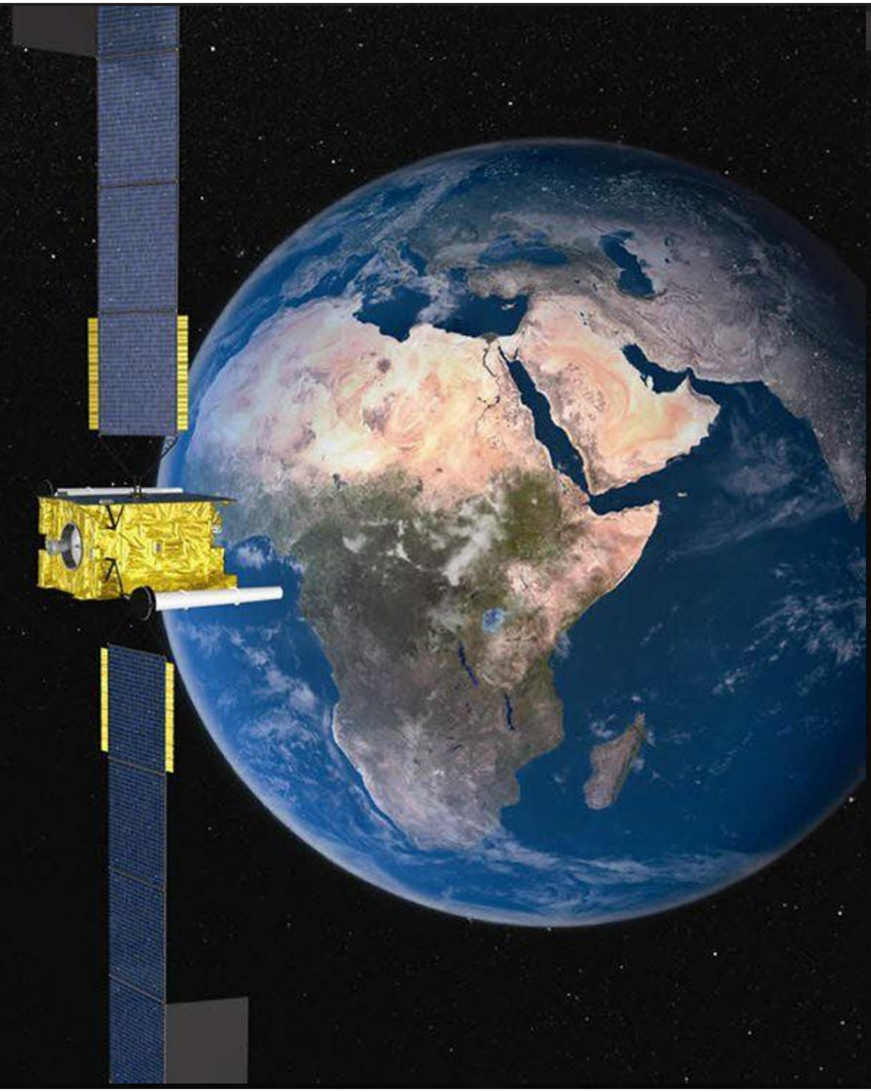
USE of Alternative data sources for the monitoring of SDG environmental indicators:

