Use of UAV(s) for Agriculture and Forestry Applications

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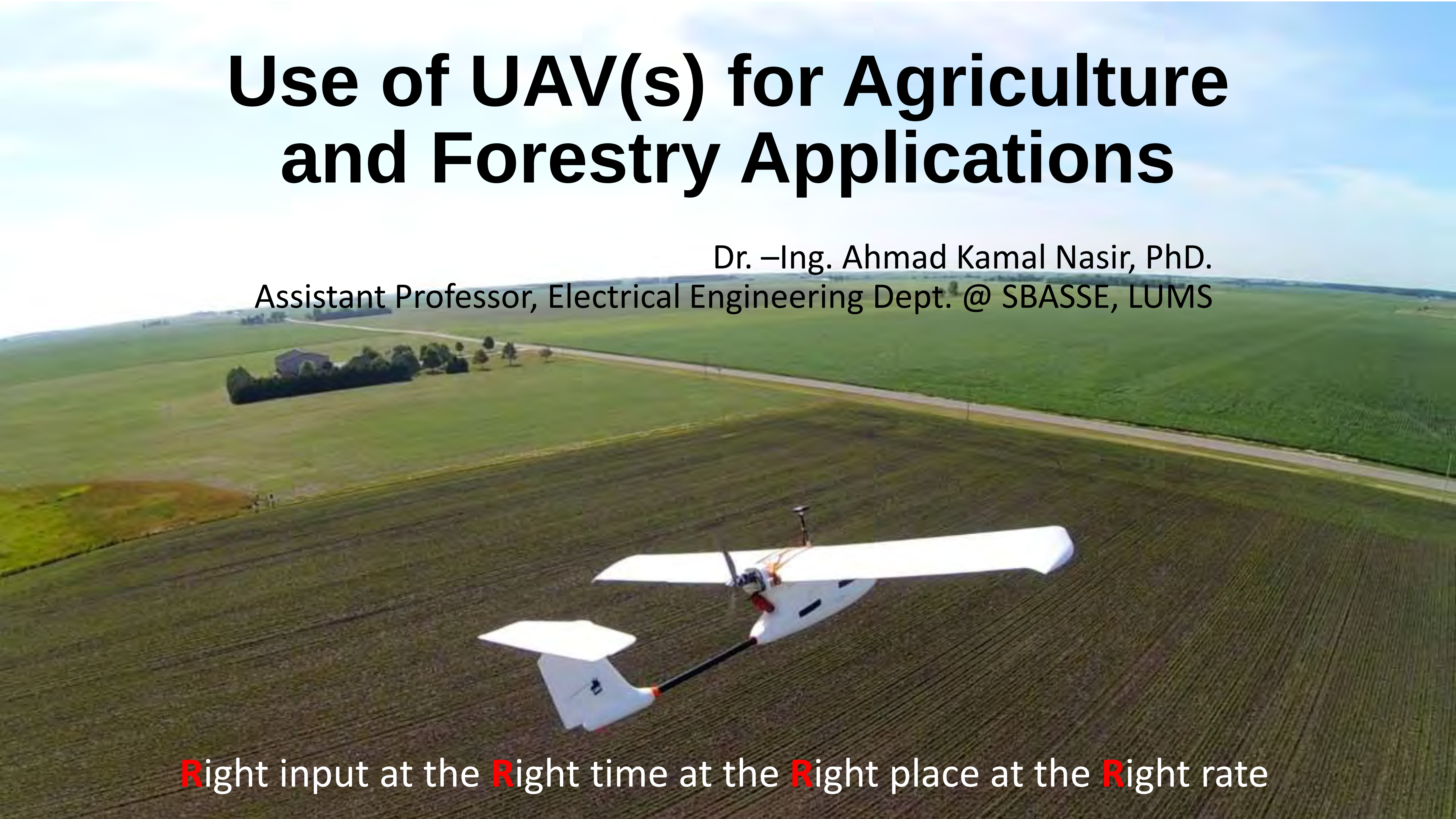


Right input at the **R**ight time at the **R**ight place at the **R**ight rate

Precision Agriculture and Forestry Research Cluster

Areas

Mobile Robotics
Artificial Intelligence
Knowledge Management
Precision Agriculture & Forestry

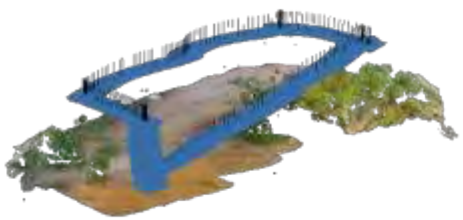

People

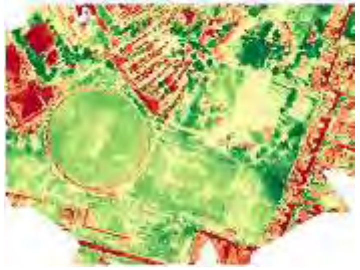
Mobile Robotics (Ahmad Kamal Nasir, EE)
Artificial Intelligence (Zehra Shah, Mian M Awais)
Knowledge Management (Mian M Awais)

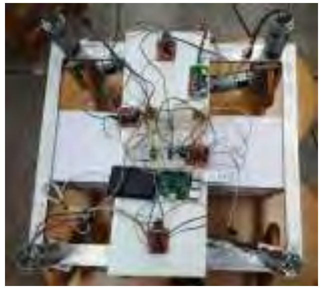
Some Projects

- Aerial Mapping of Forests/Fields 2015 – ongoing (Ahmad, Awais)
- Knowledge Based Systems for Diagnostics Crops/Livestock (Awais)
- Tree Counting 2015 – ongoing (Ahmad, Awais)
- Carbon Stock/Sink Estimation 2015 0ngoing (Awais, Ahmad)
- Tree Specie Identification (Zehra)
- Alarm/Fault Management System, IFPTMN, 2012-2015 completed (Awais, Aun Abbas, Ahmad Kazmi, Ahrar)
- Imitative Learning in Robots, 2013 completed, (Awais)
- Visual-Insertional Odometry, 2015 ongoing, (Ahmad, Abubakr)
- Gardinator: Home Gardening Assistant 2014 – ongoing (Awais, Haider Ali – DLR Germany)



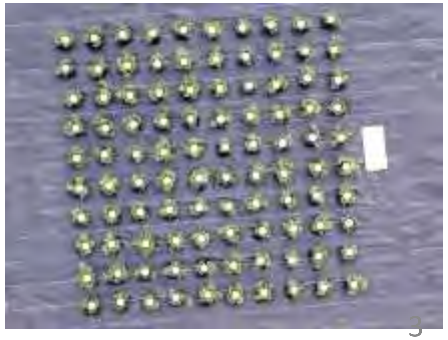








Needs for progressive farmers

- Precision or Site-Specific Agriculture practices considers **R**ight input at the **R**ight time at the **R**ight place at the **R**ight rate. It requires
  - Map the **field yield variability** in order to determine best strategy for **optimum fertilizer usage**
  - Monitor the **health, nutrient and water** of crops at **every few centimeters** in order to identify low yield areas
- Chemical applications (Pesticide)
- Crop and Livestock inventory management



