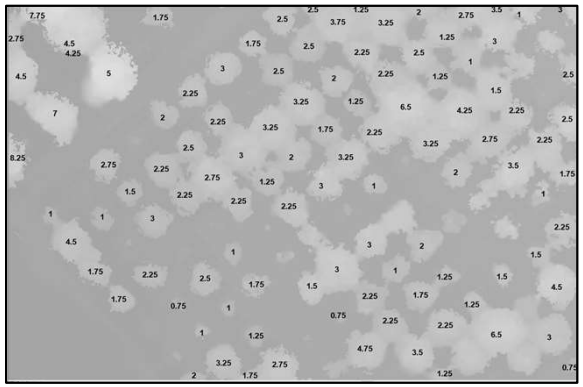
Tree counting

Tree height (m)

Range	No. Trees
0-4	12623
4 - 8	7526
8 - 12	1547
12 - 16	545
16 - 23	158

85.6 % accuracy

Digital Surface model(DSM)



Geographical Area	273 ha.
Retina net Model Accuracy	85.3%
Kappa	0.72
Total number of Trees	22426
Tree height	5m-25m
Average height	4.8m
Canopy cover area	3m²-91m²

Projected Canopy area (Sq.m)

Range	No. Trees
< 5.0	14515
5-10	5409
10-19	2029
19-37	418
<37	55

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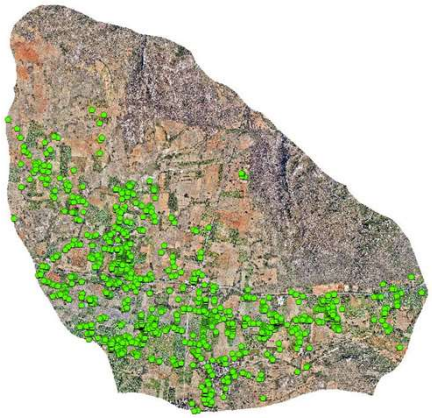
Species level identification using UAV image & DL

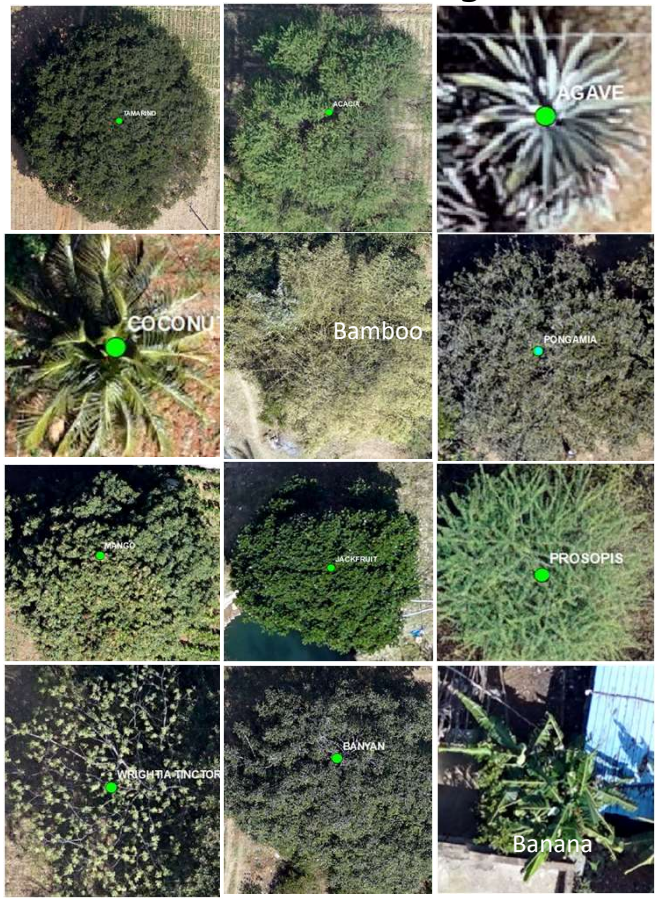
Ground Truth Collection



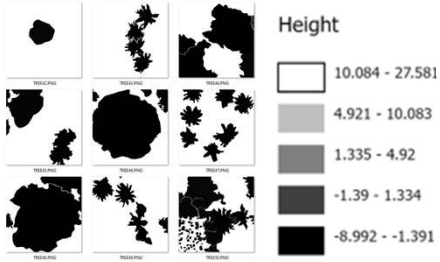
Training Samples (223)

