Examples of land monitoring based on high and medium resolution satellite imagery

Technical Presentation
AfricaGIS November 2017

DEFENCE AND SPACE

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International Partnership Programme (IPP)

United Kingdom Space Agency: funder and programme manager

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.

Under the IPP programme portfolio, 22 projects have been commissioned to date, 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

Examples of land monitoring based on high and medium resolution satellite imagery.

The city government of Dakar, Senegal, has a requirement to generate revenues for developing and maintaining city infrastructure and services. Using very high resolution satellite data the land parcels and building extents (including heights) can be monitored through a combination of 3D image analysis and field data collection. This project provides the framework for field teams to collect and maintain an accurate database of property, thereby enabling tax calculations to be made in order to support sustainable and transparent revenue generation for the City.

Both Ethiopia and Kenya are flood and drought prone with significant mortality and economic losses attributed to these events in each country. This project focuses on building resilience to these events in order to both lessen risk and support economic growth. In Ethiopia it will focus on building an improved understanding of flood and drought hazards and risks. In Kenya it focuses on the effectiveness of EO data for the micro-insurance market and Government Institutions; an important tool for farmers who currently have little or no access to insurance.

Satellite image analysis for operational maintenance of a property database for Dakar

The partners:

Airbus Defence and Space: project lead

New Africa Consulting: local partner
Experienced in geospatial data handling, education and local language

United Kingdom Space Agency: funder and programme manager

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

Dakar IPP Project: progress highlights

Acquisition of Imagery

- Two sets of Airbus Elevation1 product (ortho-image & height data) covering Dakar received; new image data in preparation

Software Development

- Change detection software development completed for first release, with promising results.

Local staff training & operations

- Team of 14 staff trained in land parcel data capture. Work instructions evolved through training. Production well advanced and all target areas now completed.

Mobile Data Capture

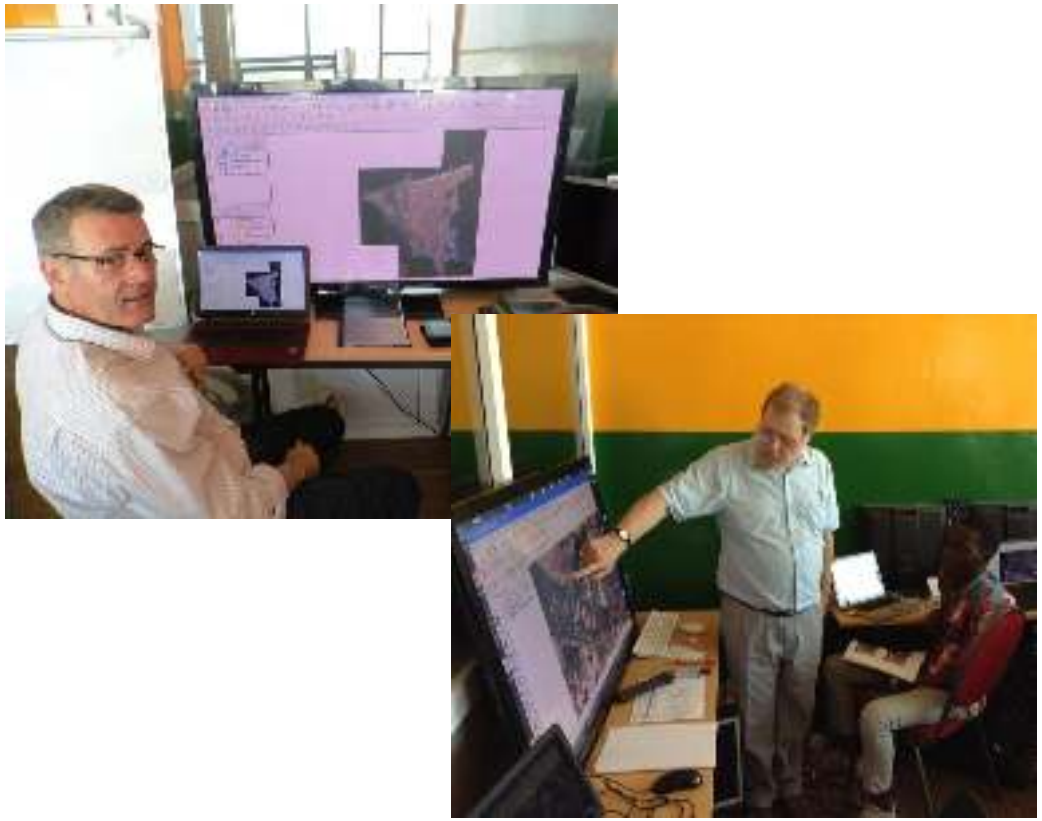
- Preparations completed for mobilisation for training local team in mobile data capture. Mobile application prepared and deployed on tablets for training followed by data capture in the field.