Satellite Data and Geospatial datasets



Lorenzo De Simone, Office of the Chief Statistician, FAO | 8 April 2020

EO-STAT

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FAO' custodianship of SDGs

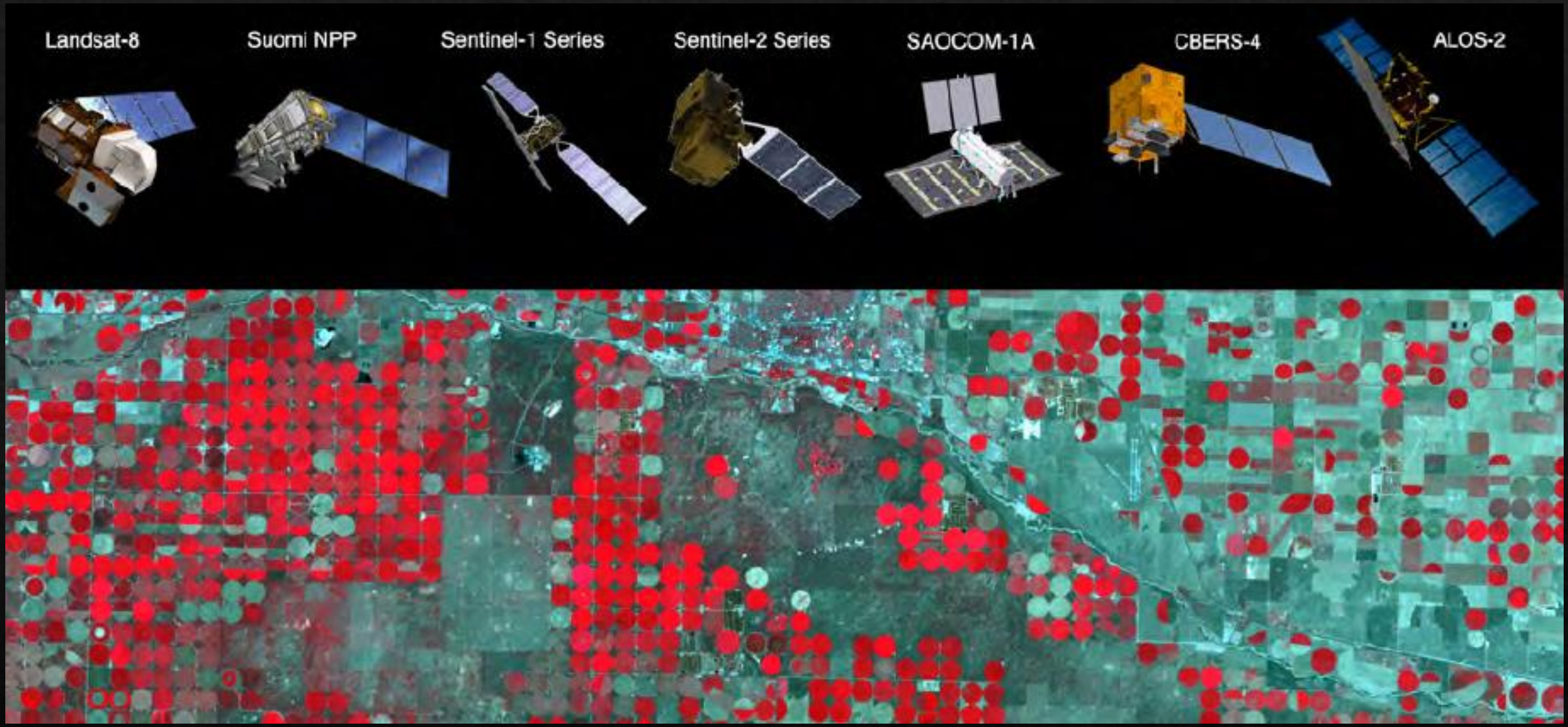
1) FAO is custodian agency of 21 SDG indicators. Under this mandate, FAO:
2) FAO supports countries to develop the statistical capacity to generate, disseminate and use national data, as well as realign their national monitoring frameworks to SDG indicators.
3) Leads the methodological development of indicators, collecting data from national sources, ensuring their comparability and consistency, and disseminating them at global level.
4) Contributes to monitoring progress at the global, regional and national levels, providing inputs to the global and regional SDG progress reports, providing analytical reports, and, more recently, developing its own digital SDG progress report

	SDG Indicators under FAO custodianship	Reporting Rate 2020 [reference period 2015–2019]*	% Change (absolute)
2.1.1	Prevalence of Undernourishment	82.1%	−2.0%
2.1.2	Prevalence of moderate or severe food insecurity in the population, based on the Food Insecurity Experience Scale	45.9%	16.8%
2.3.1	Volume of production per labour unit by classes of farming / pastoral / forestry enterprise size	1.5%	1.5%
2.3.2	Average income of small-scale food producers, by sex and indigenous status	2.6%	2.6%
2.4.1*	Proportion of agricultural area under productive and sustainable agriculture	0.0%	0.0%
2.5.1.a	Number of plant genetic resources for food and agriculture secured in medium or long term conservation facilities	50.5%* (with reference period 2010–2019)	9.2%
2.5.1.b	Number of animal genetic resources for food and agriculture secured in medium or long term conservation facilities	8.7%	−16.8%
2.5.2	Proportion of local breeds classified as being at risk of extinction	39.3%	5.6%
2.a.1	The agriculture orientation index for government expenditures	58.2%* (53% with reference year to 2017)	2.0%
2.c.1	Indicator of (food) price anomalies	78.1%	67.3%
5.a.1	(a) Percentage of people with ownership or secure rights over agricultural land (out of total agricultural population), by sex; and (b) share of women among owners or rights-bearers of agricultural land, by type of tenure	3.0%	3.0%
5.a.2	Proportion of countries where the legal framework (including customary law) guarantees women's equal rights to land ownership and/or control	8.0%	8.0%
6.4.1	Change in water use efficiency over time	26.0%* (with reference period 2008–2017)	26.0%
6.4.2	Level of water stress: freshwater withdrawal as a proportion of available freshwater resources	64.3%	34.7%
12.3.1	Food Loss Index	0.0%	0.0%
14.4.1	Proportion of fish stocks within biologically sustainable levels	Not applicable	Not applicable
14.6.1	Progress by countries in the degree of implementation of international instruments aiming to combat illegal, unreported and unregulated fishing	56.0%	56.0%
14.7.1	Sustainable fisheries as a percentage of GDP in Small Island Developing States, Least Developed Countries and all countries	54.1% * (with reference period 2011–2019)	54.1%
14.b.1	Progress by countries in the degree of application of a legal / regulatory / policy /institutional framework which recognizes and protects access rights for small-scale fisheries	61.1%	61.1%
15.1.1	Forest area as a percentage of total land area	100.0%	0.0%
15.2.1*	Progress towards sustainable forest management	69.2%	−2.0%
15.4.2	Mountain Green Cover Index	100.0%	6.9%

