

# The European Commission's science and knowledge service

## Joint Research Centre



European  
Commission

# Earth Observation for Agriculture and Food Security policy support

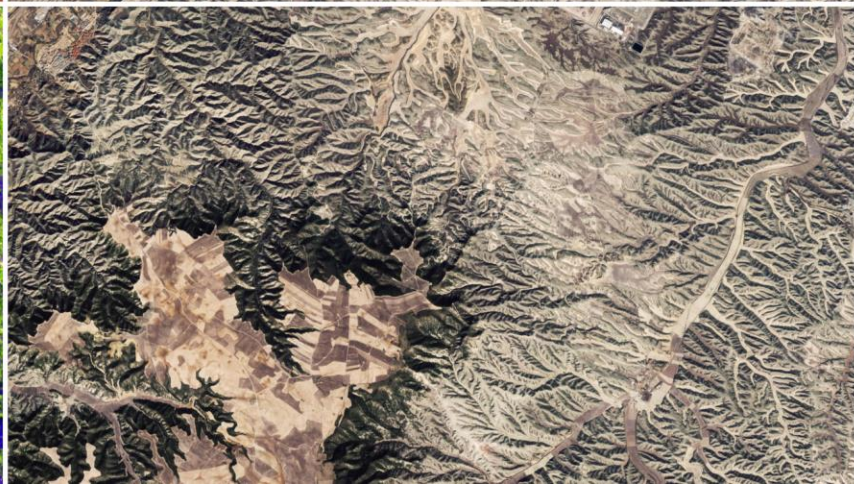
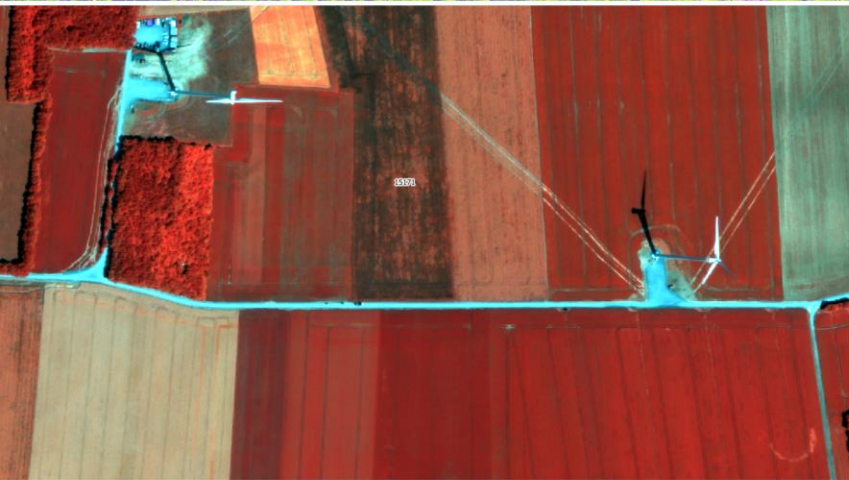
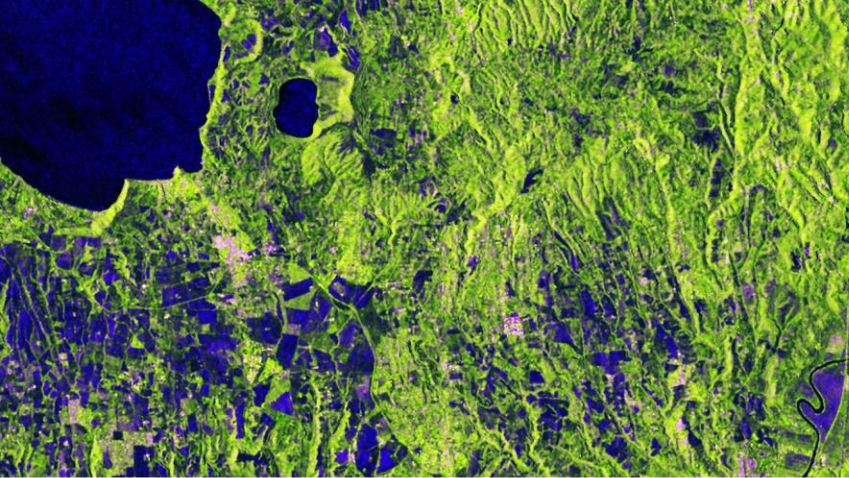
Felix Rembold, Food Security Unit, D5

EU Delegations training  
Brussels, 8 October 2019

# Contents

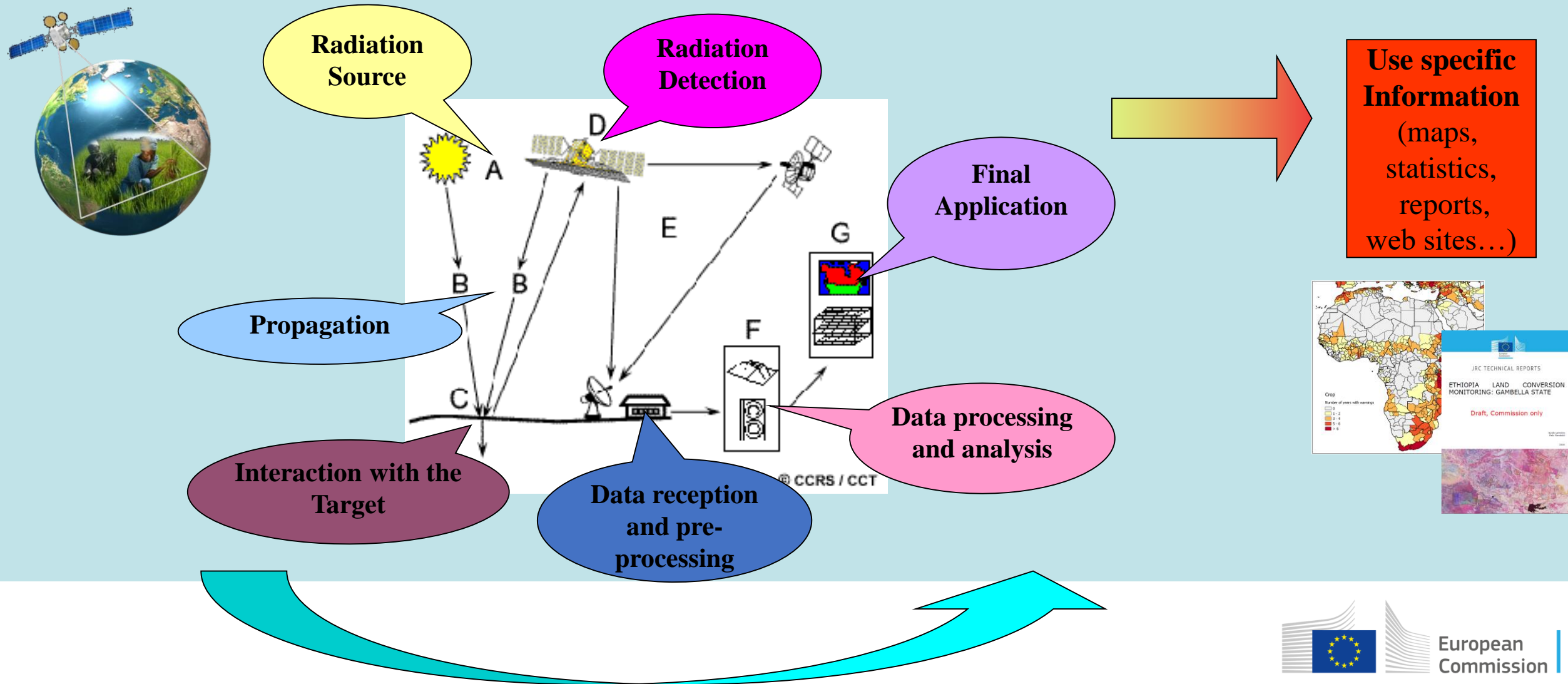
- What is Earth Observation?
- How can it support agriculture and development policies?
- New opportunities and the COPENICUS programme
- JRC experience and examples in support to:
  - Land
  - Natural resources, water, deforestation, land degradation...
  - Agricultural early warning, yield/production forecasts
  - Food Security assessment
  - Risk Management
  - Others: Climate change, land restoration, invasive species...





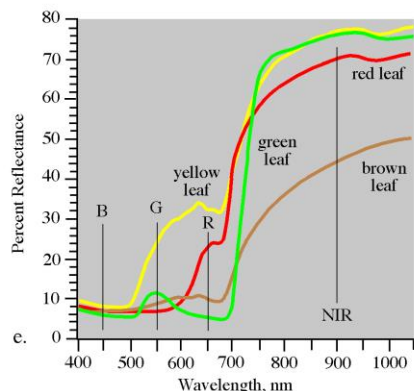
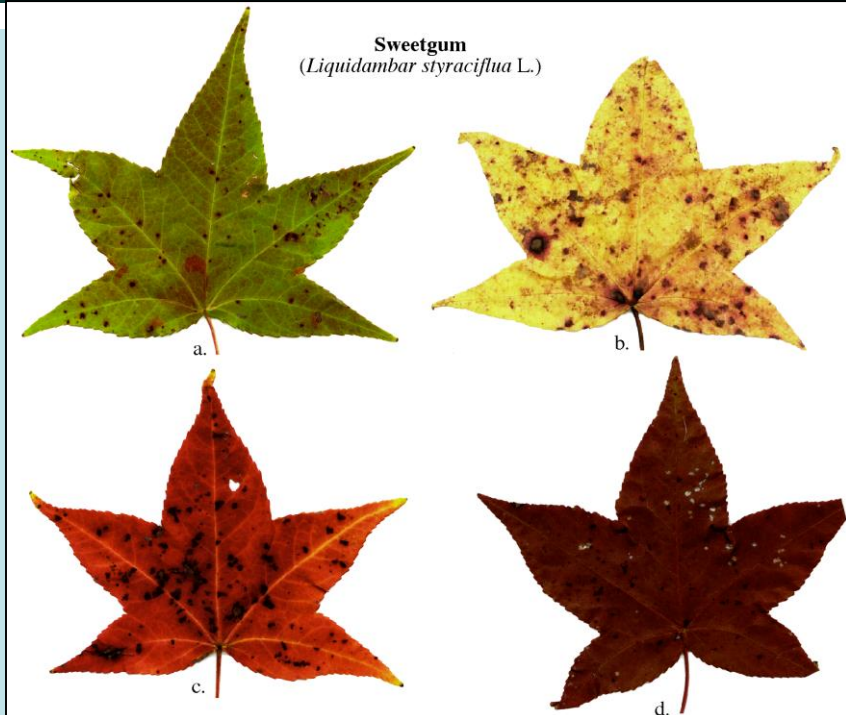


# The typical RS scenario





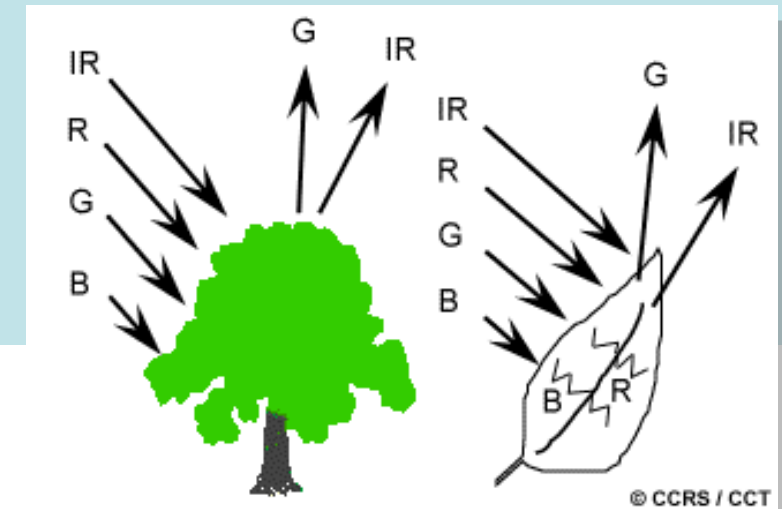
# Vegetation reflectance basics



- Leaves: Chlorophyll strongly absorbs radiation in the red and blue wavelengths but reflects green wavelengths.
- Leaves appear "greenest" in the summer, when chlorophyll content is at its maximum.
- In autumn, there is less chlorophyll in the leaves, so there is less absorption and proportionately more reflection of the red wavelengths, making the leaves appear red or yellow.
- The internal structure of healthy leaves act as excellent diffuse reflectors of near-infrared wavelengths.

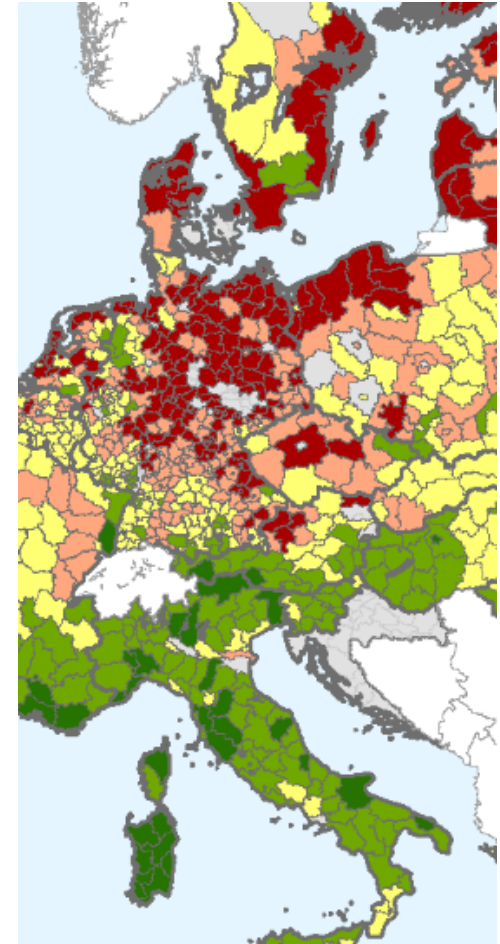
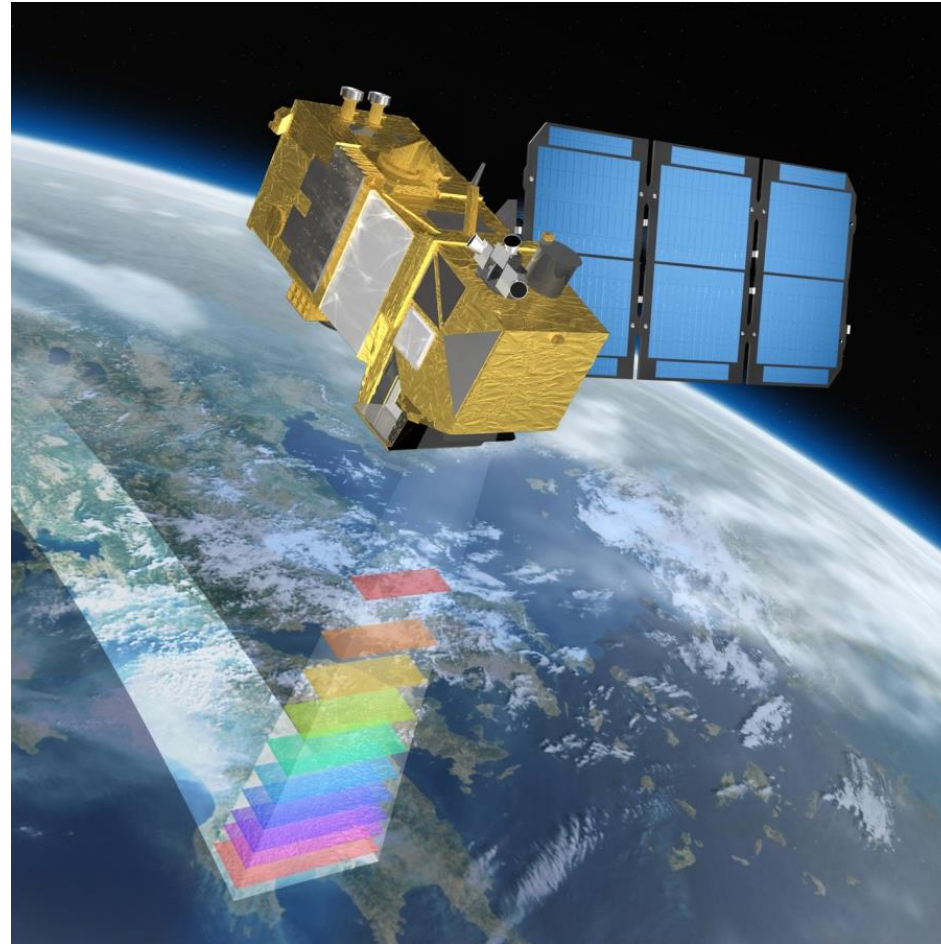
Vegetation indices (like the NDVI) are band operations that optimize the analysis of the vegetation signal

[More info: Canada Natural resources remote sensing tutorial](#)