Solution!: An Eye In The Sky

What UAS options are available to you?: Rotary

DraganFly X6

$36,000.00

http://www.draganfly.com

MicroDrone MD4-200

€ 50,000.00

http://www.microdrones.com

Mikrokopter

$ 3- $15k

http://www.mikrokopter.us/

DJI Phantom (<$1000) http://www.dji.com/product/phantom-2/

What UAS options are available to you?: Fixed Wing

Swinglet CAM

http://www.sensefly.com

$ 20- $25 K

Trimble-Gatewing

http://uas.trimble.com/

Precision Hawk

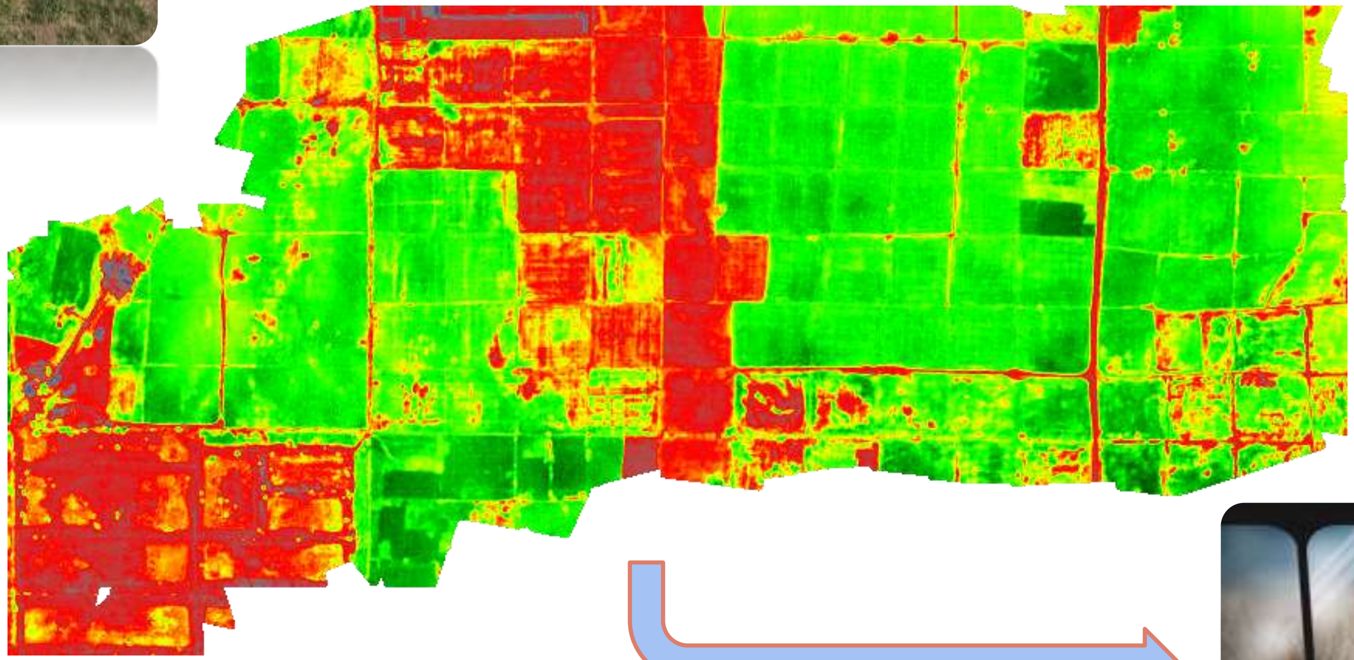
Our Indigenous Solution

Left figure, developed fixed wing UAV for forestry/agriculture land aerial survey. Right figure, ground control station

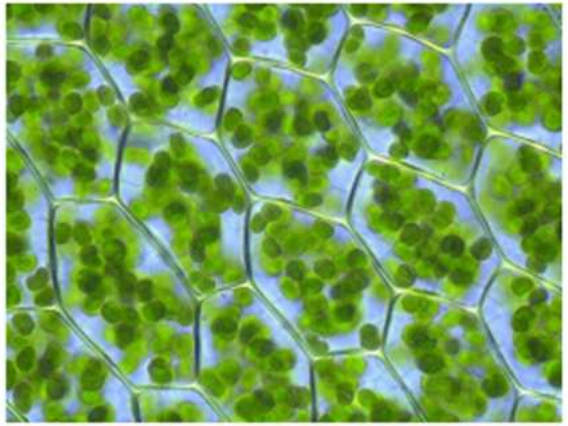
Methodology: It’s all about the data analytics

Green = Healthy

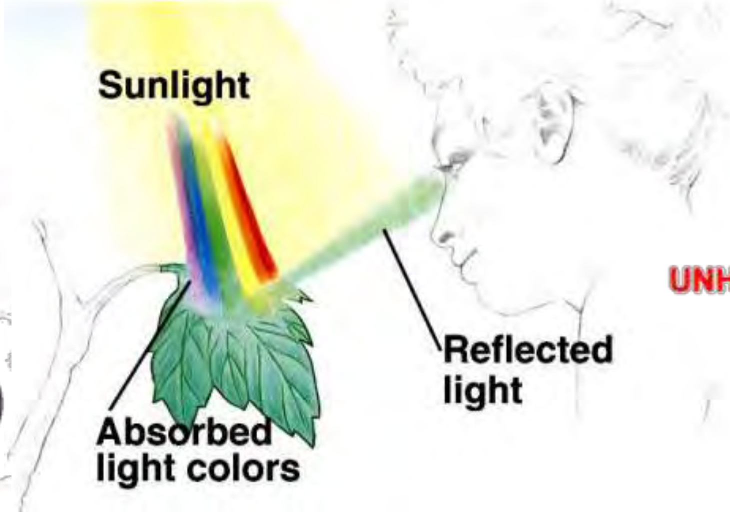
Red = Low health / Fallow land



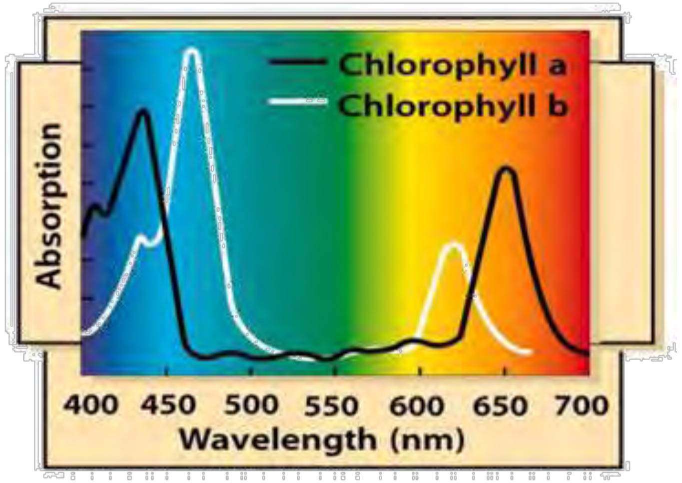
Methodology:



Chloroplasts within plant cell



Natural color image of soybean



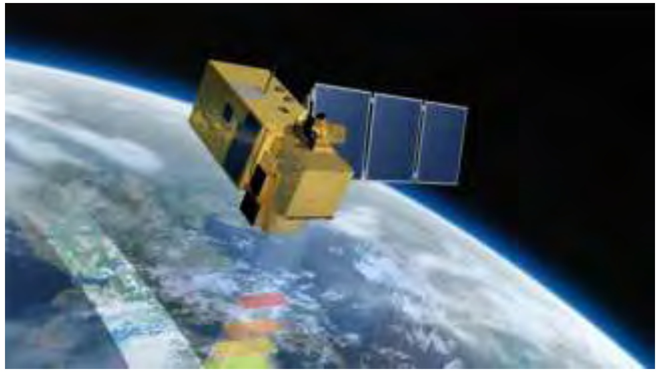
BLUE

GREEN

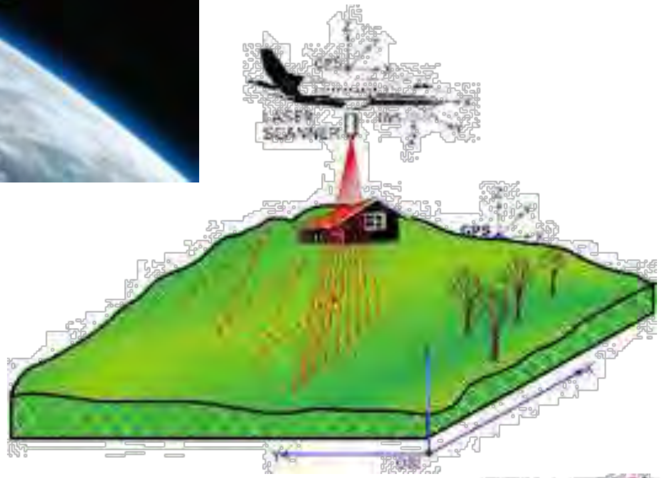
RED

NEAR INFRARED

Other Solutions

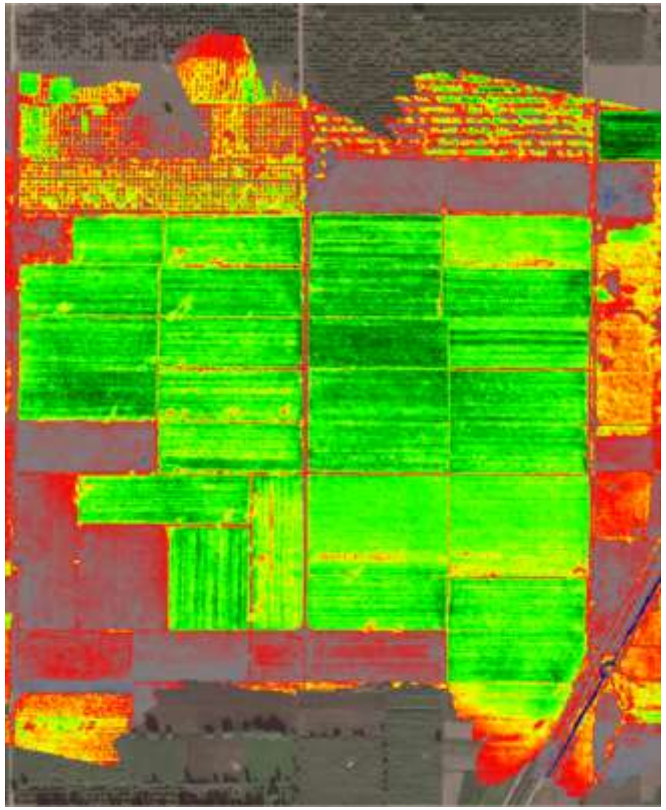


- Satellite
  - Global Coverage (Large Scale)
  - Low Spatial Resolution (0.3 m)
  - Cloud Cover
  - Low Temporal Resolution
- Airborne-Lidar
  - Regional Coverage (Medium Scale)
  - Medium Spatial Resolution (0.1 m)
  - On Request
- Unmanned Aerial System (UAS)
  - Local Coverage (Small Scale)
  - Very High Spatial Resolution (0.05 m)
  - All-Time Ready (Repeatability)