How satellite data can help SDG monitoring

Geospatial information and satellite earth observations offer unprecedented opportunities to support national and global statistical systems. Key benefits:

- More timely statistical outputs, reduced frequency of surveys
- Spatially-explicit information (disaggregation)
- Improvement of survey design through stratification



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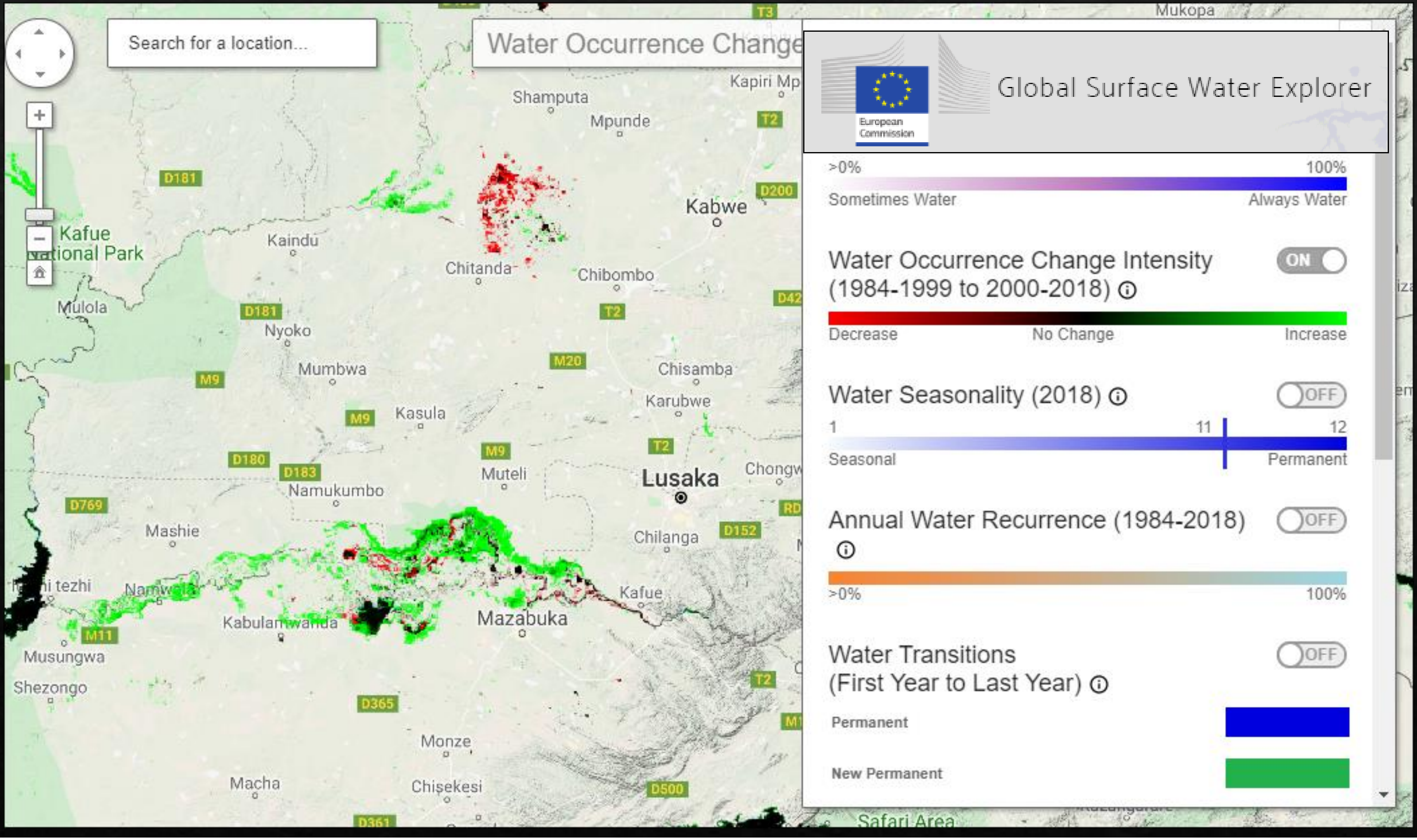
Relevance of EO data to the monitoring and reporting of SDG's under FAO custodianship

