CAP monitoring in Romania using Copernicus data – Challenges and Perspectives


Institution:
* Terrasigna, Romania,
** Romanian Agency for Payments and Intervention in Agriculture (APIA), Romania.
Structure of presentation

1. The Romanian agricultural landscape
2. DataBio project
3. Copernicus data for agriculture monitoring in Romania
4. Validation and results
5. Conclusions and perspectives
Several social-economical events in Romania's history have produced consequences that still make great influence on the current agricultural development.

In 2007, Romania joined the EU, marking a new era in the agricultural economy and rural development of the country.

In this context, Romania had to quickly adapt their agricultural economy and rural development in order to integrate into the EU internal market and fully adopt the Common Agricultural Policy (CAP).
The Romanian Agricultural Landscape

• According to the Food and Agriculture Organisation of the United Nations (FAO) in 2011 Romania holds **139.820 km²**, more than half of its territory

• The total area eligible for CAP support in 2018 sums **96.781 km²** according to the Romanian Agency for Payments and Intervention in Agriculture (APIA)

• The Eurostat Yearbook 2010 places Romania on **rank 6 in EU** with **0.41 ha arable land per inhabitant**, almost double comparing with the EU average

• Agriculture in Romania is not yet established as a strong economic branch. According to the Romanian National Statistics Institute, in 2013 the agriculture contributed mere **5.6% to the national GDP** while employing close to **30% of the country’s workforce**
The Romanian Agricultural Landscape

- Between 2016 and 2018 the total declared area **increased** with 2500 km$^2$.
- Between 2016 and 2018 the total number of plots eligible for CAP support decreased with 49,291 (0.79%).
- Currently (2018) 9,678,170 hectares corresponding to 6,141,512 plots are registered for CAP support.

Romania - total declared area and number of plots registered for CAP support (2016-2018) Data Source: Agency for Payments and Intervention in Agriculture (APIA), Romania
The current structure of agricultural holdings (2018) reveals that the small plots (< 5 ha) represent 95% of the total number of plots registered for CAP support while accounting for only 46% of the total area.

Medium-size plots (5 - 30 ha) represent 4.31% of the total number of registered plots and 30% of total area.

Big plots (> 30 ha) represent < 1% of the total number of registered plots and 24% of total area.

<table>
<thead>
<tr>
<th>Plots / Holdings</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of plots</td>
<td>Area (ha)</td>
<td>%</td>
</tr>
<tr>
<td>0-5 ha</td>
<td>5902049</td>
<td>4340670</td>
<td>46</td>
</tr>
<tr>
<td>5 -10 ha</td>
<td>140743</td>
<td>966924</td>
<td>10</td>
</tr>
<tr>
<td>10-20 ha</td>
<td>78584</td>
<td>1081416</td>
<td>11</td>
</tr>
<tr>
<td>20-30 ha</td>
<td>28662</td>
<td>692460</td>
<td>7</td>
</tr>
<tr>
<td>30-50 ha</td>
<td>23215</td>
<td>883897</td>
<td>9</td>
</tr>
<tr>
<td>50-100 ha</td>
<td>13913</td>
<td>937294</td>
<td>10</td>
</tr>
<tr>
<td>&gt; 100 ha</td>
<td>3637</td>
<td>518091</td>
<td>5</td>
</tr>
</tbody>
</table>

Romania - Structure of agricultural holdings (2016 - 2018) based on UAA size
Data Source: Agency for Payments and Intervention in Agriculture (APIA), Romania
The Agency for Payments and Intervention in Agriculture (APIA) performs annual verifications of the farmers that applied for subsidies using 3 approaches:

- “classical” on-site verifications;
- compliance verifications;
- verifications using remote sensing techniques.

In 2015, 56,669 farmers were selected for verifications:

- 7,091 - “classical” on-site verifications;
- 7,686 - compliance verifications
- 41,892 - verifications using remote sensing techniques.