# Opportunities for monitoring, checks, condition, forecasts and statistics







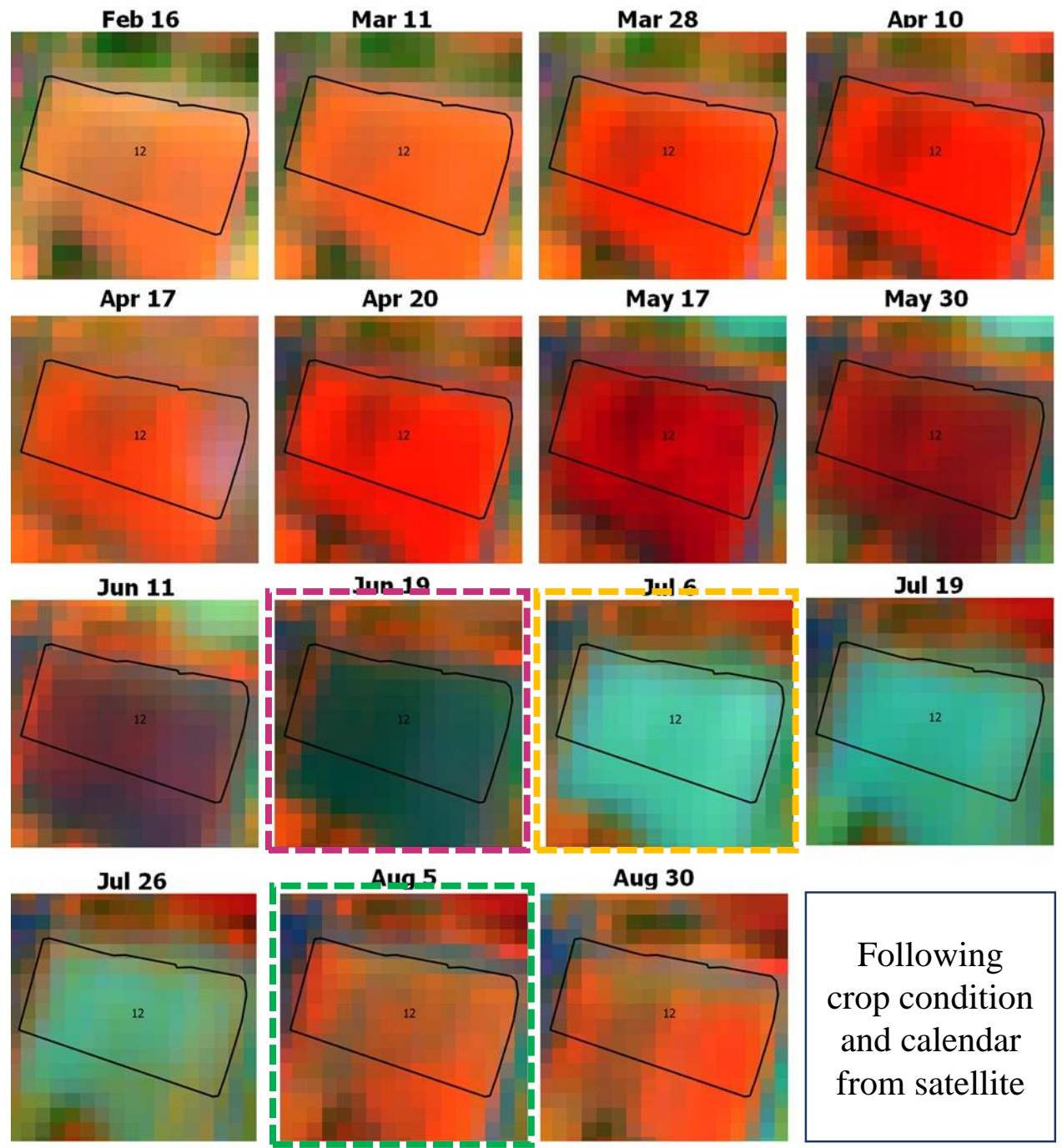
Harvested



Ploughed



Replanted



Following crop condition and calendar from satellite

# How can it support agriculture and FS policies?

## Food & Agriculture at the Intersection of Multiple SDGs

**Goal 1:** Nearly 40% of global workforce works in agriculture; 75% in poorest countries (FAOSTAT)

**Goal 2:** Sufficient, reliable food availability, access, utilization as population increases

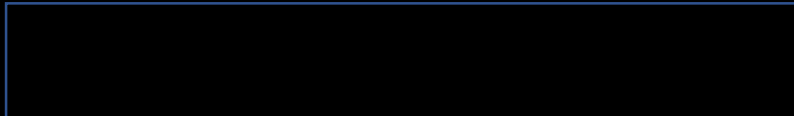
**Goal 3:** Early warning of food shortages can mitigate human mortality & reduce risk

**Goal 6:** Water uses 2/3 of freshwater (Clay, 2004)

**Goal 12:** Improved agricultural practices can increase sustainable usage of natural resources; monitoring of production can help mobilize policies to reduce post-harvest losses

**Goal 13:** Two way link between agriculture & climate change

**Goal 15:** Sustainable agricultural production practices to prevent land degradation



EO can:

Provide near real time evidence and contribute to baseline information for many indicators

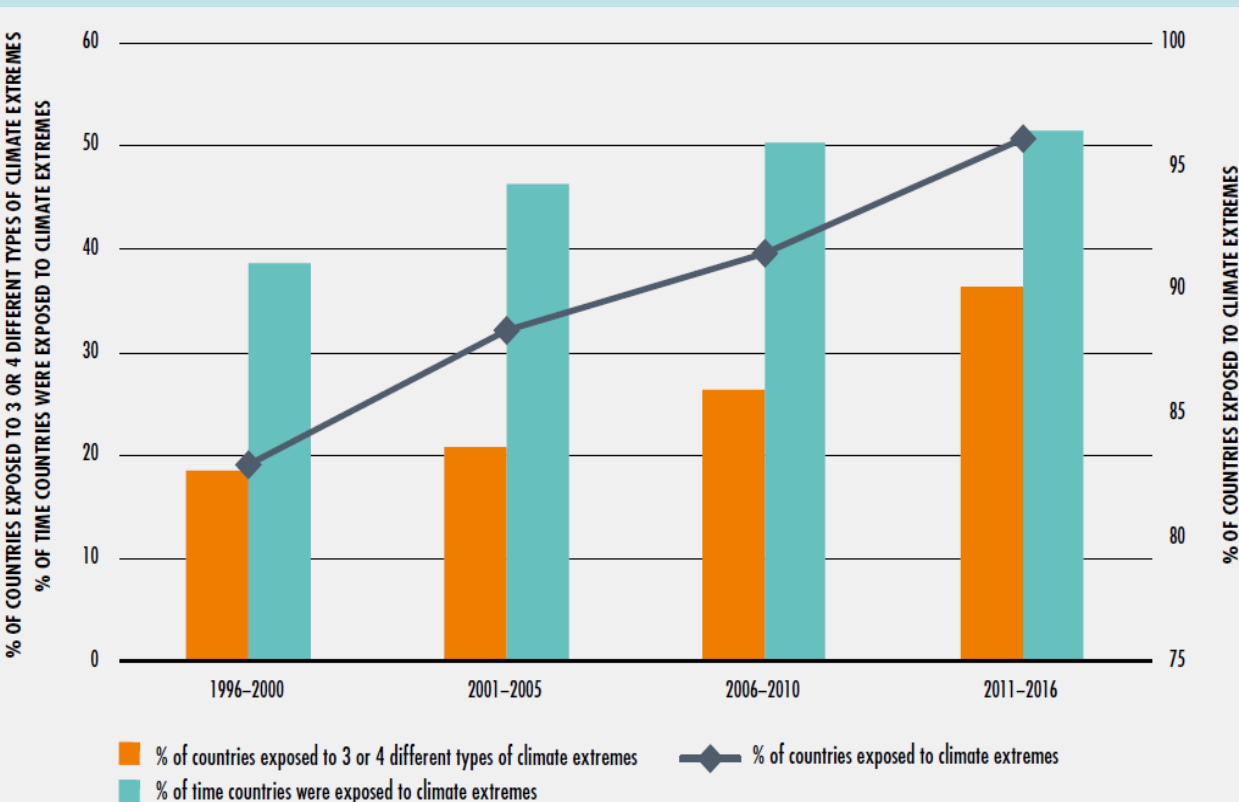
Support change monitoring (Land use and land use change, GHG emissions, water availability and quality, land degradation...)

Feed into models that help predicting indicators

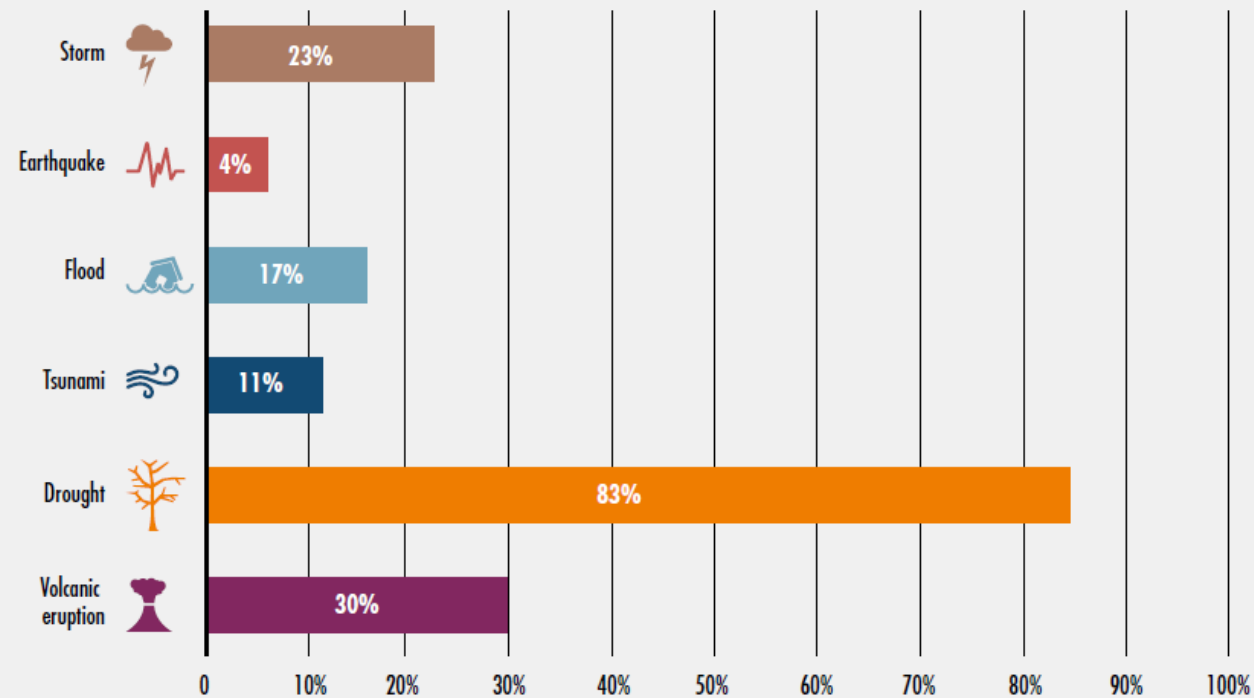


# Increased exposure to more frequent and multiple types of climate extremes

- Exposure of low and middle income countries to climate shocks

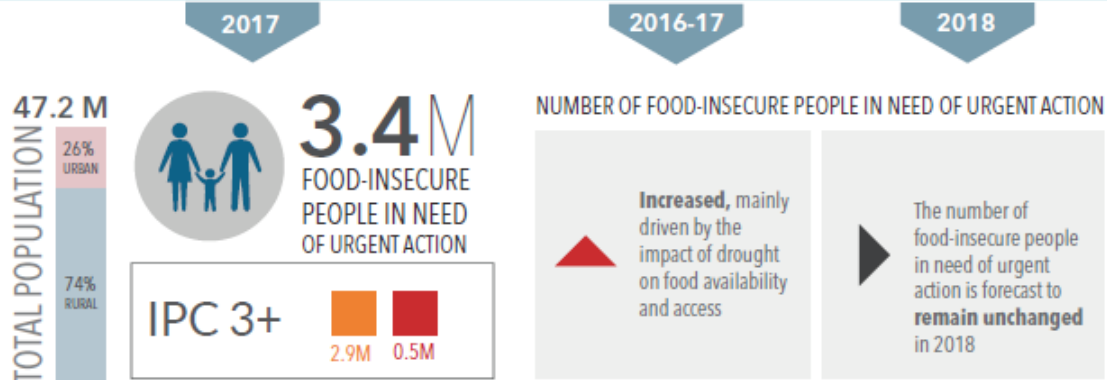


**A) DAMAGE AND LOSS IN AGRICULTURE AS SHARE OF TOTAL DAMAGE AND LOSS ACROSS ALL SECTORS BY TYPE OF HAZARD**

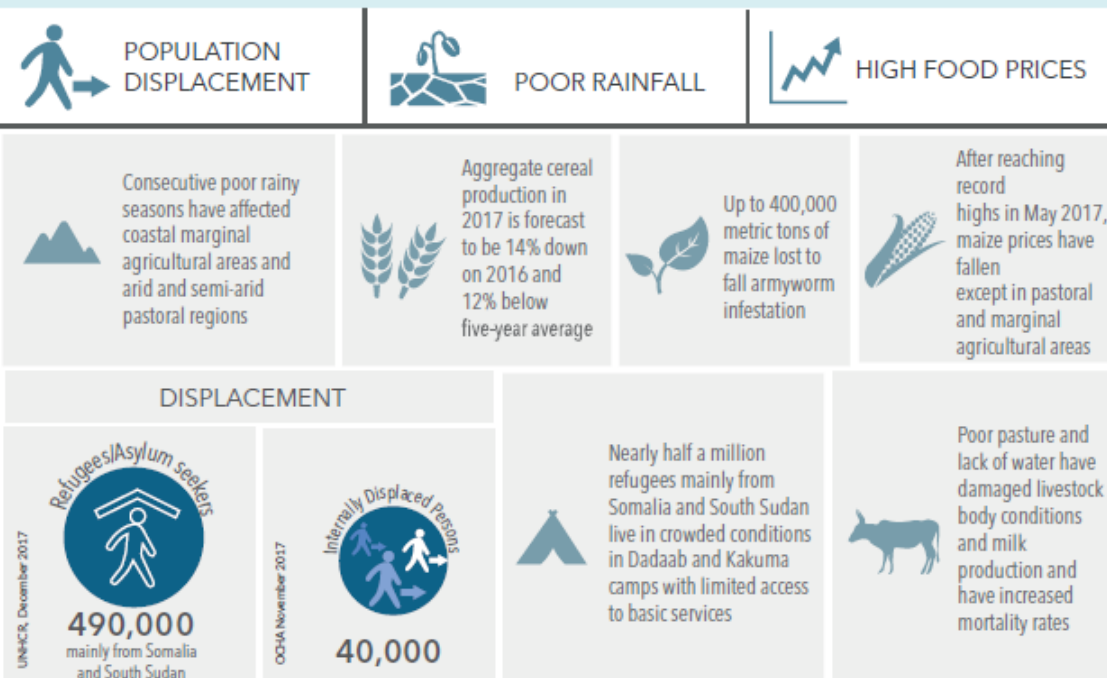


# Food security – Kenya 2016-18

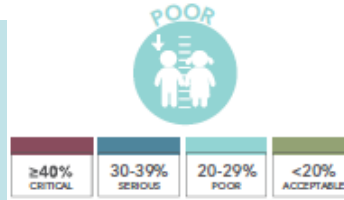
## KEY FOOD INSECURITY FIGURES AND TRENDS



