Advancing Land-Cover Classification in Croatia: Implementation of a Pilot Project for ARKOD+ and CROLIS LU Initial Layer Creation

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Pilot initiator

- Ministry of Agriculture
- Responsible for 90% of Croatian LU/LC area (cumulative ARKOD area)
- legally required to collect and maintain data for strategic decision-making and various reports, including climate-related ones essential for calculating greenhouse gas emissions from land use

AGENCIJA ZA
PLAĆANJA U
POLJOPRIVREDI,
RIBARSTVU I
RURALNOM
RAZVOJU

Total land use in the Republic of Croatia

ARKOD≈20%

ARKOD + (plus)≈20%

Infra≈10%

Forest ≈ 50%
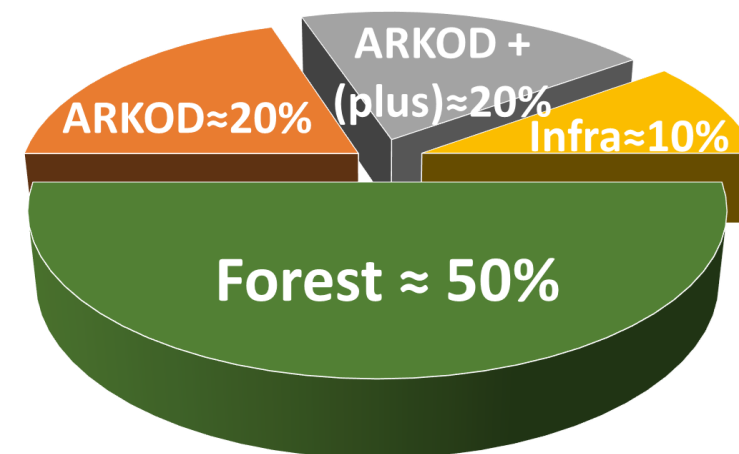
CAP goals 2023 / 2027 for climate and environment

3 main goals:

- Improve sector resilience
- Improve quality of life in rural areas
- **Strengthen environment protection**
  - **Mitigation of climate change**
  - **Sustainable management of natural resources**
  - **Biodiversity protection**

- Spatial data will play an important role for policy makers

CROLIS legal basis and obligations

- Legal regulations are required for all EU member states including Croatia
- Pilot was initiated to tackle it in a timely manner

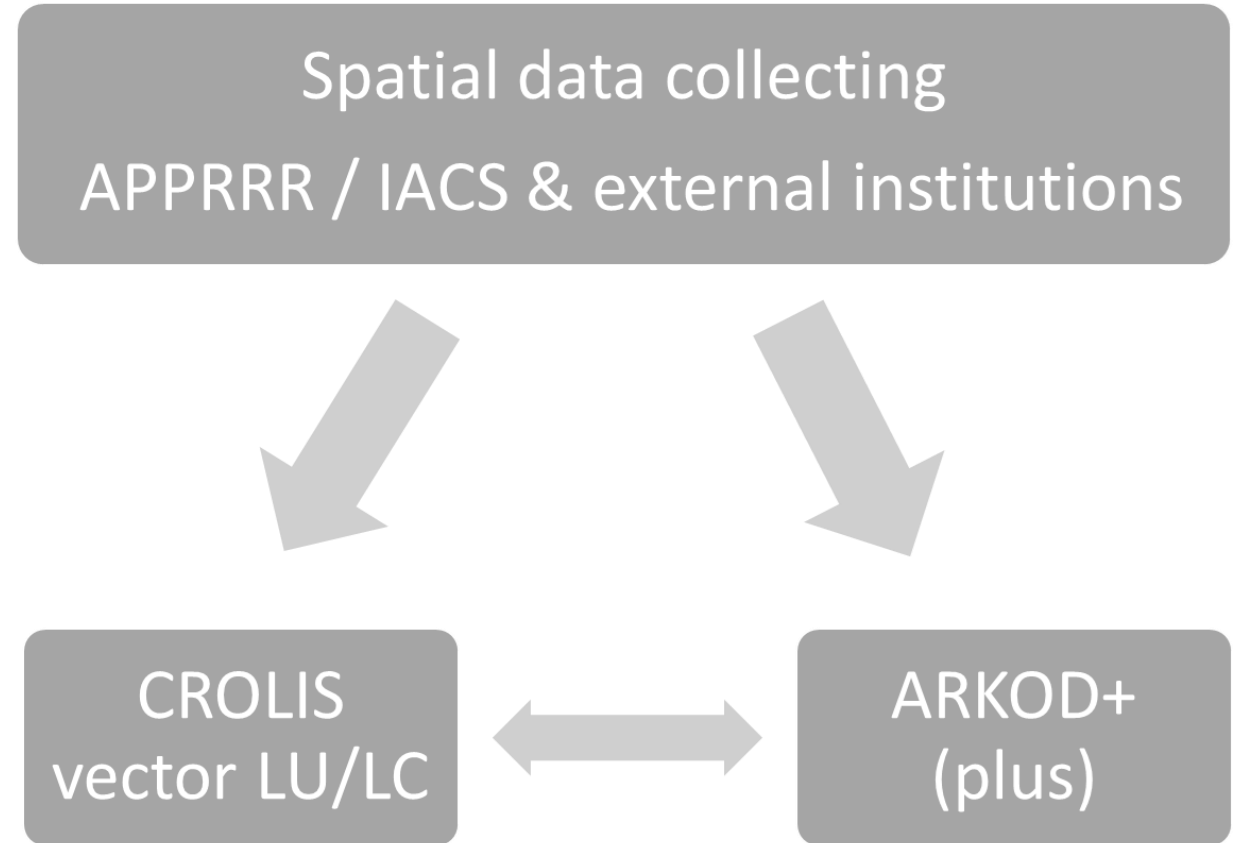Low carbon strategy → EU Green deal → Law on Climate change → LULUCF regulation → Law on Agriculture → New CAP/ Strategic plan

Paying Agency - main activities

- As part of CROLIS project, PA has largest scope and complexity
- Main stakeholder for distribution of LU/LC data to and from various institutions

Spatial data collecting
APPRRR / IACS & external institutions

CROLIS vector LU/LC

ARKOD+ (plus)

Challenge - establishment of ARKOD+

Delineation & classification

AREA 0,8 – 1,0 mil ha

Difference between north and south part of Croatia

Karst pastures / Abandoned land

Example – northern Croatia, Varaždin

Example – southern Croatia, Šibenik

Pilot project

ICERS

Contractors

- Sinergise d.o.o.
- KING ICT d.o.o.