The overall reported error rate for the 2014 campaign is 2.93%, while for 2013 is 2.01%.
Copernicus data for agriculture monitoring in Romania

Challenges
- large area to be surveyed
- geographical variability
- small / narrow plots
- crops diversity
- clouds

A service for agriculture monitoring in Romania should be able to
- address small / narrow plots distributed over diverse location
- provide results for a broad variety of crops
- make use of the Copernicus Sentinel temporal resolution

Copernicus Sentinel-2
- 10 m spatial resolution
- 5 days revisiting time
- superior radiometric resolution
- archive since 2015
- sustainability (no data costs)
- continuity
DATABio – Data-driven Bioeconomy

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 732064

This project is part of BDV PPP

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DataBio Consortium

- 48 Partners
- 17 states (14 member states)
- 70+ associated partners
- 3 pilots focused on forestry, agriculture & fishery
Romania, CAP support monitoring

- Under the framework of DataBio project Terrasigna developed a CAP support monitoring service for 3 areas of interest
- The AOIs are located in the most representative agricultural areas
- 2 iterations: 2017 and 2018
- 885,290 plots, 2,116,138 hectares
- Representative sample. The 3 AOIs sum up to 21% out of the total declared area in Romania and 14% out of the total number of plots registered under the CAP.
- Input EO data: Copernicus Sentinel-2 and LANDSAT
- Romanian National Projection System - Stereo 70 (EPSG 3844)
• **Very small plots (< 0.5 ha)** account for a small total area (4%) despite their count (34.2%).

• **Small plots (0.5-2 ha)** account for 17% of the total area and 46% of total count.

• **Medium plots (2-10 ha)** account for 26% of the total area and 15% of total count.

• **Large plots (>10 ha)** account for 53% of the total area and 5% of total count.

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**Total declared area and plots count within the 3 AOIs (2018)**

Data Source: Agency for Payments and Intervention in Agriculture (APIA), Romania
Romania, CAP support monitoring

• **New innovative approach developed by Terrasigna.**

• **Input data:**
  ✦ Earth Observation data ingested as satellite images time series (SITS): Copernicus Sentinel-2 & LANDSAT
  ✦ declared crop types - geometry + crop code (following APIA classification index)

• The classes of pixels with similar evolution are extracted from the SITS through a fuzzy-statistic approach. Each pixel receives a confusion matrix, expressing the probability of belonging to a specific crop type in every individual scene (i.e. at every observed moment).

• **The final results are observed crops maps and compliance maps of discrete levels of trust.** The level of trust can be expressed at pixel or parcel level. Low level of trust means that, from the algorithm’s point of view, the current location (pixel or parcel) was cultivated with a different crop then the one declared. A high level of trust means that the observed crop matches the declared one.
Classes of pixels with similar evolution are extracted from the SITS through a fuzzy-statistic approach. Each pixel receives a confusion matrix, expressing the probability of belonging to a specific crop type in every individual scene.

The main results are crops maps and compliance maps with discrete levels of trust. The information can be expressed at both pixel and plot level. Low level of trust indicates a different crop comparing to the one initially declared.
Sentinel-2 natural colors mosaic (27.04.2018)

Background image: Copernicus Sentinel data, 2018
Compliance map

- **compliant** (the result matches the farmer declaration)
- **insufficient evidence** (not enough information for crop identification)
- **non-compliant** (the result does not match the farmer declaration)
### Validation campaigns

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Validation data source</strong></td>
<td>Ground truth data</td>
<td>Ground truth data</td>
<td>Ground truth data</td>
<td>Reference data</td>
</tr>
<tr>
<td><strong>Sample size</strong></td>
<td>46 plots, 1702 ha</td>
<td>66 plots, 278 ha</td>
<td>54 plots, 2640 ha</td>
<td>6406 plots, 77.221 ha</td>
</tr>
<tr>
<td><strong>Number of crops</strong></td>
<td>6</td>
<td>7</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td><strong>Overall accuracy</strong></td>
<td>91.3%</td>
<td>97%</td>
<td>96.5%</td>
<td>98.3%</td>
</tr>
</tbody>
</table>
Validation using reference data

- **Reference plots** derived independently against VHRO, Sentinel-2 & other data sources

- **Independent validation** for all 3 AOI (only West completed so far!) against the declaration

