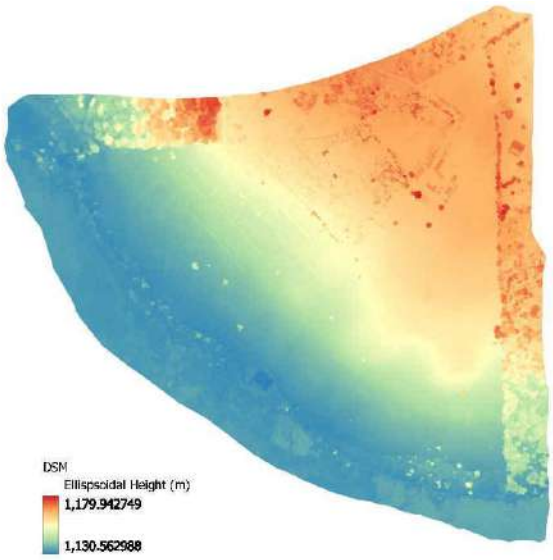
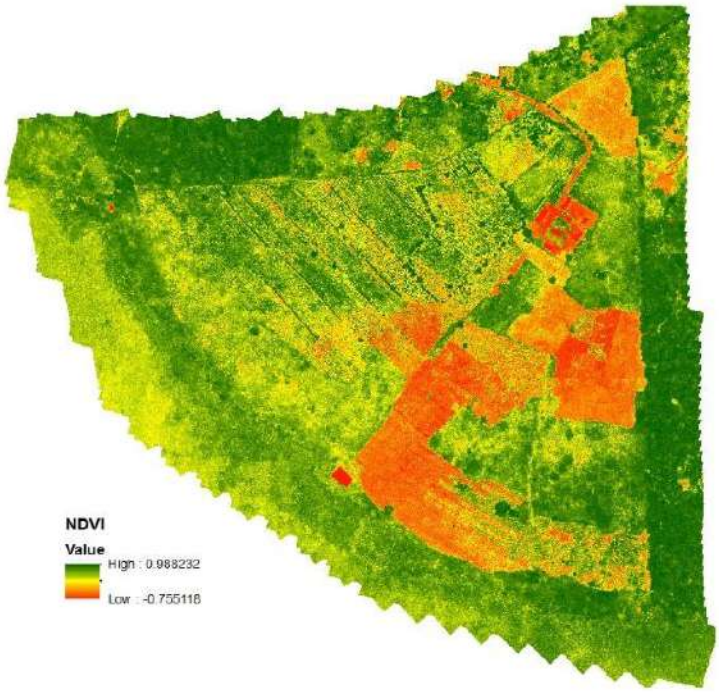
Using Drones for Coffee Yield Estimation and Crop Health Analysis