SDG Indicator		Role or Earth Observations			
		Primary source	Secondary source or proxy	Disaggregation	Survery design
2.1.1	Hunger		✓		✓
2.1.2	Severity of food insecurity		✓		✓
2.3.1	Productivity of small-scale food producers		✓	✓	
2.3.2	Income of small-scale food producers		✓	✓	
2.4.1	Agricultural sustainability	✓	✓	✓	
5.a.1	Women's ownership of agricultural land				✓
5.a.2	Women's equal right to land ownership				✓
6.4.1	Water use efficiency	✓	✓	✓	✓
6.4.2	Water stress	✓	✓	✓	✓
12.3.1	Global food losses		✓	✓	
14.4.1	Fish stock sustainability		✓		
14.6.1	Illegal, unreportd underregulated fishig		✓		
15.1.1	Forest area	✓		✓	✓
15.2.1	Sustaiable forest management	✓		✓	✓
15.4.2	Mountain Green Cover Index	✓		✓	✓

Earth observation for water related SDG

Satellite observations of the water cycle cover a broad range of parameters and at present hydro-meteorological and space agencies around the world are operating instruments to monitor all phases of the cycle.

SDG example: 6.6.1: change in extent of water-related ecosystems



Geospatial data for SDG 6.4.1 (Change in water use efficiency over time)

Satellite observation, alone or in combination with model-based data, can inform on WUE in agricultural sector.

Observable variables for agriculture: biomass (and yield, if crop is known); water consumption (actual evapotranspiration).

Examples from FAO WaPOR database

$$WUE = A_{we} \times P_A + I_{we} \times P_I + S_{we} \times P_S$$

Where:

- WUE = Water use efficiency (USD/m^3, or EUR/m^3);
- A_{we} = Irrigated agriculture water use efficiency (USD/m^3 or EUR/m^3);
- I_{we} = Industrial water use efficiency (USD/m^3 or EUR/m^3);
- S_{we} = Services water use efficiency (USD/m^3 or EUR/m^3);
- P_A = Proportion of water withdrawn by the agricultural sector over the total withdrawals;
- P_I = Proportion of water withdrawn by the industry sector over the total withdrawals; and
- P_S = Proportion of water withdrawn by the service sector over the total withdrawals.

Geospatial data for SDG 6.4.2 (Water stress)

Satellite observation, in combination with model-based data, can partially inform on TWW (for agriculture) and TRWR.

Observable variables: precipitation (P), water consumption (actual evapotranspiration, ETa).

Examples from FAO Water Accounting

ETa due to irrigation

TWW = Withdrawals A + other sectors

Stress (%) = TWW / (TRWR - Env.) * 100

TWRW = IRWR + ERWR

P – ETa (at basin level)

How WaPOR works

Ministry of Foreign Affairs of the Netherlands

IHE DELFT

IWMI International Water Management Institute

Consortium:

eleaf

vito

ITC UNIVERSITY OF TWENTE.

WATERWATCH FOUNDATION

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Geospatial data for SDG 15.4.2 (Mountain Green Cover Index)

In 2020 FAO:

1) Produced a global MGCI time series 2000-2018 with national estimates disaggregated by mountain range. Land cover statistics were also calculated
2) Results were shared with countries to support SDG reporting
3) Developed an EO tool to facilitate validation
4) Developed an MCGI StoryMap app to raise awareness and describe methodology
5) Submitted paper to peer review journal (in process)

Geospatial data for 2.4.1

(Proportion of agricultural area under productive and sustainable agriculture is based on farm surveys as the primary data source)

2.4.1 is a complex land-based indicator defined as:

$$SDG2.4.1 = \frac{Area\ under\ productive\ and\ sustainable\ agriculture}{Agricultural\ land\ area *}$$

The nominator inludes11 sub-indicators, among which the prevalednce of soil degradation which embeds further 4 sub-sub indicators.

