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

Satellite Data and Geospatial datasets
CONTENTS

1) FAO’s role as custodian
2) Key advantages of EO data for SDG Monitoring
3) Relevance of EO data to indicators under FAO’s custodianship
4) Examples from SDGs 15, 6 and 2
5) EO-STAT
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.
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
Relevance of EO data to the monitoring and reporting of SDG’s under FAO custodianship

<table>
<thead>
<tr>
<th>SDG Indicator</th>
<th>Role or Earth Observations</th>
<th>Primary source</th>
<th>Secondary source or proxy</th>
<th>Disaggregation</th>
<th>Survey design</th>
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<tbody>
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<td>2.1.1 Hunger</td>
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<td>2.1.2 Severity of food insecurity</td>
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<td>2.3.1 Productivity of small-scale food producers</td>
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<tr>
<td>2.3.2 Income of small-scale food producers</td>
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<td>2.4.1 Agricultural sustainability</td>
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<td>2.4.2 Women’s ownership of agricultural land</td>
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<tr>
<td>5.a.1 Women’s equal right to land ownership</td>
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<td>5.a.2 Water use efficiency</td>
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<td>6.4.1 Water stress</td>
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<td>6.4.2 Water use efficiency</td>
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<td>12.3.1 Global food losses</td>
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<td>14.4.1 Fish stock sustainability</td>
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<td>14.6.1 Illegal, unreported, underregulated fishing</td>
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<td>15.1.1 Forest area</td>
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<td>15.2.1 Sustainable forest management</td>
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<td>15.4.2 Mountain Green Cover Index</td>
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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;
- \(P_S\) = Proportion of water withdrawn by the service sector over the total withdrawals.
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:

\[
\text{TWW} = \text{Withdrawals A} + \text{other sectors}
\]

\[
\text{ETa due to irrigation}
\]

\[
\text{TWRW} = \text{IRWR} + \text{ERWR}
\]

\[
\text{P} - \text{ETa (at basin level)}
\]

\[
\text{Stress (\%)} = \frac{\text{TWW}}{\text{TRWR} - \text{Env.}} \times 100
\]
How WaPOR works
15.4.2 is essentially a LCLU based indicator and FAO has developed in 2020 a methodology to measure and monitor using freely available global land cover data and elevation data. Countries can use the methodology as is, or can customize using national datasets. Methodology was used by FAO to support countries reporting in 2020.

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:

\[
\text{SDG2.4.1} = \frac{\text{Area under productive and sustainable agriculture}}{\text{Agricultural land area}}
\]

The nominator includes 11 sub-indicators, among which the prevalence of soil degradation which embeds further 4 sub-sub indicators.

EO data can be used as key data source, or as complementary. It can be used to improve survey design.
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 between yield observed in the field and vegetation index time series derived from satellite data
- Estimation through Harvest Index

\[
\text{Crop Yield (e.g regression)} = f \left( \int_{146}^{157} \text{LAI} \right)
\]
Soil health

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

RUSLE \[ A = R \times K \times LS \times C \times P \]

- 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
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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.

<table>
<thead>
<tr>
<th>EO DATA</th>
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<tbody>
<tr>
<td>NDVI</td>
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<tr>
<td>Crop Type Map</td>
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<tr>
<td>Precipitation</td>
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<tr>
<td>SOC map</td>
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</tbody>
</table>
Soil health

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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.

<table>
<thead>
<tr>
<th>EO based Vegetation Indexed and Salinity Indexes</th>
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<tbody>
<tr>
<td>NDVI</td>
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<tr>
<td>Soil adjusted vegetation index (SAVI)</td>
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<tr>
<td>Salinity index (SI-T)</td>
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<tr>
<td>Brightness Index (BI)</td>
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<tr>
<td>Normalized difference salinity index (NDSI)</td>
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<tr>
<td>Salinity Index (SI)</td>
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<tr>
<td>Etc.</td>
</tr>
</tbody>
</table>

\[
\text{NDVI} = \frac{Red - NIR}{Red + NIR}
\]

\[
\text{Soil adjusted vegetation index (SAVI)} = \frac{(NIR - R)}{(NIR + R + L)(1 + L)}
\]

\[
\text{Salinity index (SI-T)} = \frac{(R)}{NIR} * 100
\]

\[
\text{Brightness Index (BI)} = \sqrt{R^2 + NIR^2}
\]

\[
\text{Normalized difference salinity index (NDSI)} = \frac{(R - NIR)}{(R + NIR)}
\]

\[
\text{Salinity Index (SI)} = \sqrt{B * R}
\]
Soil health

1. Soil erosion
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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.
What is EO-STAT?

- EOSTAT is an FAO initiative led by the Office of the Chief Statistician, aiming at building capacity in countries 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