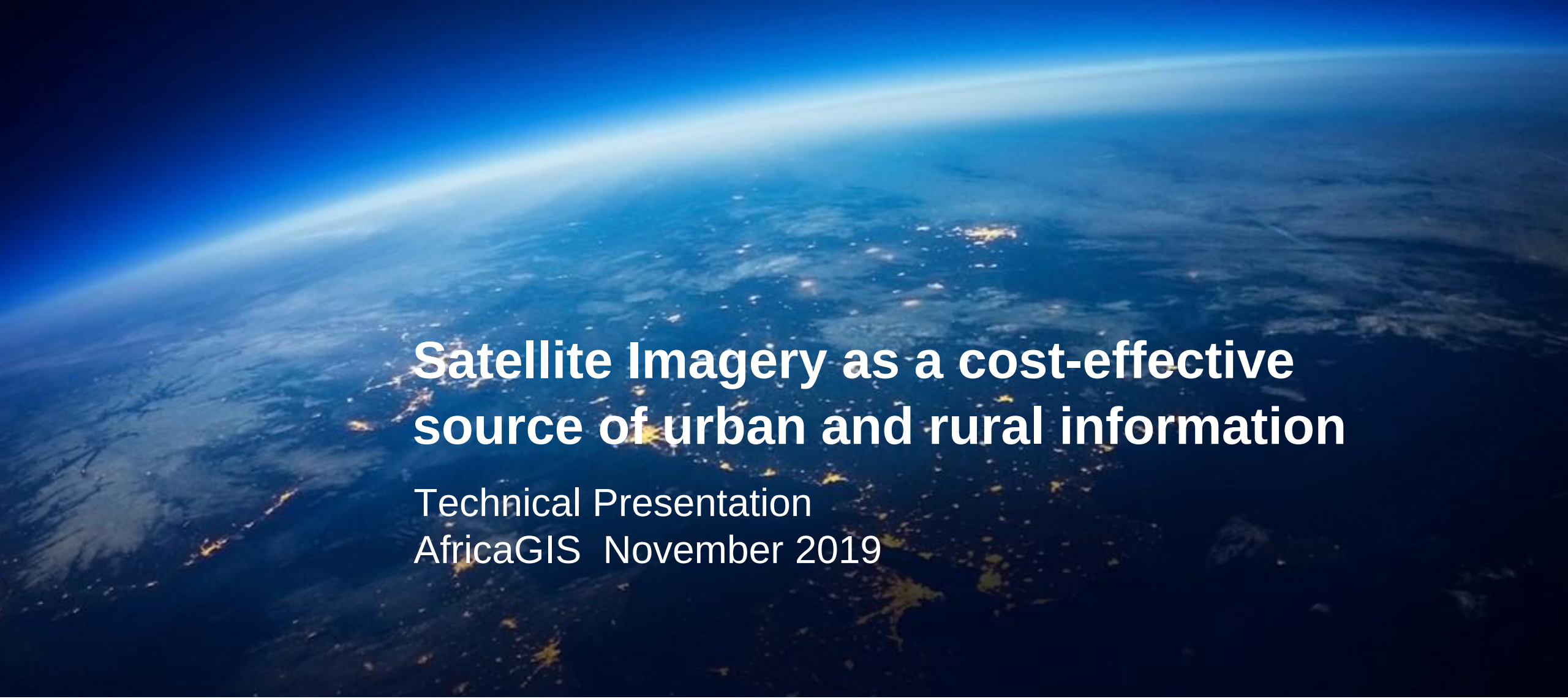

Satellite Imagery as a cost-effective source of urban and rural information

Technical Presentation
AfricaGIS November 2019

DEFENCE AND SPACE

AIRBUS

Urban Land Monitoring

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Background

- Like many cites in Africa Dakar is growing rapidly, presenting a challenge for the provision of public services
- Revenue generation through property taxation is seen as a potential source for improvement of public finances
- Efficient systems, therefore, need to be in place to collect and manage information…
- …and keep it up-to-date to ensure fairness
- This project addresses ways of maintaining up-to-date property records in a rapidly changing city
- Particularly focusing on vertical change, given the shortage of land to expand into

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Dakar IPP Project

- The International Partnership Programme (IPP) is a five year, £152 million programme run by the UK Space Agency. IPP focuses strongly on using the UK space sector's research and innovation strengths to deliver a sustainable economic or societal benefit to emerging and developing economies around the world.
- In Call 1, 22 projects were commissioned; further projects are being supported under Call 2. These projects are run by a large variety of organisations across industry, academia and non-profit entities. UK and international organisations are involved in the project consortiums.
  https://www.gov.uk/government/publications/international-partnership-programme-call-1-projects

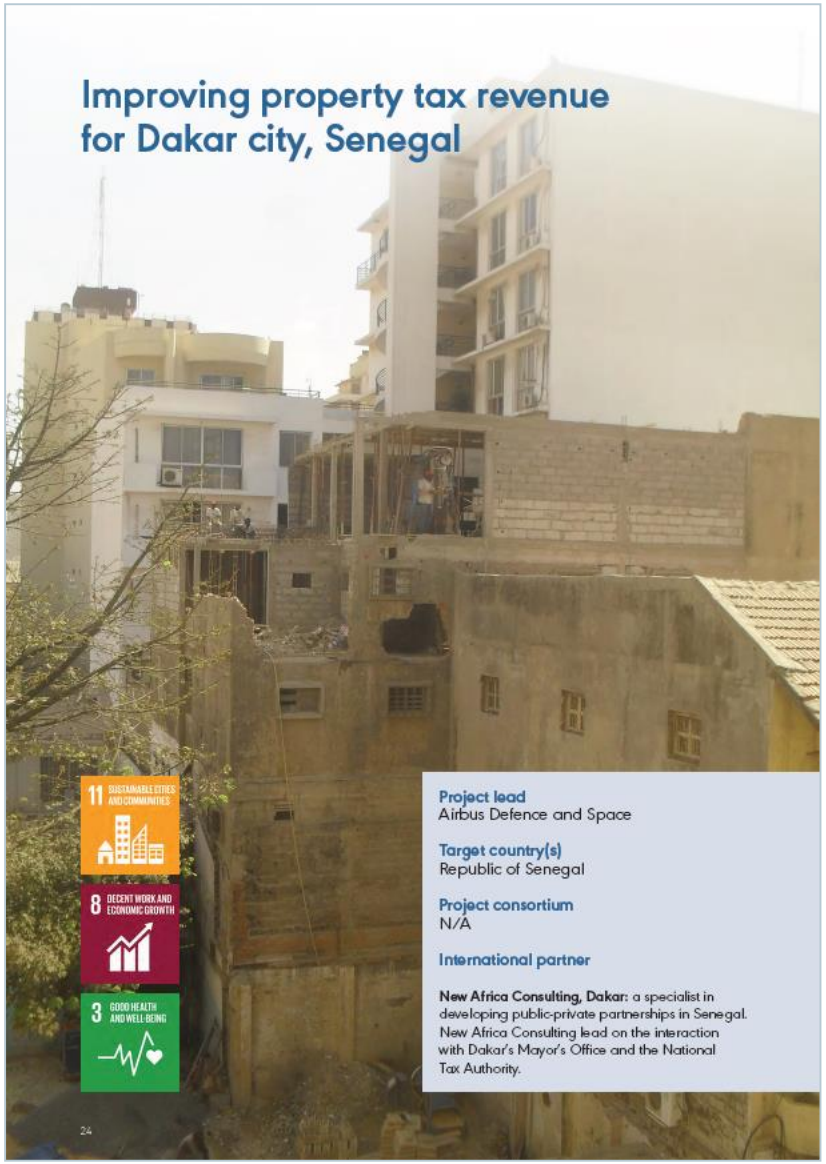
UKSA: funder and programme manager

Airbus Defence and Space: project lead

New Africa Consulting: local partner

IPP and SDGs

- All IPP projects have been assessed on their applicability to the SDGs to ensure alignment of IPP with the SDGs
- These projects are technical solutions to specific problems and they are being monitored for their long-term impacts and cost-effectiveness