Dakar IPP Project: Land parcel capture

- Training in image interpretation techniques
- Techniques applicable to both aerial images and satellite
- More than 64,000 land parcels mapped to date
- The objective is a team of qualified technicians

Dakar IPP Project: Land parcel capture

Training mission May/June 2017 : Data collection



Training

Field verification

Dakar IPP Project: Land parcel capture

Parcel boundaries in a new development zone

Dakar IPP Project: Land Parcels Collected

Commune	Parcel Count
Ngor	2,552
Yoff	13,613
Camberene	6,161
Parcelles Assaines	11,626
Patte d'Oies	4,140
Plateau	1,107
Medina	2,107
Gueule Tapee-Fass-Coloban	5
Hann Bel-Air	1,393
Fann Point-E	842
Grand-Yoff	5,979
HLM	-
Biscuiterie	-
Grand Dakar	2,414
Dieuppeul-Derkle	-
Liberte	1,263
Mermoz Sacre-Coeur	2,936
Ouakam	8,391
Ile de Goree	-
Total	**64,529**

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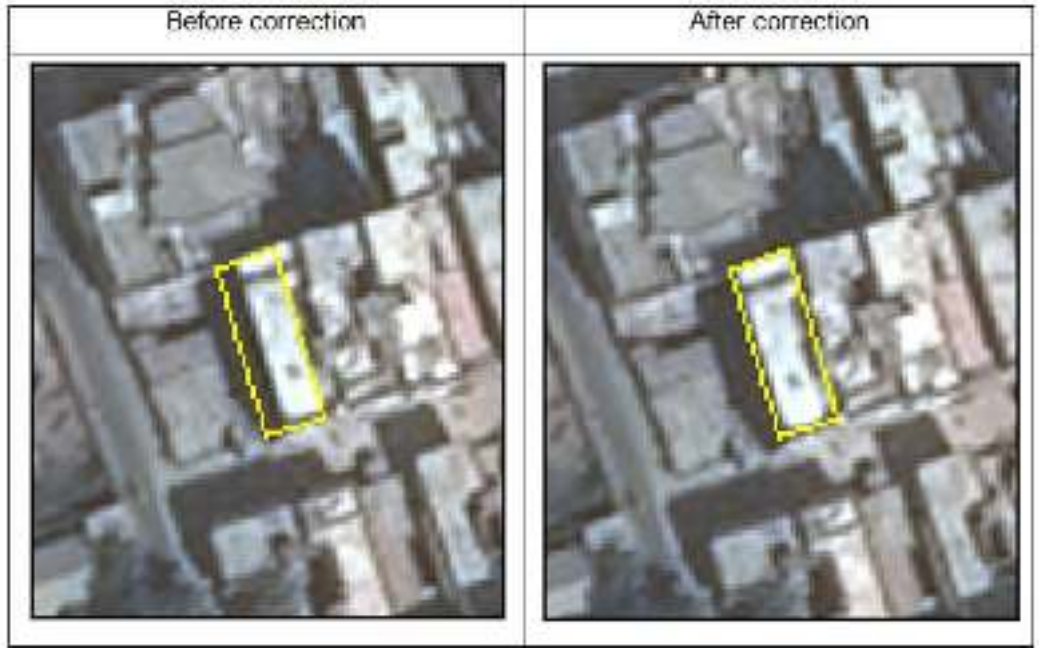
Dakar IPP Project: Software Application