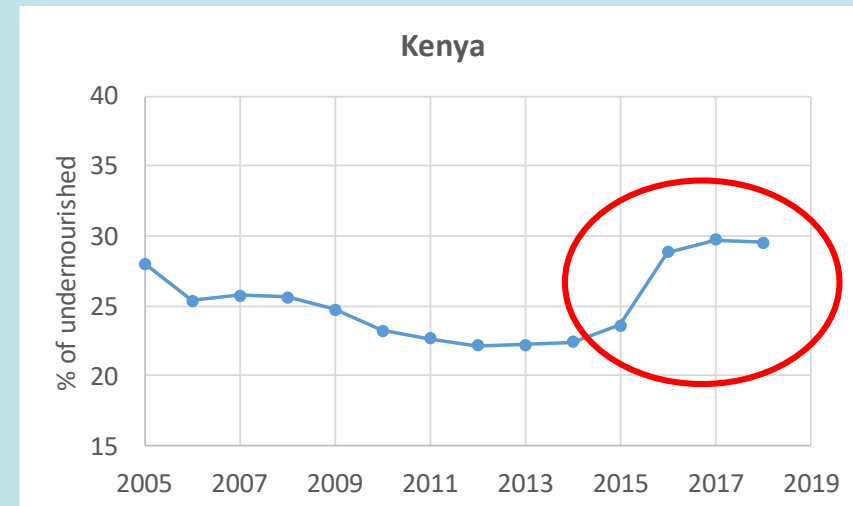
## KEY FACTORS DRIVING FOOD INSECURITY



**26%**  
Children aged 0-59 months stunted



Source: FSIN – Global Report Food Crises 2018



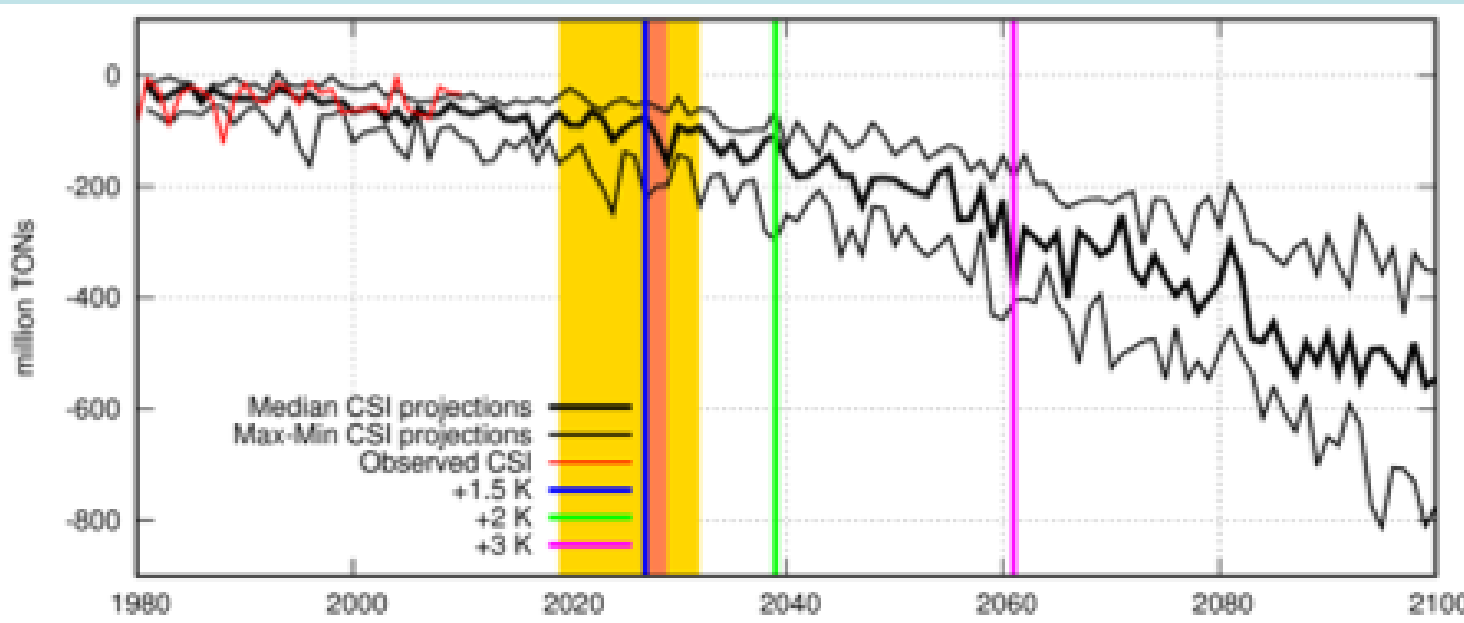
Source: FAO



# Climate extremes and crop yield

## *Global Maize production*

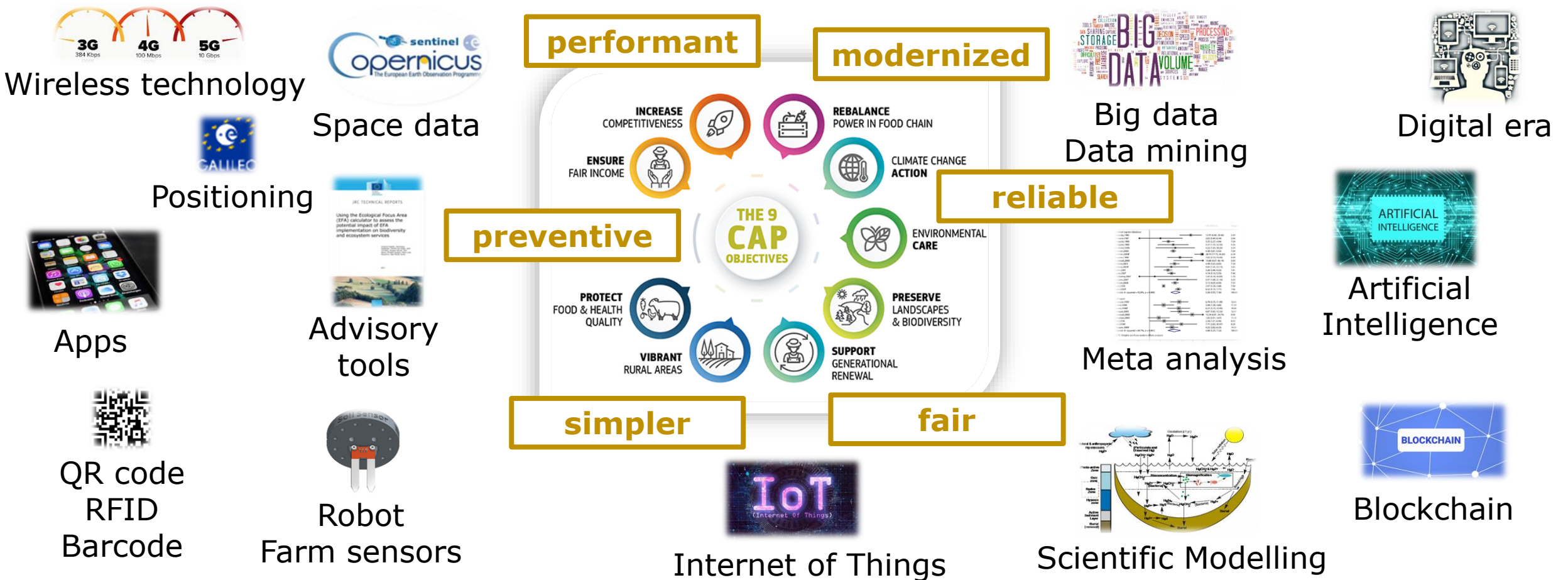
•  $\Delta T = 1.5\text{ K}$  •  $\Delta T = 3\text{ K}$



- Global production  $\approx 1$  billion tons
- Calibrated combined heat and water stress index
- 11 high resolution, bias corrected RCP8.5 climate scenarios
- Timing when the worst observed climatic extremes become the norm.

- For some crops the increase in frequency and intensity of extremes could lead to a substantial production decline in absence of adaptation

# Challenged global agriculture with multiple technological opportunities





# How does the JRC FS unit use EO for policy support?



**Using crop growth models and satellite based biophysical indicators the JRC provides timely yield forecasts for Europe and neighbouring countries to the European Commission. DG AGRI, EUROSTAT**

**To help manage farmers aid, using monitoring and control systems, the JRC supports the implementation of the Integrated Administration and Control System (IACS). DG AGRI, MEMBER STATES**



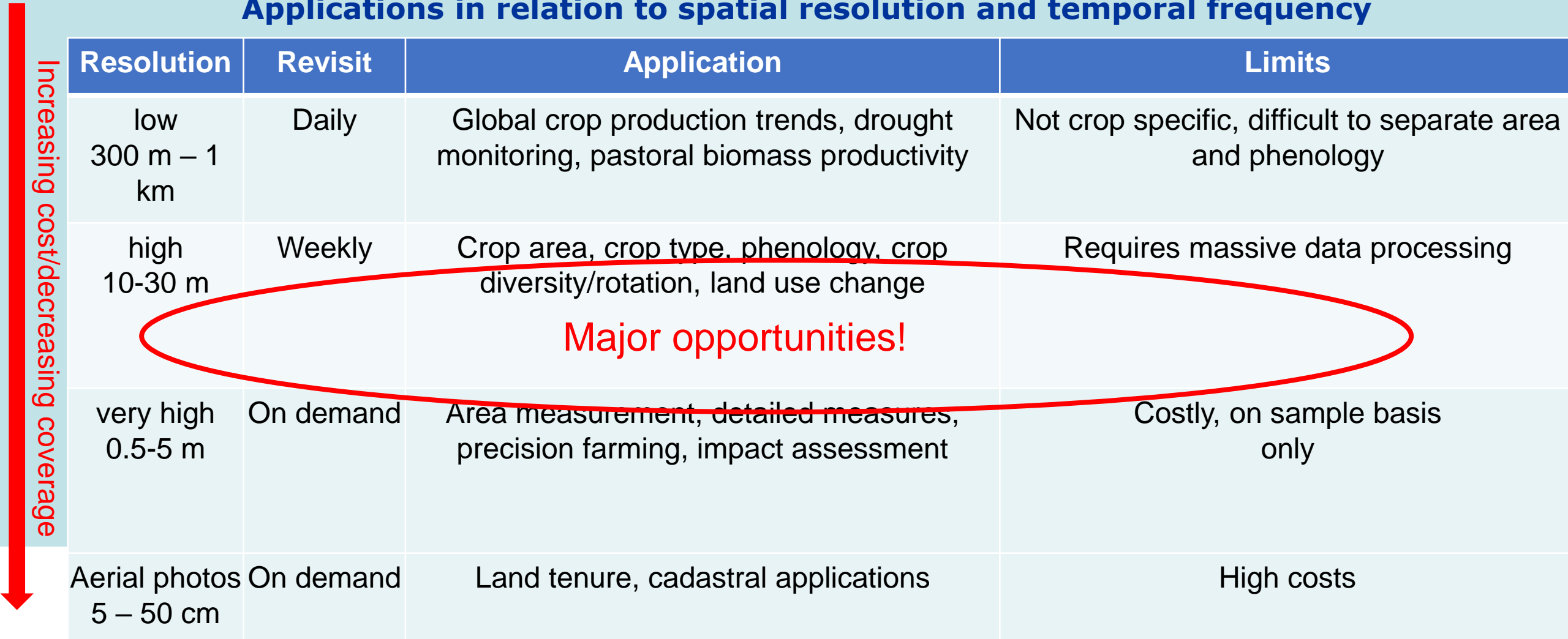
**JRC multidisciplinary approach to food security: Monitoring and assessments in collaboration with international partners + research (including nutrition). DG DEVCO, UN Agencies, Member States development agencies, National Governments**

**Climate change impact on agricultural production and adaptation. IPCC scenarios, modelling and downscaling. Monitoring and forecasting extremes. DG AGRI, DG CLIMA**



# EO applications for agricultural monitoring

## Applications in relation to spatial resolution and temporal frequency

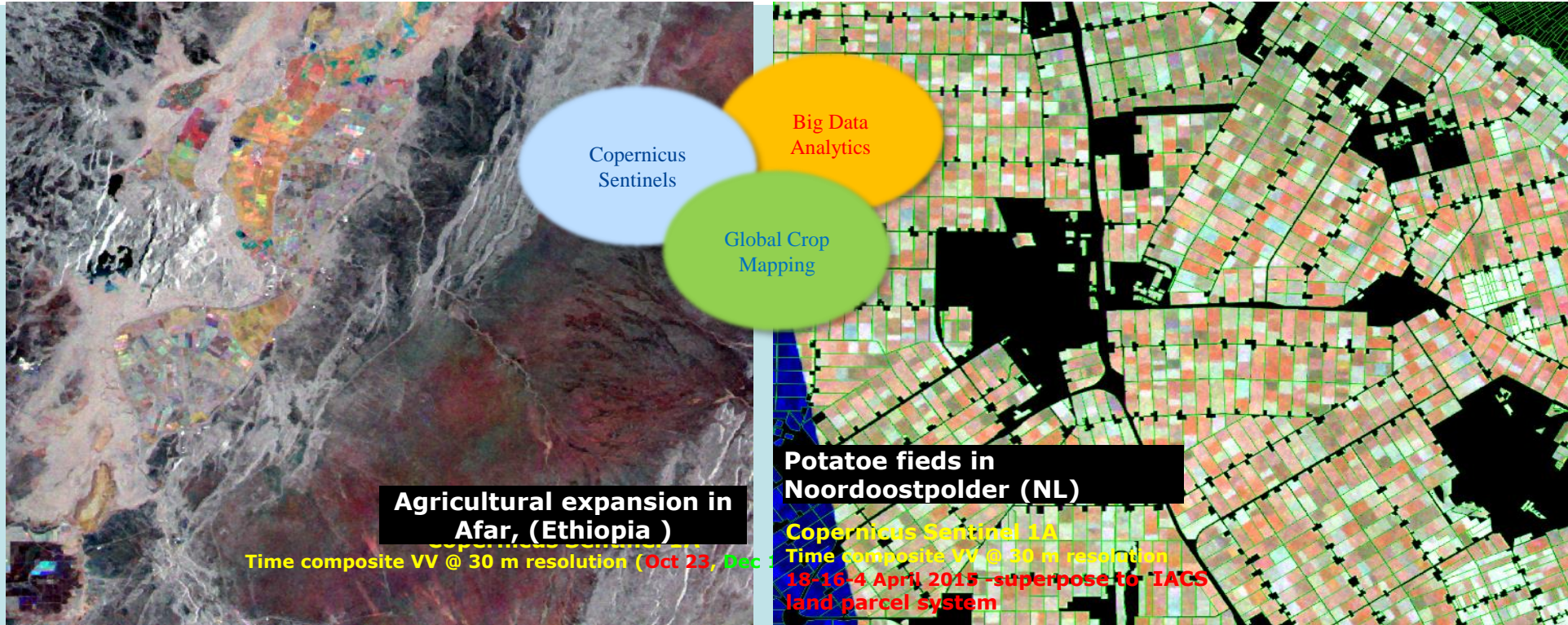


Resolution	Revisit	Application	Limits
low 300 m – 1 km	Daily	Global crop production trends, drought monitoring, pastoral biomass productivity	Not crop specific, difficult to separate area and phenology
high 10-30 m	Weekly	Crop area, crop type, phenology, crop diversity/rotation, land use change	Requires massive data processing
very high 0.5-5 m	On demand	Area measurement, detailed measures, precision farming, impact assessment	Costly, on sample basis only
Aerial photos 5 – 50 cm	On demand	Land tenure, cadastral applications	High costs

**Major opportunities!**



# New opportunities in the 10/20m resolution domain



- Free and open data of COPENICUS (Sentinel sensors), 3- 10 days revisit capacity, 10 m spatial resolution range
- Towards global crop mapping, area and yield at high resolution – requires big data approach!

**"The Union Earth  
observation and  
monitoring  
programme"**

**Monitor the  
environment**

**Foster downstream  
applications in a number  
of fields**



## Services monitoring Earth Systems



Land



Marine



Atmosphere

## Horizontal services



Emergency



Security



Climate  
Change

## Examples of products in land service:

- Urban atlas, tree cover  
density, EU DEM, CORINE  
<http://land.copernicus.eu/>  
land cover...



# Global Land Service - 1

- **Support and consolidate:**

- EU contribution to **GEO/GEOSS**
- **EU policies** at international level
  - e. g. Climate and Development policies
- **EU commitments** under international treaties and conventions
  - e. g. UN "Rio" and climate conventions

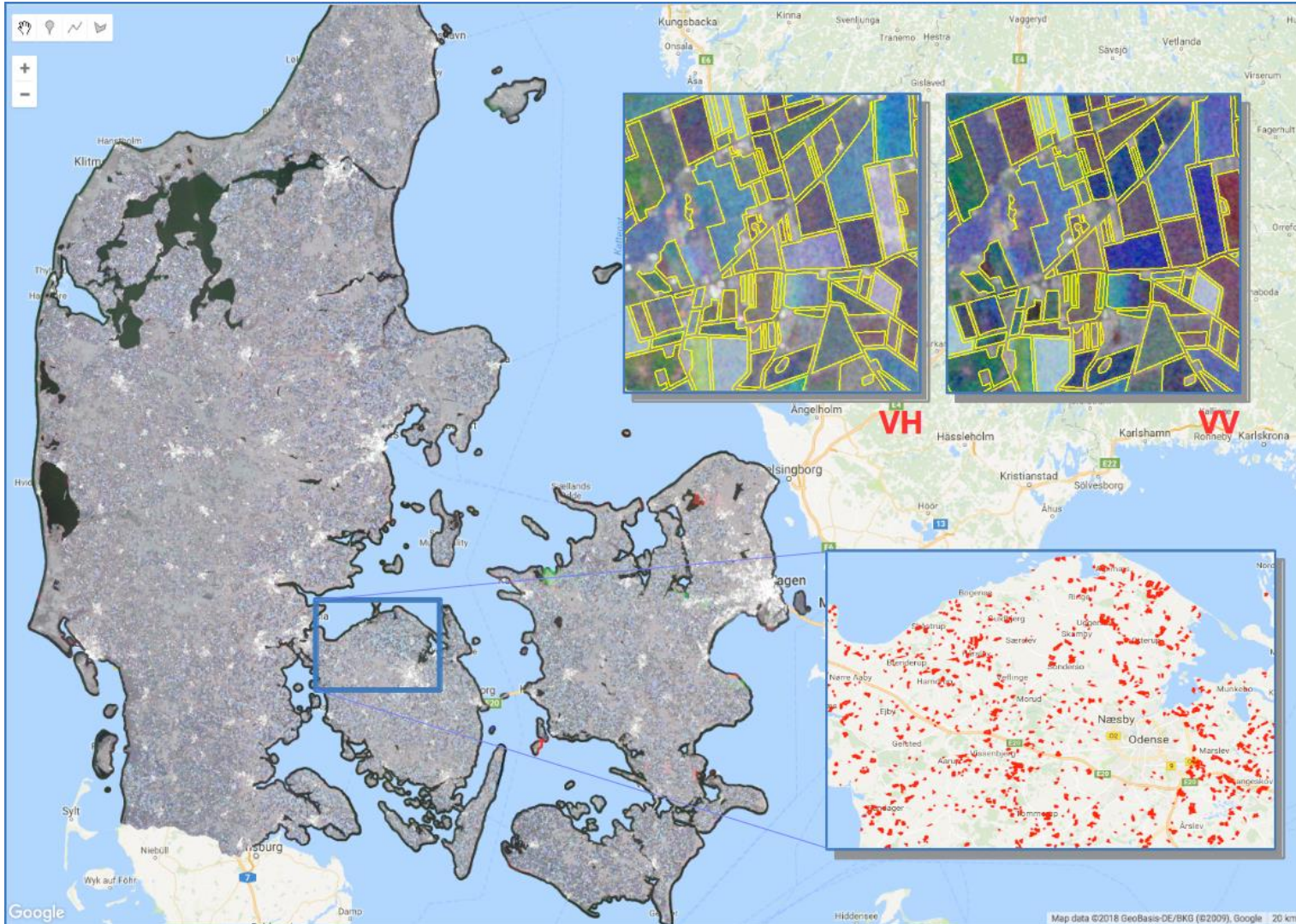
- **Policies focus:**

- Crop Monitoring and Food security in and outside Europe
- Biodiversity, Protected areas and Forest cover monitoring
- Drought Assessment and Desertification
- Carbon modeling, land use and land cover change
- Support to Earth Observation African Activities





# *New CAP monitoring at the parcel scale for a whole country*



S1 provides consistency

**Machine learning** applied to  
S1 temporal series

Splits 95-5 “outliers”

S2 provides additional  
markers to confirm relevant  
outliers

Supports “traffic light”  
approach



# Growing number of initiatives and visibility of Earth Observation in Africa

## **Policy frameworks**

Malabo declaration, AU space policy, Agenda 2063...