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Dakar Change Monitoring Project (Dakar IPP Project)

The principal objectives of this project are to:

- Demonstrate and prove that change monitoring of land and buildings from satellite data can be fully incorporated into a procedure for generating property-based tax revenues
- Assist development of an operational property revenue system for Dakar City
- Focus on training and knowledge transfer to ensure that future operations can be fully implemented by a local technical team
- Develop a methodology that can be rolled-out to similar cities where infrastructure and services can be improved and enhanced by local revenues generated from a property-based tax system

Components:

- Development of a technological application
- Training / Learning by doing
- Development of a methodology for the maintenance of the database over time

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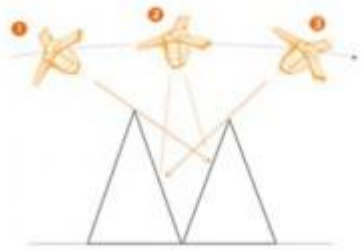
Satellite Image Data



- Airbus Pleiades satellite imagery used
- Elevation1 product generated from Tri-stereo data
  - Ortho layer
  - DSM layer
  - DTM layer
- Imagery used for GIS data capture
- Basis of change analysis
- Three acquisitions used (to date)

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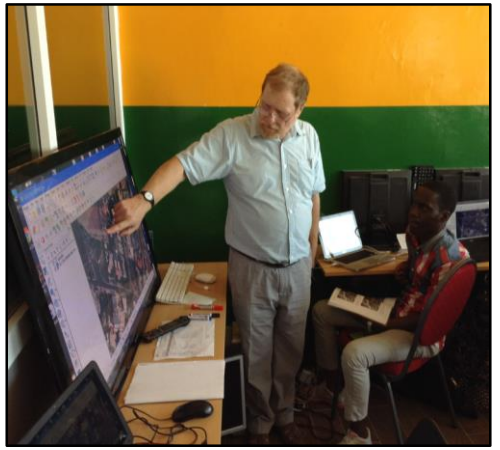
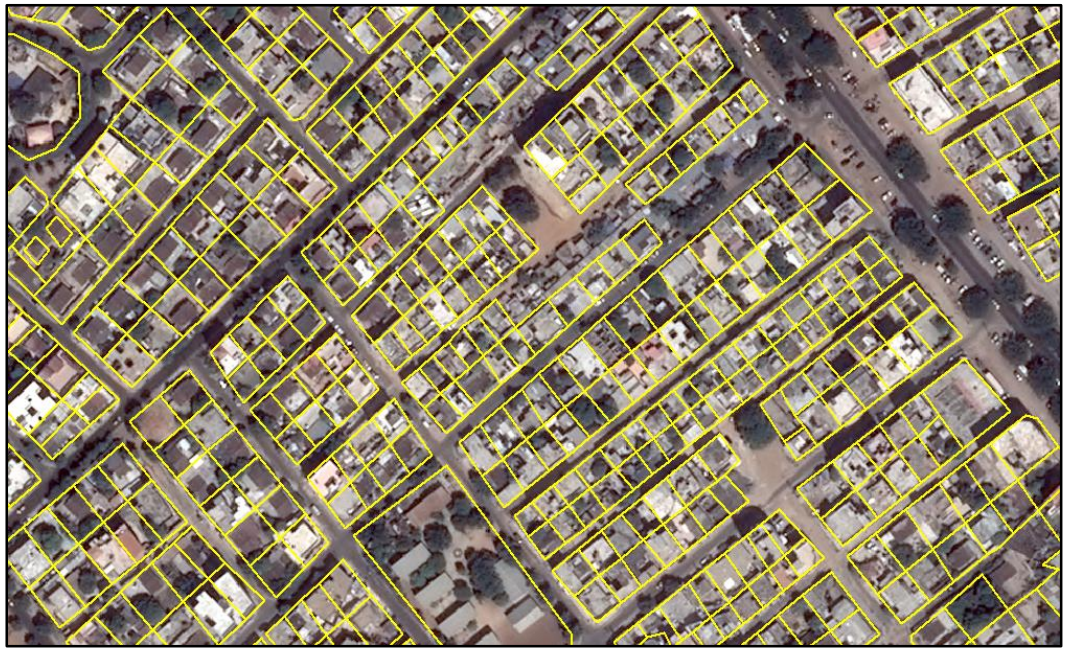
Land Parcel Data

- Required to form the unit of the change assessment and valuation
- Data captured by local partner **New Africa Consulting (NAC)** based in Dakar
- Local Office set up, Server, PCs
- Toolkit created in Quantum GIS
- Work instructions prepared in English & French
- Training mission by UK staff
- 90,000 parcels captured across city by the team
- Local and UK based QA





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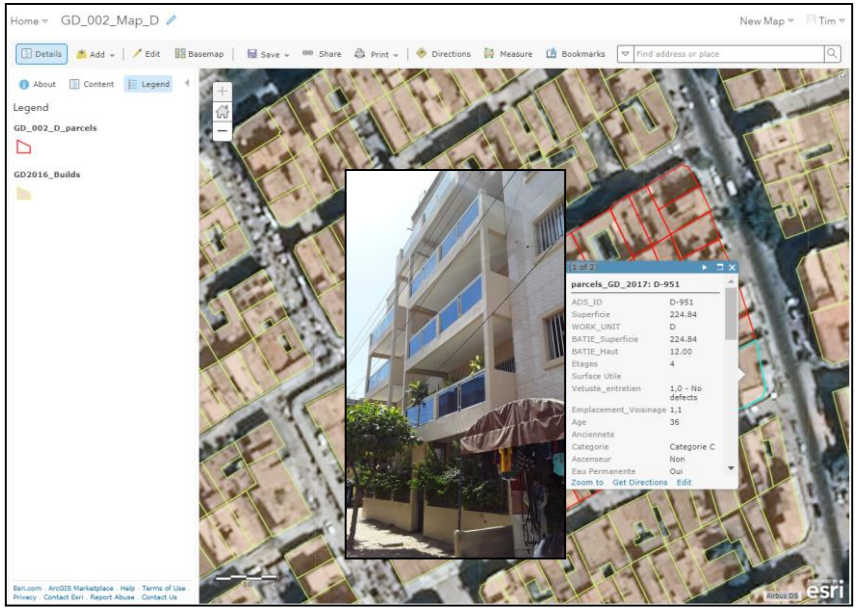
Field Collected Property Data

- Data required for valuation calculations and change verification
- Data captured by NAC team following training mission
- Simplified property valuation model used
- Used ArcGIS online and 7” tablets
- Work units assigned to individual tablets
- Synchronised over wifi back in the office
- UK team able to review remotely