Software Application developed for first stage testing

- Change detection run against 2015 and 2017 data; new image data acquired in September
- Image and height change incorporated into change algorithms
- Key features of software:
  - Parallax correction – adjustment of every and parcel according to detected parallax shift
  - Shadow detection and masking



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Dakar IPP Project: Change detection analysis

Locating areas of change

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Dakar IPP Project: Change detection analysis

Change of height

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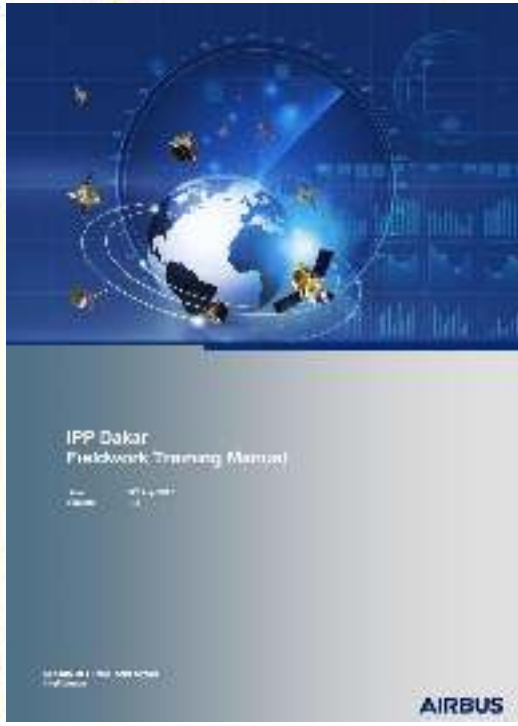
Dakar IPP Project: Reference Data

- **Training mission in July 2017**
  - Training based on manual, updated with input from local team
  - Training provided on Samsung Galaxy tablets operating Arc Collector data collection software customised for the project
  - Practice data capture local to NAC offices, data syncing to server online under trainer supervision
- **Roll out of data collection across target sites**
  - Following training NAC teams working independently with no Airbus supervision
  - Teams working in morning and afternoon shifts, to maximise data capture within limited window
  - Simplified specification being used when access to properties is difficult; still captures enough information to verify property changes



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Dakar IPP Project: First Change Detection

Change Analysis

- Output of test change analysis has been manually reviewed against imagery to generate training dataset for fine-tuning and onward development of the change software
- New Imagery acquisition from September 2017,
- This is being used for change detection vs January 2017 data
- Results of change detection analysis will be compared with output from the manual assessment for accuracy analysis

Field Verification

- The NAC team are currently collecting full field data for a sample area in Grand Dakar
- This area is where pilot work was done late last year, where we have previous field data
- Assessment between the two field data will be done to assess success of image change detection process