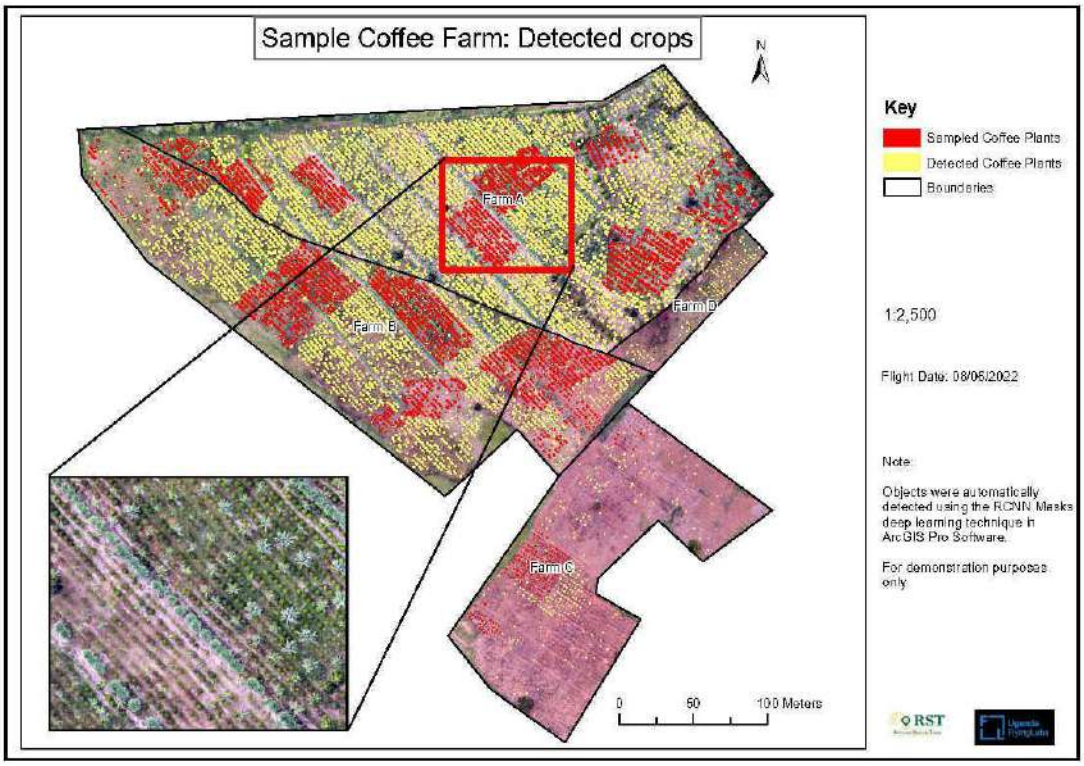
Othormosiac of Ventura Farm

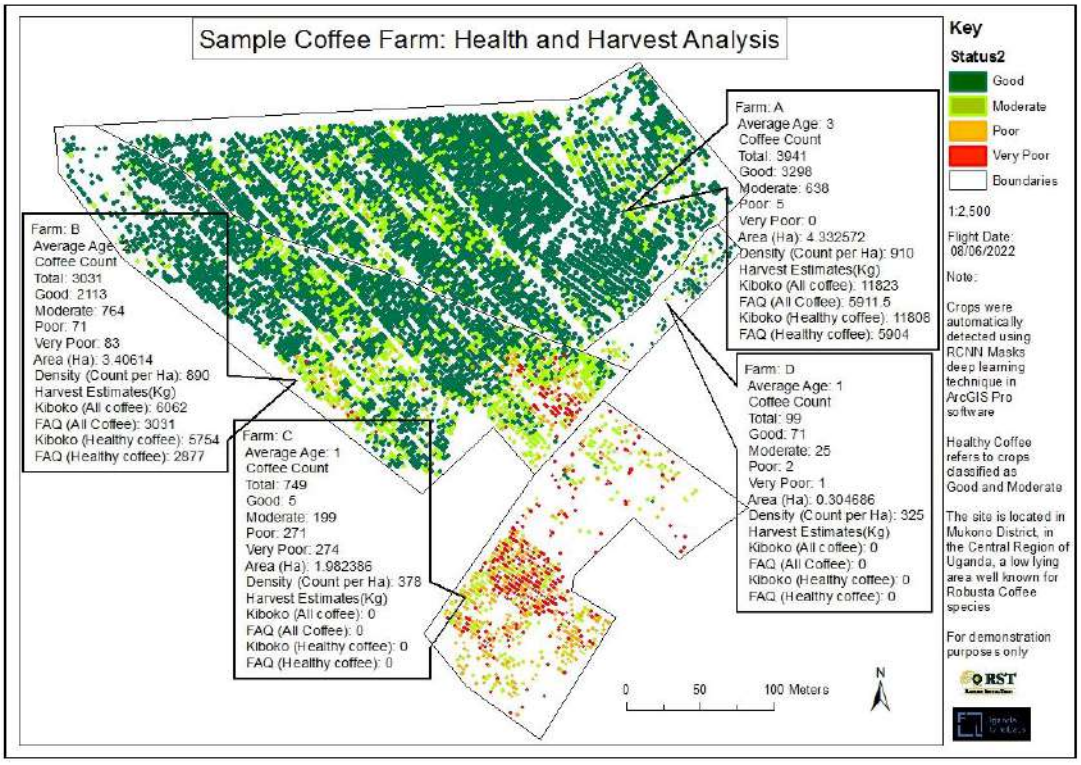


Digital Surface Model (DSM) of Ventura Farm to aid in water drainage and mitigate flood risk



Normalized Difference Vegetation Index (NDVI) to assess plant health


Sample Coffee Farm: Detected crops
N
Farm A
Farm B
Farm C
Farm D
0
50
100 Meters
Key
Sampled Coffee Plants
Detected Coffee Plants
Boundaries
1:2,500
Flight Date: 08/06/2022
Note:
Objects were automatically detected using the RCNN Masks deep learning technique in ArcGIS Pro Software.
For demonstration purposes only
RST


Sample Coffee Farm: Health and Harvest Analysis
Farm: A
Average Age: 3
Coffee Count
Total: 3941
Good: 3298
Moderate: 638
Poor: 5
Very Poor: 0
Area (Ha): 4.332572
Density (Count per Ha): 910
Harvest Estimates(Kg)
Kiboko (All coffee): 11823
FAQ (All Coffee): 5911.5
Kiboko (Healthy coffee): 11808
FAQ (Healthy coffee): 5904
Farm: B
Average Age: 3
Coffee Count
Total: 3031
Good: 2113
Moderate: 764
Poor: 71
Very Poor: 83
Area (Ha): 3.40614
Density (Count per Ha): 890
Harvest Estimates(Kg)
Kiboko (All coffee): 6062
FAQ (All Coffee): 3031
Kiboko (Healthy coffee): 5754