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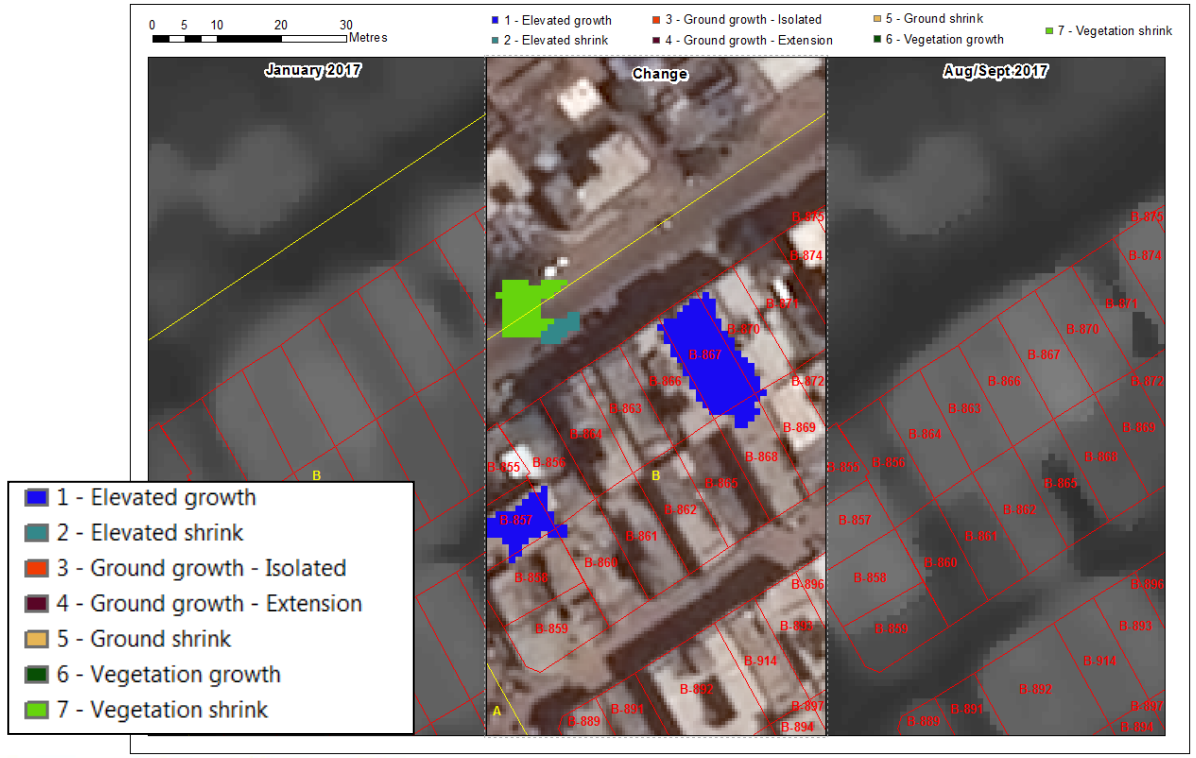
Change Software

- Software Application developed using python to analyse differences between two dates of imagery
- Software analyses both height (DSM & DTM) layers and image layers
- Key features of software:
  - Parallax correction – adjustment of every building and parcel according to detected parallax shift
  - Shadow detection and masking



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Change Software

- Raster classifications are then assigned to land parcels
- Parcels are given a range of attributes, based on height and image change statistics
- These are then modelled into an overall change classification
- This modelling has been refined through manual interpretation results, using two independent reviews
- Currently analysing the accuracy of change monitoring (target to minimise number of real changes missed)

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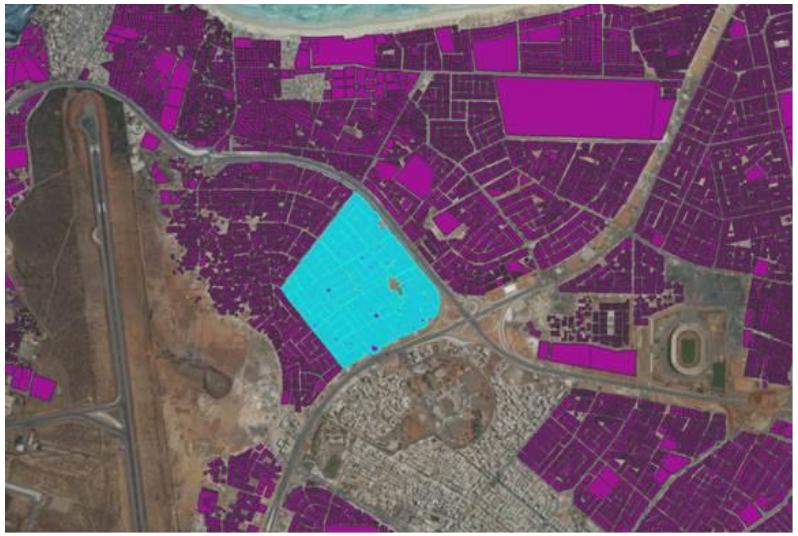
Change Detection Results

Yoff stable area
Jan-Sept 2017

Changed Parcels Orange
(45/1370) 3%



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Change Detection Accuracy Assessment

- One area (Yoff) completed for review with 3D viewing in SocetSet

				Manual Review							
	CLASS	DESCRIPTION	TYPE	1	2	3	4	5	6	7	TOTAL
				CHANGE					NO CHANGE		
SOFTWARE	1	Bare ground to building	CHANGE	1						6	7
	2	Building decrease in height		1					5		6
	3	Building Increase in height		4		52	1		10	3	70
	4	Building Increase in plan are		16		5			8	9	38
	5	Building to bare ground									0
	6	No change, building exists	NO CHANGE			6			73	21	100
	7	No change, No building		1					1	12	14
	TOTAL										235

- False positives are higher than anticipated (but not a problem)
- False negatives are 6% (slightly above target) but detailed review has highlighted that manual inspection is picking up minor features which are much less than one storey (next slide)

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Change Detection Example

Yoff growth area Jan 2017, Sept 2017 and April 2018

Change Jan/Sept correctly identified; change Sept/April false positive due to stairwell cover

Conclusions

The project has…

- Developed a software analysis tool to identify urban change using satellite imagery (height and ortho layers)
- Built capacity in Dakar, through the local partner NAC, with GIS and fieldwork skills
- Calculated the cost-effectiveness of using satellite imagery compared with a field-work only approach for compiling and maintaining an up-to-date database for all properties in the city

Based on the detailed costs and impacts of the project

- the satellite supported method has a Cost-Effectiveness Ratio of 0.317 for Dakar and a field-only method has a CE Ratio of 0.647
- On this basis each £500K spent on the satellite-supported analysis would generate the city an £1.6M of additional revenue, whereas the equivalent spend on a field-only method would generate £770K

Rural land monitoring

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International Partnership Programme: Kenya Drought Resilience Project

Project Objective:
To develop satellite-derived vegetation index values that can be used to improve drought resilience at a local level in Kenya

The analysis is based upon **free-to-use** Sentinel-2 imagery

Two market sectors are identified:
- Micro-insurance
- Government institutions

Project Lead	AIRBUS
Project Consortium Kenya: UK:	BUILDING AFRICA vivideconomics UNIVERSITY OF OXFORD
Co-funded by	UK SPACE AGENCY

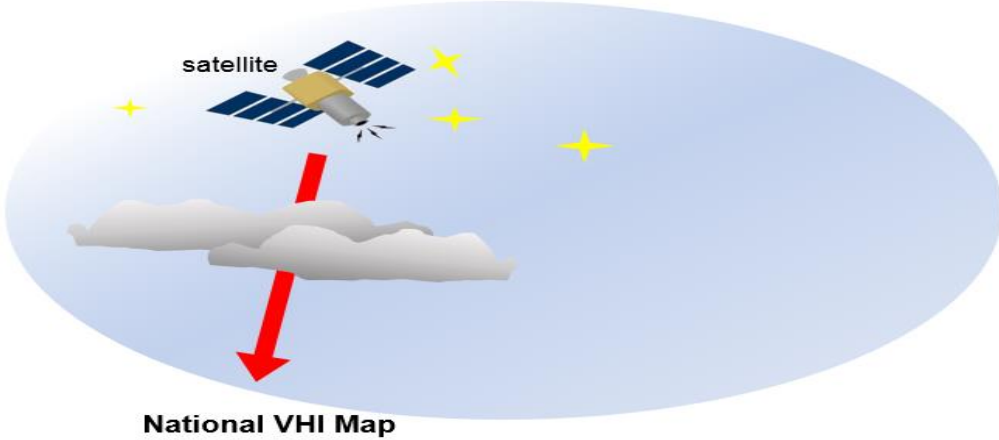
VHI: Vegetation Health Index

An index to monitor crop performance

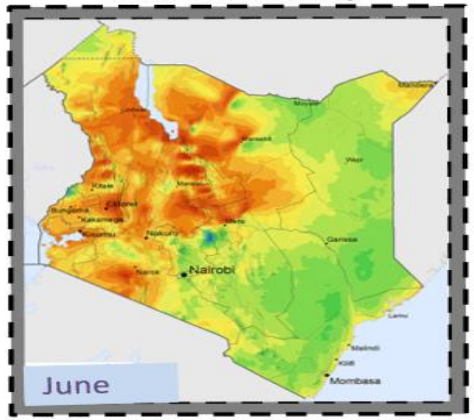
The VHI is a satellite based index developed by agricultural scientists and Earth Observation experts to monitor the health status of the crops. It was tested and validated on the ground in African environments *.