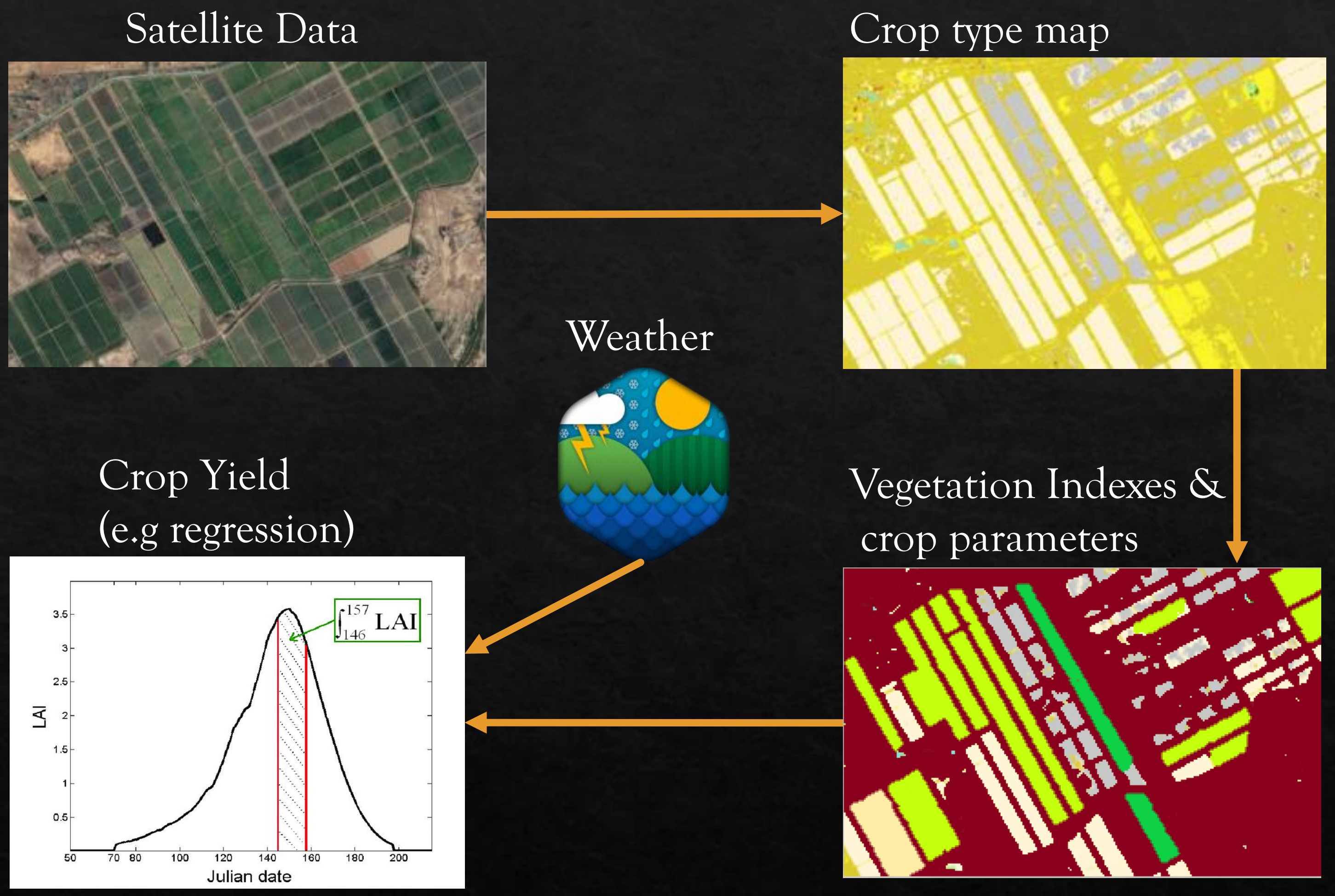
EO data can be used as key data source, or as complementary. It can beused to improve survey design.