## **Infrastructure**

African Space Agency, national Space Agencies, networks

## **Projects (mainly Environment and Agriculture)**

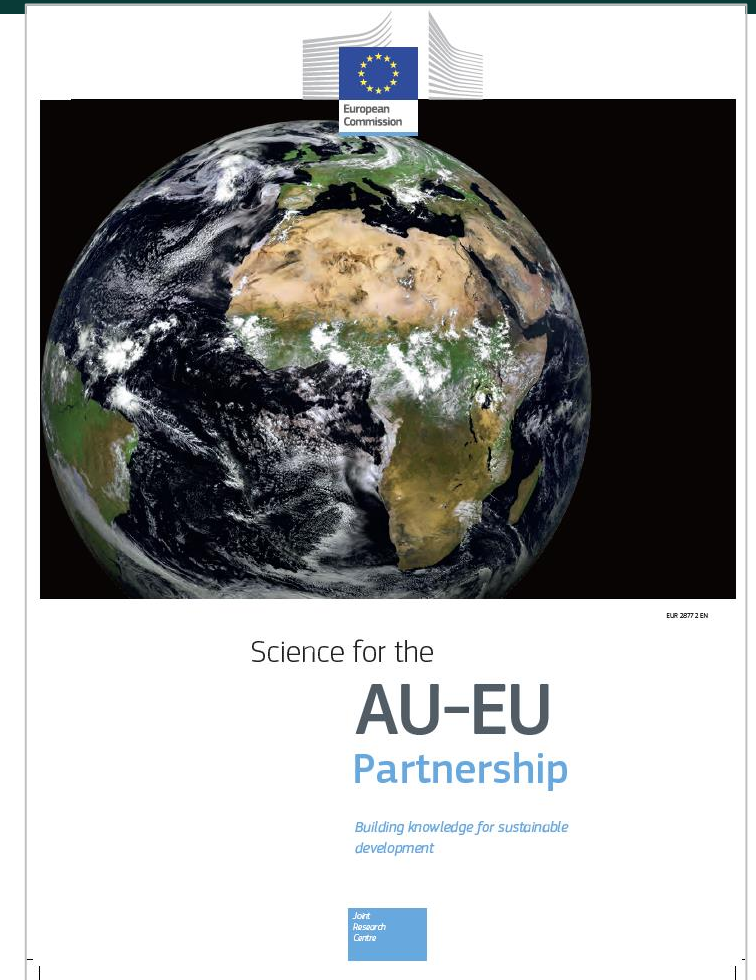
MESA, GMES&Africa, G4AW, STARS, Digital Earth Africa...

## **Capacity**

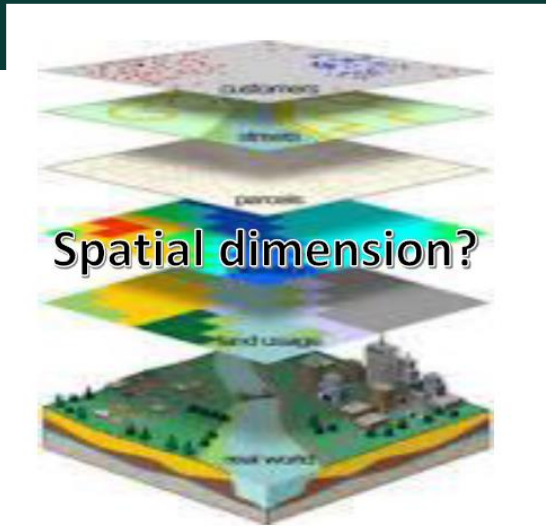
RECS, AARSE, international conferences and trainings, ITC, UN organizations

## **International research collaboration**

FP7-HORIZON 2020, GEO



# Land: the importance of the spatial dimension

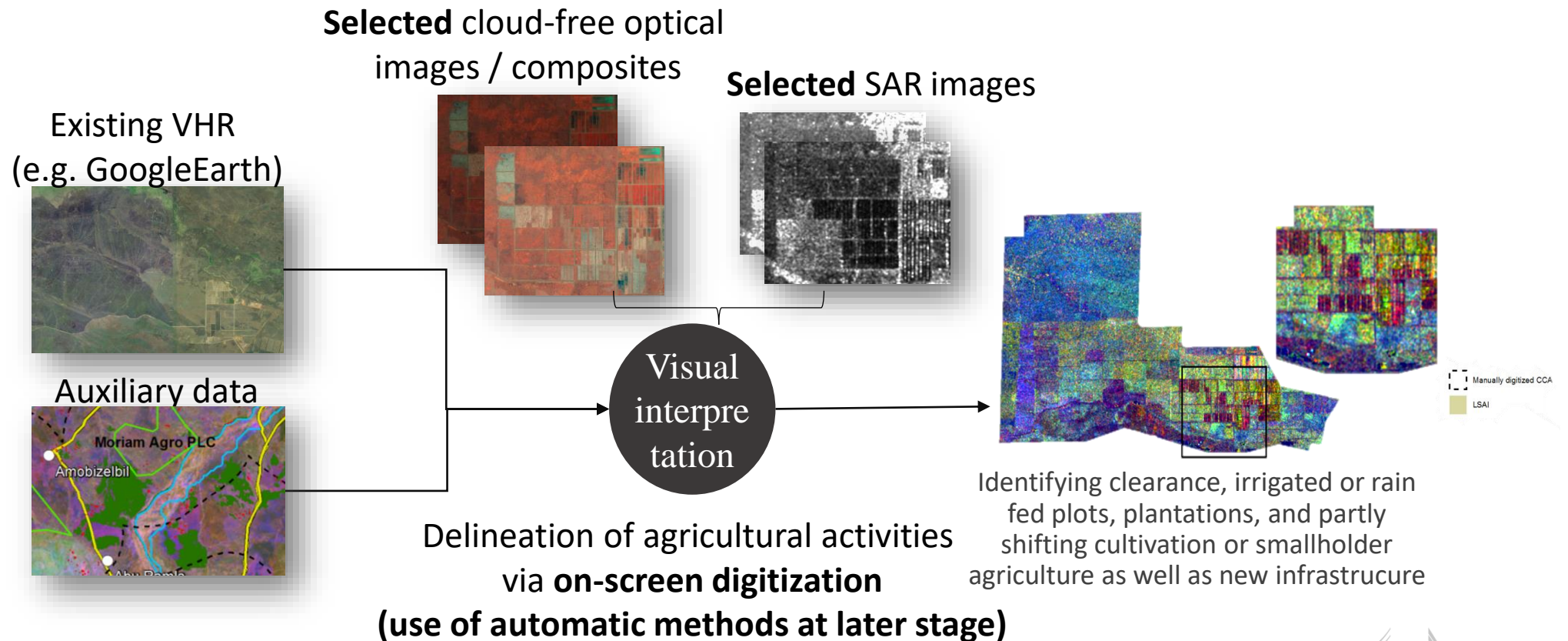


- There is a strong spatial dimension in land governance and land administration/management systems need a spatial framework to operate
- This framework maybe very sophisticated or based just on a simple spatial reference layer for identification of land plots (with functions of: use, possession, value or other..)
- The spatial accuracy and updates in time depend on specific purpose
- EO potential mainly to improve baseline information, monitoring, mapping, evidence for conflict resolution etc... **This applies for example to VGGT support projects, land grabbing, LAND MATRIX**



# Developing a basic tool for large scale investment monitoring in Ethiopia

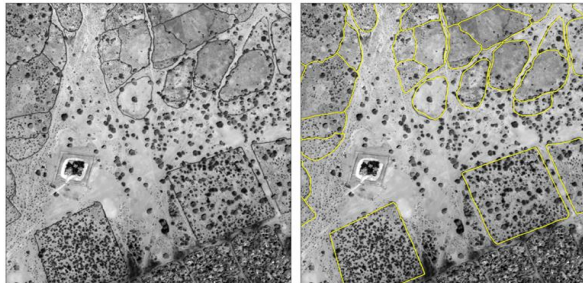
Collaboration between GIZ, EU, JRC in developing a tool for Ethiopian Authorities for monitoring large scale land investments with EO data



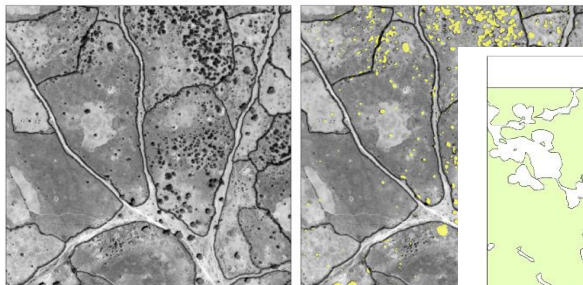
# Pastoral land governance – mapping pastoral enclosures

Pastoral enclosures are typical for many rangeland areas in East Africa with increasing pressure on natural resources and sedentarization

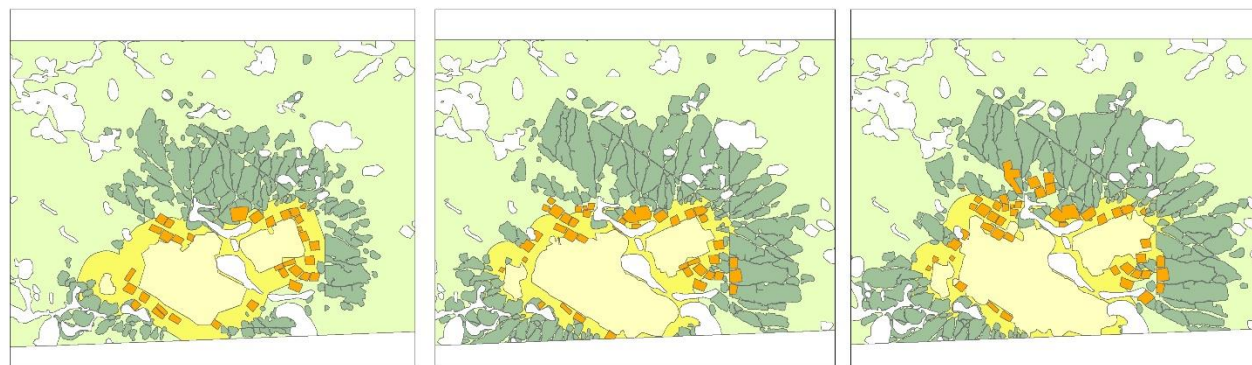
Objective: mapping enclosures and their changes over time for understanding main governance and management dynamics as well as long term dynamics



Delimitation on VHR images



Change analysis on VHR and Sentinel



2006

2010

2013

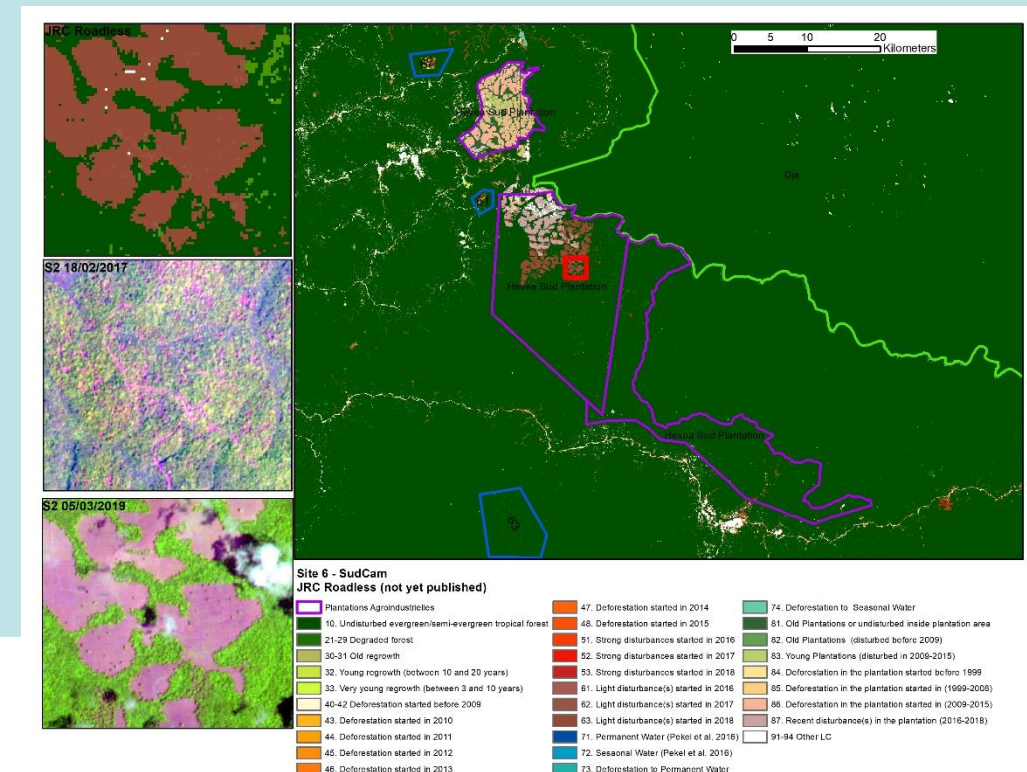
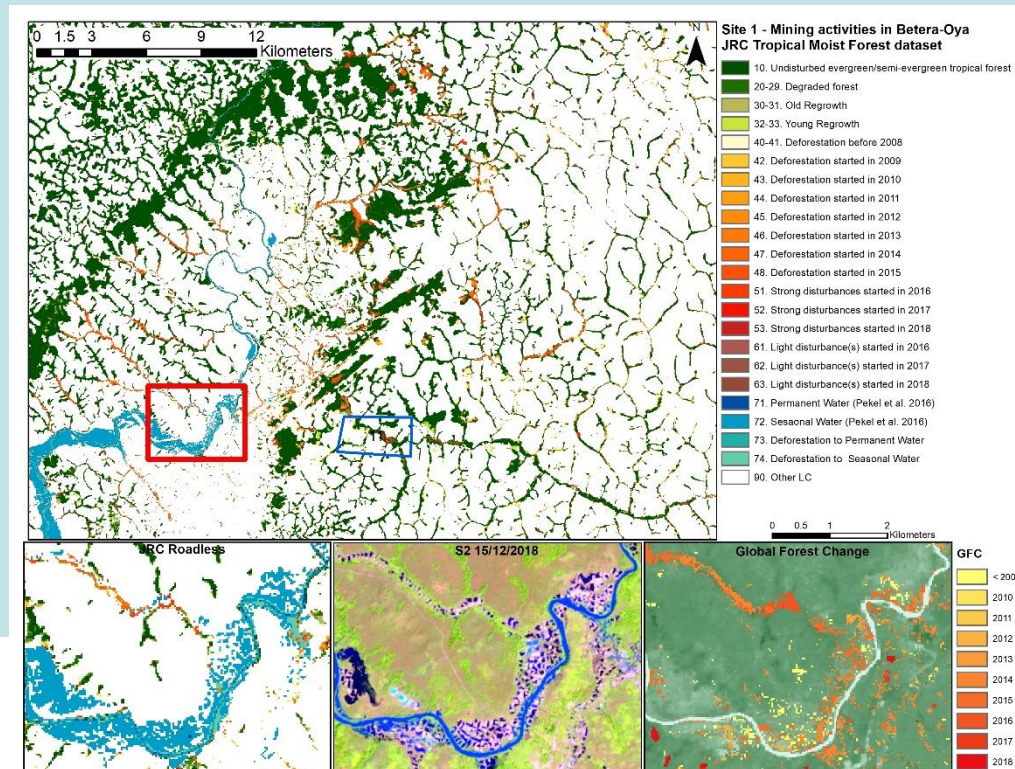




# Natural resources (Cameroon)

Technical support to the LandCam project in three study cases

- Small scale mining activities
- Agricultural intensification
- Implementation of rubber and oil palm plantations






Please cite as: **FAO & JRC.** 2012. *Global forest land-use change 1990–2005*, by E.J. Lindquist, R. D’Annunzio, A. Gerrand, K. MacDicken, F. Achard, R. Beuchle, A. Brink, H.D. Eva, P. Mayaux, J. San-Miguel-Ayanz & H-J. Stibig. FAO Forestry Paper No. 169. Food and Agriculture Organization of the United Nations and European Commission Joint Research Centre. Rome, FAO.