Duration of the project

- Contract signed – 23 May 2023
- Deadline for implantation period – 15 December 2023
- Final deadline - Corrective maintenance up to 15 March 2024

Financial value

- Total 29.525 EUR

Working packages (WP)

WP1 – Analysis of input data and proposal for implementation methodology

WP2 – Proposal for algorithm development for automatic classification for testing zones

WP3 – Analysis of classification results on selected testing zones

WP4 – Selection of algorithms and their implementation on the entire territory of Croatia

WP5 – Suggestions for future methods of field visits and ground truth data preparation

WP6 – Web browser and final reports

WP7 – Corrective maintenance

Implementation WP1-WP6
15 Dec 2023

Implementation WP7
15 March 2024

Training data

7 LU/LC classes:

1. forest,
2. water,
3. build-up area,
4. permanent grasslands,
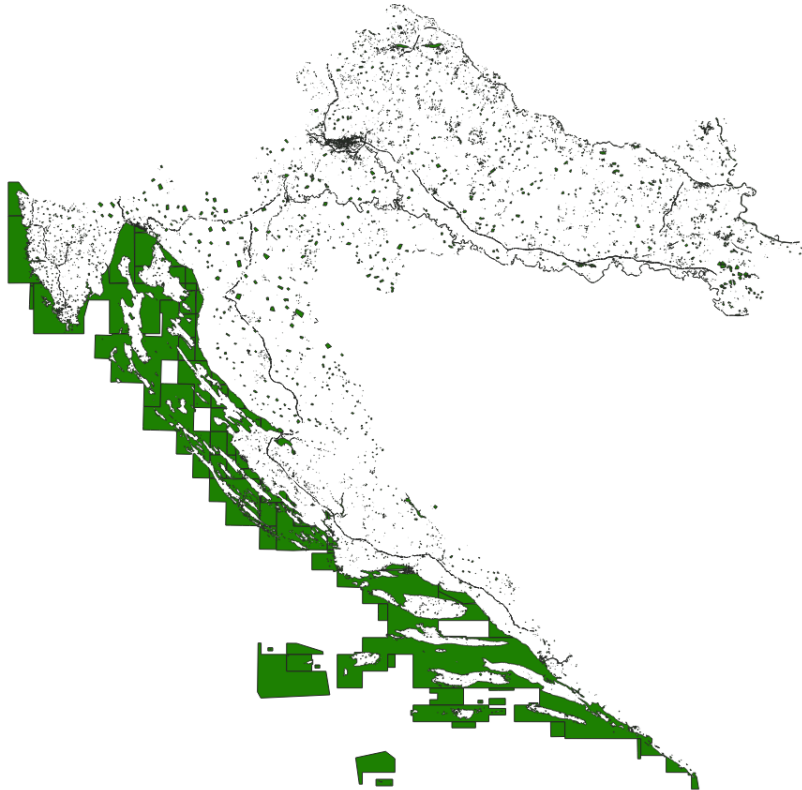5. arable land,
6. permanent crops and
7. karst pastures.