1048x1048 pixel grids

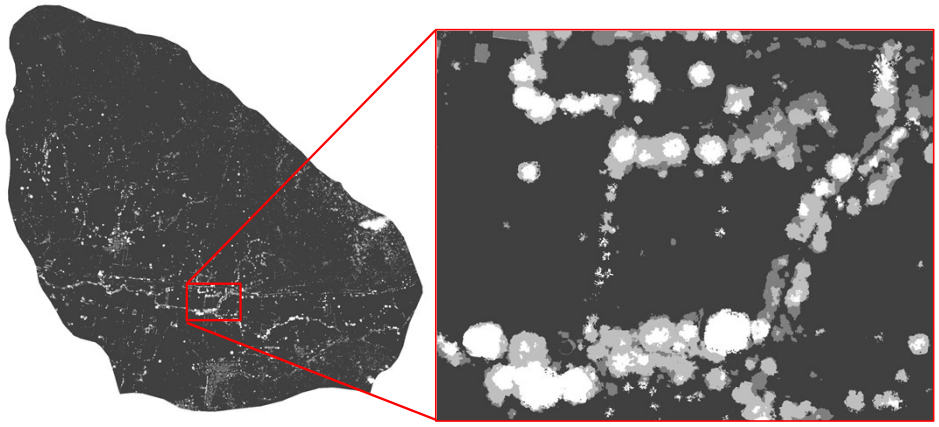
Major Tree Species identified on UAV RGB image



Images & Labels



Tree Height Estimation (using UAV DSM & DTM)



Zoomed view showing different tree heights

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Tree Species level identification using UAV image & DL

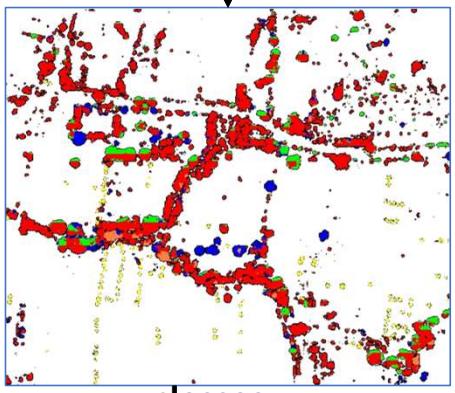
Model Training & Validation (U-Net, Deeplabv3 & FCN)

↓

Inference (Prediction)

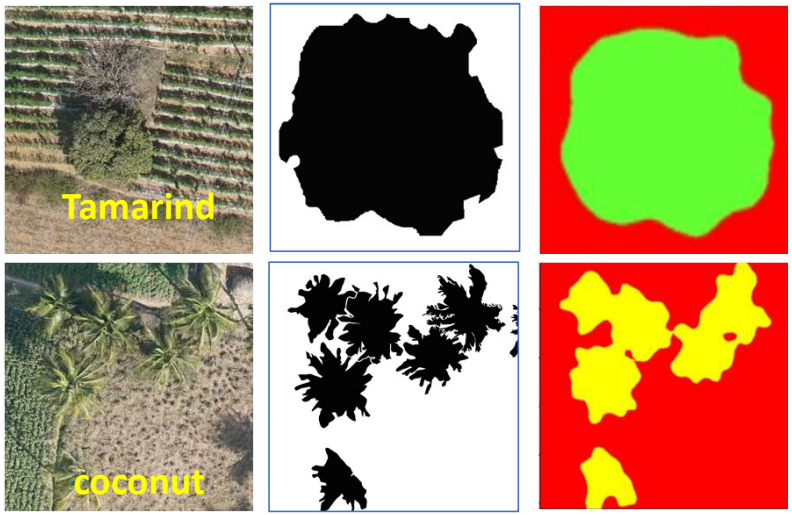
↓

Output



classes

Sample model prediction results



Model comparison

Model	Backbone	Mean accuracy	mIoU
U-Net	ResNet-50	0.87	0.69
DeepLab	ResNet-50	0.88	0.73
FCN	ResNet-50	0.85	0.67