It ranges from 0 (no vegetation, bare soil) to 100 (perfect status of the crops). The values can be represented in a false colour map.

Generally, if the index goes below 30 – 35 the crop is dead. Similar values are recorded after crop planting but before emergence, when the fields still appear like seedbeds.



National VHI Map



VHI: Vegetation Health Index

Calculated with a combination of satellite derived Temperature and Vegetation information.

100 = good conditions (**green**)
50 = medium (**orange**)
0 = no vegetation (**red**)

*O. Rojas, A. Vrieling, F. Rembold. Assessing drought probability for agricultural areas in Africa with coarse resolution remote sensing imagery. Remote Sensing of Environment 115 (2011) 343–352

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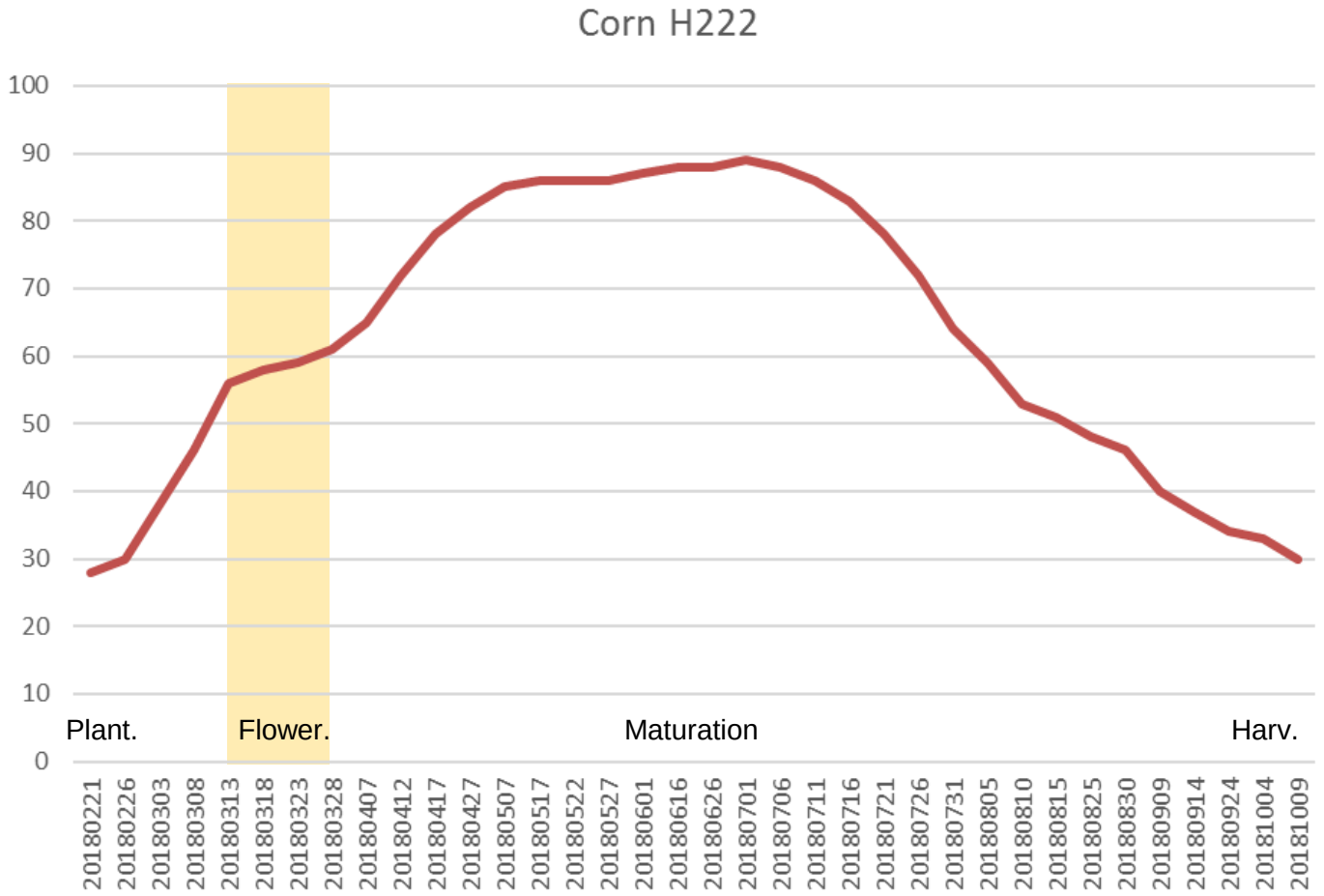
The VHI map and the multi-temporal plot



The VHI map is produced every 5 or 10 days throughout the year

As the crops grow, their status can be monitored through VHI plots from planting to harvest

Each pixel of the VHI map is 20m x 20m

No meteo-station network collects such granular information

Particularly key is the flowering time: if the VHI is low (generally below 40) the crop is not likely to yield grains