Subindicator	Theme	Sub-indicator	Relevance of EO Data		
			Key data source	Complementary data source	Improve survey design
1	Land productivity	Farm output value per hectare		Crop productivity	✓
2	Profitability	Net farm income			✓
3	Resilience	Risk mitigation mechanisms		Farm diversification	✓
4	Soil health	Prevalence of soil degradation	Soil erosion, Reduction in soil fertility, Salinization of irrigated land, and Waterlogging		✓
5	Water use	Variation in water availability	Actual Evapotranspiration and Interception		✓
6	Fertilizer pollution risk	Management of fertilizers		Use of cover crops and buffer strips along waterways	✓
7	Pesticide risk	Management of pesticides		Crop rotation and the planting time	✓
8	Biodiversity	Use of agro-biodiversity-supportive practices		Natural or diverse vegetation on a farm, diverse farm production, and crop or crop/pasture rotation.	✓
9	Decent employment	Wage rate in agriculture			✓
10	Food security	Food insecurity Experience Scale (FIES)			✓
11	Land tenure	Secure tenure rights to land			✓

Land Productivity

Crop type maps can be used to estimate yield and productivity.

- Different approaches can be used depending on availability of in situ data (Regression, Inversion, AI)
- Based on relationship bewteem yield observed in the field and vegetation index time series derived from satellite data
- Estimation through Harvest Index



Yield = $f(\int_{146}^{157} LAI)$

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Soil health

1. Soil erosion
2. Reduction in soil fertility
3. Salinization of irrigated land
4. Waterlogging

RUSLE $A=R*K*LS*C*P$

A is the average annual soil loss (t ha-1 y-1)
R is the rainfall-runoff erosivity factor
K is a soil erodibility factor
LS is a slope length-steepness factor (dimensionless)
C is a cover management factor (dimensionless)
P is a support practice factor (dimensionless)

EO DATA
Precipitation
Digital Elevation Model
NDVI
Land Cover

Soil health

1. Soil erosion
2. Reduction in soil fertility
3. Salinization of irrigated land
4. Waterlogging

EO data be used to make an approximation of soil fertility based on crop growth.

This can be done with the Normalized Difference Vegetation Index (NDVI) based on satellite data

Another proxy for soil fertility could be SOC. When available, national SOC maps can be used, however, there are also several global datasets available

EO DATA
NDVI
Crop Type Map
Precipitation
SOC map

EO-STAT

Soil health

1. Soil erosion
2. Reduction in soil fertility
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Multispectral and hyperspectral data can be used to detect, monitor, and map the salinity in the soil.

The spectral reflection of salt features at the soil surface has been used as a direct indicator.

There is also an indirect approach to detect areas affected by soil salinity, namely by using the performance level of vegetation

EO based Vegetattion Indexed and Salinity Indexes	
NDVI	$\frac{Red - NIR}{Red + NIR}$
Soil adjusted vegetation index (SAVI)	(NIR - R) / (NIR + R +L) (1 + L)
Salinity index (SI-T)	(R / NIR) * 100
Brightness Index (BI)	$\sqrt{R^2 + NIR^2}$
Normalized difference salinity index (NDSI)	(R -NIR) / (R + NIR)
Salinity Index (SI)	$\sqrt{B * R}$
Etc.	

Soil health

1. Soil erosion
2. Reduction in soil fertility
3. Salinization of irrigated land
4. Waterlogging

The Modified Normalized Difference Water Index (MNDWI) is a time and cost-effective tool to identify waterlogged areas.

The index ranges from -1 to +1, where positive values indicate water and negative values vegetation.

The MNDWI is based on the Normalized Difference Water Index (NDWI) of McFeeters (1996). The MNDWI is a better index than NDWI for extracting water features mixed with vegetation from the satellite image.

EO DATA	
MNDWI	$\frac{G - SWIR}{G + SWIR}$

EO-STAT

What is EO-STAT ?

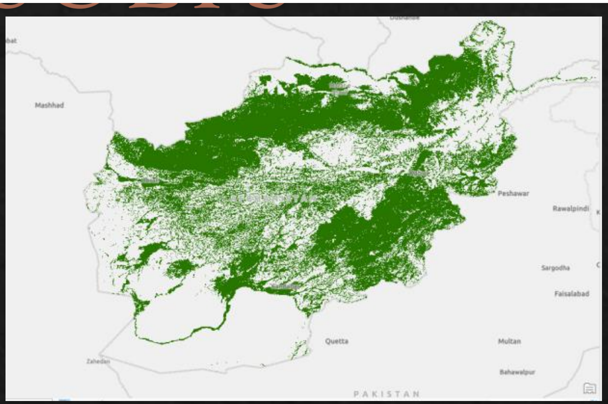
- EOSTAT is an FAO initiative led by the Office of the Chief Statistician, aiming at building capacity in coutries in the use of EO to produce national agricultural statistics and support the process of modernization of agricultural statistical systems.
- **4 pilots** are implemented: **Senegal**, **Uganda**, **Afghanistan** and **Lesotho.**
- Principal national counterparts: **DAPSA, UBOS, NSIA, MAFS**
- Data pipeline and analysis using **Sen2Agri deployed on the UN Global Platform, and Google Earth Engine**