forests

build-up / water

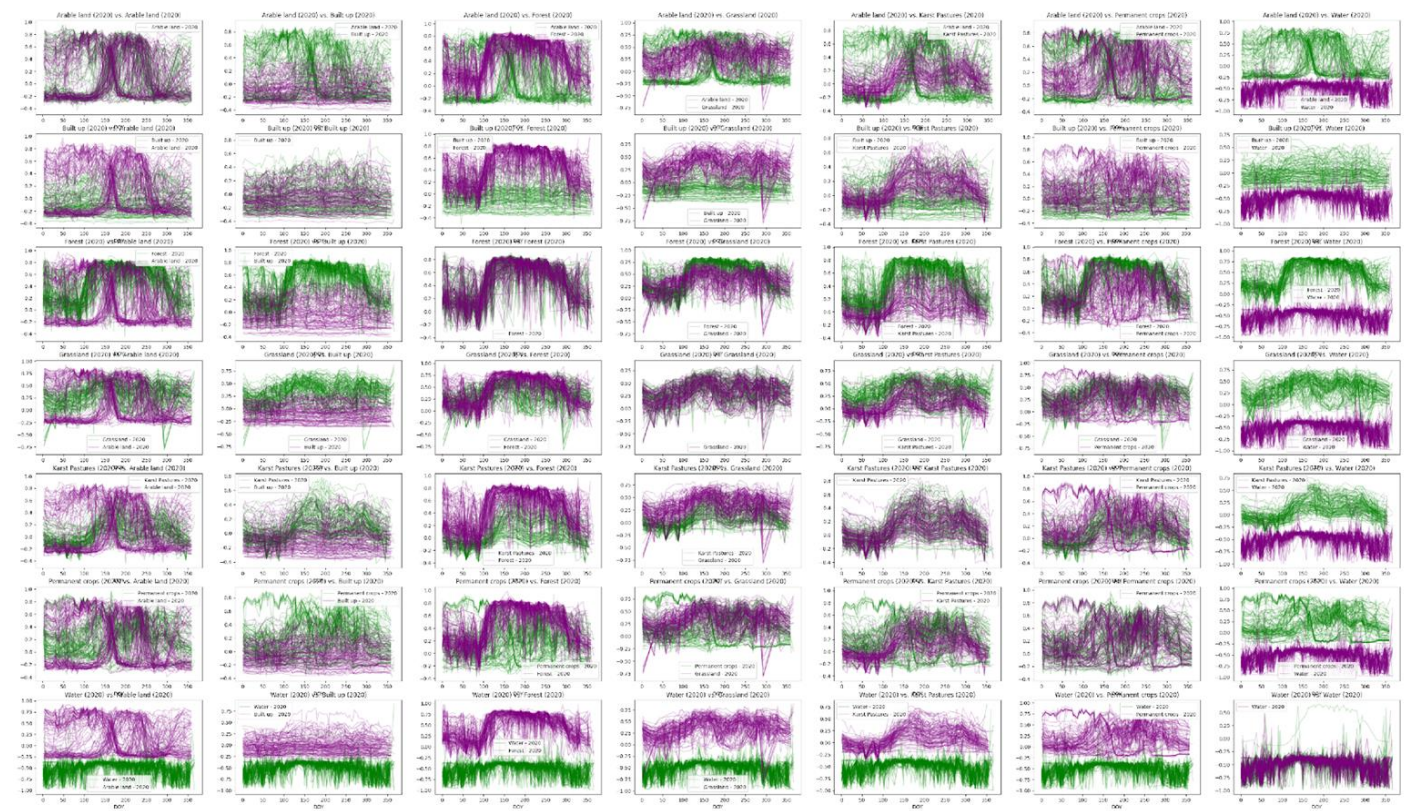agricultural parcels
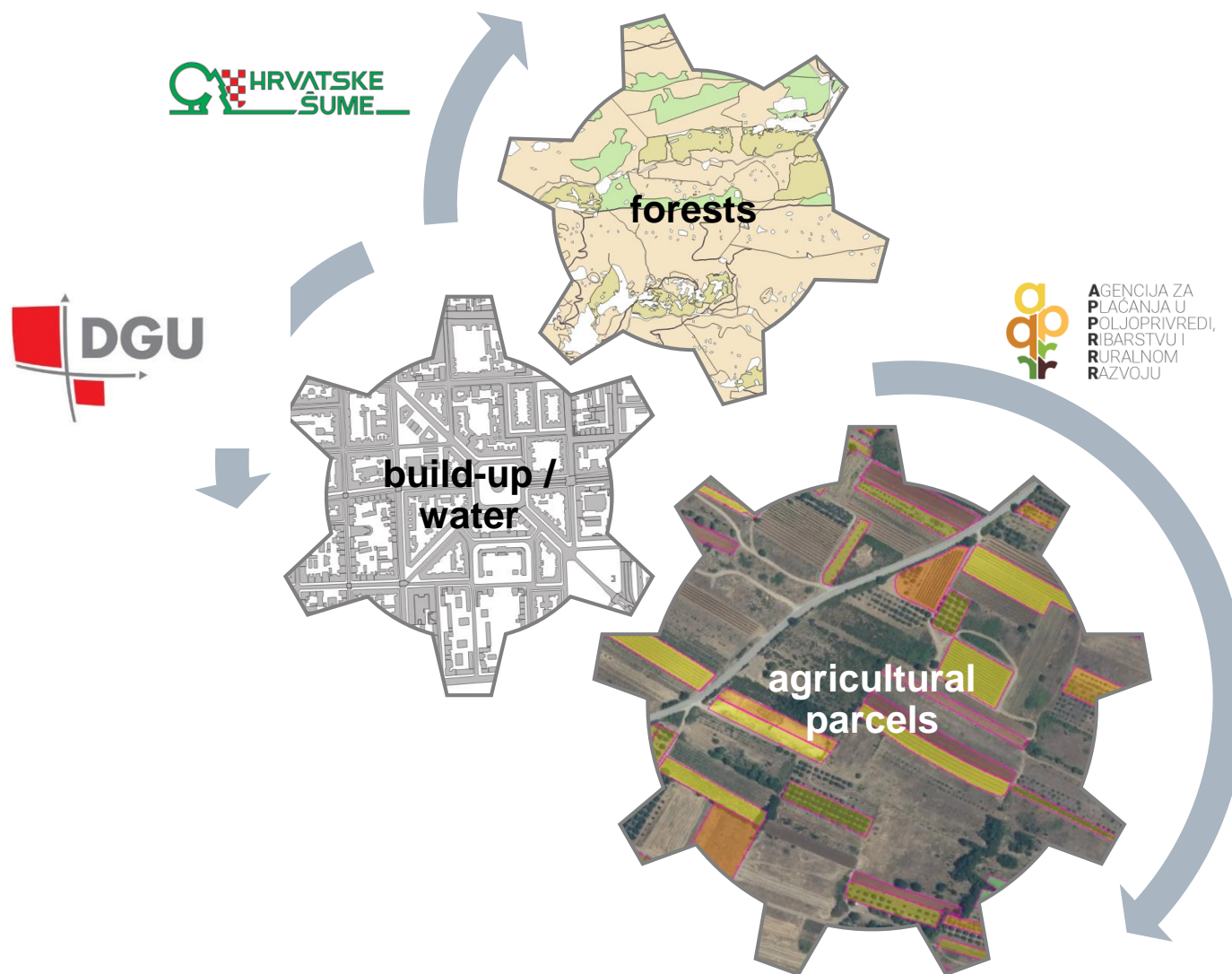
Validation of IACS controls data