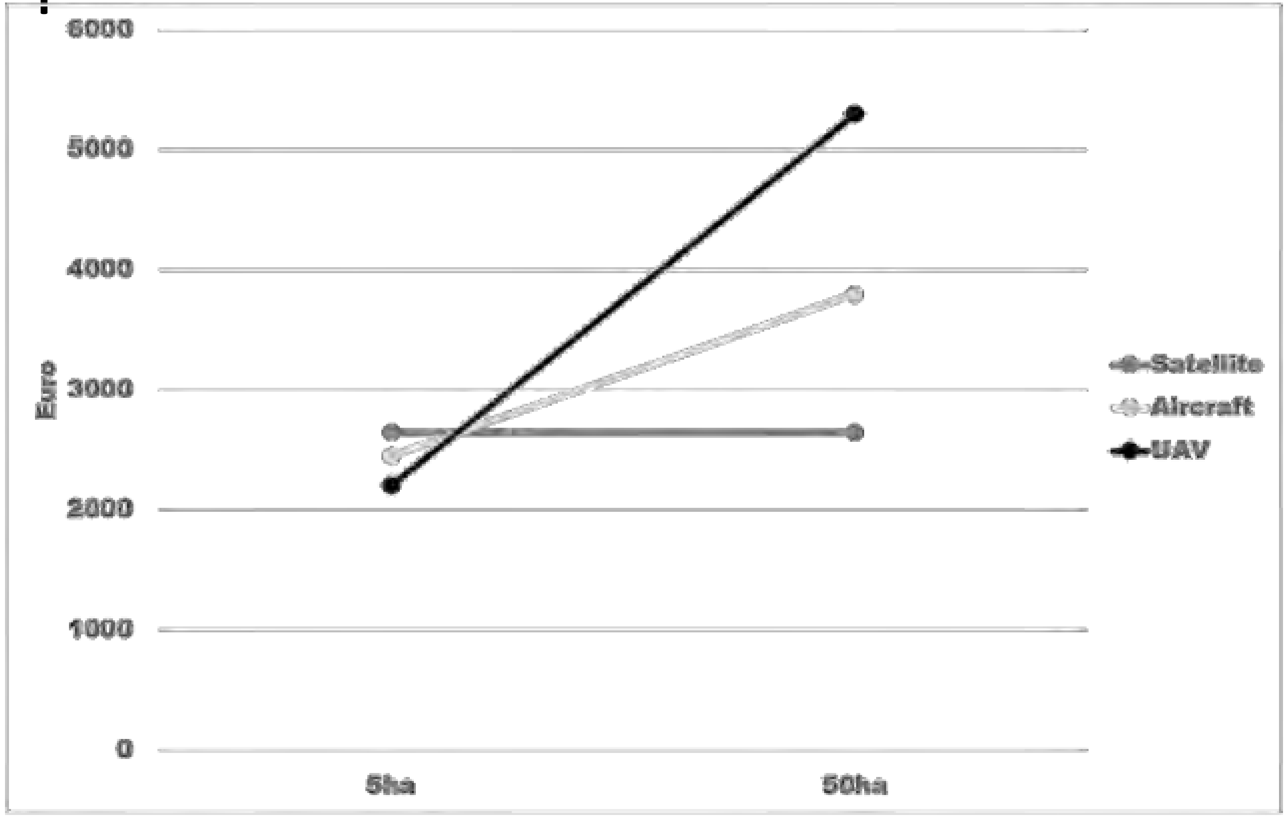
Technology Comparison

~ 50 cm/pixel (20 inch/pixel)



~ 5 cm/pixel (2 inch/pixel)

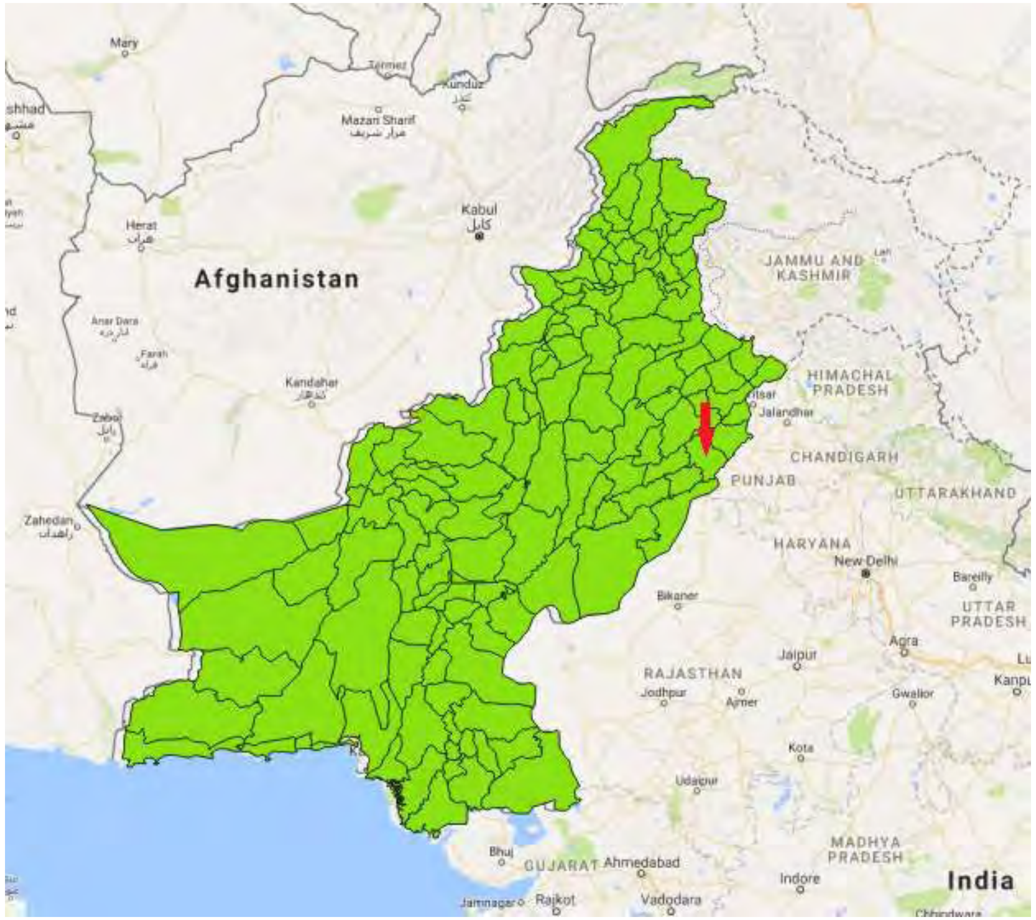
Cost Comparison



A cost comparison between UAV, Aircraft and Satellite remote sensing in shows that UAVs are cost effective for small areas.