This information is an early warning for both farmers and insurers

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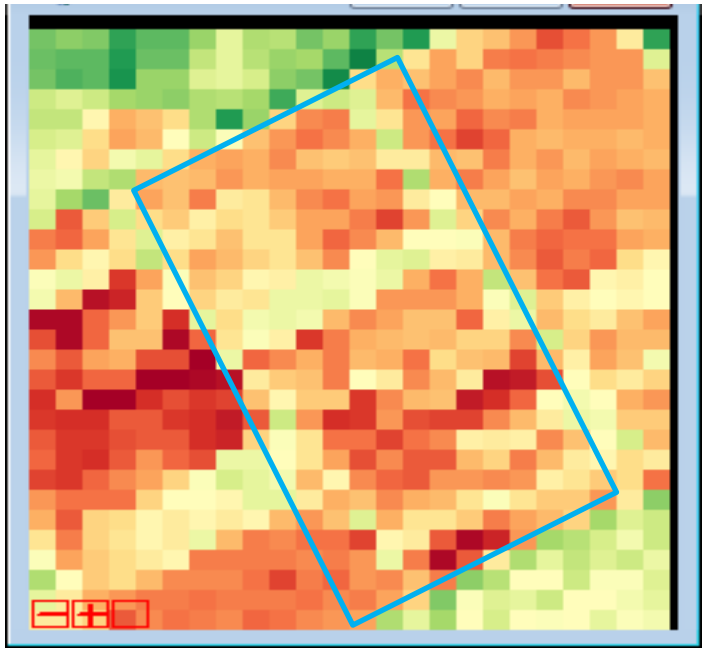
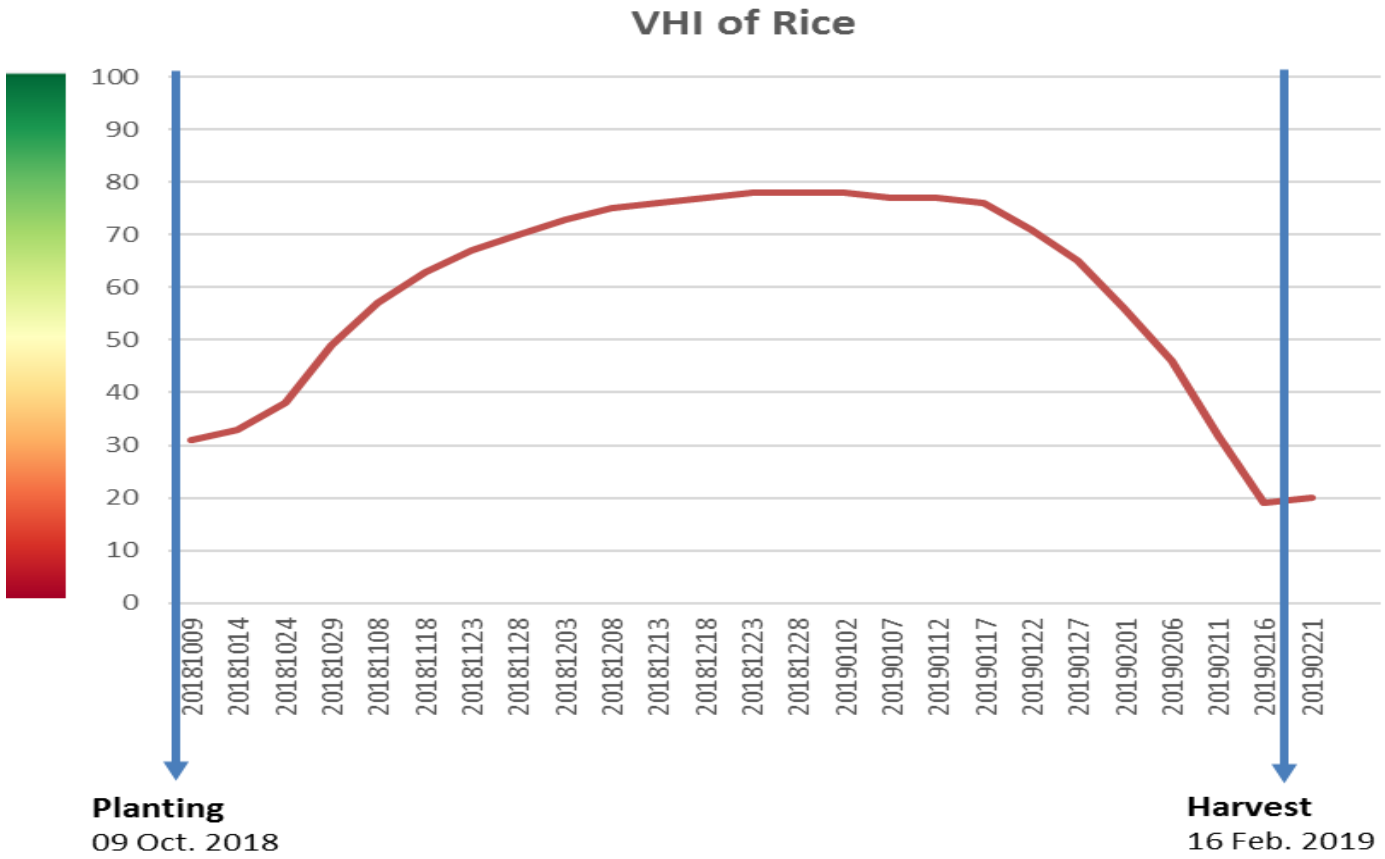
A typical VHI map for Rice



Rice shamba



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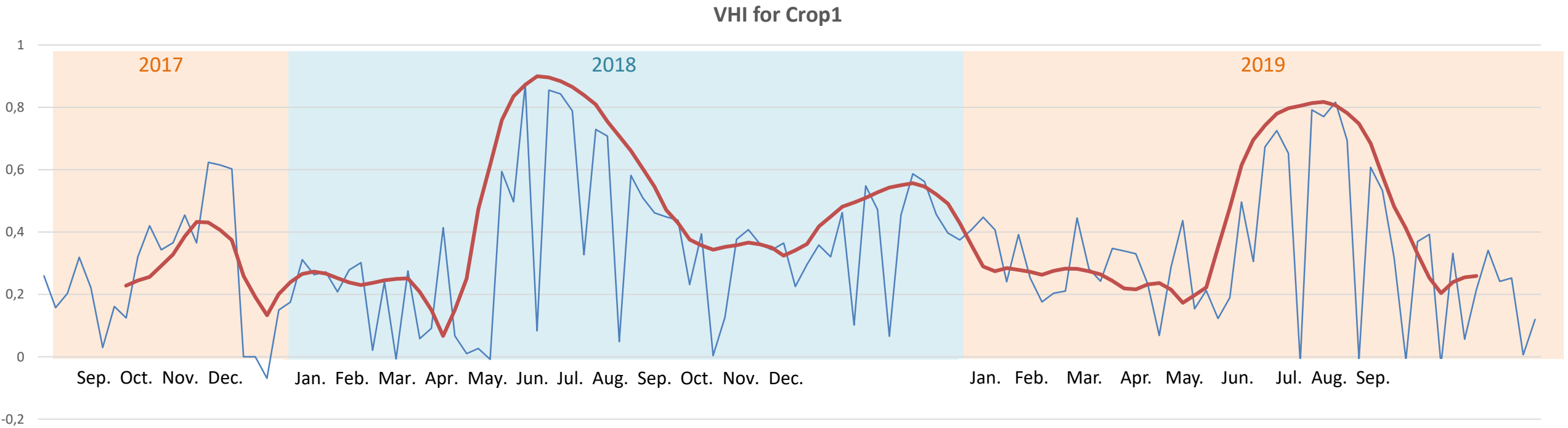
The VHI cloud removal process



The VHI process estimates the value of each VHI pixel also in cloudy or even rainy days