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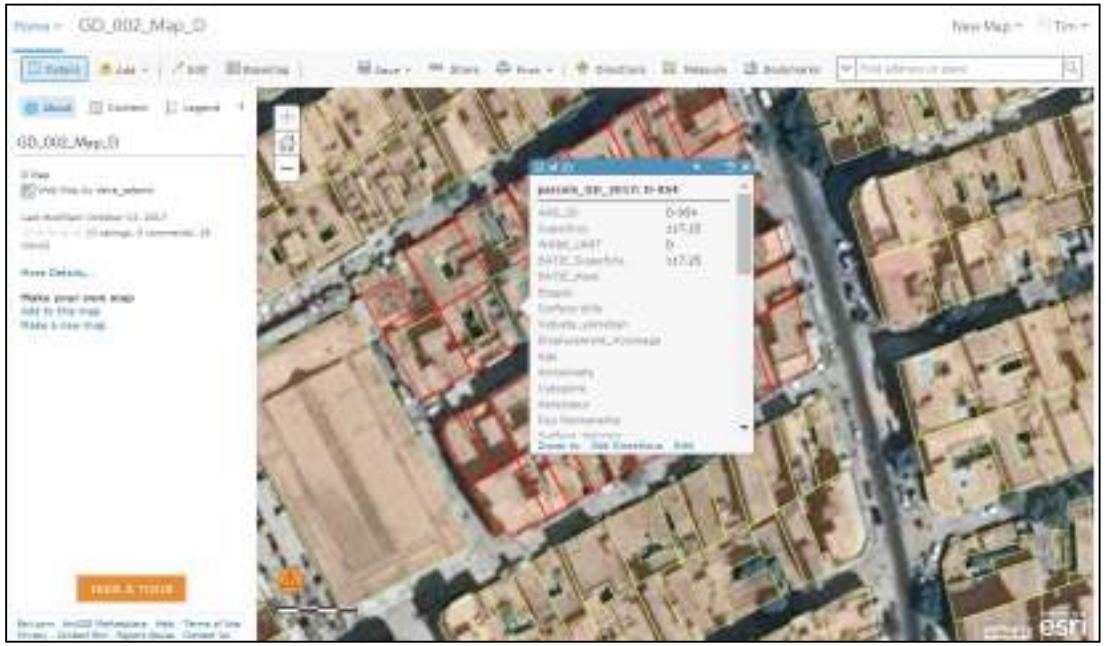
Dakar IPP Project: First Change Detection

Field Verification contd..

- The Grand Dakar area is of particular interest to DGID having already surveyed the area themselves
- Current data capture is being done in accordance with simplified valuation model
- This simplification is speeding up data collection considerably allowing over double the number of properties to be collected.
- Data synchronisation working well after initial difficulties



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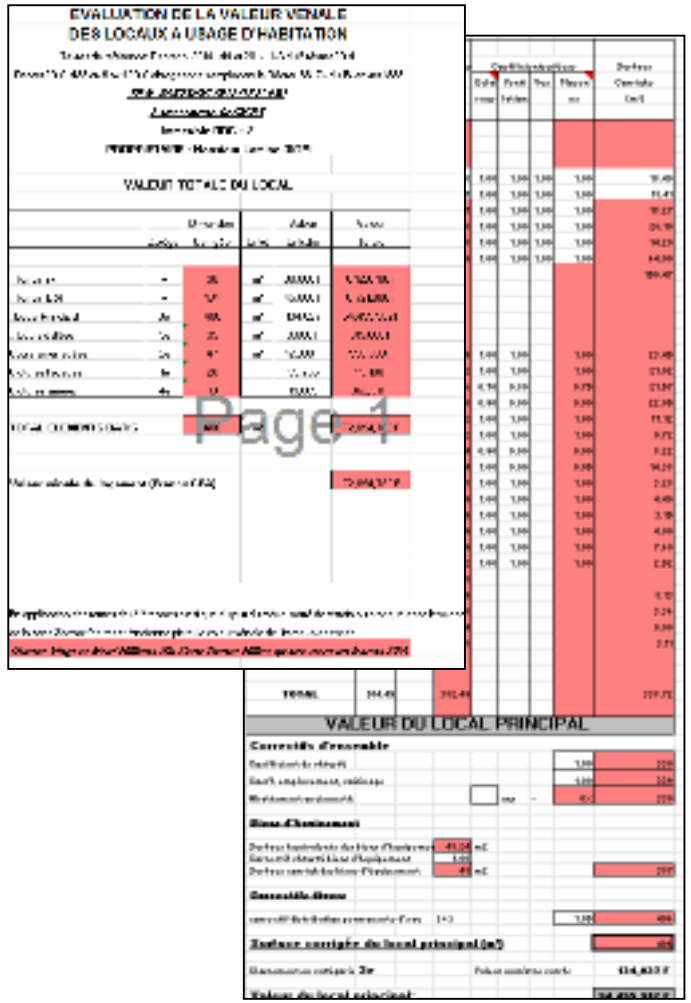
Dakar IPP Project: Valuation Modelling