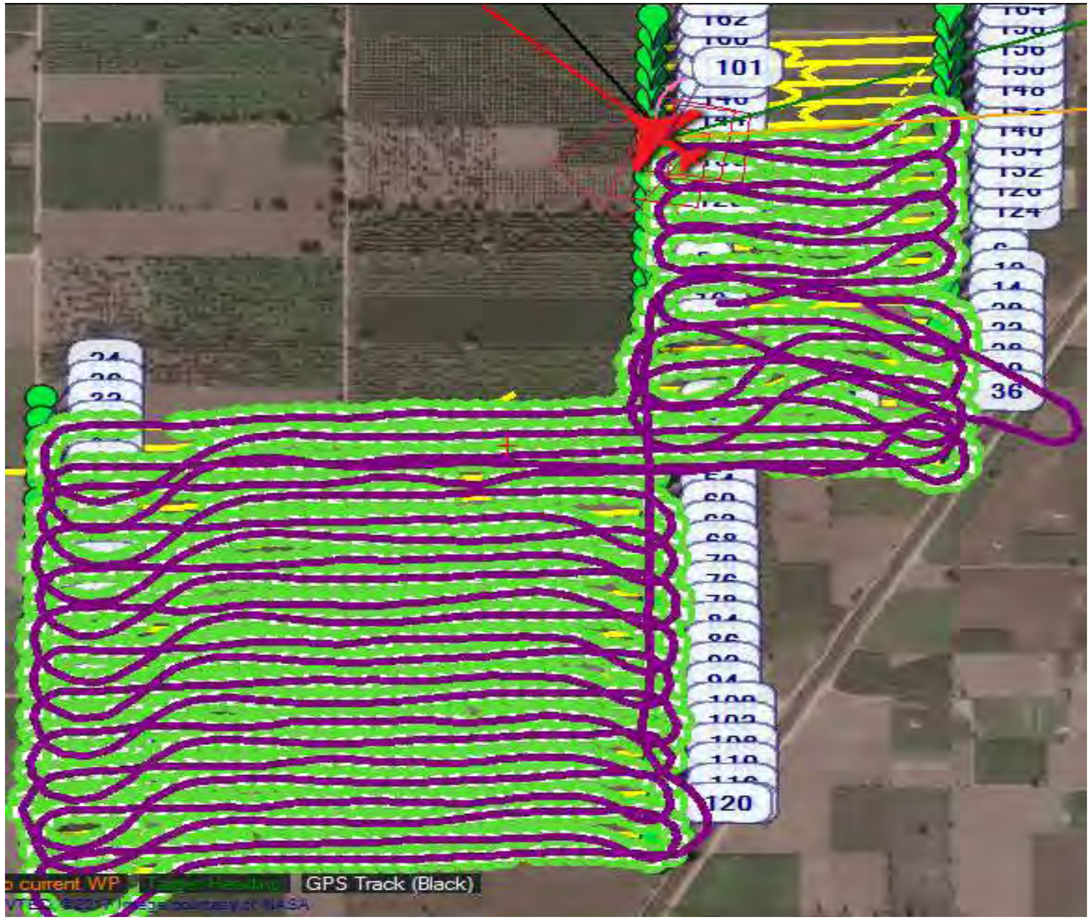
Matese, A., Toscano, P., Di Gennaro, S.F., Genesio, L., Vaccari, F.P., Primicerio, J., Belli, C., Zaldei, A., Bianconi, R. and Gioli, B., 2015. Intercomparison of UAV, aircraft and satellite remote sensing platforms for precision viticulture. *Remote Sensing*, *7*(3), pp.2971-2990.

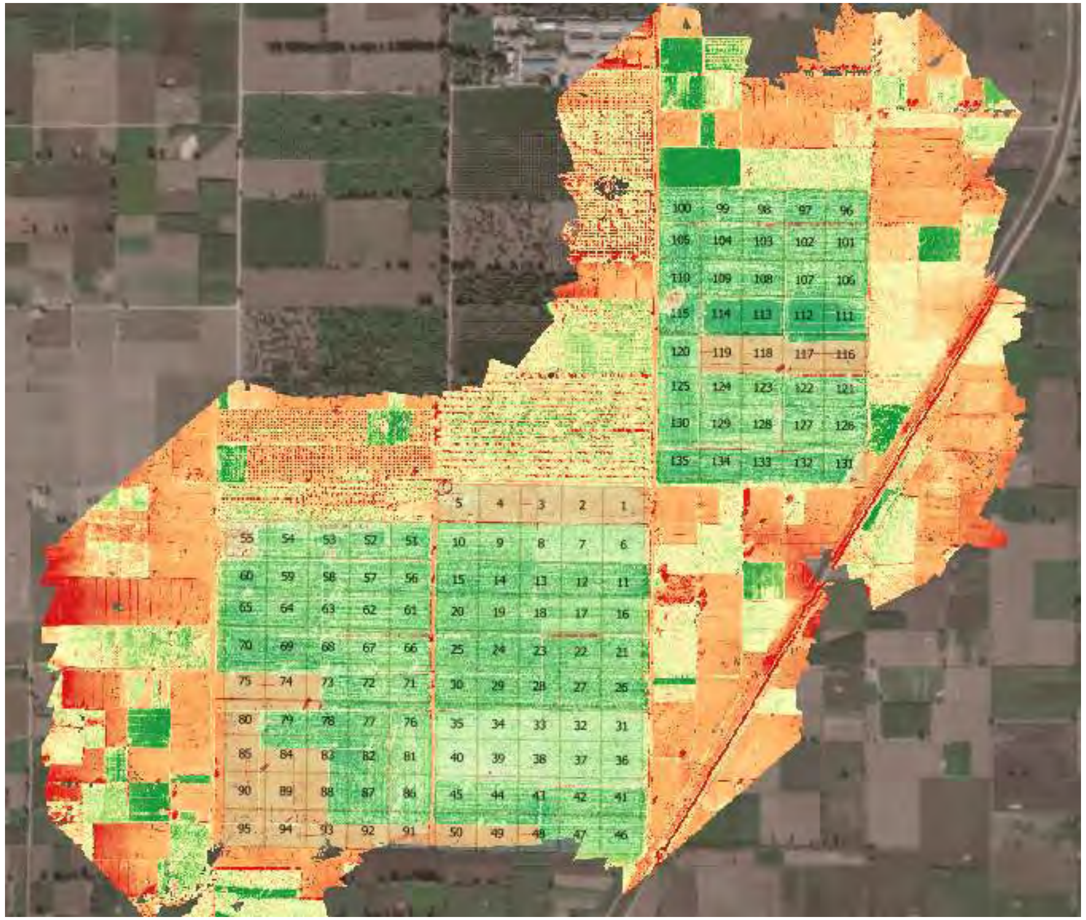
Nestle Sar-Sabz Farm Renla-Khurd Pakistan Nov 2016



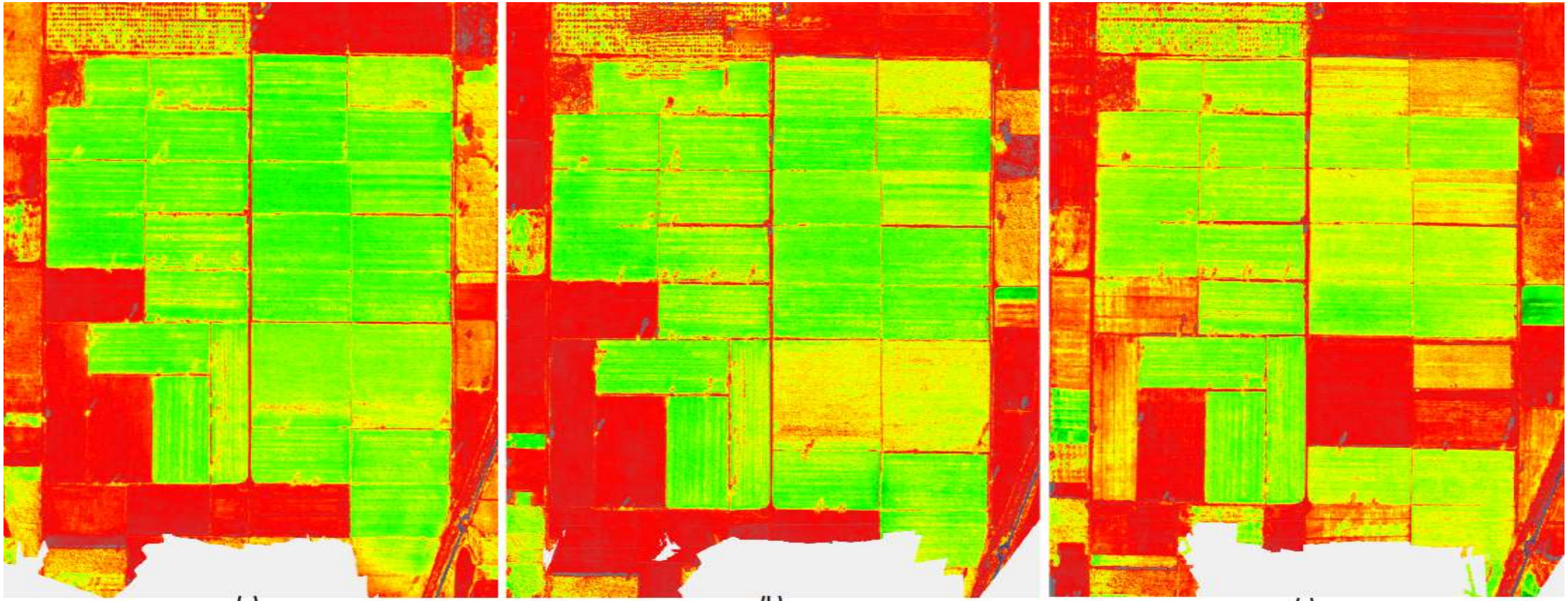
A. K. Nasir and M. Tharani, “USE OF GREENDRONE UAS SYSTEM FOR MAIZE CROP MONITORING,” in *ISPRS Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences* , 2017