- **Representative reference sample:** (West AOI) 6406 plots (6.58% of total) summarising 77,221 ha (21% of total)

- The validation focused on the 8 most predominant crops. The 8 crops sum up to more than 90% of the total declared area

- The results are detailed for 7 plots classes:
  - very small plots <1ha,
  - small plots: 1-1.5ha, 1.5-2.5ha,
  - medium plots: 2.5-5ha, 5-10ha, 10-20ha,
  - large plots: >20ha
Validation - overall conclusions all crops

- **Overall performance**: 98.3% correct estimations
- Increased performance for the large plots
Validation - winter wheat

- **Overall performance**: 98.3% correct estimations, 0.73% omissions

<table>
<thead>
<tr>
<th>Plot class</th>
<th>Total declared area (ha)</th>
<th>Reference area (ha)</th>
<th>Correct estimation (%)</th>
<th>Omission (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1 ha</td>
<td>4773 ha</td>
<td>130 ha</td>
<td>99.1%</td>
<td>1.25%</td>
</tr>
<tr>
<td>1 - 1.5 ha</td>
<td>5232 ha</td>
<td>226 ha</td>
<td>98.6%</td>
<td>1.54%</td>
</tr>
<tr>
<td>1.5 - 2.5 ha</td>
<td>9963 ha</td>
<td>619 ha</td>
<td>97.5%</td>
<td>0.97%</td>
</tr>
<tr>
<td>2.5 - 5 ha</td>
<td>17913 ha</td>
<td>1919 ha</td>
<td>98.2%</td>
<td>1.27%</td>
</tr>
<tr>
<td>5 - 10 ha</td>
<td>18847 ha</td>
<td>3073 ha</td>
<td>98.5%</td>
<td>1.14%</td>
</tr>
<tr>
<td>10 - 20 ha</td>
<td>18808 ha</td>
<td>4494 ha</td>
<td>98.3%</td>
<td>0.60%</td>
</tr>
<tr>
<td>&gt; 20 ha</td>
<td>48720</td>
<td>22208</td>
<td>99.4%</td>
<td>0.25%</td>
</tr>
</tbody>
</table>
## Validation - overall results