- We are trialling a simplified valuation model potentially to be used for valuing properties in Senegal.
- Originally the model could have required up to 200 attributes collecting for a typical sized property with attributes being required for every room.
- The new model ultimately requires no internal inspection of properties.
- This means that the potential take up of the techniques we are developing through this project is much more likely.
- Information now is only needed for:
  - Building extents
  - Neighbourhood
  - Building class
  - Age
  - Condition/Upkeep
  - Plumbing (y/n)
  - Lift (y/n)



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Dakar IPP Project: Valuation Modelling

- With the new valuation model, it is now much easier to make an assessment of property values on an individual basis, as well as on a whole district basis.
- To make these assessments we can use:
  - Building data provided by ANAT/DTGC,
  - Land parcel data as captured by NAC,
  - Building Height data derived from DSM – DTM
- Information on land rates as provided by DGID for different districts in Dakar.
- Then we can make observations on the building category, condition, age, etc.

VALEUR DU METRE CARRE DE TERRAIN NU

TITRE I - REGION DE DAKAR

1. - COMMUNE DE LA VILLE DE DAKAR

A. - DAKAR-PLATEAU

Secteur n° 1 : Entre la Corniche, les Avenues André Peytavin, Georges Pompidou, les Allés Robert Delmas et le Boulevard de la Libération :

1°) - En bordure de la Corniche 300 000

2°) - En bordure des Grands axes et de la Place de l'Indépendance 250 000

3°) - Autres terrains du Secteur 150 000

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Dakar IPP Project: Valuation Modelling

- Using this data we will be able to make an initial broad assessment of total property values across Dakar.
- Based on this and the existing rates of taxation the total potential revenue for Dakar can be calculated
- Current estimates of 50M€ to 100M€ revenue will be refined in the next project period
- The change methodology will help to ensure that the property database is up-to-date and accurate for all citizens

Dakar IPP Project: next steps

Testing of image classification

- Comparison of the results of image analysis with data collected in the field

Development of an operational system for data maintenance

- Operational procedure for image analysis and field data collection

Monitoring and evaluation of project impacts

- Assessment of the long term impacts of having an accurate and maintained property database for Dakar

Development of a road map for future exploitation

- An operational image analysis procedure to improve the efficiency of maintaining a property database

The rainbow over our farms

A satellite-based resilience strategy for drought and floods

UK SPACE AGENCY

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IPP (International Partnership Programme) Ethiopia-Kenya Project

Project Lead	AIRBUS
Project Consortium Ethiopia:	EDRI GeoSAS CONSULTING
Kenya:	BUILDING AFRICA
UK:	SAYERS AND PARTNERS UNIVERSITY OF OXFORD :vivideconomics
Funded by	UK SPACE AGENCY

IPP (International Partnership Programme) Ethiopia-Kenya Project

Aim: use satellite-derived index values to develop a Dashboard that can be used to improve drought resilience at a basin level in Ethiopia and a local level in Kenya.

Dashboard is a web-based tool based on satellite data, modelled data, local data and contextual data.

Two market sectors are identified:

- **Micro-insurance**
- **Governmental institutions**

2017 Drought

Exceptional drought in East Africa in 2017 !

Year	Floods	Drought	People affected
1961	Uhuru Floods		
1968 1977/78 1982 1985 1990	Several events affecting Horn of Africa, Ethiopia, Lake Victoria basin and the coastal areas of the Athi, Lamu and Tana River basins.		Millions
1975 1977 1980 1983/84	Several events affecting East Africa Region	Several events widespread	Millions
1991/92		Arid and semi-Arid districts of NE, Rift Valley, Eastern and Coast	1.5 Millions
1995/96		widespread	1.41 Millions
1997/8	El Nino Floods		1.5 Millions
1999/2000		widespread	4.4 Millions
2003	Eastern Province at Budalang'i and the lower reaches of the Nzoia River and in Nyanza Province at Ahero		
2004		widespread	
2011		Regionwide	
2012	Nationwide		
2016/17		Kenya, 23 counties	