FAQ (Healthy coffee): 2877
Farm: C
Average Age: 1
Coffee Count
Total: 749
Good: 5
Moderate: 199
Poor: 271
Very Poor: 274
Area (Ha): 1.982386
Density (Count per Ha): 378
Harvest Estimates(Kg)
Kiboko (All coffee): 0
FAQ (All Coffee): 0
Kiboko (Healthy coffee): 0
FAQ (Healthy coffee): 0
Farm: D
Average Age: 1
Coffee Count
Total: 99
Good: 71
Moderate: 25
Poor: 2
Very Poor: 1
Area (Ha): 0.304686
Density (Count per Ha): 325
Harvest Estimates(Kg)
Kiboko (All coffee): 0
FAQ (All Coffee): 0
Kiboko (Healthy coffee): 0
FAQ (Healthy coffee): 0
0
50
100 Meters
N
Key
Status2
Good
Moderate
Poor
Very Poor
Boundaries
1:2,500
Flight Date:
08/06/2022
Note:
Crops were automatically detected using RCNN Masks deep learning technique in ArcGIS Pro software
Healthy Coffee refers to crops classified as Good and Moderate
The site is located in Mukono District, in the Central Region of Uganda, a low lying area well known for Robusta Coffee species
For demonstration purposes only
RST

OVERVIEW	
Flying Labs	Uganda Flying Labs
Geographic area	Mukono District, Central Region, Uganda
Date range	March - June 2022
Sector program	EcoRobotics
Main SDGs	GOAL 1: No Poverty