Sar-Sabz Farm Flight (135 acres)





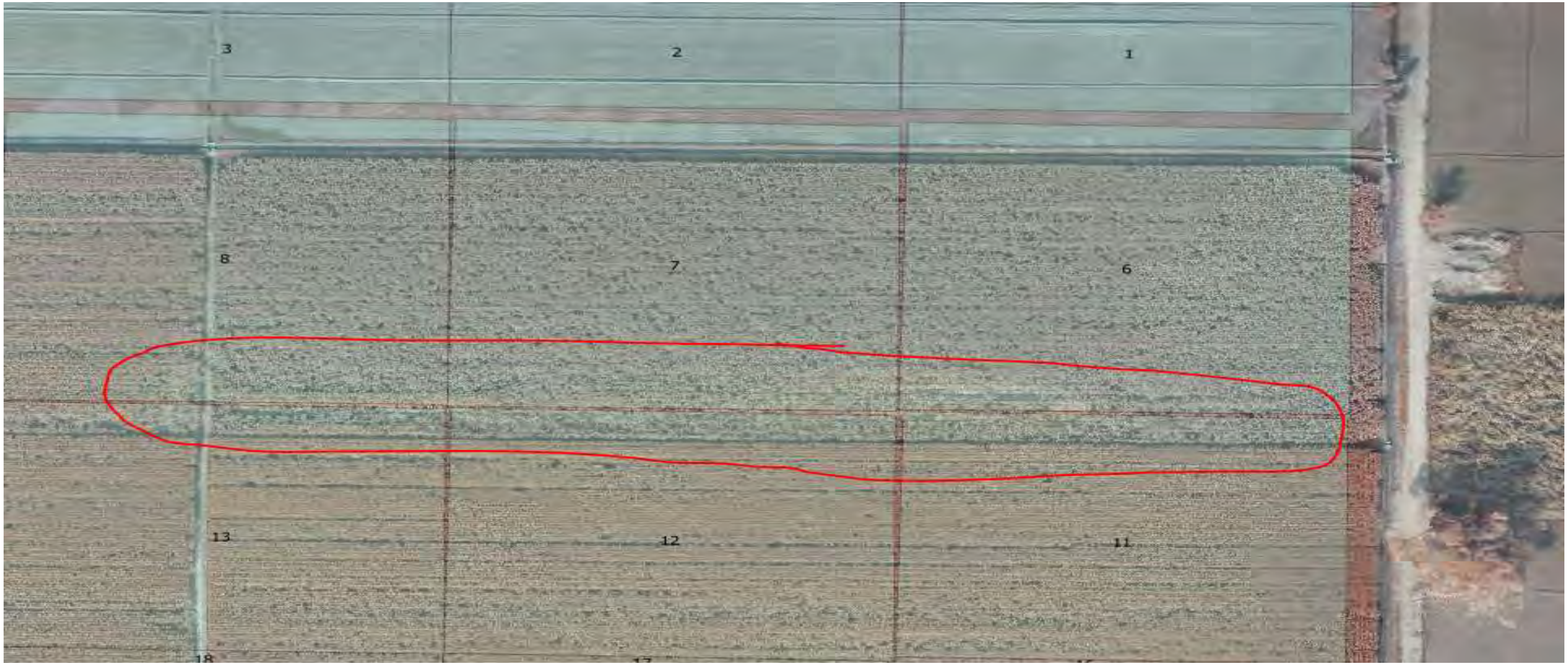
Maize Crop Yield Map Multiple Flights: 15Nov, 27Nov, 15Dec 2016



(a) (b) (c)

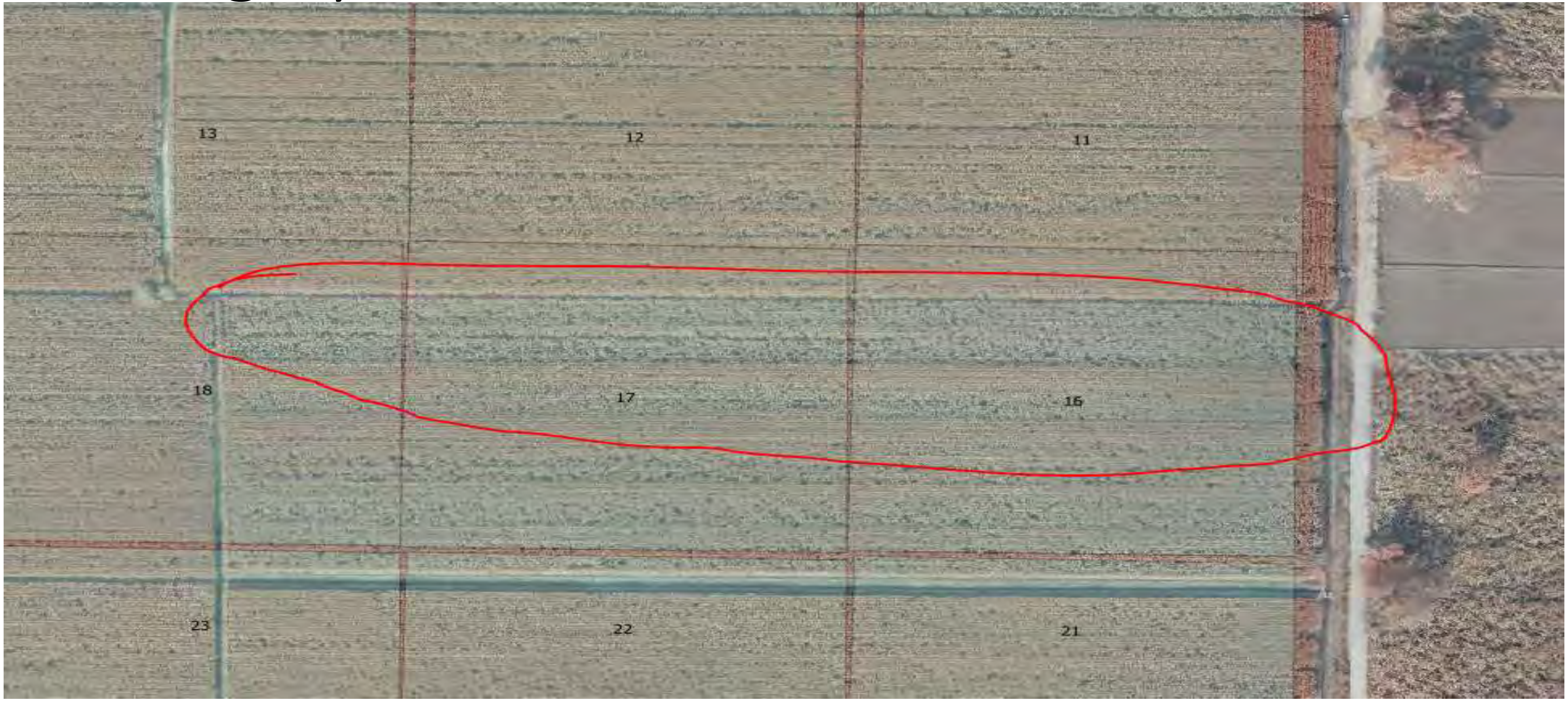
Benefit: Identification of Land Level Problems

Benefit: Identification of Low Plants Count Areas



Benefit: Identification of Nitrogen Concentration Problem Due to Flood Irrigation