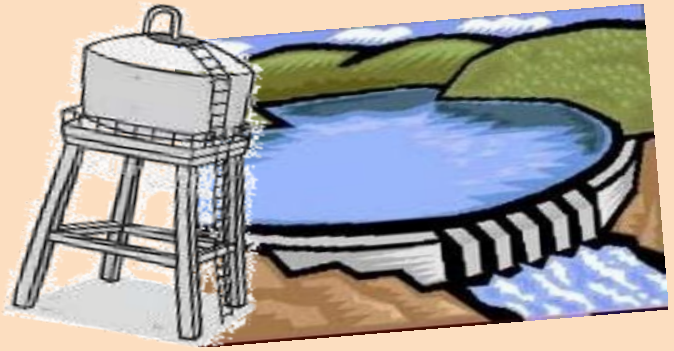
How can we build drought/flood resilience?

Improved farming techniques

Improved water management techniques

Irrigation

Improved weather forecasting



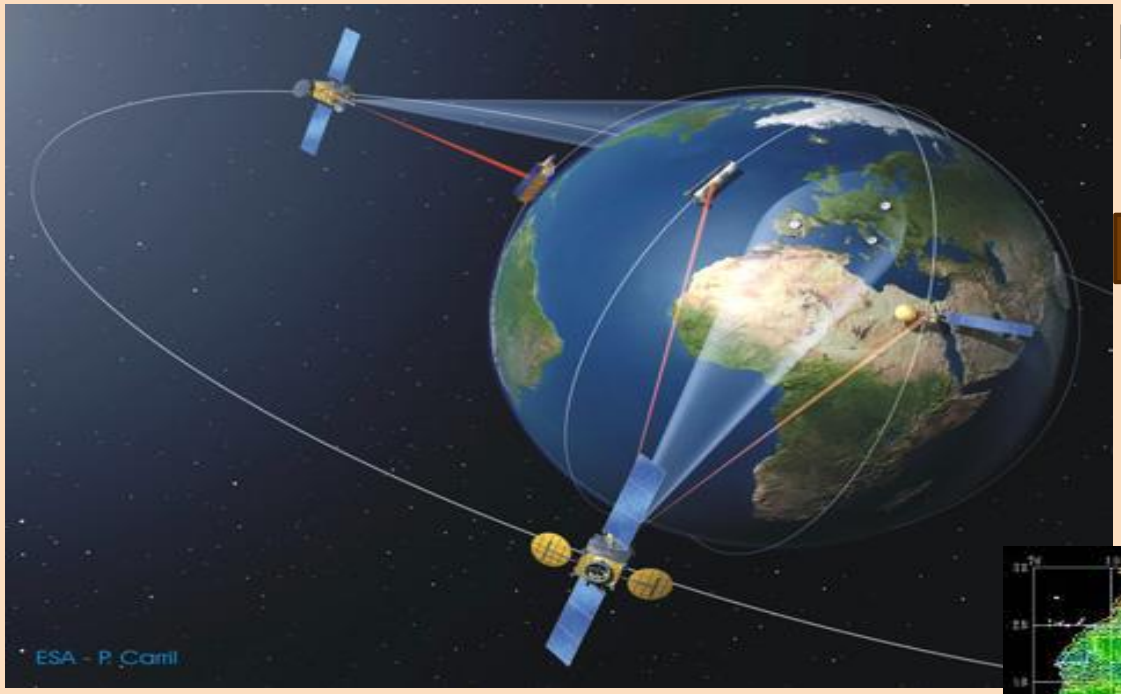
Water Infrastructure

…hope!