FAO  
FORESTRY  
PAPER




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# Global forest land-use change 1990–2005






Food and Agriculture  
Organization of the  
United Nations








**JRC**  
EUROPEAN COMMISSION



**ITC**  
UNIVERSITY OF TWENTE



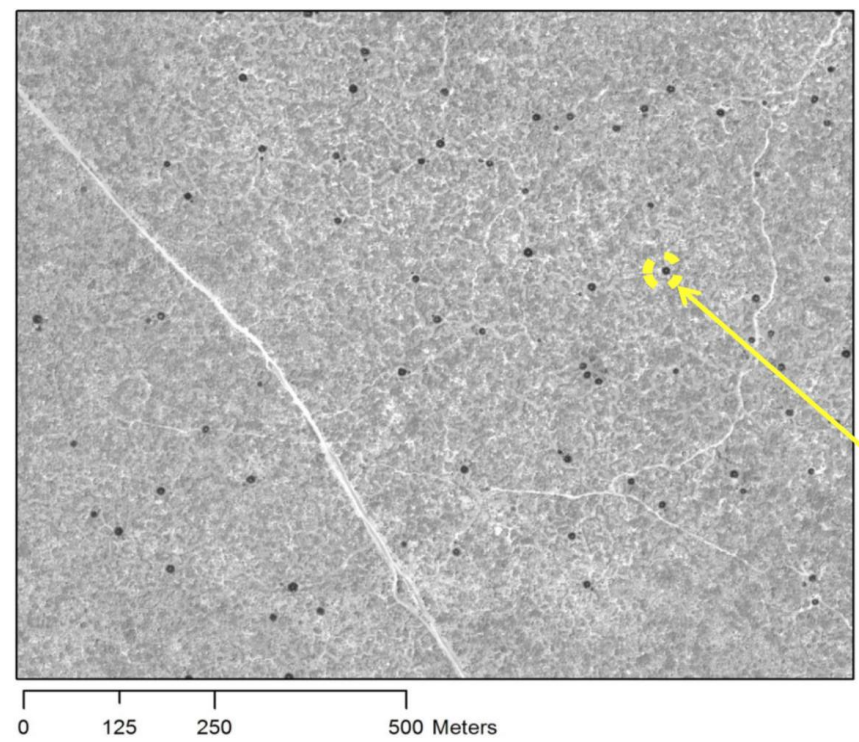
Somalia Water and Land Information Management  
(SWALIM) Project

## Monitoring charcoal production sites by VHR satellite images

**PROSCAL**  
2<sup>nd</sup> Programme Steering Committee

**Mogadishu, 18 September 2017**

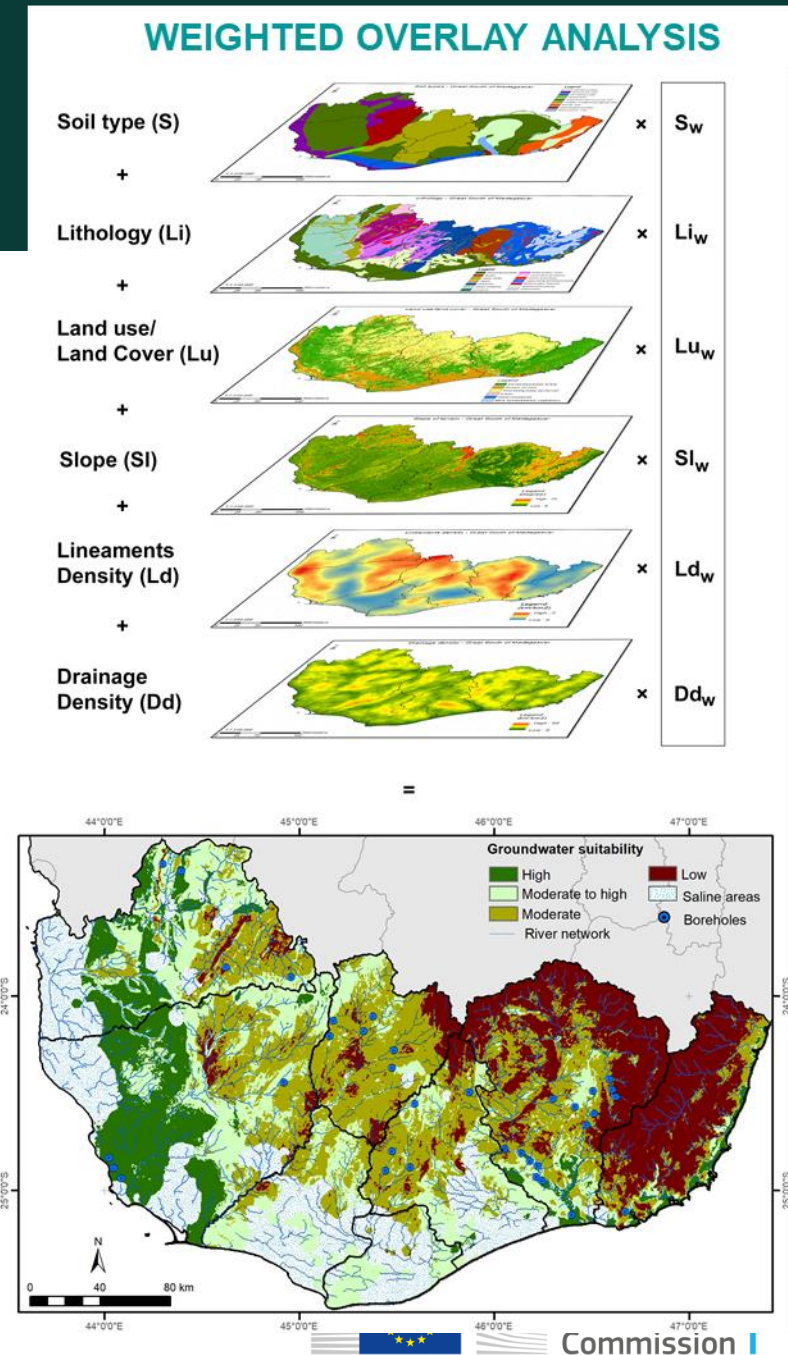
**UGO LEONARDI**  
FAO – SWALIM Remote Sensing Specialist  
[ugo.leonardi@fao.org](mailto:ugo.leonardi@fao.org)





# Water: Delineation of Groundwater Potential Zones

- Problem:** Drought prone areas with low water supply.  
 Access to water for agriculture and potable drinking water is a major challenge.  
 The **success rate of drilling** productive wells is **very low** (and expensive).
- Objective:** EU/JRC and UNICEF collaborate on a hydrological study **to generate new** data that would improve sector knowledge on the **availability and quality of** groundwater.
- Where:** South of Madagascar (UNICEF-Madagascar) and selected zones in Ethiopia (UNICEF-Ethiopia).
- Contribution of EU-JR:**
  - To assist UNICEF by making available the expertise and capacities of JRC in **remote sensing technology** and skills to utilize high spatial and spectral resolution images for the production of thematic maps that will be used to **identify groundwater sources**.
  - Capacity **building training** for utilization of the technology (Ethiopia).



Water Occurrence (1984-2015) ⓘ

>0%

ON ☐

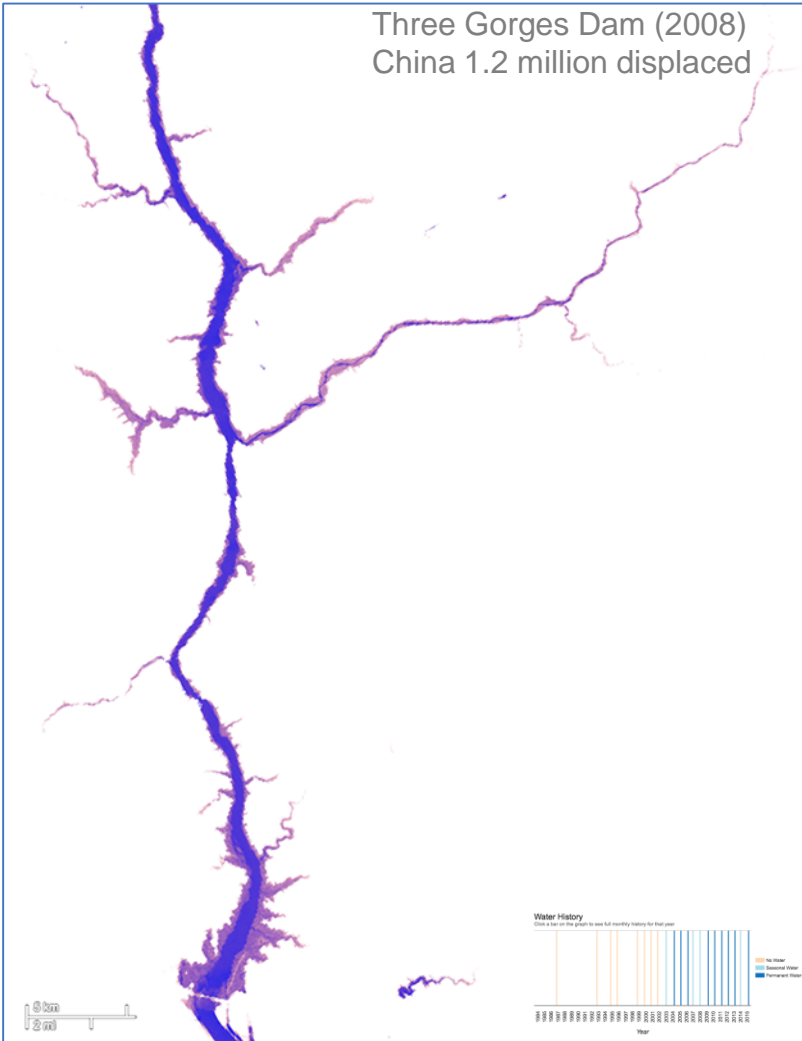
100%

Sometimes Water

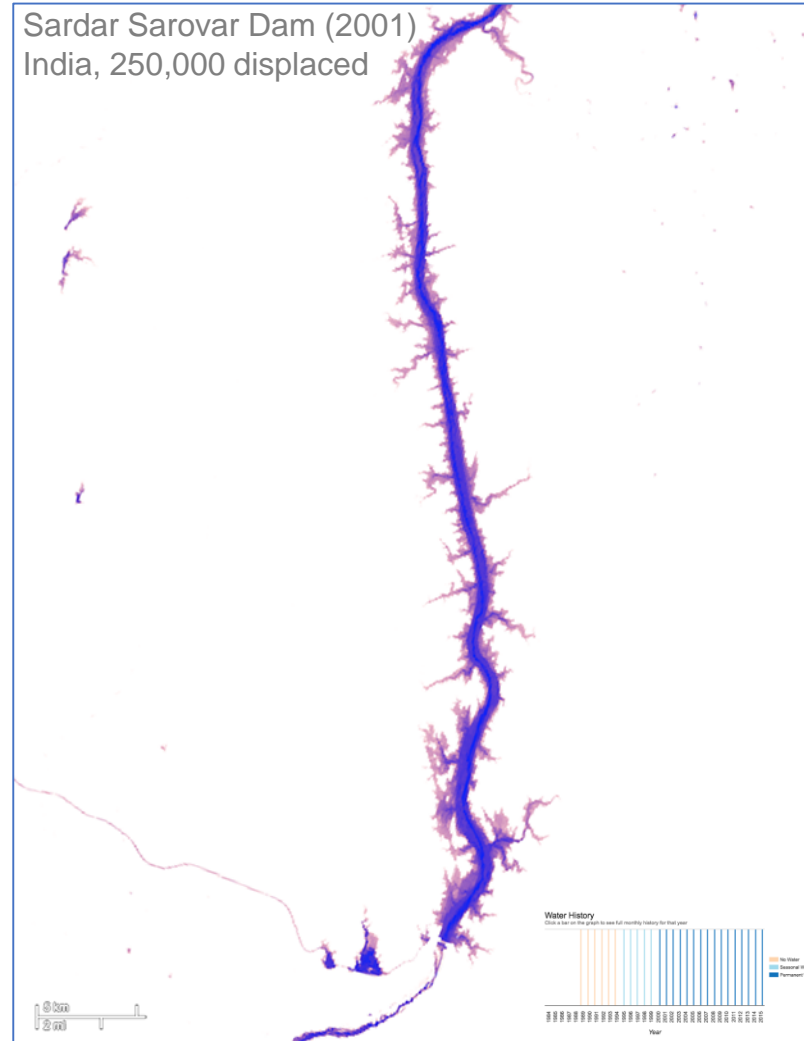
Always Water

SDG 6.6.1 Change in the extent of water-related ecosystems over time

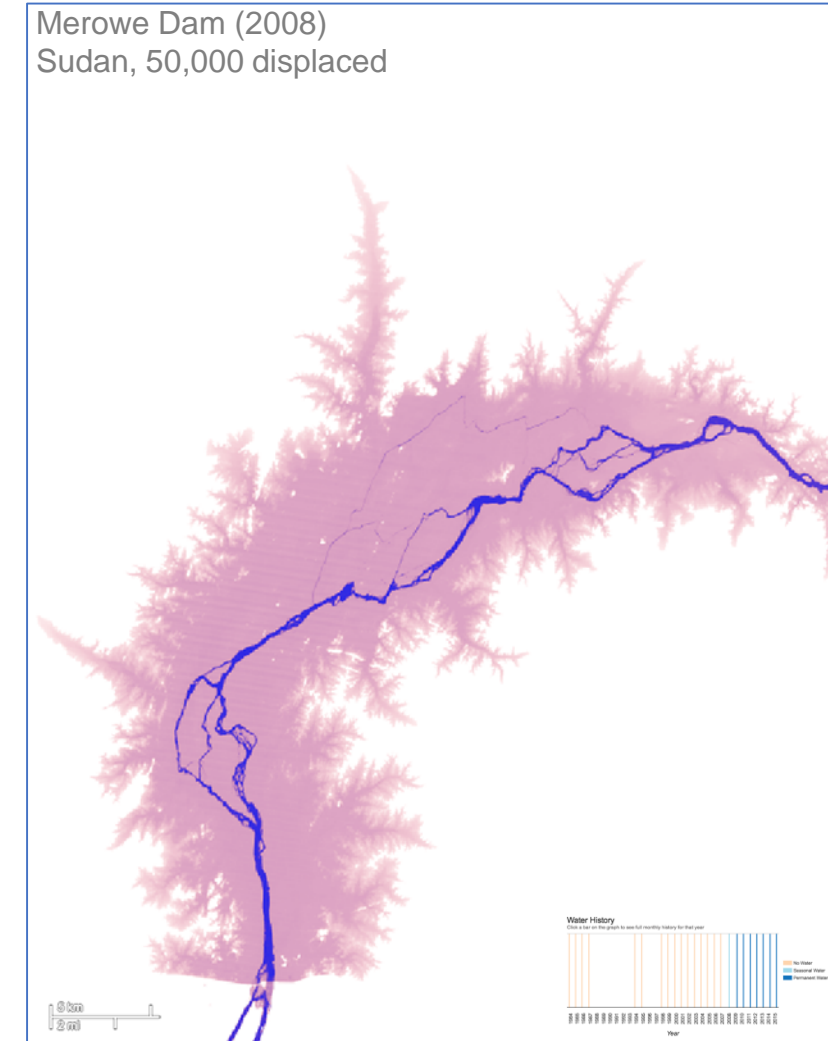
Three Gorges Dam (2008)  
China 1.2 million displaced



Sardar Sarovar Dam (2001)  
India, 250,000 displaced



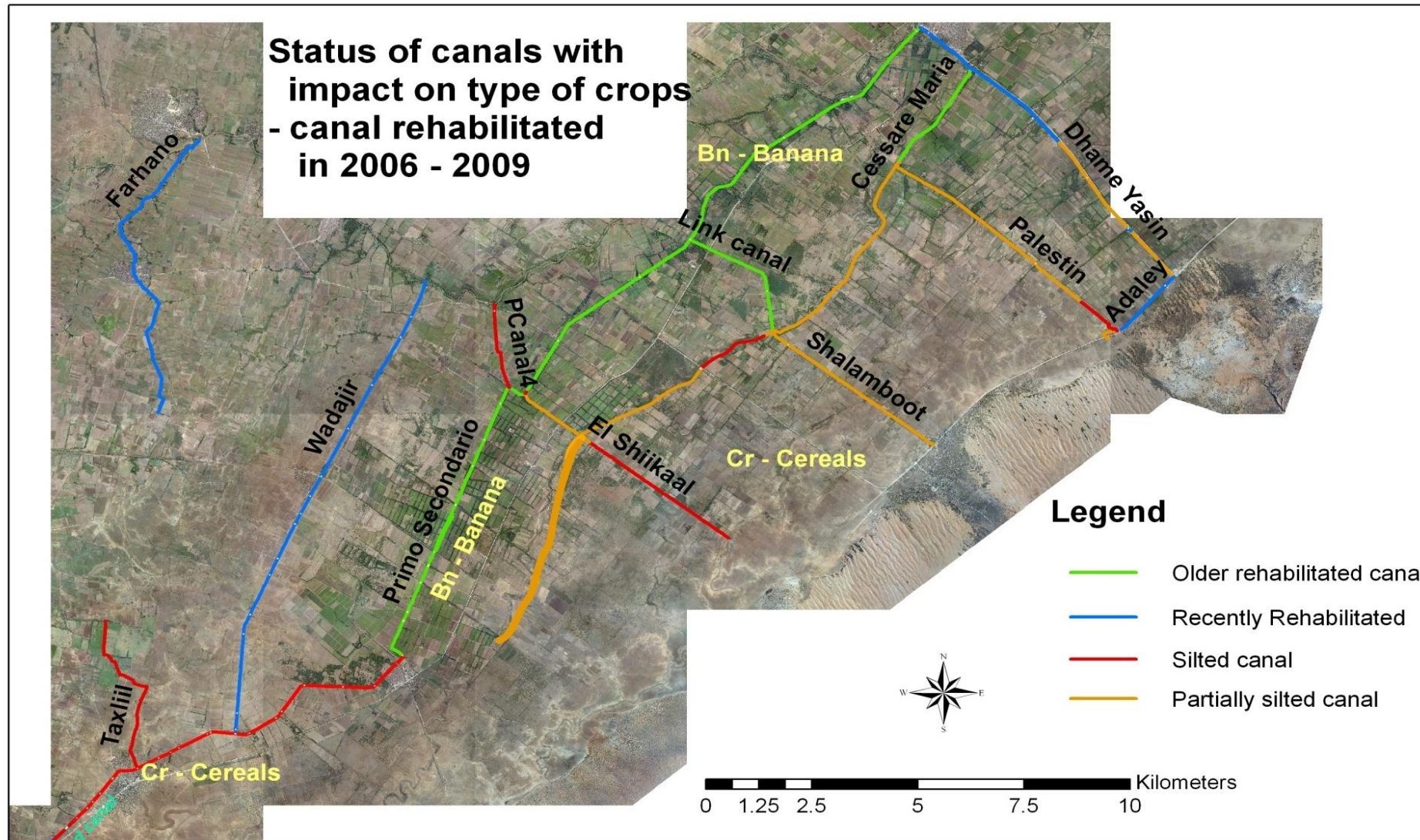
Merowe Dam (2008)  
Sudan, 50,000 displaced