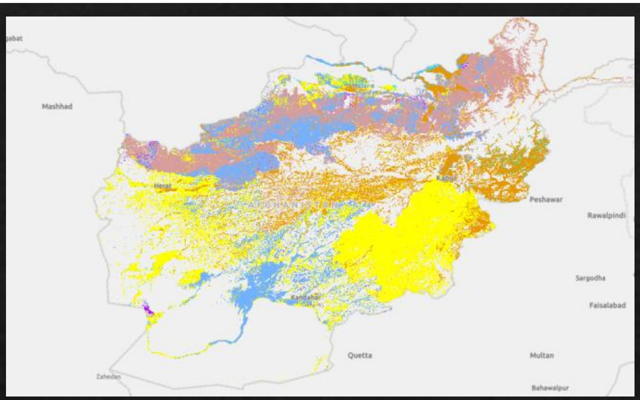
Afghanistan

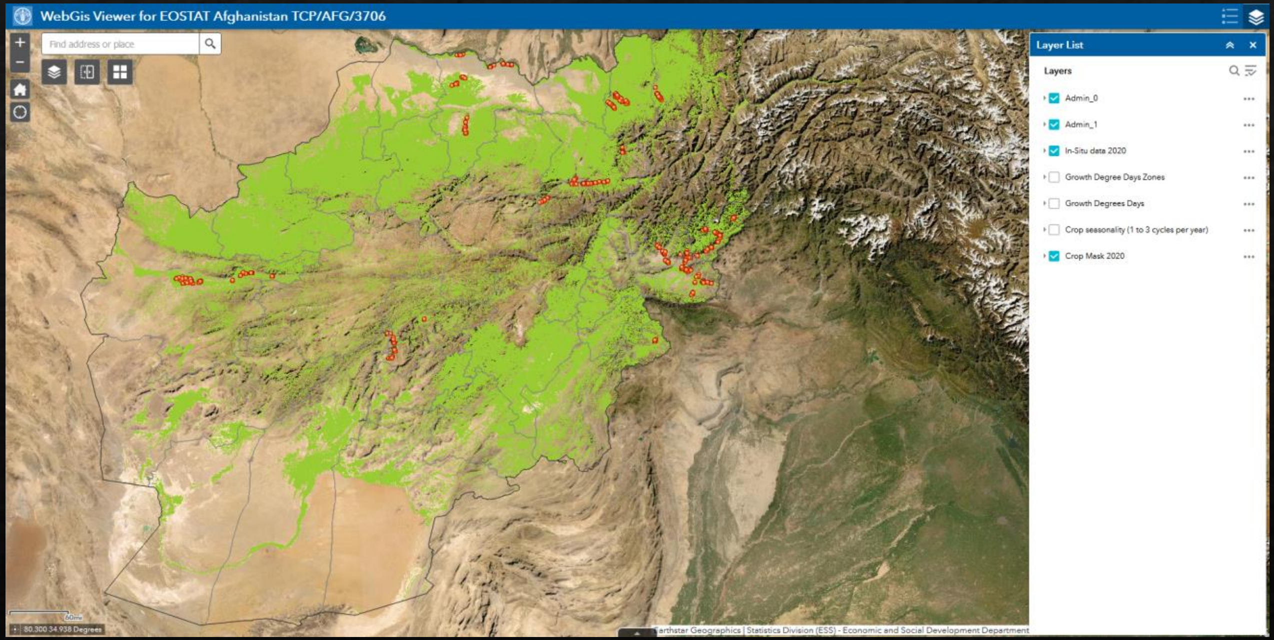
- In situ data gathered from NSIA
- Algorithm dev and benchmarking
- Crop mask
- Crop seasonality map
- Crop type map
- Map viewer [Link]
- Training

NEXT STEPS Q2-Q4 2021

- Automatisation of crop classification and development of a google app
- Training