Crop Insurance

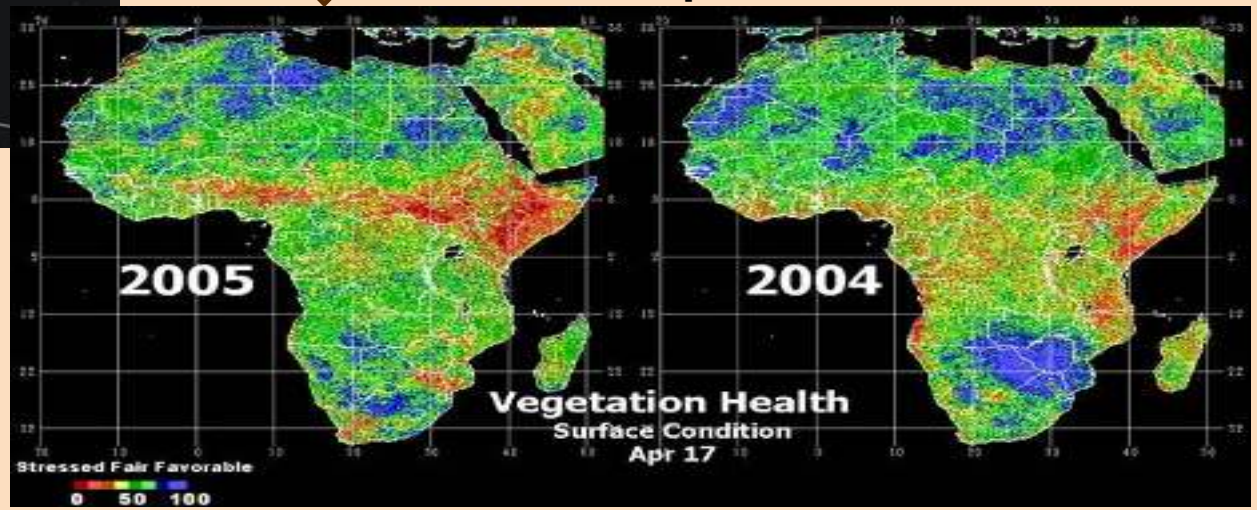
Resilience planning/investment

Help from satellite technologies

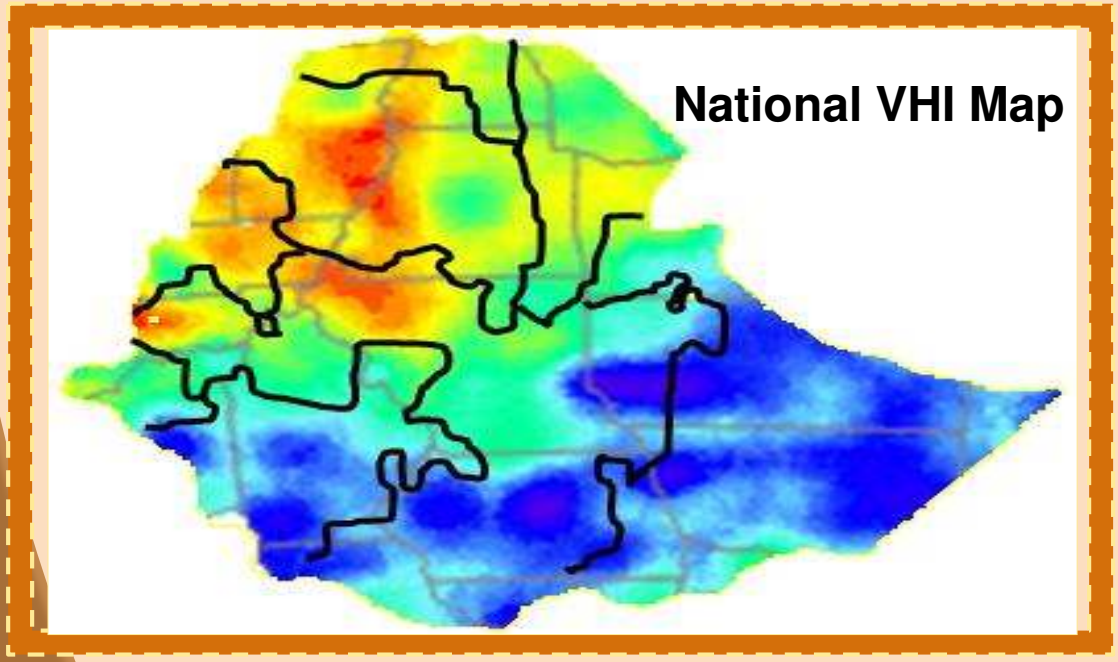


From space…

…to maps of our Earth!