Optimization of seeding rate: Non-Uniform Sowing by Labor

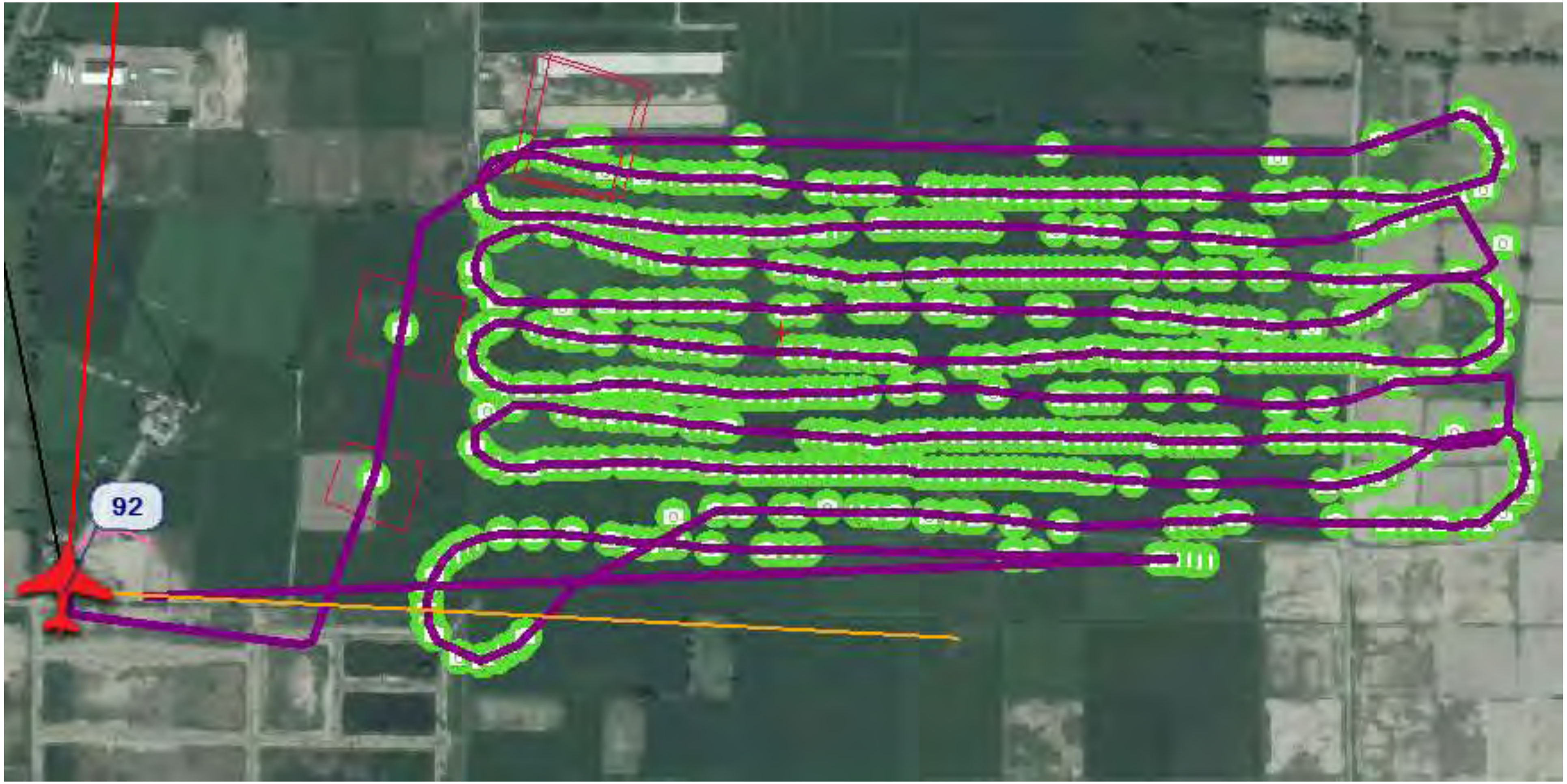


UAS for Girdawari (Crop Reporting Service, Punjab Agriculture Department) at Kala Shah KaKu using **UAS**

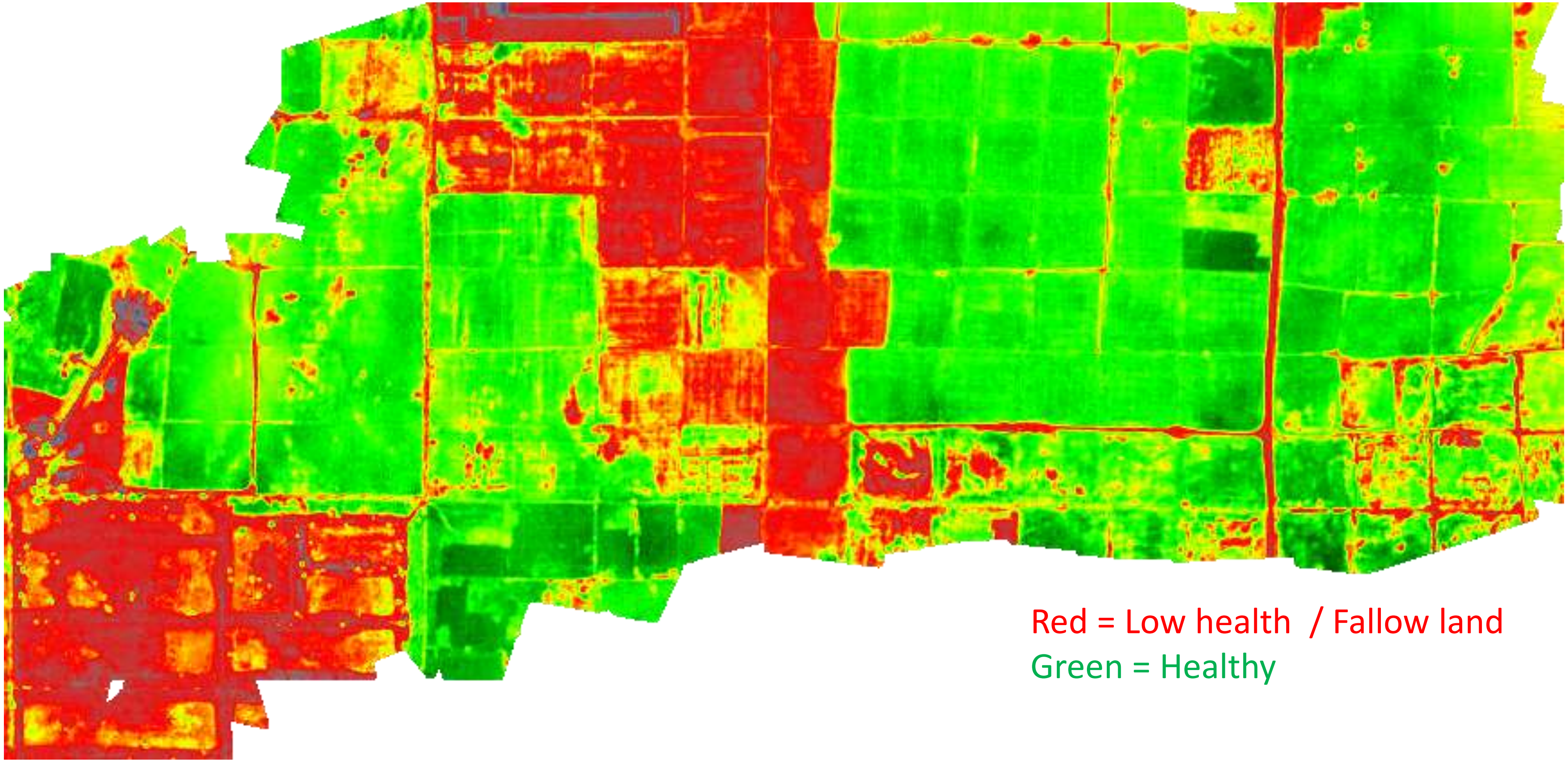
- A test Flight was carried out on **2nd March 2017** at KSK in accordance with the Crop Reporting Service Requirements.
- Mr Anwar Baig Director CRS,
- Mr. Azaz A.D CRS, Mr. Farooq(SO CRS), Mr Waseem Mirza and other CRS representatives were also present

Planned Mission at the Sample Village using **UAS,** 100 Acres

Executed Mission at the Sample Village using UAS



Kala Shah KaKu – Health Map (03 March 2017)