Blue line: VHI without cloud removal

Red line: VHI with cloud removal

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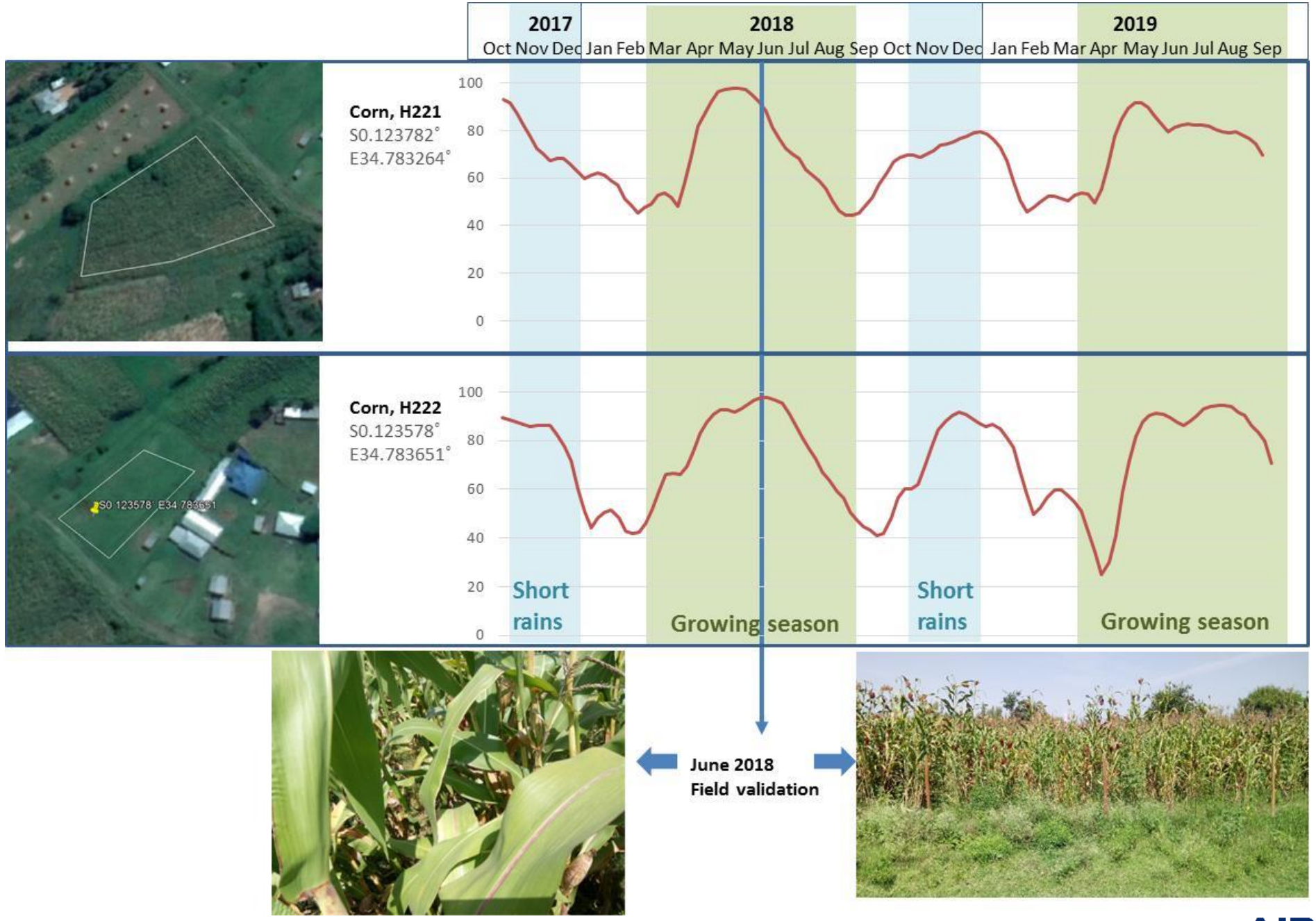
VHI time series: corn



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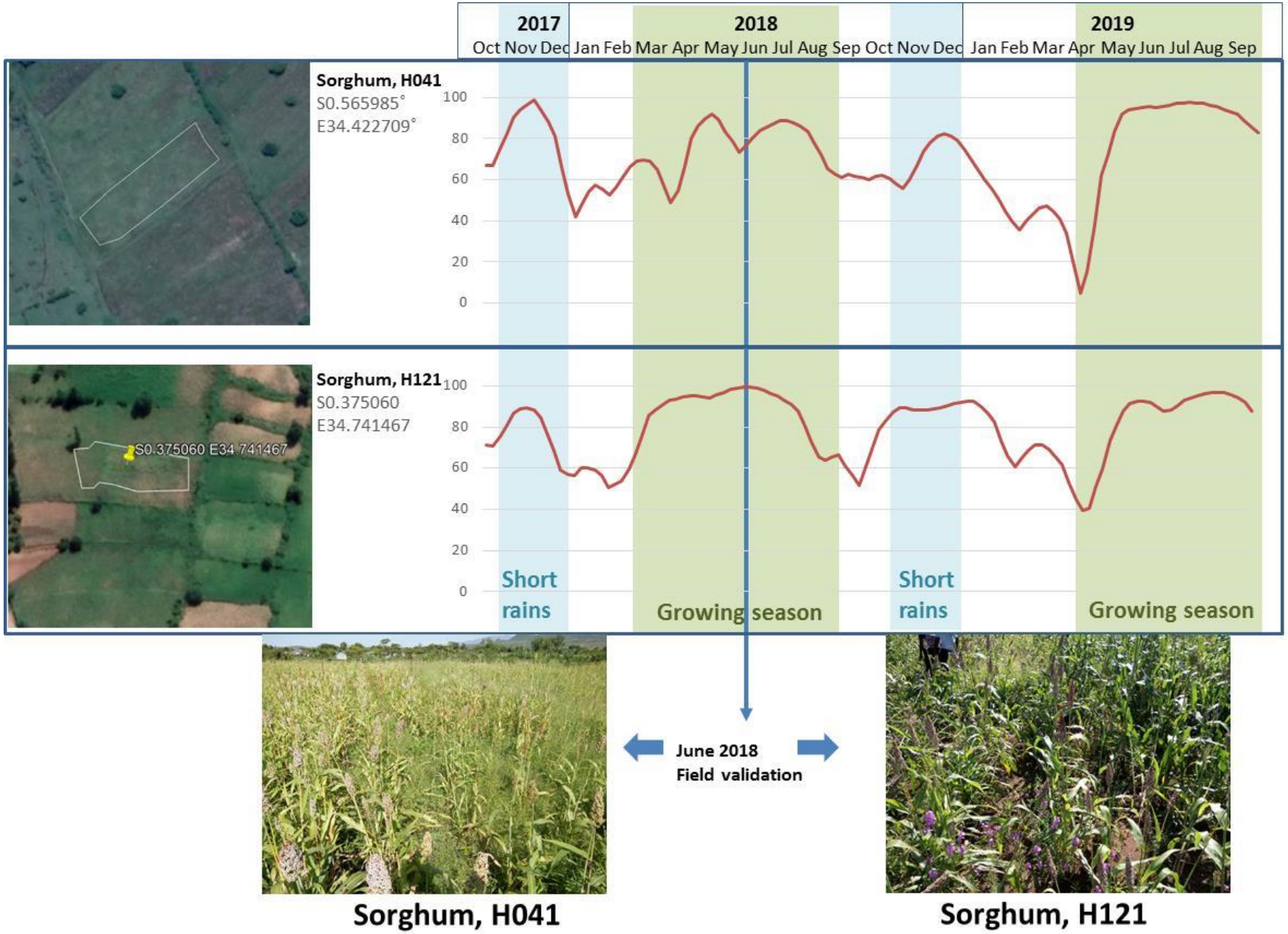
VHI time series: sorghum



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VHI time series: grazing

June 2018, Field validation

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VHI time series: sugar cane

June 2018, Field validation

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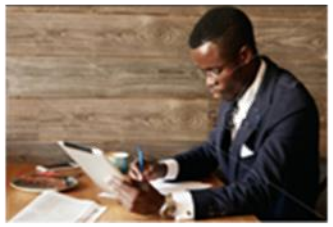
A VHI based insurance system

The adoption of VHI may save considerable time and costs to both farmers and insurers

In addition, the method improves transparency and speeds up payments

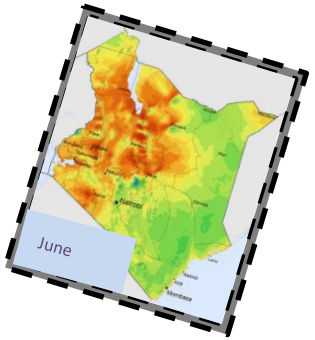
Traditional insurance system



Registration in the insurance scheme → Drought → The farmer claims: insurance paperwork → The insurance calls out a surveyor → The surveyor issues a report → If approved the insurance pays out

Modern insurance system

Registration in the insurance scheme → Drought →



The map is a claim, a survey and a report: **all in one!** →

If approved the insurance pays out

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An example of application of the VHI

We consider a large rice farm close to Kisumu (Animos).

The farmers grow rice and corn in a crop rotation scheme.