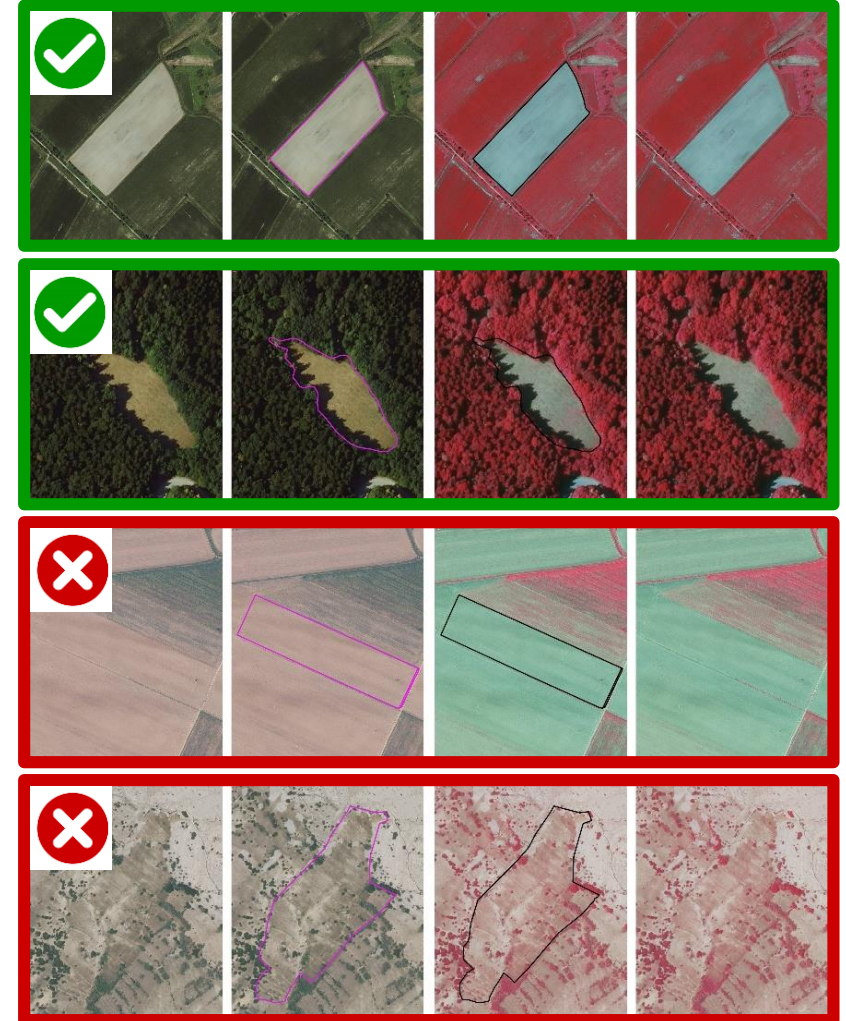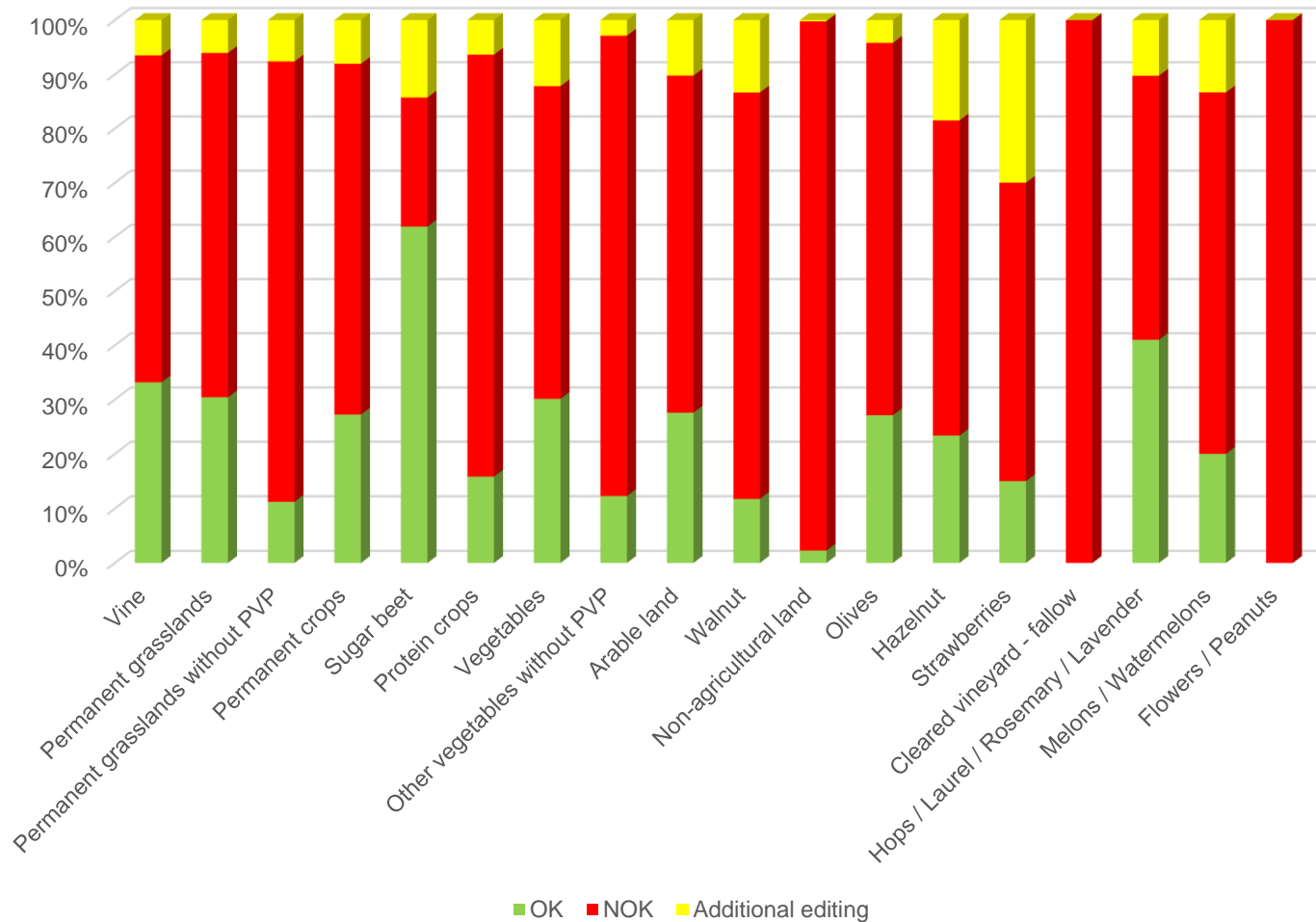
*Validation of training data using aerial imagery*