<table>
<thead>
<tr>
<th></th>
<th>&lt; 1 ha</th>
<th>1 - 1.5 ha</th>
<th>1.5 - 2.5 ha</th>
<th>2.5 - 5 ha</th>
<th>5 - 10 ha</th>
<th>10 - 20 ha</th>
<th>&gt; 20 ha</th>
<th>overall performance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Winter wheat</strong></td>
<td>99.1%</td>
<td>98.6%</td>
<td>97.5%</td>
<td>98.2%</td>
<td>98.5%</td>
<td>98.3%</td>
<td>99.4%</td>
<td>98.7%</td>
</tr>
<tr>
<td></td>
<td>N=130 ha</td>
<td>N=226 ha</td>
<td>N=619 ha</td>
<td>N=1919 ha</td>
<td>N=3073 ha</td>
<td>N=4494 ha</td>
<td>N=22.208 ha</td>
<td></td>
</tr>
<tr>
<td></td>
<td>98.6%</td>
<td>97.5%</td>
<td>98.2%</td>
<td>98.5%</td>
<td>98.3%</td>
<td>99.4%</td>
<td>99.5%</td>
<td>99.9%</td>
</tr>
<tr>
<td><strong>Maize</strong></td>
<td>99%</td>
<td>94.4%</td>
<td>90.7%</td>
<td>88.1%</td>
<td>90.1%</td>
<td>93.1%</td>
<td>99.1%</td>
<td>93.7%</td>
</tr>
<tr>
<td></td>
<td>N=22 ha</td>
<td>N=30 ha</td>
<td>N=81 ha</td>
<td>N=216 ha</td>
<td>N=396 ha</td>
<td>N=679 ha</td>
<td>N=4877 ha</td>
<td></td>
</tr>
<tr>
<td><strong>Sunflower</strong></td>
<td>97.8%</td>
<td>97.8%</td>
<td>99.6%</td>
<td>96.7%</td>
<td>99.3%</td>
<td>99.1%</td>
<td>99.5%</td>
<td>98.8%</td>
</tr>
<tr>
<td></td>
<td>N=25 ha</td>
<td>N=41 ha</td>
<td>N=109 ha</td>
<td>N=320 ha</td>
<td>N=664 ha</td>
<td>N=1008 ha</td>
<td>N=3663 ha</td>
<td></td>
</tr>
<tr>
<td><strong>Soybean</strong></td>
<td>100%</td>
<td>92.1%</td>
<td>90.1%</td>
<td>99.6%</td>
<td>99.9%</td>
<td>100%</td>
<td>100%</td>
<td>99.3%</td>
</tr>
<tr>
<td></td>
<td>N=4 ha</td>
<td>N=18 ha</td>
<td>N=41 ha</td>
<td>N=186 ha</td>
<td>N=558 ha</td>
<td>N=800 ha</td>
<td>N=2370 ha</td>
<td></td>
</tr>
<tr>
<td><strong>Rapeseed</strong></td>
<td>99.7%</td>
<td>99.6%</td>
<td>98.9%</td>
<td>99.6%</td>
<td>98.6%</td>
<td>99.4%</td>
<td>99.8%</td>
<td>99.5%</td>
</tr>
<tr>
<td></td>
<td>N=77 ha</td>
<td>N=93 ha</td>
<td>N=268 ha</td>
<td>N=811 ha</td>
<td>N=1107 ha</td>
<td>N=1633 ha</td>
<td>N=8346 ha</td>
<td></td>
</tr>
<tr>
<td><strong>Hayfields</strong></td>
<td>98.1%</td>
<td>97.3%</td>
<td>99.2%</td>
<td>99.2%</td>
<td>99.1%</td>
<td>99.5%</td>
<td>99.5%</td>
<td>99.3%</td>
</tr>
<tr>
<td></td>
<td>N=111 ha</td>
<td>N=165 ha</td>
<td>N=393 ha</td>
<td>N=1199 ha</td>
<td>N=2161 ha</td>
<td>N=3306 ha</td>
<td>N=7302 ha</td>
<td></td>
</tr>
<tr>
<td><strong>Peas</strong></td>
<td>n.a.</td>
<td>96.5%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>86.9%</td>
<td>100%</td>
<td>97.4%</td>
</tr>
<tr>
<td></td>
<td>N=2.4 ha</td>
<td>N=4 ha</td>
<td>N=23 ha</td>
<td>N=75 ha</td>
<td>N=93 ha</td>
<td>N=348 ha</td>
<td>N=348 ha</td>
<td></td>
</tr>
<tr>
<td><strong>Winter barley</strong></td>
<td>100%</td>
<td>100%</td>
<td>91.5%</td>
<td>95.3%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>98.7%</td>
</tr>
<tr>
<td></td>
<td>N=10 ha</td>
<td>N=3.5 ha</td>
<td>N=24 ha</td>
<td>N=58 ha</td>
<td>N=1477 ha</td>
<td>N=442 ha</td>
<td>N=1682 ha</td>
<td></td>
</tr>
<tr>
<td><strong>All crops</strong></td>
<td>97.8%</td>
<td>97.4%</td>
<td>96.6%</td>
<td>97.5%</td>
<td>98%</td>
<td>98.2%</td>
<td>98.2%</td>
<td>98.3%</td>
</tr>
<tr>
<td></td>
<td>N=336 ha, 433 plots</td>
<td>N=543 ha, 433 plots</td>
<td>N=1446 ha, 722 plots</td>
<td>N=4454 ha, 1216 plots</td>
<td>N=8075 ha, 1109 plots</td>
<td>N=12.261 ha, 1060 plots</td>
<td>N=50.106 ha, 1060 plots</td>
<td></td>
</tr>
</tbody>
</table>
Conclusions and perspectives

✦ **Solid results** supported by the results of the validation campaigns

✦ **Full validation** for all 3 AOIs (2018)

✦ More **field campaigns** (2019)

✦ Implementation at **national level** (2019)

✦ **Trials in other countries / geographical areas** (?)!
Thank you!
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