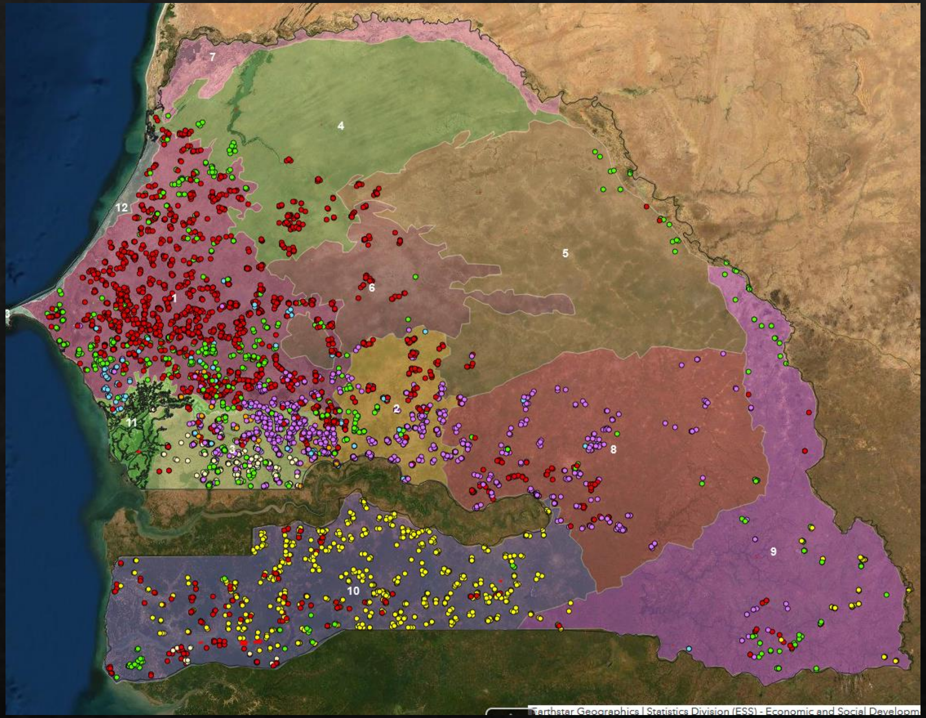






Senegal

- Sen2Agri tool box deployed on UNGP
- Historical situ data gathered from DAPSA and QA-QC
- Prototype crop mask produced
- Crop type map produces
- 4 Trainings delivered (field work and Sen2Agri toolbox)

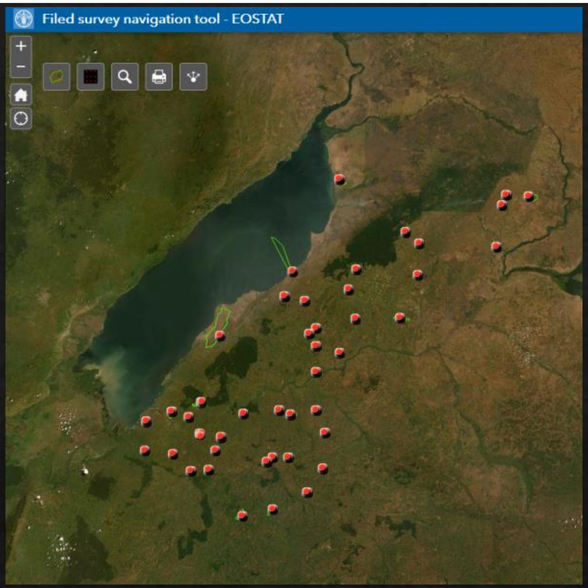


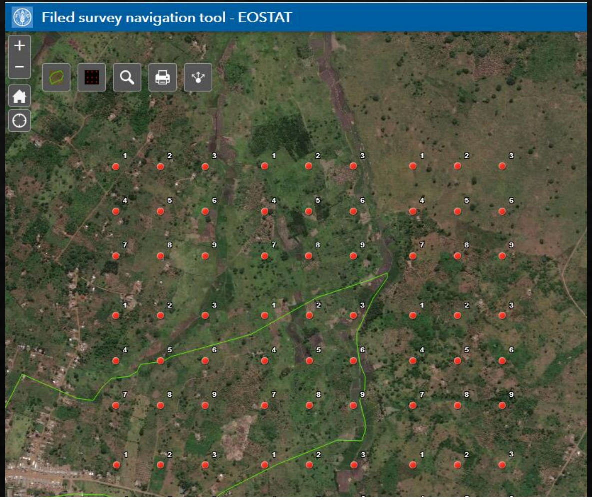
Uganda

- Ad hoc field survey protocol developed and implemented
- 1 training delivered on best practices in field data collection

NEXT STEPS Q1-Q2 2021

- Development of crop mask and crop type map
- Extraction of crop acreage statistics and crop yield
- Hands-on webinar





Thank you