Distribution of training data

Distribution of validated training dataset for
7 LU/LC classes

Sentinel 2 NDVI series for 250 samples of 7 LU/LC classes for 2020

LU/LC classification methodologies

We compared the machine-learning (pixel-based LightGBM) approach with the object-based model. For segmenting areas into objects, Felzenszwalb Segmentation to the maxNDVI image for the whole year was used.

Legend:
- Water
- Arable land
- Meadows
- Forest
- Build-up
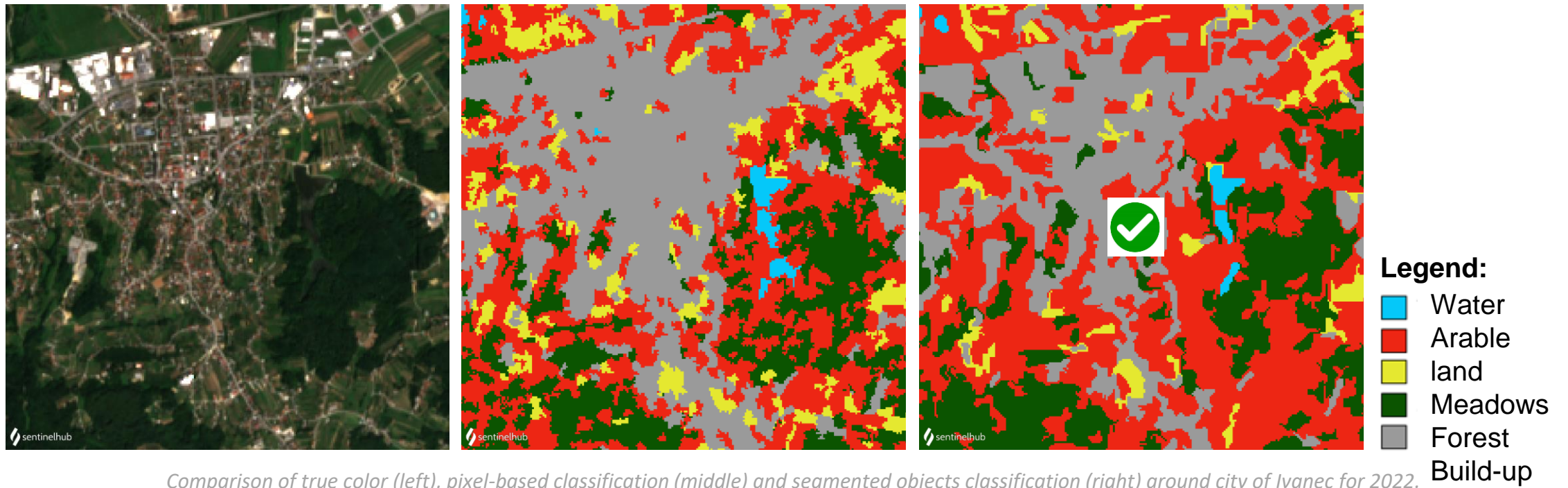
Comparison of true color (left), pixel-based classification (middle) and segmented objects classification (right) around city of Ivanec for 2022.
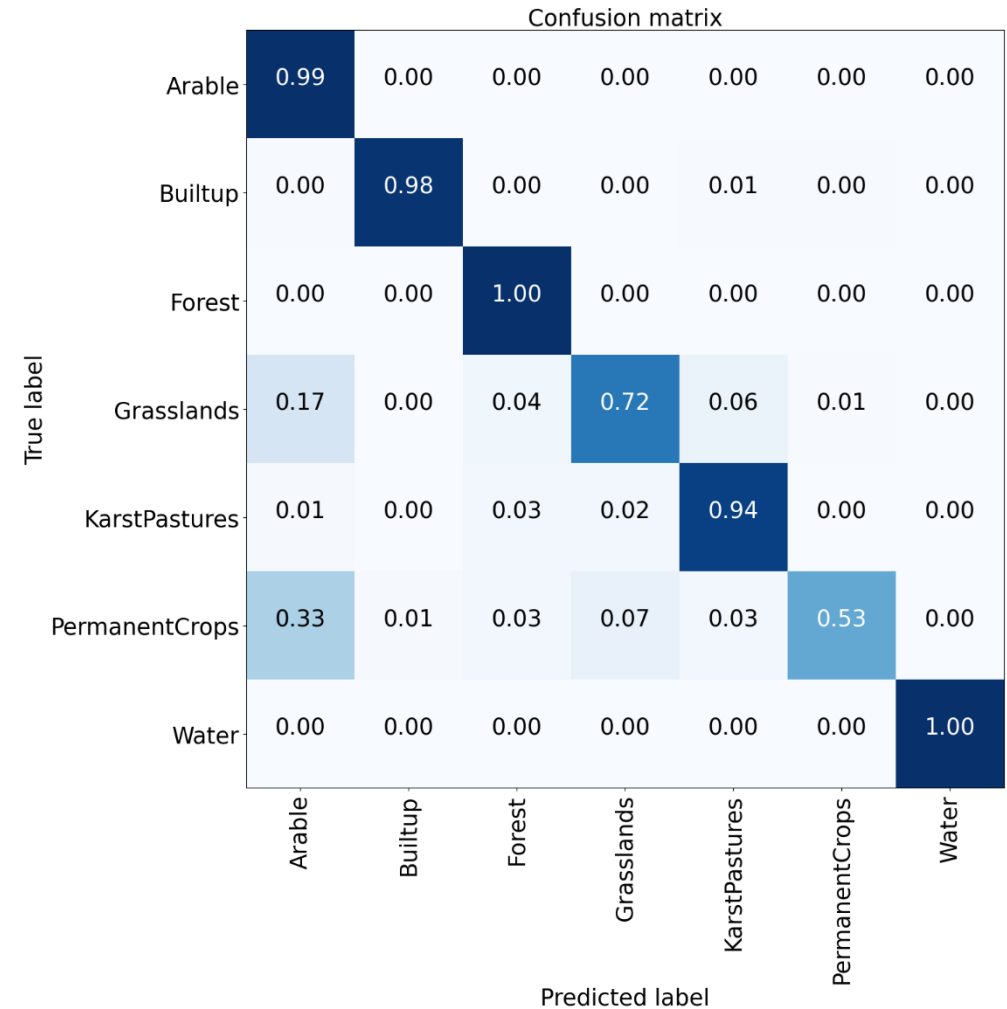
LU/LC classification 1st iteration

- segmentation into objects was done by considering quarterly values of Normal Difference Vegetation Index (NDVI), Normal Difference Built-up Index (NDBI) and Normal Difference Water Index (NDWI) to reduce influence of changes within objects during the year.