SCOPE	
Project stakeholders	Uganda Coffee Development Authority (UCDA) Opportunity Bank Uganda Local farm owners
People impacted	Local coffee farmers in Uganda
Number of people impacted	1 local coffee farmer
Challenge	Ugandan farmers, agricultural support officers and financiers lack a reliable and fast mechanism for monitoring of coffee crops to quickly identify plant health issues. Hence they have low chances of combating the risks of depletion of potential yields in a timely manner. The conventional methods of plant health assessment done by experts entails carrying out on-site ground surveys making them expensive and time consuming. It is also impractical to examine all the crops using traditional methods, as only a few areas are sampled.
Scope	This project focused on the coffee crop in Uganda. The project sought to use drone technology and multispectral cameras for mapping and assessment of crop health as well as creating a reliable inventory. The multispectral data was used to assess crop health and crop stress. In addition, due to the low flying heights, the captured images are of very high resolution and hence, deep learning techniques were used for automated crop identification.
Outcome	The drone images were processed in PIX4Dmapper and PIX4Dfields software. The outputs included a high resolution orthomosaic, point cloud, Digital Surface Model (DSM) and reflectance maps. Deep learning techniques in ArcGIS Pro software were applied to the orthomosaic to automatically identify the coffee stands on the farm.

	The reflectance maps were used to generate a Normalized Difference Vegetation Index (NDVI) used as an indicator of health. The health of each crop was ascertained by overlaying the identified crops and the NDVI map. Using PIX4Dsurvey, a point cloud of the terrain surface was extracted, which was used to generate a Digital Terrain Model (DTM) and later a slope map. With this, an erosion risk map was generated taking into consideration the steepness of the terrain on the farm and the bareness of the ground. Estimates of yield for the year were made which depended on factors such as crop health and age. Upon a review of the results by the farmer, certain actions were agreed to be taken to improve the status of the poor performing crops and maximize harvests on the farm. These include: 1. Organic manure in areas where crops had not thrived because of being planted in infertile rocky soils. 2. Planting new trees in areas where gaps were identified according to the observations from the obtained image. 3. Additional trenches with linings of elephant grass were dug in areas identified to be at a high risk of soil erosion.
Impact	The farm owner was moved to adopt the use of drones as a way of monitoring the health of crops on his farm. He expressed a desire to work with the Uganda Flying Labs team for a follow up flight to assess the success of the interventions he had decided on, and possibly take on a periodic arrangement of monitoring works using drones on his farm. The officials of the Uganda Coffee development Authority upon review of the results, promised to get in touch with more farmers to conduct similar exercises in the future over their farms.
Next steps	Discussions were held with the farmer about plans for periodic monitoring of crops on the farm and assessment for other crops.

COMMUNITY ENGAGEMENT AND STAKEHOLDER SUPPORT	
Consent for data acquisition	Consent was received from the local coffee farmer
Activities to engage with the community	The farmer was engaged through a physical meeting where the goals and the expected benefits of the project were explained
Community groups engaged with	Farm workers
Community attendance	3 people
Community feedback	None
Stakeholder support	Explanations on how to interpret the maps resulting from the exercise were given such as NDVI results, slope results and the floods assessment results

DATA ACQUISITION	
Size of area	44 ha (0.44 km^2)
Drone	DJI Phantom 4 multispectral
Sensor(s)	Multispectral sensor including one RGB sensor for visible light imaging and five spectral bands for multispectral imaging
Flight plan software	DJI GS Pro
Flight height	75 meters above ground
GSD (Accuracy)	4 cm/pix
Number of images acquired	10722 images
Number of flights	4 flights
Time invested in data acquisition	2 days
Georeferencing	Onboard RTK-enabled GPS

DATA PROCESSING & ANALYSIS	
Processing software	PIX4Dmapper, PIX4Dfields
Processing time	3 weeks
Data products	Orthomosaic, Digital Surface Model (DSM), Normalized Difference Vegetation Index (NDVI), Digital Terrain Model (DTM) and reflectance images for individual bands
Analysis tools	ArcGIS Pro, PIX4Dsurvey
Analysis outputs	Coffee plants (Shapefile) with attributes of age and health status and a slope map
Final outputs shared with stakeholders	Orthomosaic, DTM (contours), slope map, NDVI map, crop health map and harvest estimates
Data sharing	Email