Accuracy Assessment

Class	Accuracy	Precision	Recall
Coconut	0.89	0.91	0.88
Acacia	0.86	0.88	0.83
Bamboo	0.84	0.83	0.87
Tamarind	0.82	0.80	0.81
Shrubs	0.71	0.75	0.62
Pongamia	0.61	0.55	0.62
Agave	0.42	0.43	0.47
Others	0.42	0.57	0.58
All Trees	0.91	0.94	0.95

Lack of representative of training samples

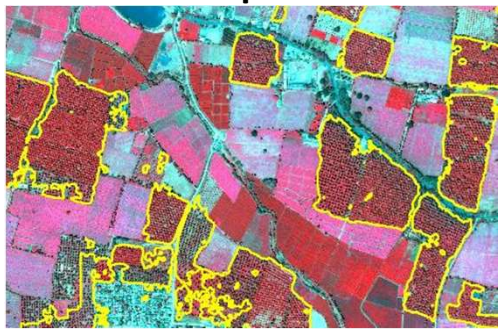
Deep Learning Framework for Inventory of Plantation Crops

Mango

Citrus

Coconut

Oil palm



Accuracy ranged from 83.2 to 94.6 per cent

Framework for plantation crops

Category	Crop Type
Fruits	Mango
	Banana
	Citrus
	Apple
	Grapes
	Pomegranate
Plantations	Coconut
	Arecanut
	Cashewnut
	Oil Palm
Commercial Plantations	Coffee
	Tea
	Rubber

Sub-categories

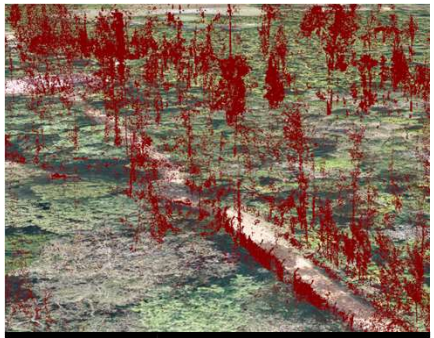
DENSITY
Very dense
Moderately dense
Medium dense
Sparse
Scattered
AGE
Old
Young
Very young

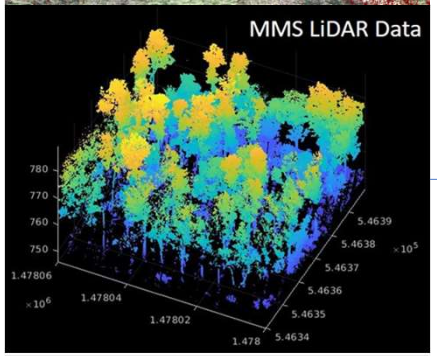
Development of Benchmark datasets

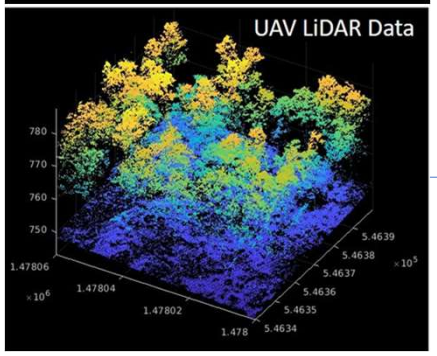
- Very High resolution (0.6m) Carto-2 and Kompsat datasets used
- U-Net, Deeplab v5 and FCN models have been adopted for development of DL model
- The accuracy ranged from 83.2 to 94.3 percent for plantation crop type mapping
- Augmentation of training sample for generation of single DL model for regional national level application