- Added 223 additional samples for build up areas.
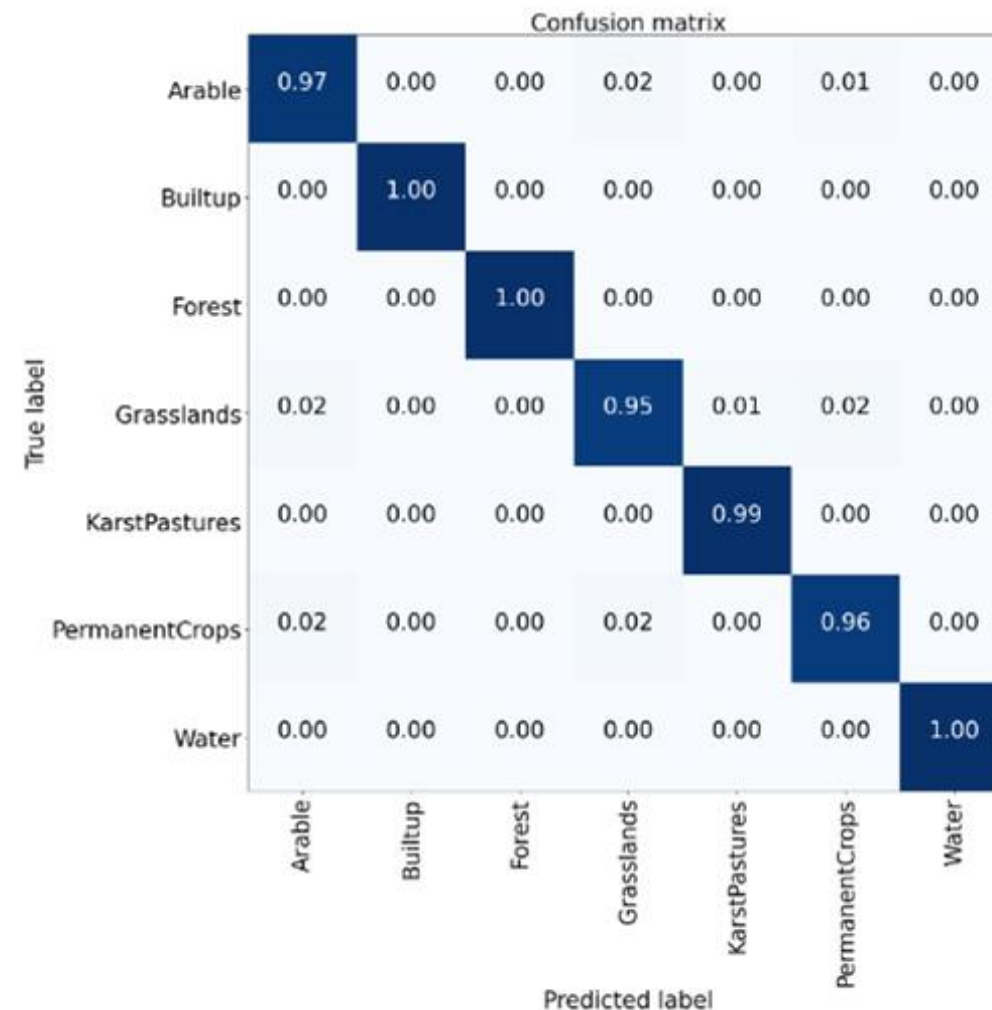
LU/LC classification 1ˢᵗ iteration

- Confusion matrix indicated issues with grasslands and permanent crops
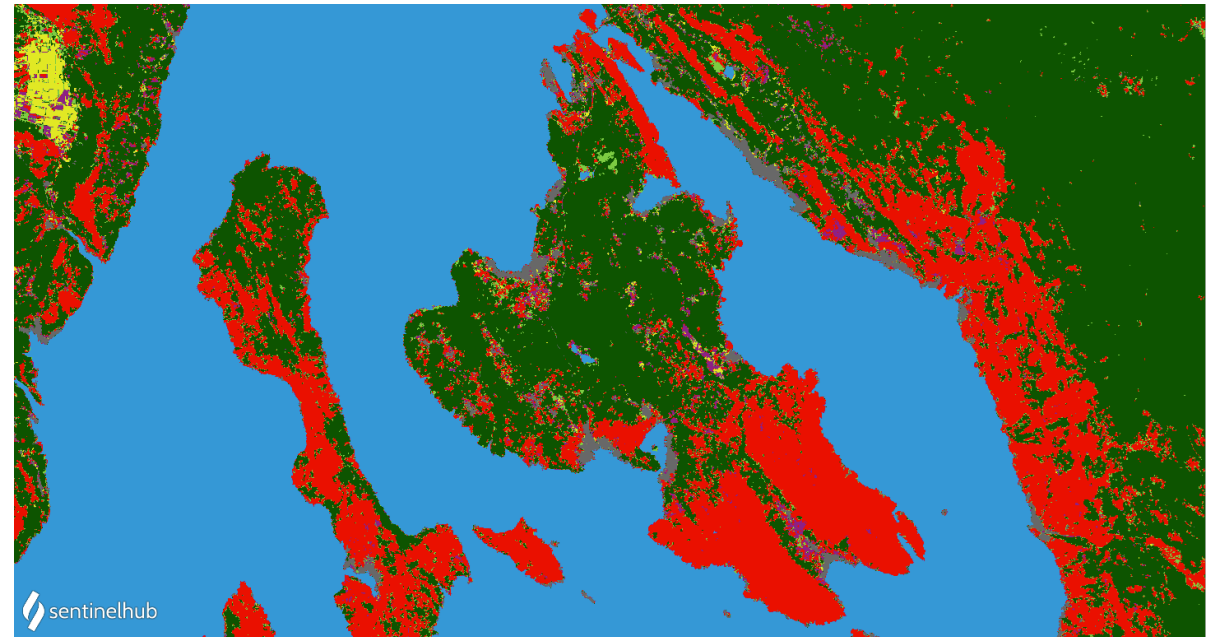- Training data contains "clean samples" so values are probably overestimating model performance.