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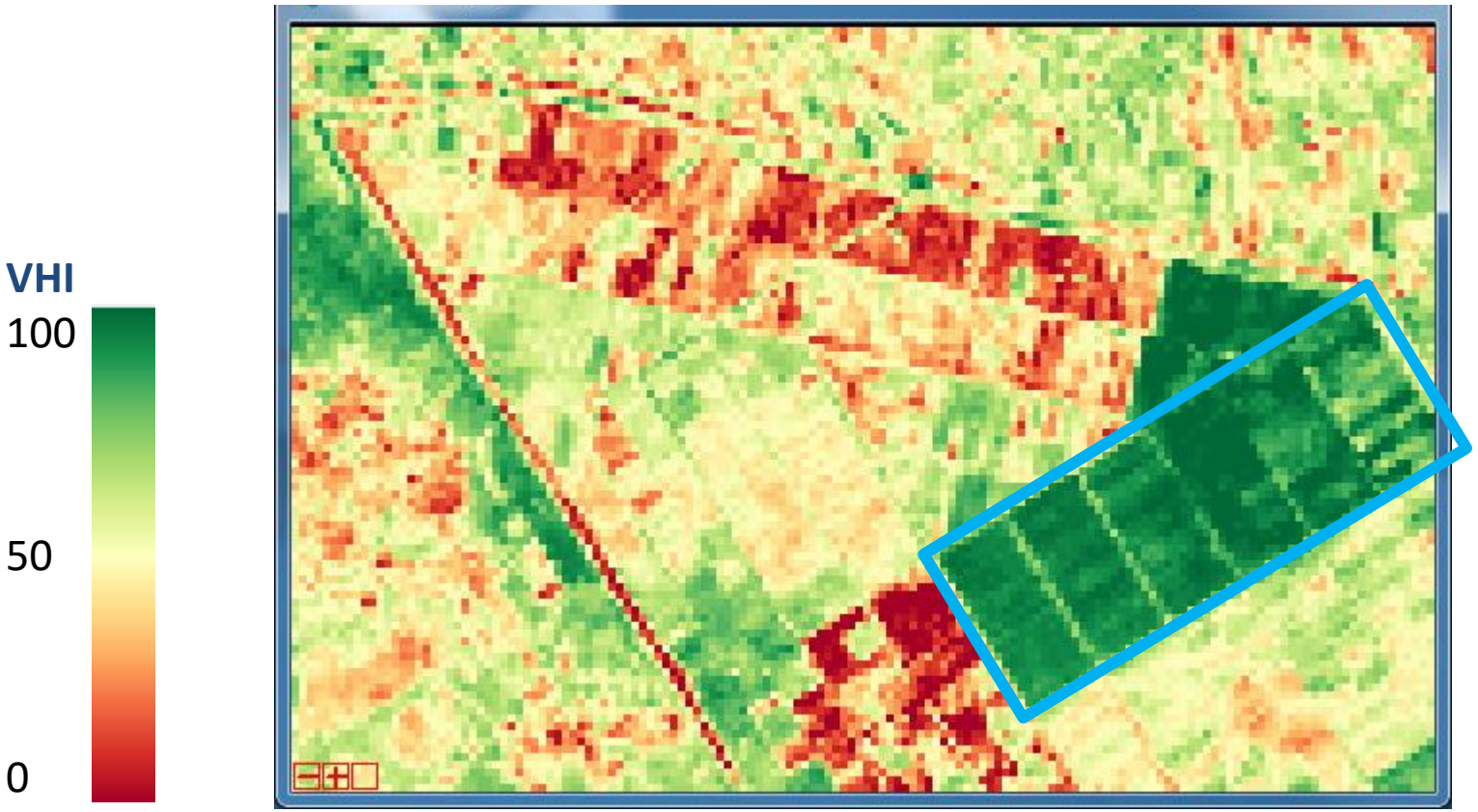
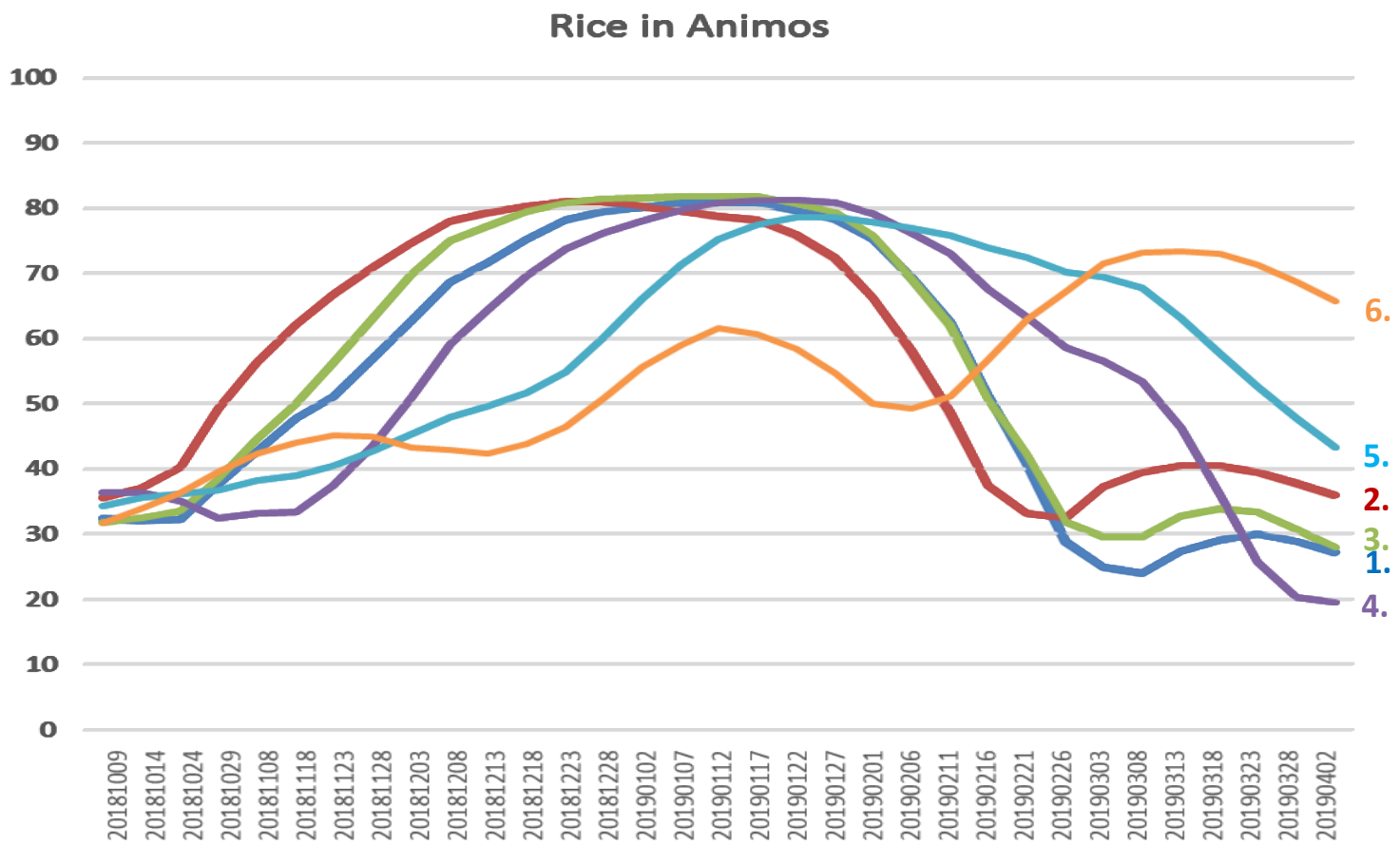
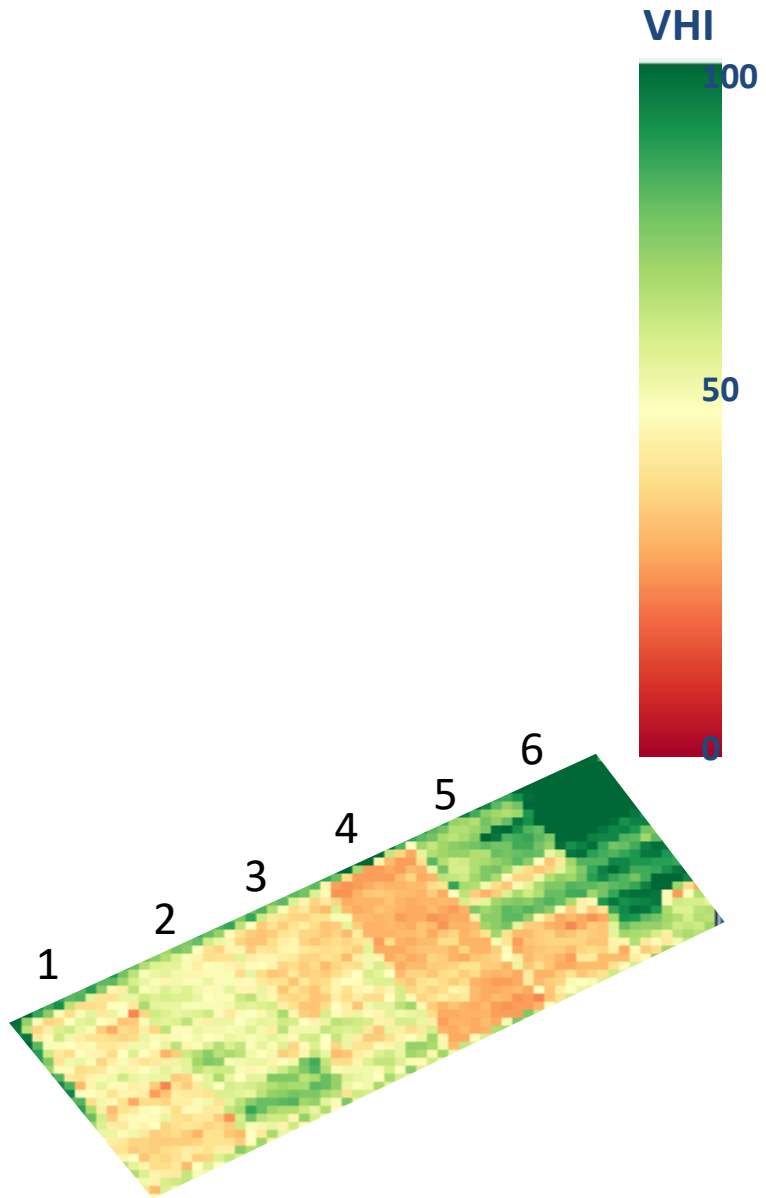
Animos Compound - Kisumu Sept. 2017 – Sept. 2019