Global Surface Water Explorer <https://global-surface-water.appspot.com/>



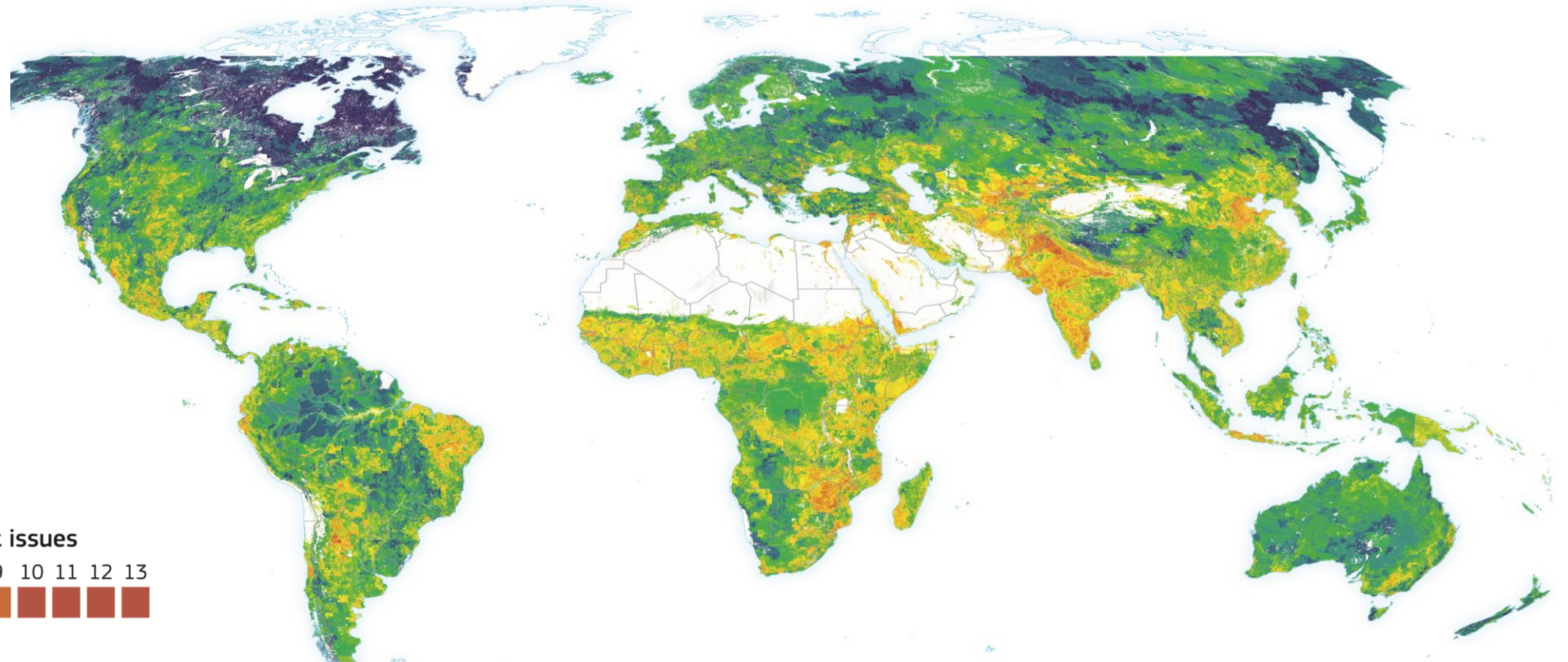
# Monitoring project implementation with VHR, infrastructure





# Land degradation, combined threats

Threats to land (source: JRC – WAD)



Number of coincident issues



Irrigation



Low-input agriculture



Income level



Population density



Fires



Decreasing land productivity



Aridity



Livestock density



High-input agriculture



Built-up area change



Population change



Tree loss



Climate-vegetation trends



Water stress



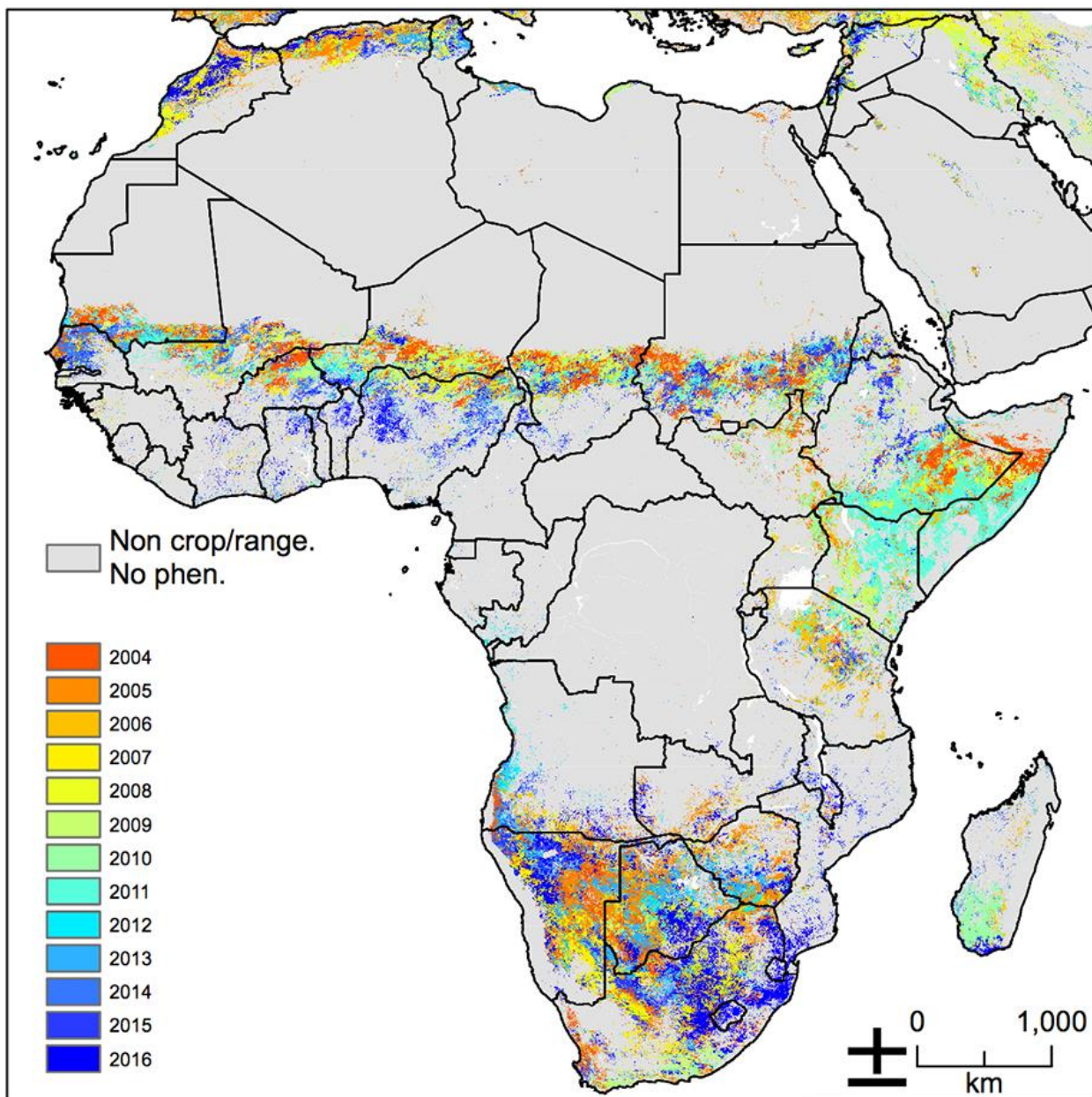
# Food security (early warning, yield forecasts, IPC...)

Information based on Earth Observation feeds early warning products, crop monitoring reports and yield forecasting

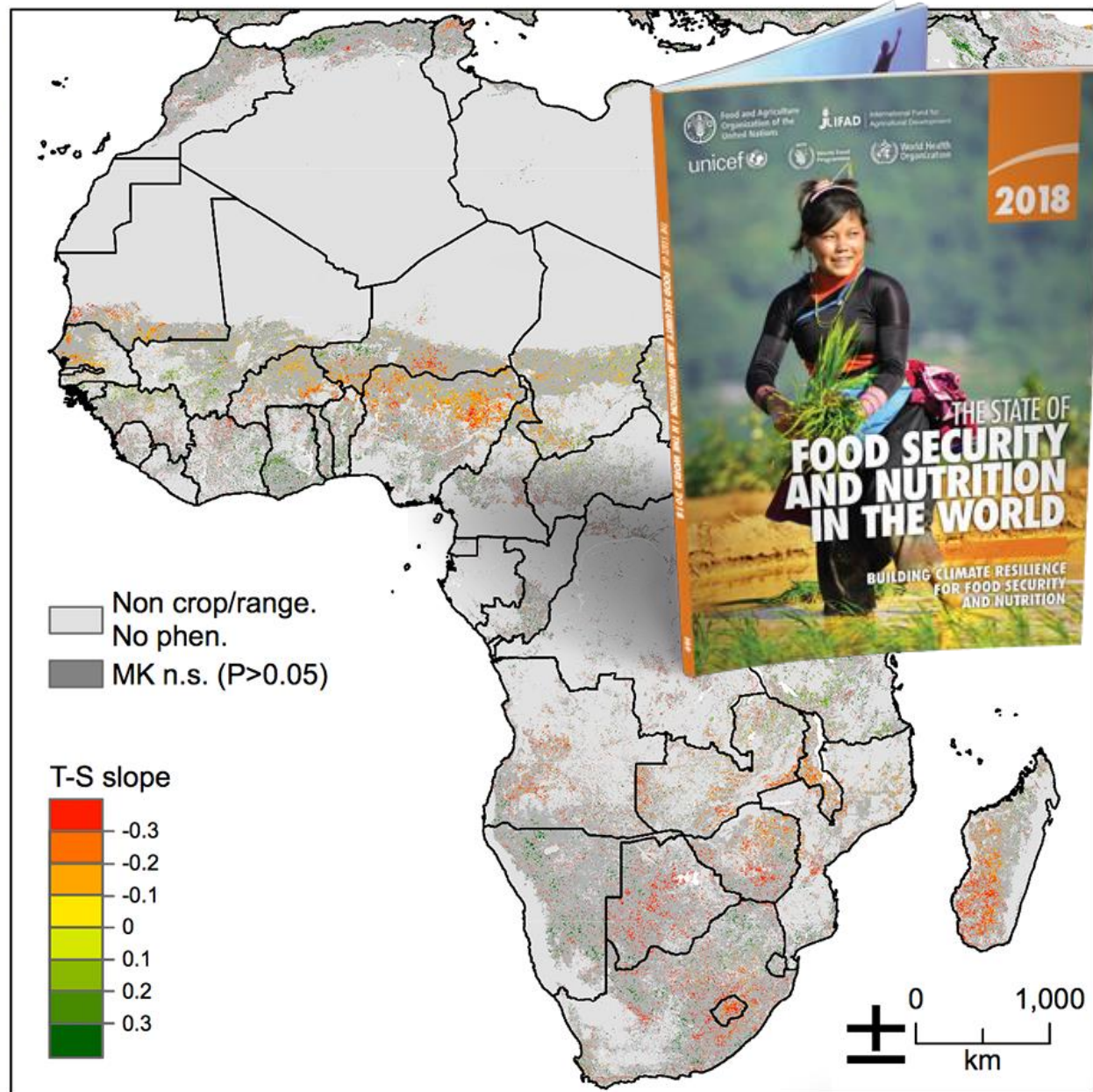
D5 produces crop monitoring reports for some countries like DPRK and Eritrea and covers 80 countries with EU food security or sust. Agriculture investments with online monitoring through the ASAP (Anomaly hotSpots of Agricultural Production) platform

Yield forecast training is provided directly or in partnership with GMES&Africa

The information is provided directly to countries, to the public or as input to multistakeholder products such as IPC/CH analysis, Global report on Food Crises, GEOGLAM reports



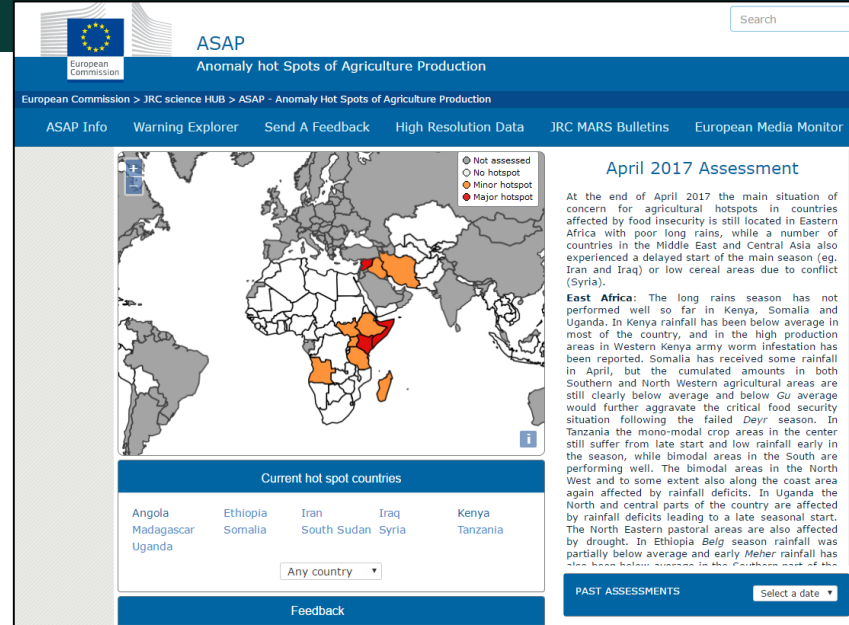
Year in which minimum cumulative NDVI was measured...  
indicative of lowest above ground biomass



Changes in growing season; red 3 days shorter per year on  
average since 2004, green 3 days longer,  
grey no measureable difference



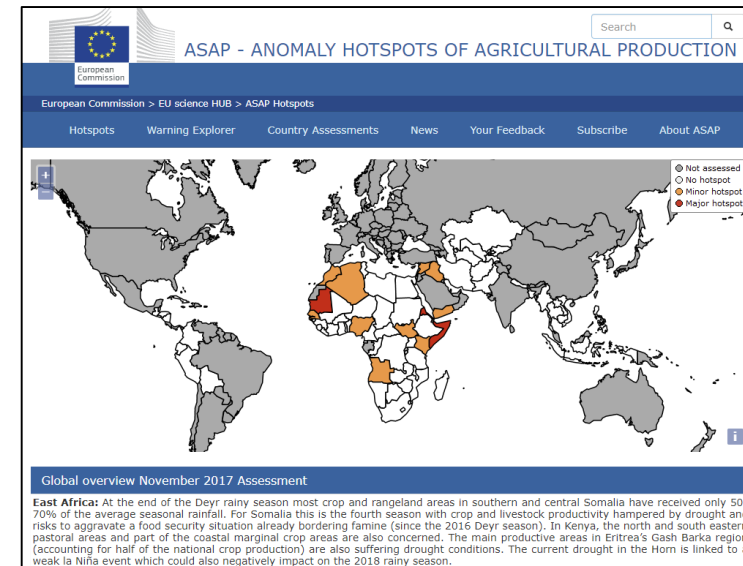
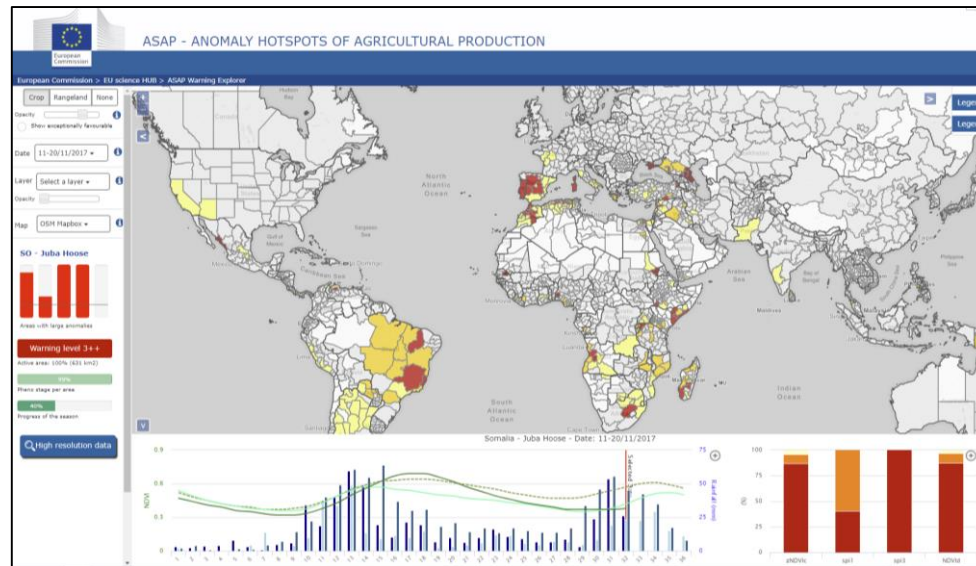
# ASAP – Anomaly hotSpots of Agricultural Production



- A new decision support system to further improve early warning of food production problems for food security assessments and contribute to existing international systems
- To exploit in a coherent, continuous and timely way global Earth Observation and climate model data
- To go beyond anomaly maps and make available analyzed information and evidence to policy makers
- To zoom in to the field level with HR information

# ASAP information

1. Automatic warning classification at first sub-national level, every 10 days (global)
2. Identification of hotspot countries by analysts, completed by short summary narratives at national level, every 30 days (80 countries)

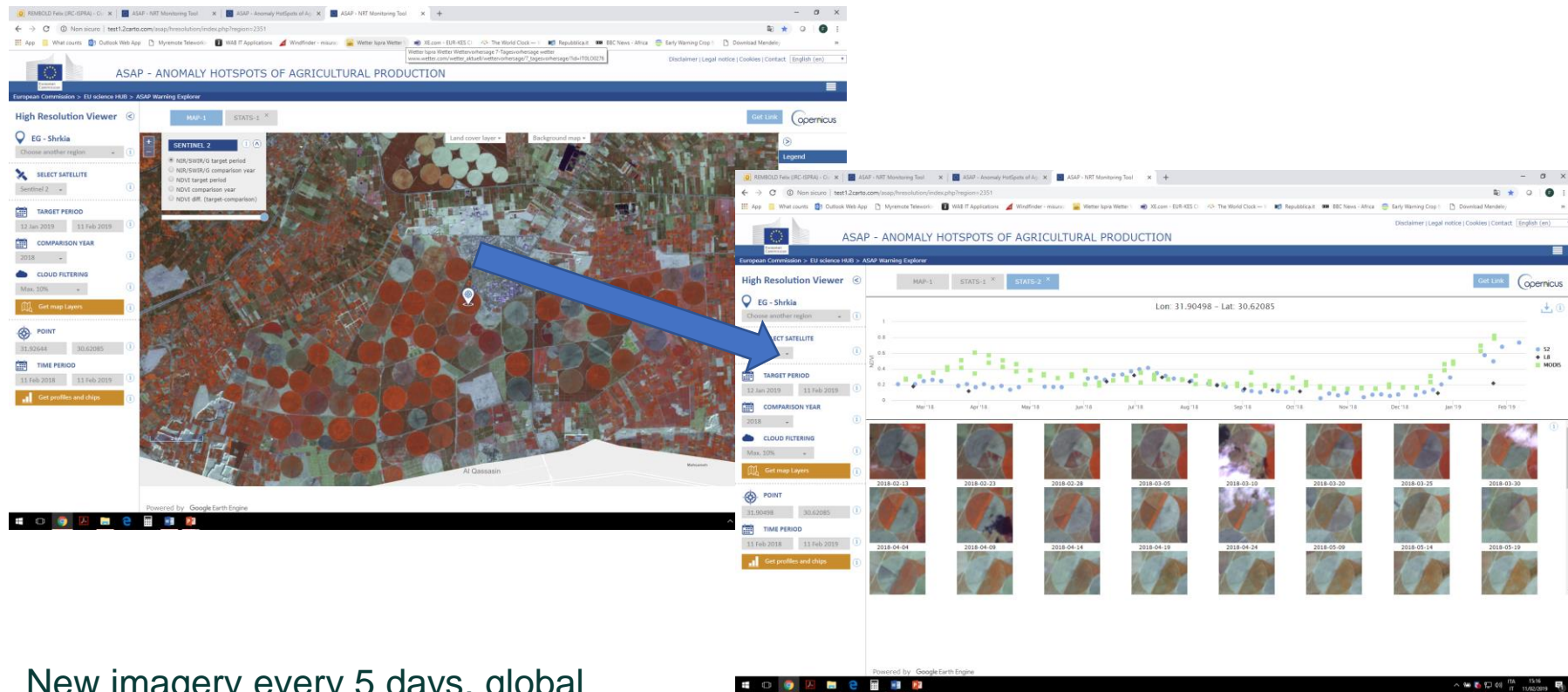


The final selection of hotspot countries depends on analysts' judgement, supported by the warning classification system and auxiliary information.