Trunk Detection using MMS + UAV LiDAR data

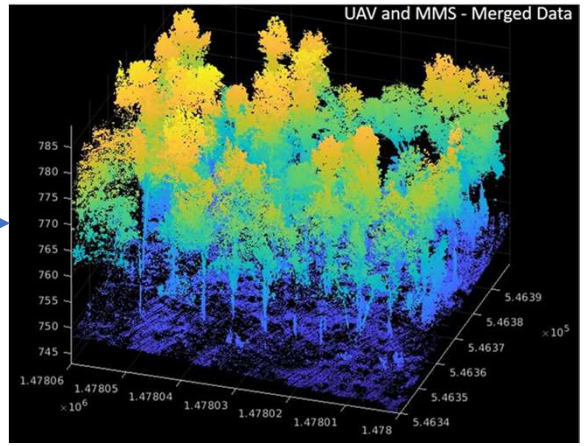
UAV LiDAR Point Cloud





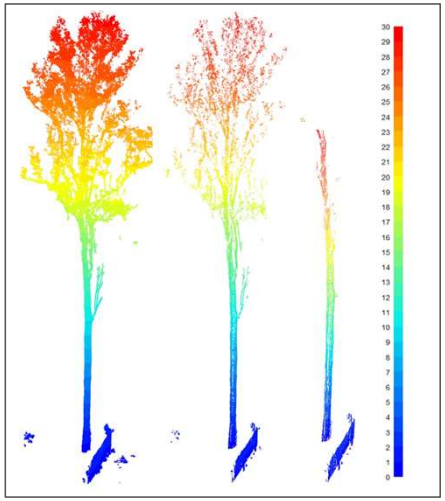


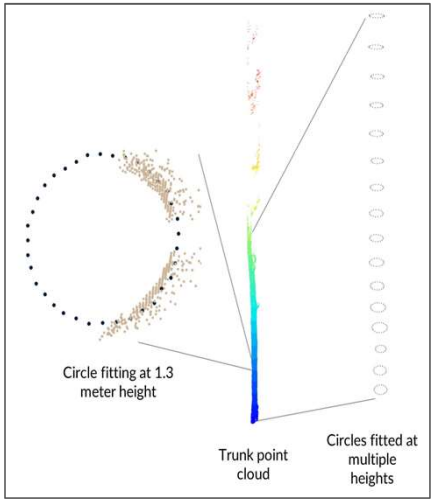
Mobile Mapping Unit



- Diameter at 1.3 meter Height
- Tree height
- Canopy Area

Central Coffee Research Institute - Balehonnur

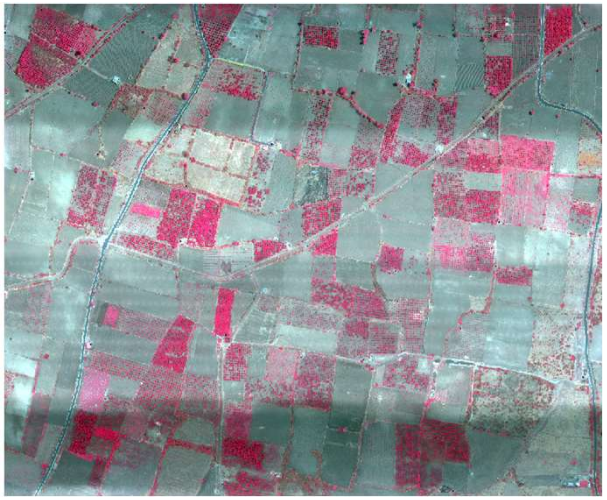




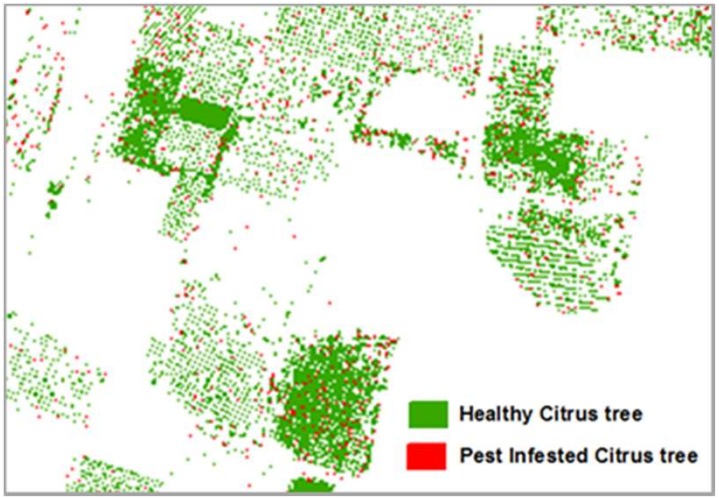
	A	B	C	D	E	F
1	ID	Easting_m	Northing_m	DBH_cm	Height_m	Area_m2
2	4	546389.3806	1478051.343	30.26290332	18.01	35.3
3	5	546395.0704	1478049.482	27.51492456	22.1	42.3
4	13	546383.8125	1478025.776	39.60516972	27.6	37.8
5	14	546397.9985	1478018.863	61.51666546	22.68	39
6	17	546395.4755	1478003.712	52.54119174	31.4	42.2

nrsc Pests and diseases identification of citrus orchards using UAV data

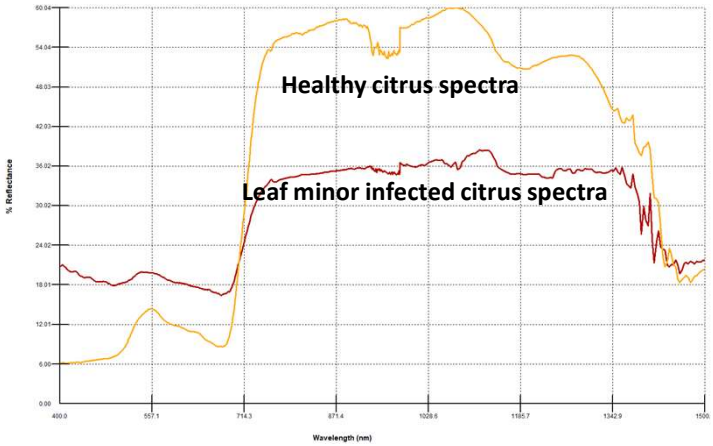