How the satellites detect drought



VHI: Vegetation Health Index
VHI is calculated for each 10x10m pixel with a combination of Vegetation and Temperature information.

Index value ranges from:
1 = good conditions (**blue - green**)
<1 = worse conditions (**yellow - orange**)
0 = extreme drought (**red**)

Index values are indicators of drought severity so:
National VHI Map = National Drought Map

Field-level data

Availability of field-level data:

- Every 10 days, 20 m resolution
- Throughout the growing season
- In the past (from the ‘80s at coarse resolution)
- In the future (early warning at flowering time)

The Dashboard (1)

The Dashboard is a username and password-protected, responsive website made available over the secure https protocol.

It comprises a **Map Data Portal** that gives users the ability to discover, view, query, download and print:

- Drought Maps created regularly from satellite data by Airbus
- Flood Model Maps created by Oxford University
- Baseline Map Data from Kenyan sources

Insurers can use the Dashboard in support to:

- develop a new crop insurance product
- manage their farm portfolio
- manage insurance claims

A traditional vs. modern insurance system

Traditional insurance system

Registration in the insurance scheme →

Flood/drought damage →

The farmer claims: insurance paperwork →

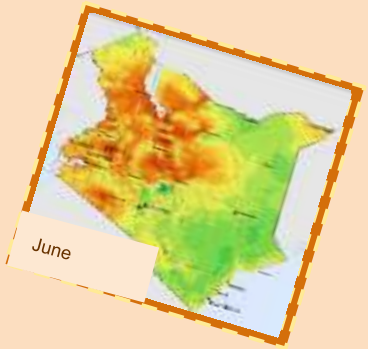
The insurance calls out a surveyor →

The surveyor issues a report →

If approved the insurance pays out

Modern insurance system

Registration in the insurance scheme → Flood/drought damage →



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

If approved the insurance pays out

The Dashboard (2)

The Dashboard will also serve the **Governmental institutions** such Ministries of Agriculture in Ethiopia (e.g. ATA, CRGE, etc.) and in Kenya (e.g. NMDA) with the following functionalities:

- See how healthy the crops are countrywide, now and in comparison with the past
- Easy decision making for the government
- View basic thematic maps (e.g. Land use/cover, cropland, etc.)
- Output reports in the form of maps, statistics and plots, at Woreda and sub-woreda level
- Download and print out mapping data
- Manage their own user information, including setting up of alerts

Benefits from a new high-tech system (1)

Survey with satellite

- A new job! Opportunity for women
- The project includes training for local operators
- Crops monitored every 10 days
- Maps at 20 m resolution
- Satellites are impartial: corruption free

Farmers

- Finally an affordable insurance!
- Satellites do not cheat
- Early warning of crop failure
- Automated Claims/Payouts/Reports

Benefits from a new high-tech system (2)

Micro-insurances

- Regional coverage, not just around met stations. So a bigger market is reached
- Different perils (e.g. flood, pests, etc.) covered.
- The overall micro-insurance scheme is cheaper and simpler to operate: no surveyor visits, no met station maintenance, no paperwork for claims & payouts
- Crop Insurance premiums cheaper than traditional insurance.

Government

- Potential nation wide coverage
- Early warning of drought events (alert already at flowering time)
- Flood modelling
- Regular, consistent outputs (maps, statistics and plots, at county and sub-county level)
- Easy decision making about where to address international aid
- Applications also on livestock in grazing lands

Thank you

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