# High Resolution Viewer

A fully autonomous platform for **field level monitoring** at the global scale. Retrieves Sentinel 1-2 and Landsat imagery quickly in a cloud computing environment and extracts time series statistics and image chips.



New imagery every 5 days, global

Powered by Google Earth Engine

# Example 2019 anomaly hotspots: major drought in Southern Africa



SPECIAL FOCUS – February 2019

Persistent rainfall deficits lead to contracted sown area and impeded crop development across parts of Southern Africa

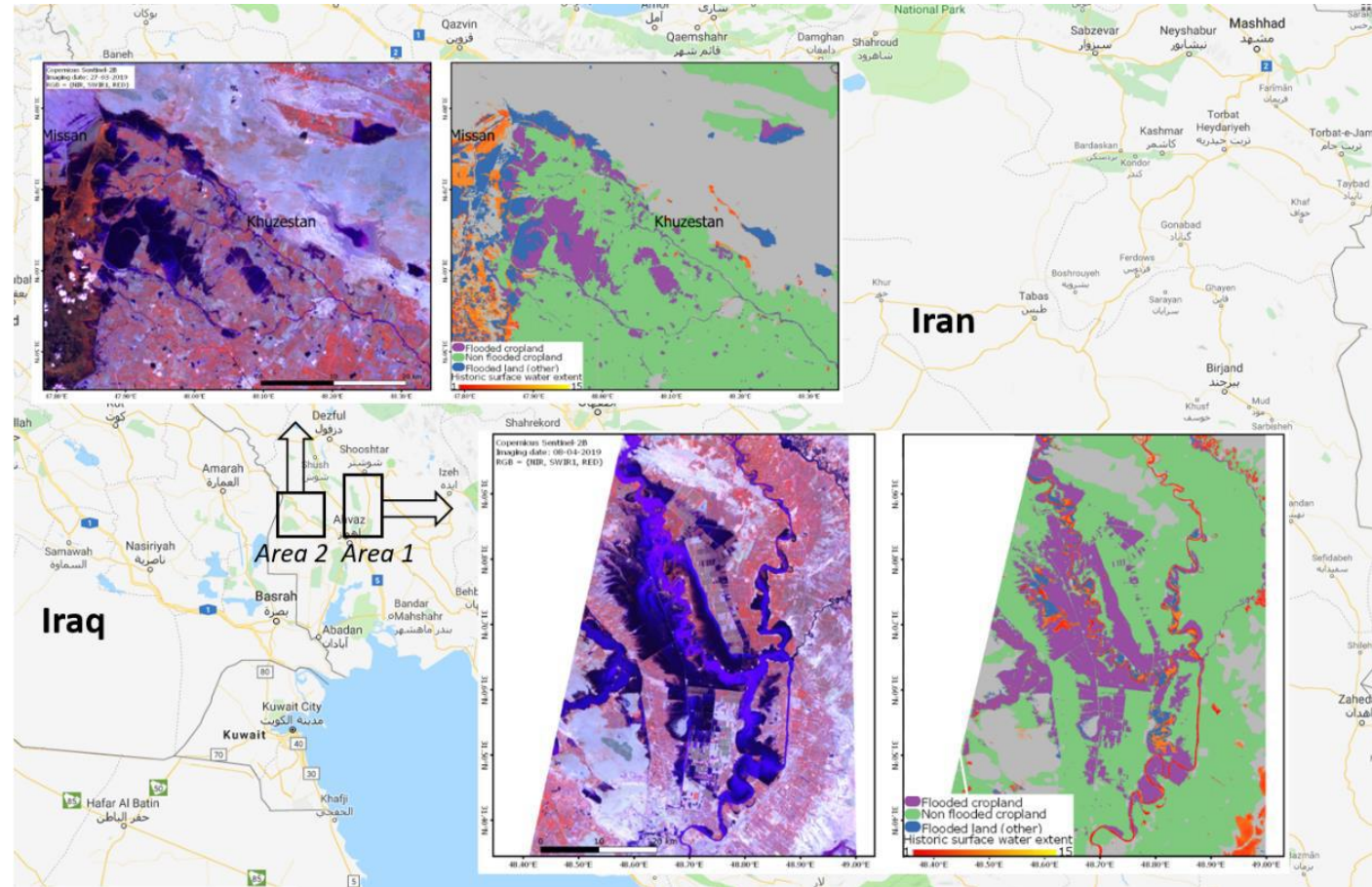
Crop failure, decrease in area planted



Figure 4. Sentinel-2 Imagery (composite 22/01-19/02) showing crop areas in Free State, close to Wesselsbron, in 2019 (left) and in 2018 (right). Source: JRC - ASAP



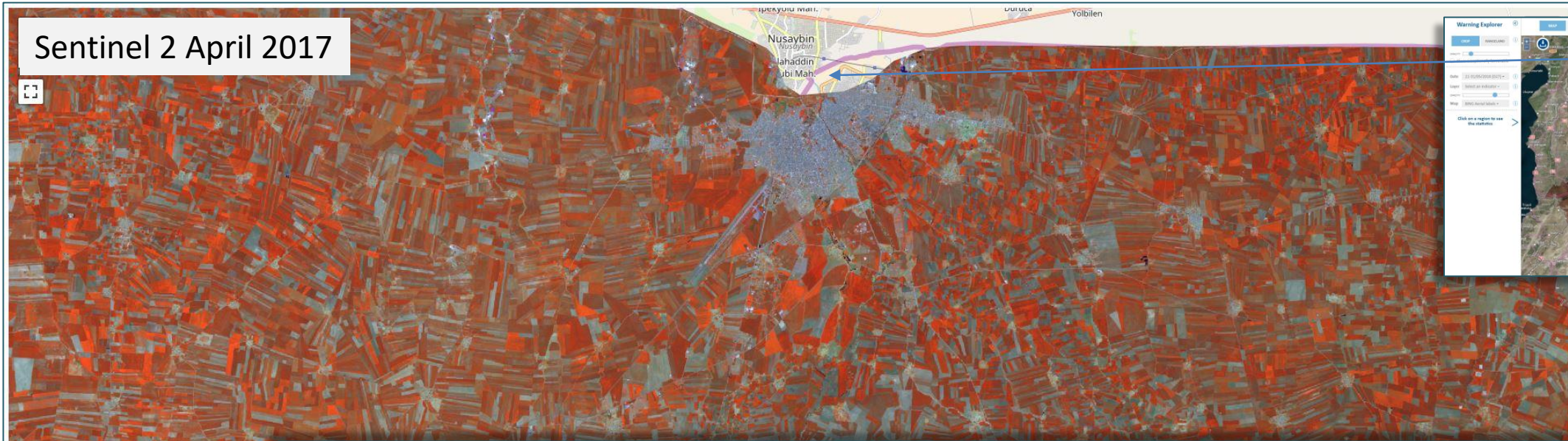
# Example 2019 anomaly hotspots : flood events in Iraq/Iran



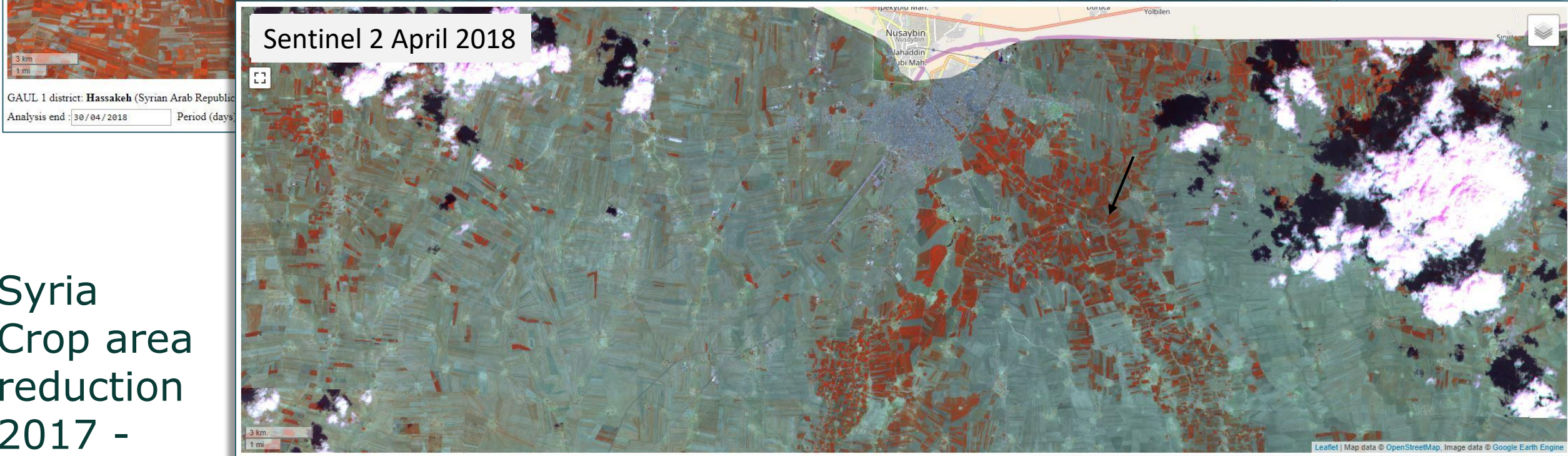
Extreme weather events  
[2019 Sudan floods link](#)



Sentinel 2 April 2017



Sentinel 2 April 2018



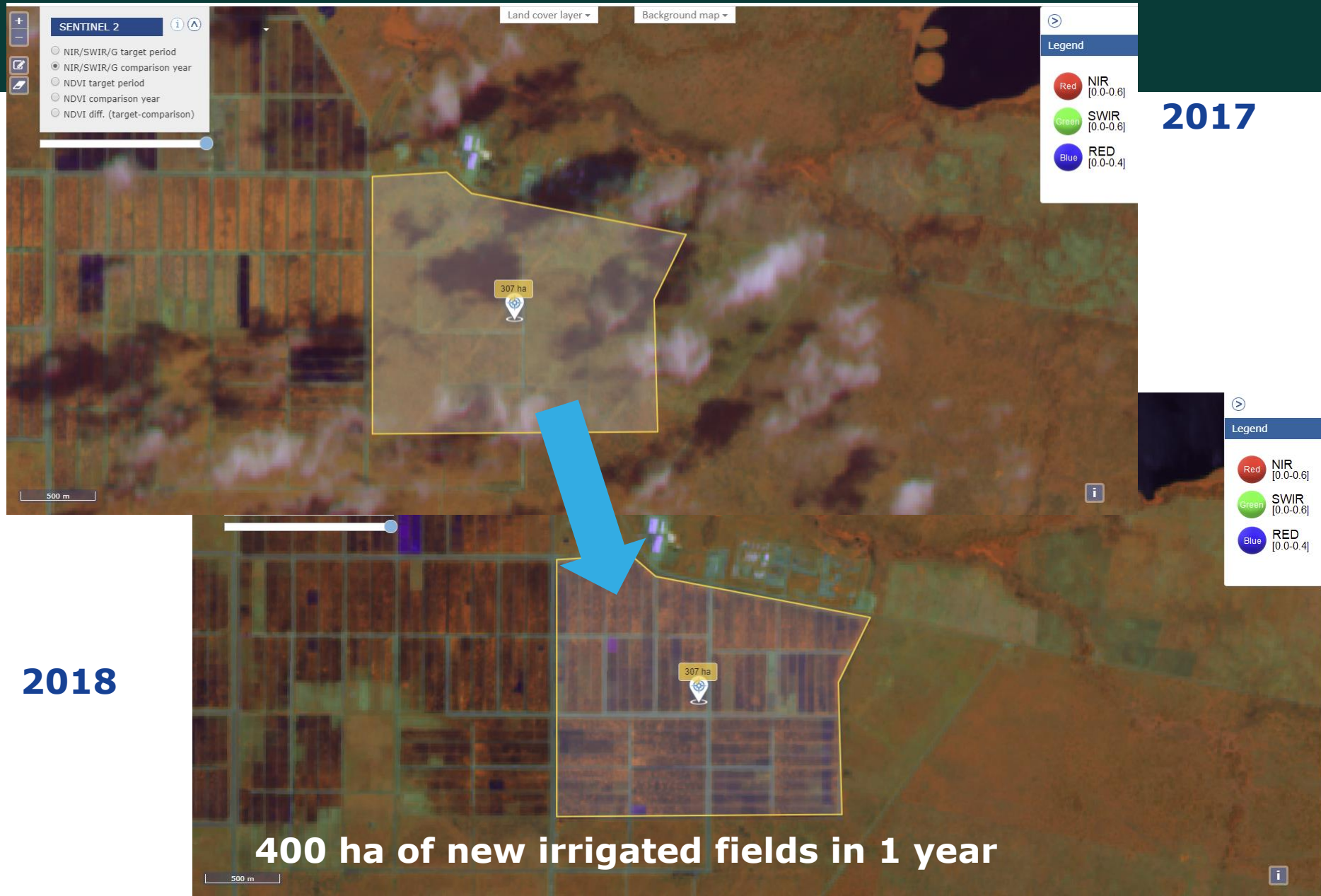
Syria  
Crop area  
reduction  
2017 -  
2018

GAUL 1 district: **Hassakeh** (Syrian Arab Republic)  
Analysis end : 30/04/2018    Period (days): 29    Max. cloud %age: 40    Retrieve imagery

Al Qamishili Hassakeh Governorate, Syria

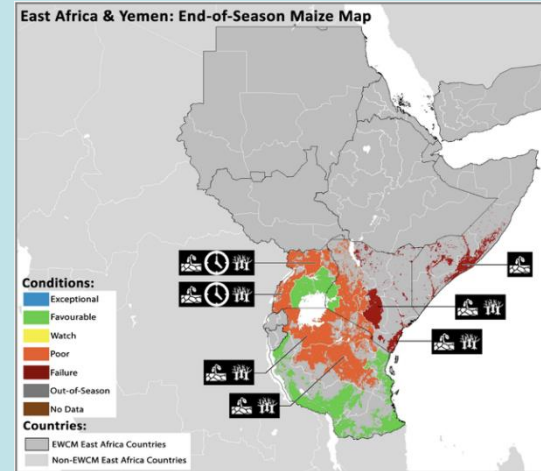


# Other applications: Monitoring large scale investments in Ethiopia

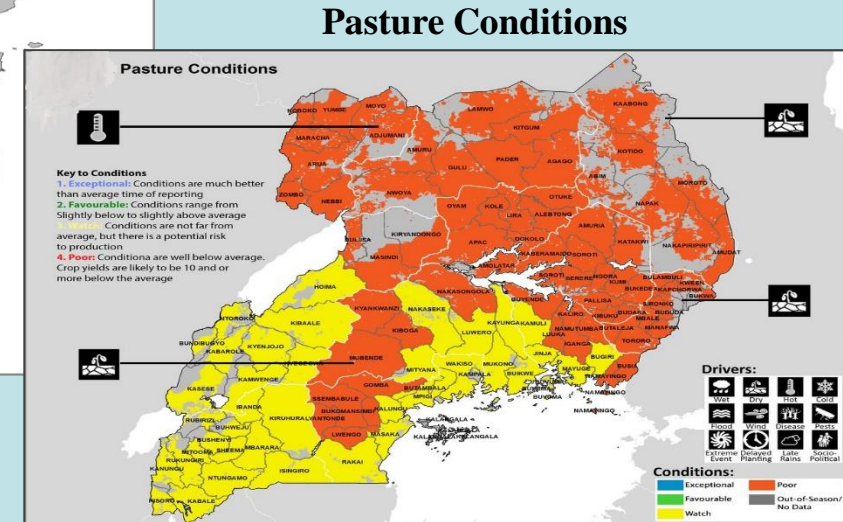


# EU Support to GEOGLAM at the country level

- GEOGLAM supports country govts. to establish national crop monitors similar to the CM4EW since 2016
- Examples include: Uganda, Tanzania, Kenya, regional crop monitor with IGAD
- COPERNICUS Global land service will provide means for agricultural monitoring baseline products complementary to existing Global Land Service products
- 2020: 1st pilot for study areas in: Northern Uganda, Western Kenya and Southern Tanzania in 2020