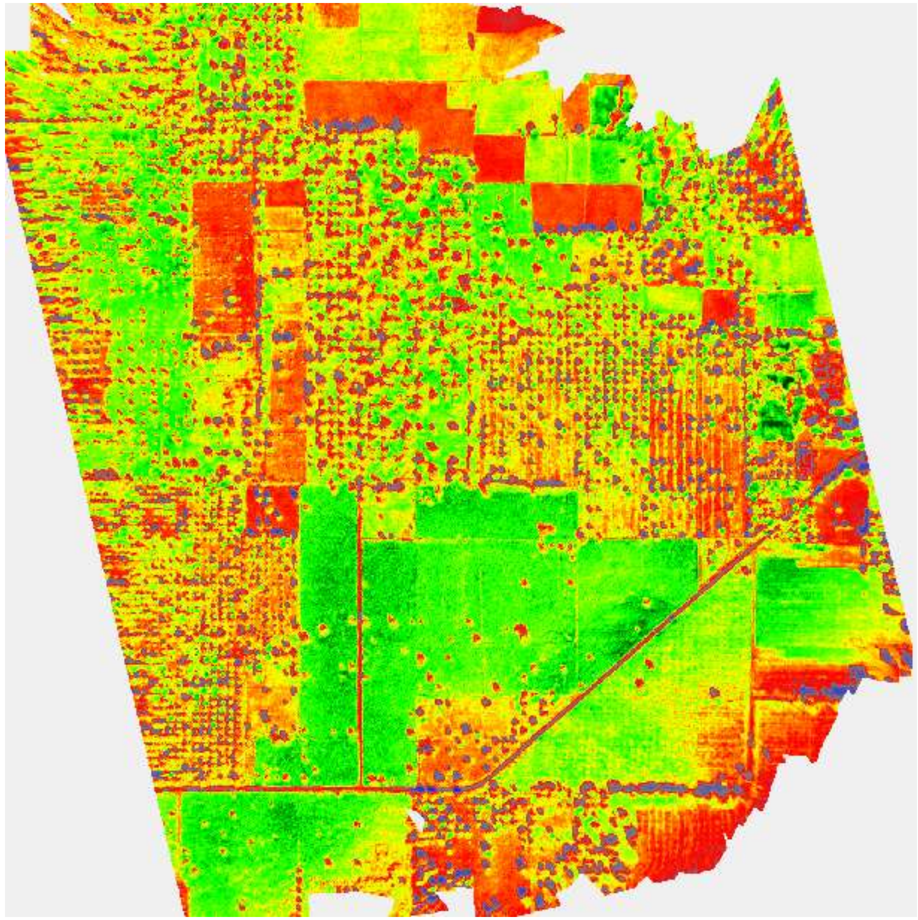


Red = Low health / Fallow land
Green = Healthy

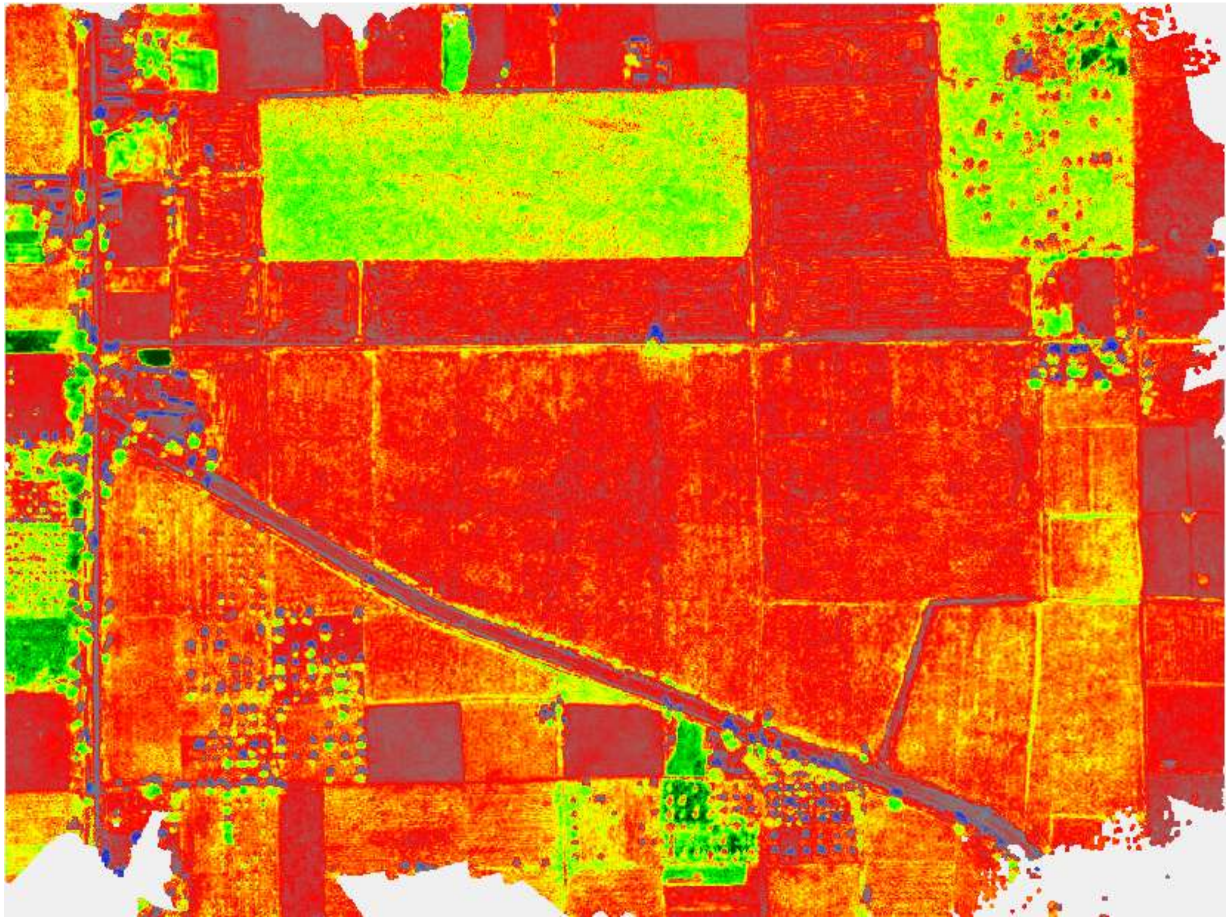
Kala Shah KaKu – Aerial Map (03 March 2017)

Kala Shah KaKu – Girdawari (03 March 2017)

Mango Farms Managment: Jahanpur – Shuja-abad (13 Nov 2016), 200 Acres



Sugarcanes: Jahanpur – Shuja-abad (13 Nov 2016), 144 Acres

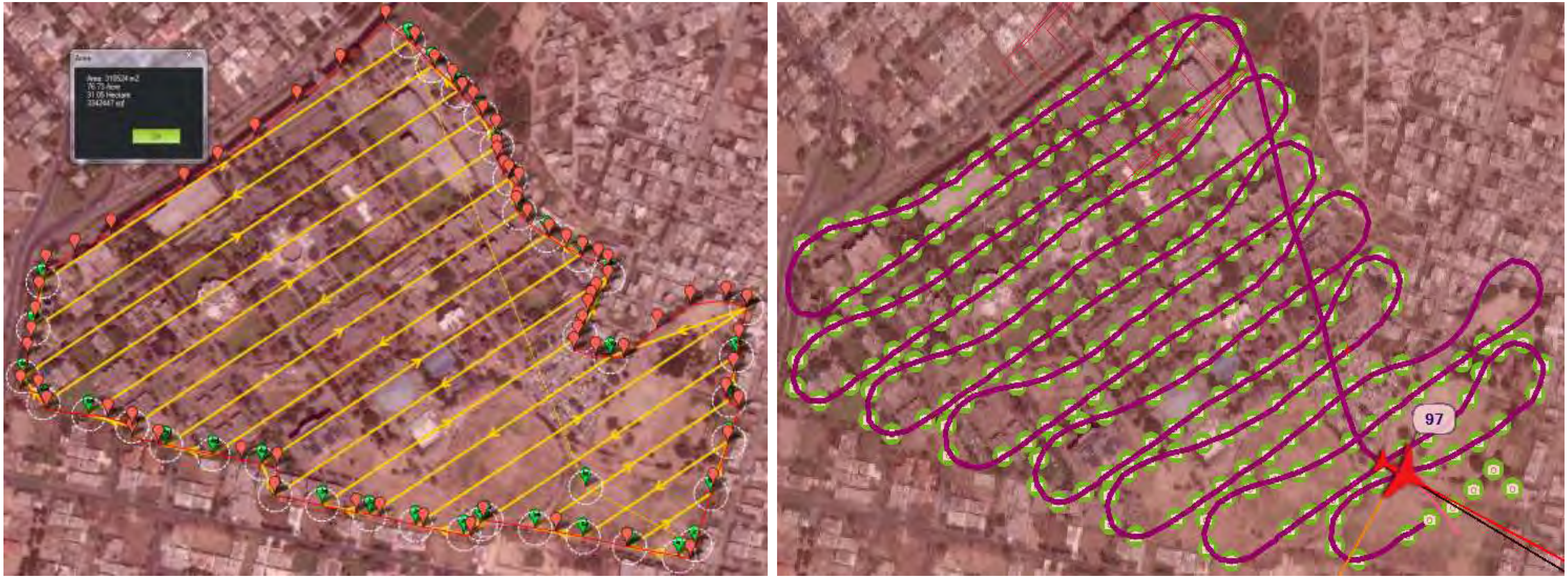


Precision Forestry

- Deforestation and Forest Degradation
  - Underdeveloped countries
  - Environmental health and the health of the people living in these regions
- Conventional Aerial Remote Sensing
  - Some low-resolution satellite images are freely available (e.g., Sentinel [1] up to 10m, Landsat [2] up to 30m resolution and MODIS [3] up to 1000m resolution).
    - The low-resolution imagery is not useful for vegetation classification and tree counting applications [4].
  - High resolution commercial (e.g. QuickBird [5] up to 0.65m resolution) satellite imagery are costly, which makes them inaccessible for researchers in developing countries (Raw data: 17 $\$/\mathrm{km}^2$).
  - The latest 0.5m resolution imagery is available at 30 $€/\mathrm{km}^2$
  - Air-borne LIDAR survey costs 450 $€/\mathrm{km}^2$ [6].