How to quantify the crop performance of the various fields for each growing season?

Focus on the six rice fields in the blue square and only in the last rice growing season: from planting (Oct. 2018) to harvest (Apr. 2019).





Which field is less performing?

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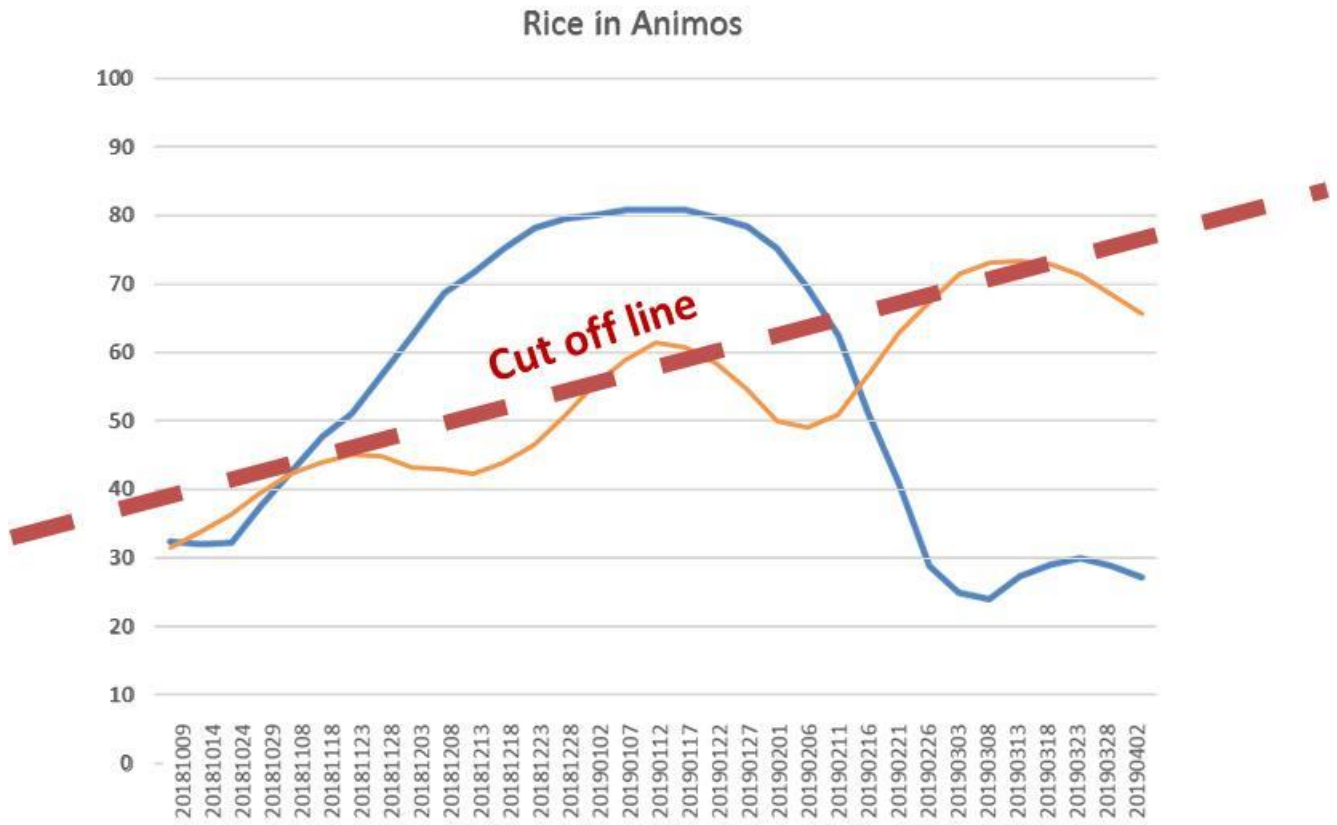
Using the results



The fields from n.1 to n.5 are performing well, just a few days apart each other in planting and harvesting times.

However, the VHI recorded for field n. 6 is anomalous. The crop growth is not consistent with the other rice fields, or farmers may not have planted rice.

Thresholds of performance and, therefore, compensation can be easily set by the insurance with a clear, undisputable policy. Airbus can provide advice on the use of these plots for this purpose.

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...some general conclusions

- The VHI can provide information for thousands of fields in very large areas, potentially nationwide, in unprecedented frequency and granularity
- The farmers' claims are easily checked from any PC, so field surveys may only be needed where VHI anomalies are really detected
- In many cases, there is no need for a survey: maps and plots are a **survey, a claim and a report**
- Full transparency: the given information is quantitative values, not opinions, and can be compared spatially and temporally
- The insurance company is expected to keep a consistent database of their farmers, geographic location, crop farmed and planting/harvesting time - the VHI shows what actually happened in the growing season

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Thank you

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