**Crop Monitor  
August 2017 for Uganda**



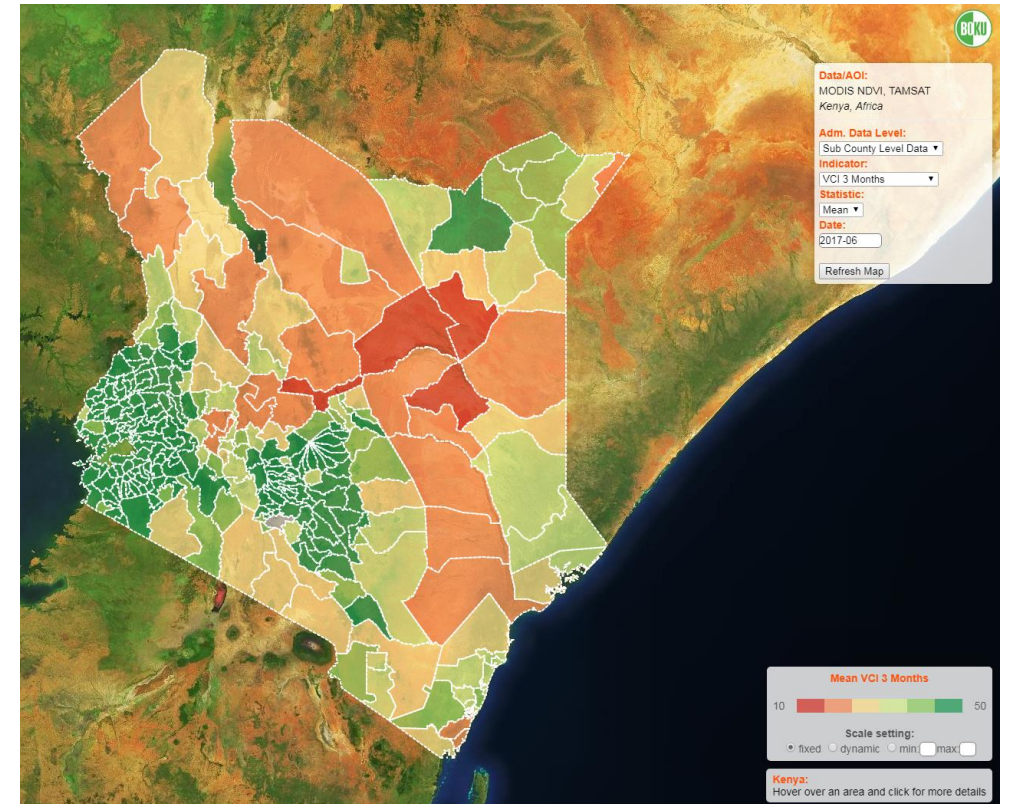
“In the past we always reacted to crop failure, spending billions of shillings to provide food aid in the region. 2017 was the first time we acted proactively because we had clear evidence from satellite data very early in the season”

Martin Owor, Commissioner Office of the Prime Minister (OPM)

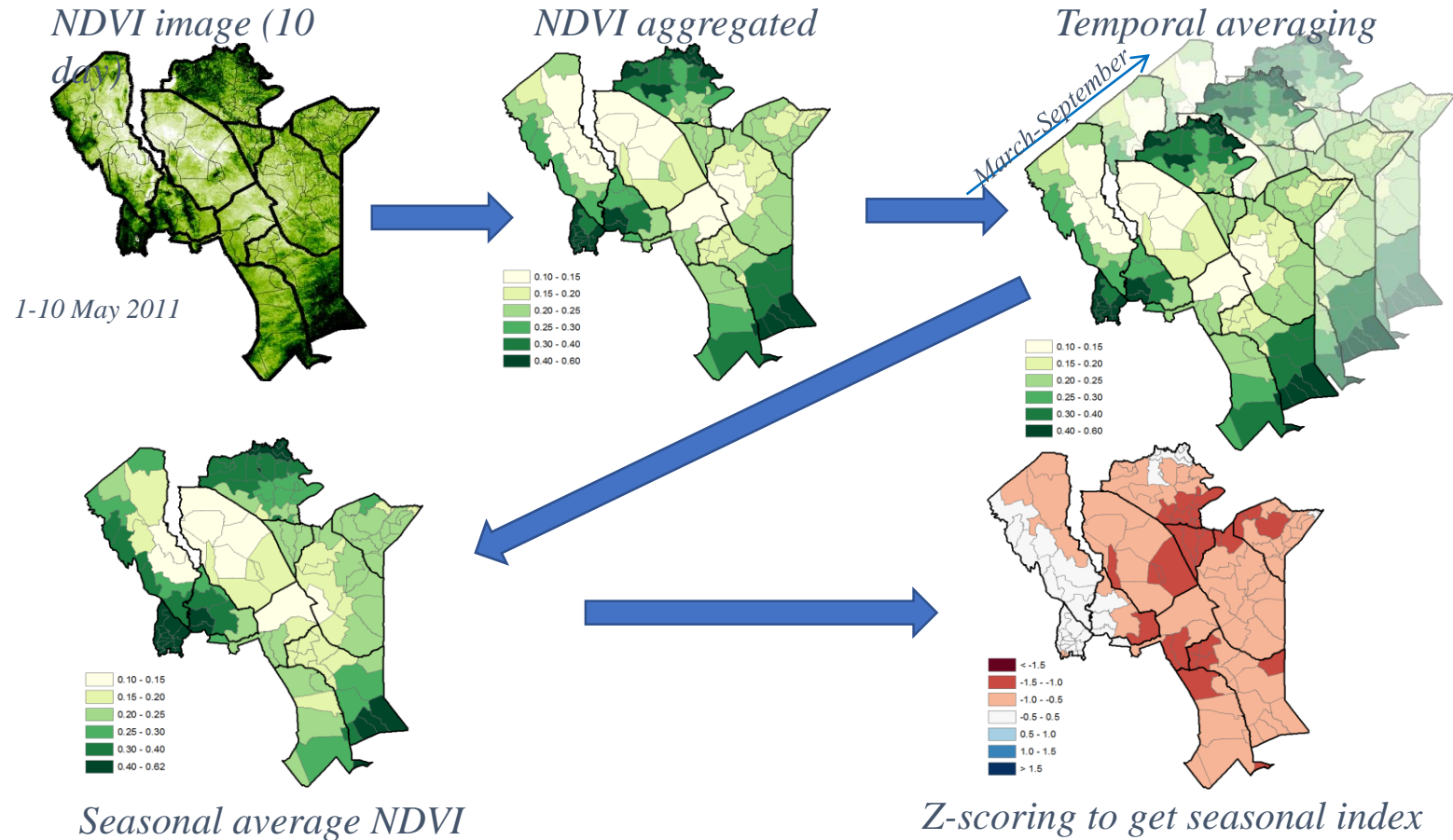


# Impact of improving drought risk management system (early warning component) with EO

- About 74% of the contingency funds disbursed (ca. 8 Mio. Euro) in 2016/2017 was used to mitigate against drought effects on livestock assets
- The pastoralists interviewed felt that the 2016/2017 drought was managed better than any other previous drought.
- The 2016/2017 drought was more severe in terms of rain scarcity (four failed or below normal rain seasons). But basically no livestock losses (as opposed to 2009 and 2011)



# Forage scarcity index (for livestock insurance)

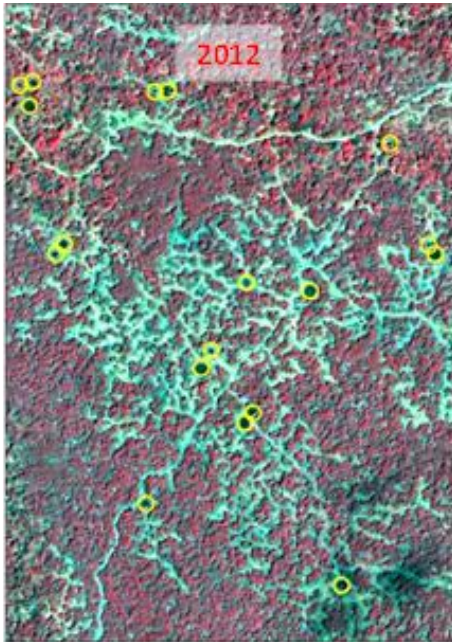


Vrieling, A., Meroni, M., Shee, A., Mude, A.G., Woodard, J., de Bie, C.A.J.M., Rembold, F., 2014. Historical extension of operational NDVI products for livestock insurance in Kenya. *International Journal of Applied Earth Observation and Geoinformation* 28, 238-251.



# Research activities examples

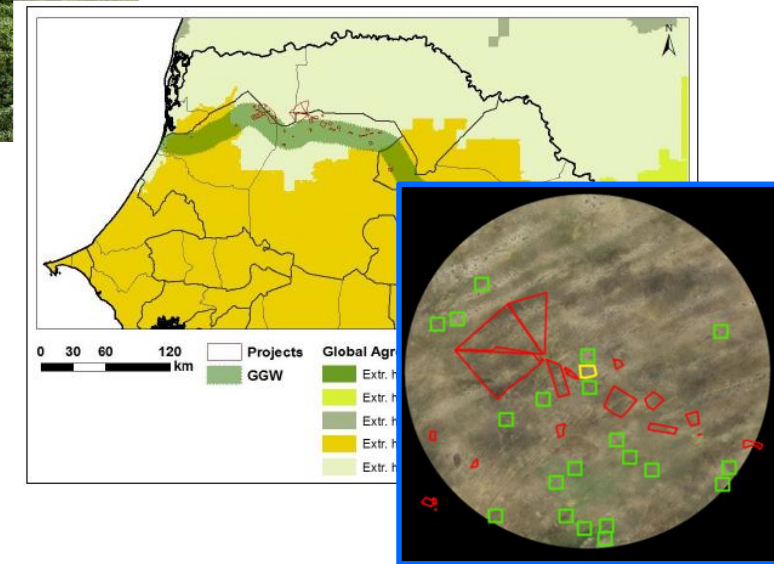
Monitoring natural resources (deforestation, invasive species...) and medium term impact of land restoration projects



*Rembold et. al 2015, Mapping areas invaded by Prosopis Juliflora in Somaliland on Landsat 8 imagery*



*Rembold et. al 2013, Mapping charcoal driven forest degradation during the main period of Al Shabaab control in Southern Somalia, Energy for Sust. Development.*



*Meroni et. al 2017, Remote sensing monitoring of land restoration interventions in semi-arid environments with a before-after control-impact statistical design*

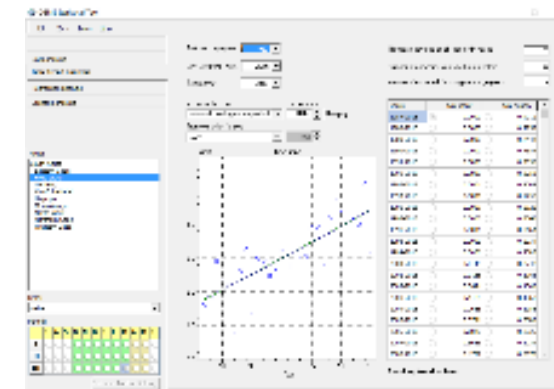
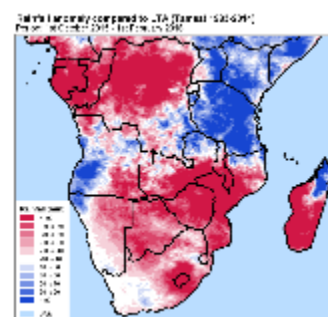
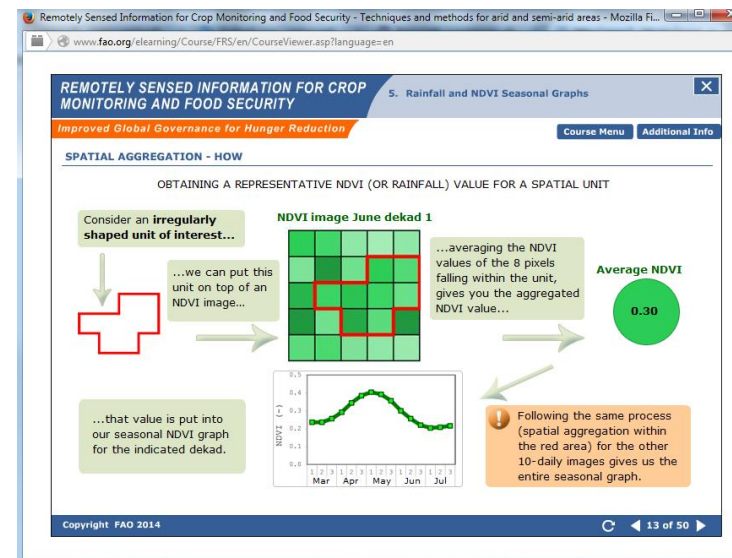
# Training with EO based agricultural monitoring tools

JRC provides training in EO crop monitoring with 3 main tools and in coordination with MESA/GMES&AFRICA and WMO:

- E-Learning Course – Understanding the basis of crop monitoring with remote sensing (produced with FAO)

<https://elearning.fao.org/course/view.php?id=155>

- ASAP – Anomaly hotspots of Agricultural Production
- CST – Statistical tool for yield forecasting (produced with Alterra and SIGMA project)
- GEE - provide training in the use of the GEE platform for agricultural monitoring







# The European Commission's Knowledge Centre for Global Food and Nutrition Security

LAUNCH EVENT  
PROGRAMME

28 November 2018

Brussels, Berlaymont, Walter Hallstein Room



[https://ec.europa.eu/knowledge4policy/global-food-nutrition-security\\_en](https://ec.europa.eu/knowledge4policy/global-food-nutrition-security_en)

Commission and its priorities

Policies, information and services



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European Commission > Knowledge for policy > Global Food and Nutrition Security

Knowledge for policy

KNOWLEDGE SERVICE

## Knowledge Centre for Global Food and Nutrition Security

We support the EU global commitment to end hunger, achieve food security and improve nutrition through a dedicated, reinforced science-policy interface and a fostered inter-policy dialogue.



# Challenges

Data quality... information accuracy

Provide the right evidence for policy needs and during right phase of policy cycle

Capacity and infrastructure in Africa

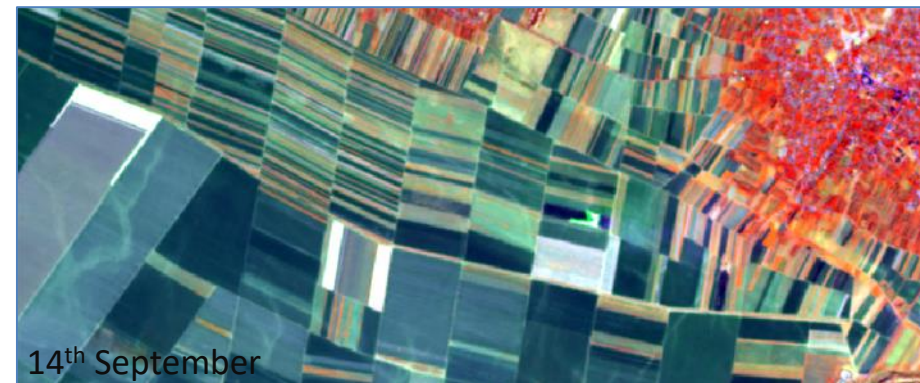
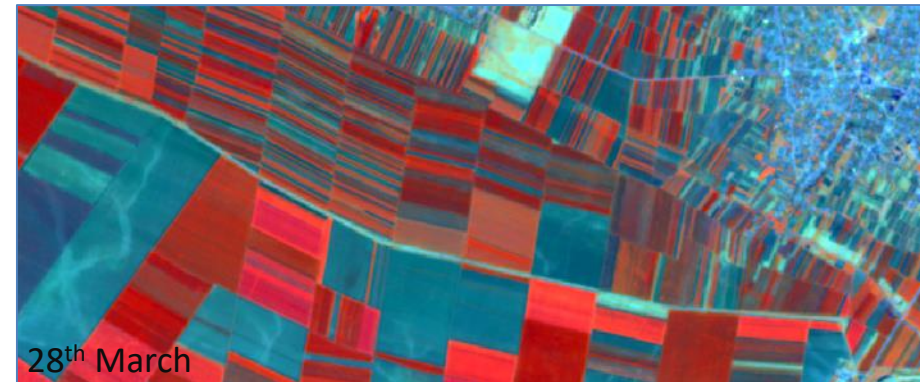
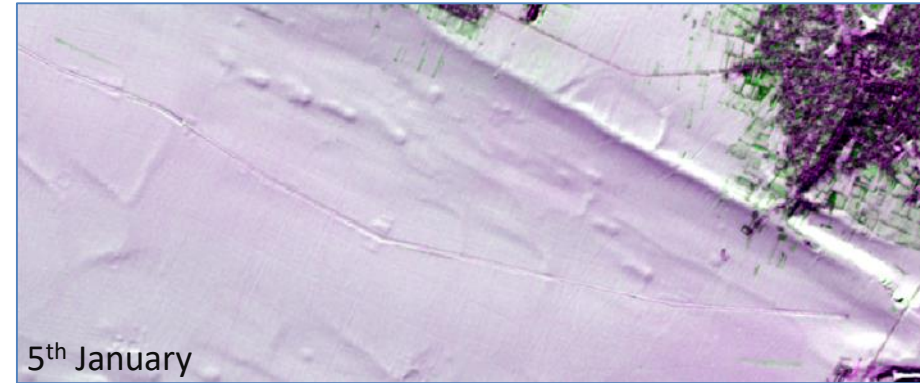
Knowledge concentration (space industry, big data, artificial intelligence...)

Need to involve private partners (JRC limited capacity)



# Future perspectives

- ① EO... agricultural knowledge at **multiple scales**; continent, country, farm, field and even within-field
- ② **Drives Research and Development**...expert systems, artificial intelligence, big data and data fusion
- ③ Promotes **policy coherence** and information sharing
- ④ A **key role for JRC**: working across policies, with space agencies, with industry, academia and with farmers from across the world





# Thanks

Any questions?



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