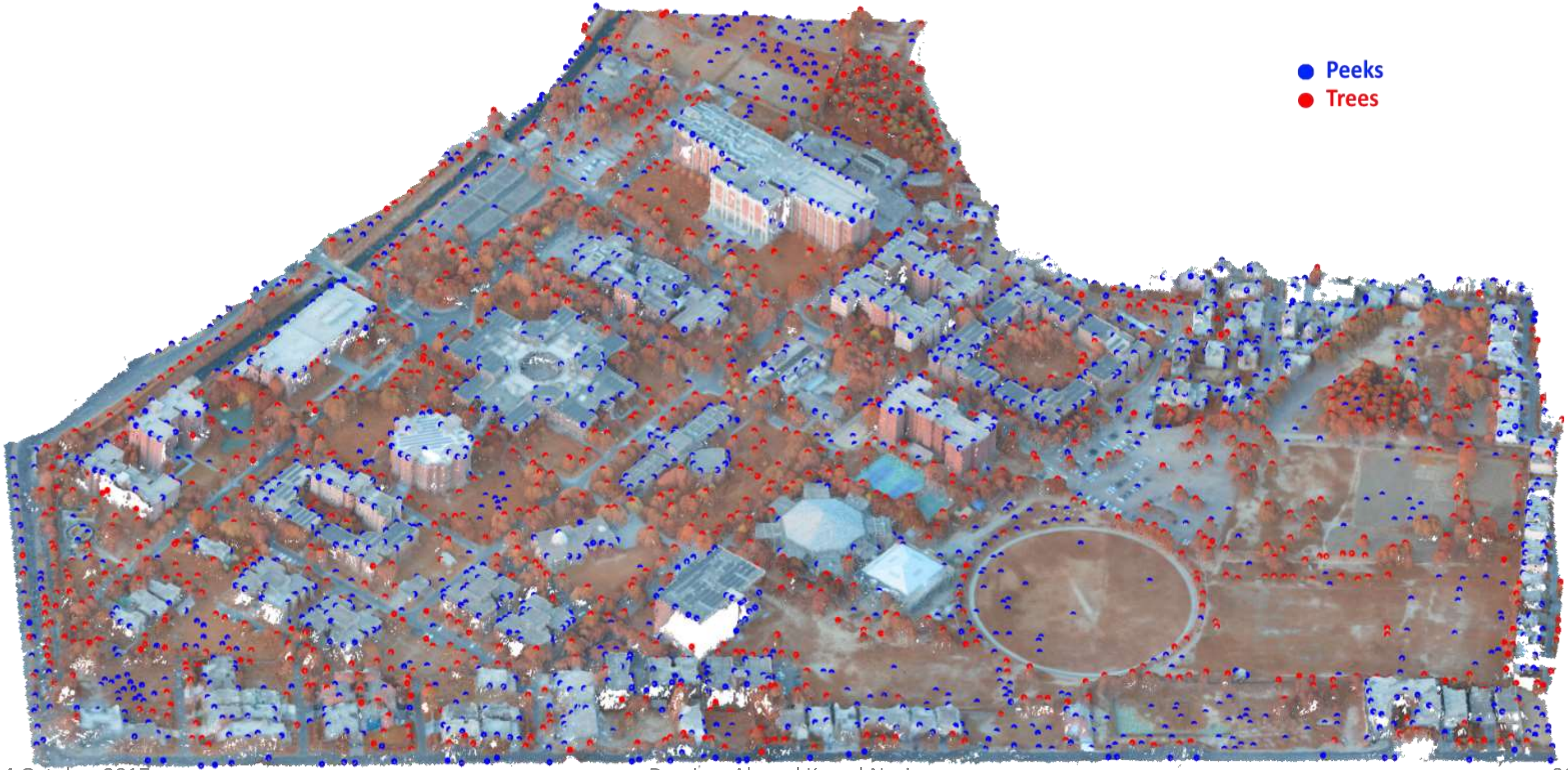
A. K. Nasir, M. M. Awais, Hubert Roth, Nasser Gyagenda, “Tree detection and counting in 3d point clouds”*, IEEE Transactions on Geoscience and Remote sensing* , 2017 (In Publication)

Flight planning LUMS Campus (100 acres)



Flight plan for the aerial survey. In the left figure, yellow lines represent the planned flight path, green markers represent the way points and the red markers represent the polygon end points.

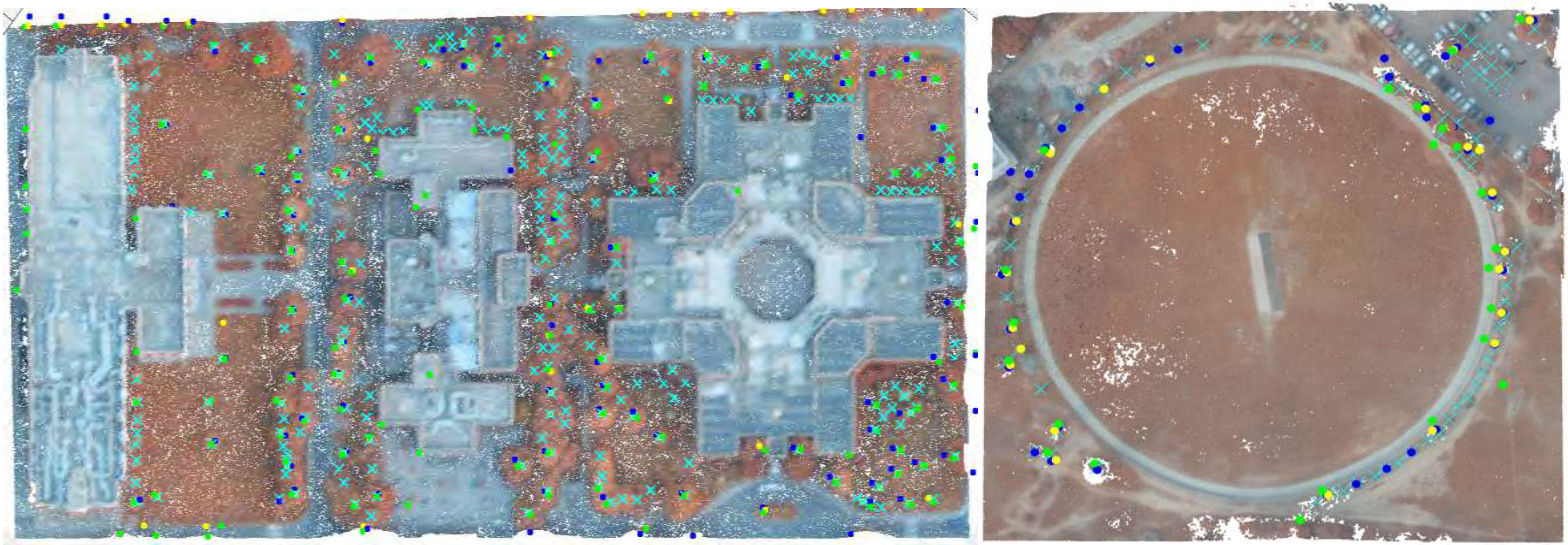
Automatic Trees Detection and Counting



Tree Height and Crown Spread Estimation in 3D

Left figure, Unfiltered Cluster, Right figure, Filtered Cluster

Multiple Flights Result



Detected trees in areas with buildings (Left) and without buildings (Right). Cyan Cross show GT Trees, while blue, yellow and green dots show detected trees from the point clouds 1, 2 and 3 respectively.

Characterization of the Algorithm in areas containing buildings Using Confusion Matrix

Actual Trees = 261	Point Cloud 1	Point Cloud2	Point Cloud 3
Total Trees Detected	119	112	140
True Positive	100	94	108
True Negative	0	0	0
False Positive	19	18	32
False Negative	161	167	153
F1 Score	53%	50%	54%
Miss Rate	62%	64%	59%
False Discovery Rate	16%	16%	23%

CHARACTERIZATION OF THE ALGORITHM IN AREAS CONTAINING NO BUILDINGS USING CONFUSION MATRIX

Actual Trees = 73	POINT CLOUD 1	POINT CLOUD2	POINT CLOUD 3
Total Trees Detected	36	23	23
True Positive	32	23	17
True Negative	0	0	0
False Positive	4	0	6
False Negative	41	50	56
F1 Score	59%	48%	35%
Miss Rate	56%	68%	77%
False Discovery Rate	11%	0%	26%

Summary

Problem → Solution → Function → Costs → Successes

- **Problem**: Population is growing quickly, productivity is not
- **Solution**: UAS are military tested, and now civilian approved
- **Function**: Lot's of data, analyzed correctly
- **Costs**: Low cost, saves money over time
- **Successes**: We can already see it working today