Confusion matrix

LU/LC classification 2nd iteration

- Increasing training data sample with additional agricultural parcels further improved results.

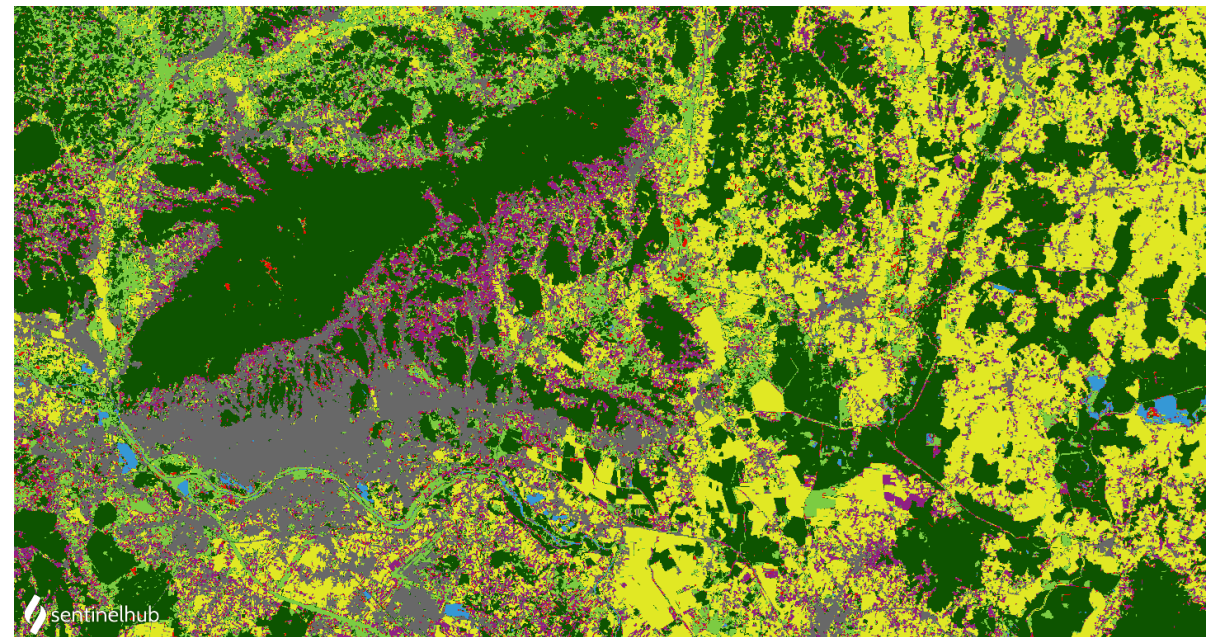Confusion matrix

CROLIS layer

Initial LU/LC layer made for 2020 and 2022 in resolution 10m.

LU/LC classification	Area 2022 [km2]
Arable land	10.982
Build-up	2.244
Forest	26.246
Permanent grasslands	3.660
Karst pastures / shrubland	11.472
Permanent crops	3.987
Water	4.660

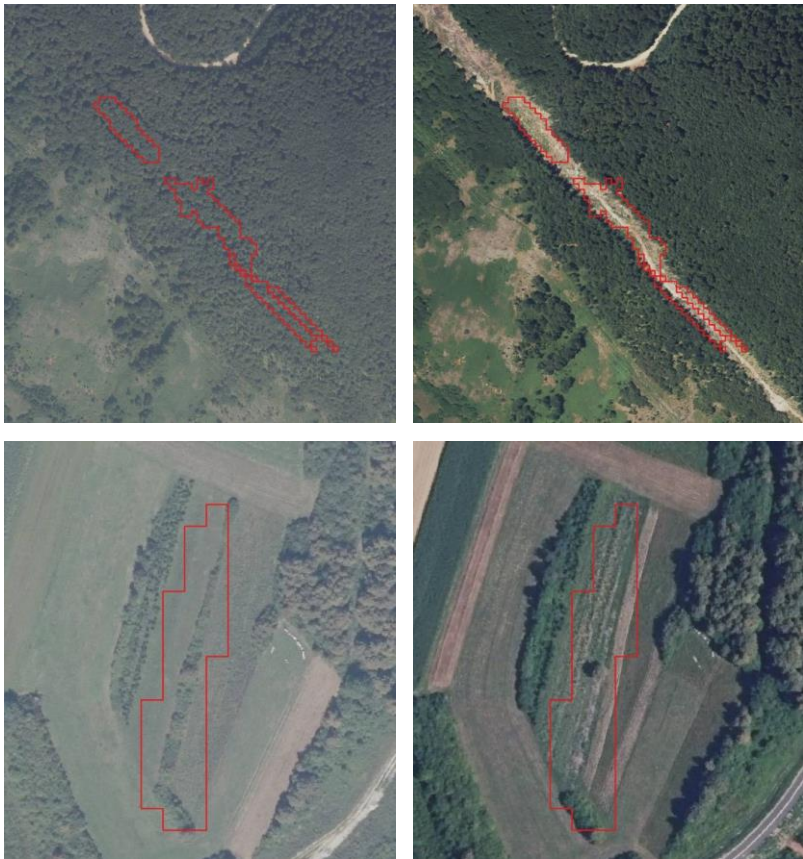# LU/LC classification changes

- Land cover changes were detected by intersecting LU/LC classes from 2020 and 2022 and retaining results where predicted classes changed.