UAV data of near Kalmeshwar, Nagpur district



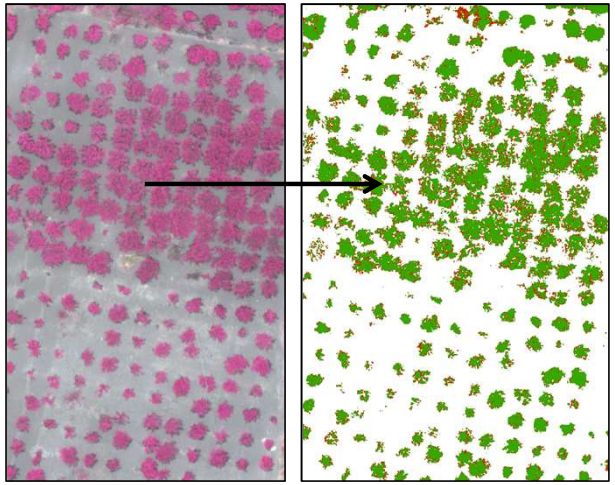
Citrus pest & disease surveillance using UAV data



Field spectra of healthy and infected citrus using spectroradiometer



Citrus orchards extracted using RF classifier



Citrus canopy infested by Leaf Minor

Trinity F 90+ drone

Summary and Way Forward

- UAV applications evolved substantially in recent years with the prospect of partially replacing manual activities for generating geospatial products and services for preparing micro-level plans
- Synergistic use of satellite data with UAV data need to be explored for various scientific applications and development of improved of data analytics and products
- Data sharing, Collaboration, Capacity Building and Institutionalization for effective utilization of Geospatial technology

Thank you