- Changes were retained only if pseudo-probability for the predicted group in each year was significant (above 0.98), and change was larger than 4 Sentinel-2 pixels.
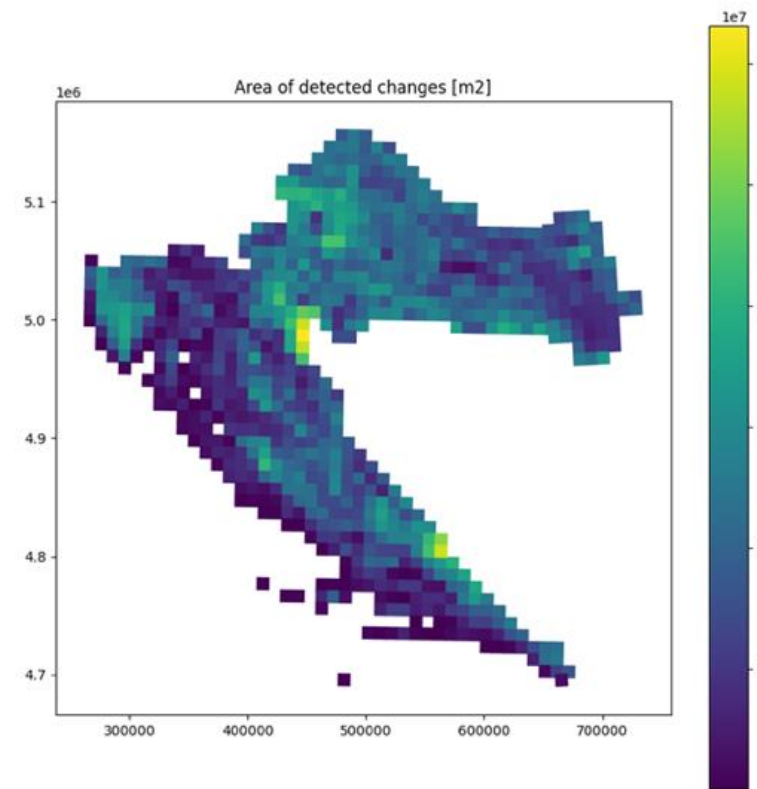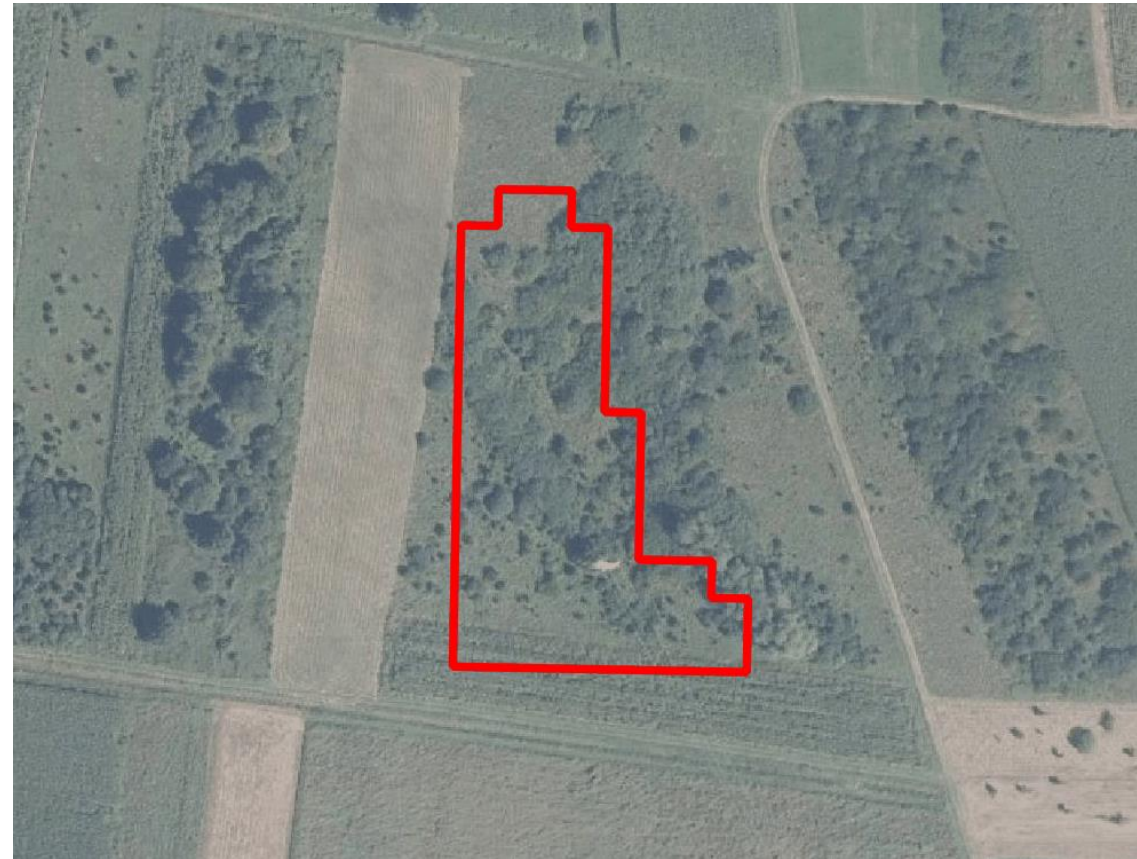

LU/LC changes between 2020 and 2022.

LU/LC classification changes

Aerial imagery 2020 (left) and 2022 (right). Red – marked areas with classification changes.

Testing drone imagery for LU/LC classification change validation purposes.

Field delineation of agricultural parcels

Delineation of agricultural fields was done on normalized aerial imagery with 0,5m resolution, which included spectral bands for red (R), green (G), blue (B), and near-infrared (NIR).

For scaled-up processing in Python eo-grow - Earth observation framework was used.

eo-grow General Structure Overview. Source: https://github.com/sentinel-hub/eo-grow
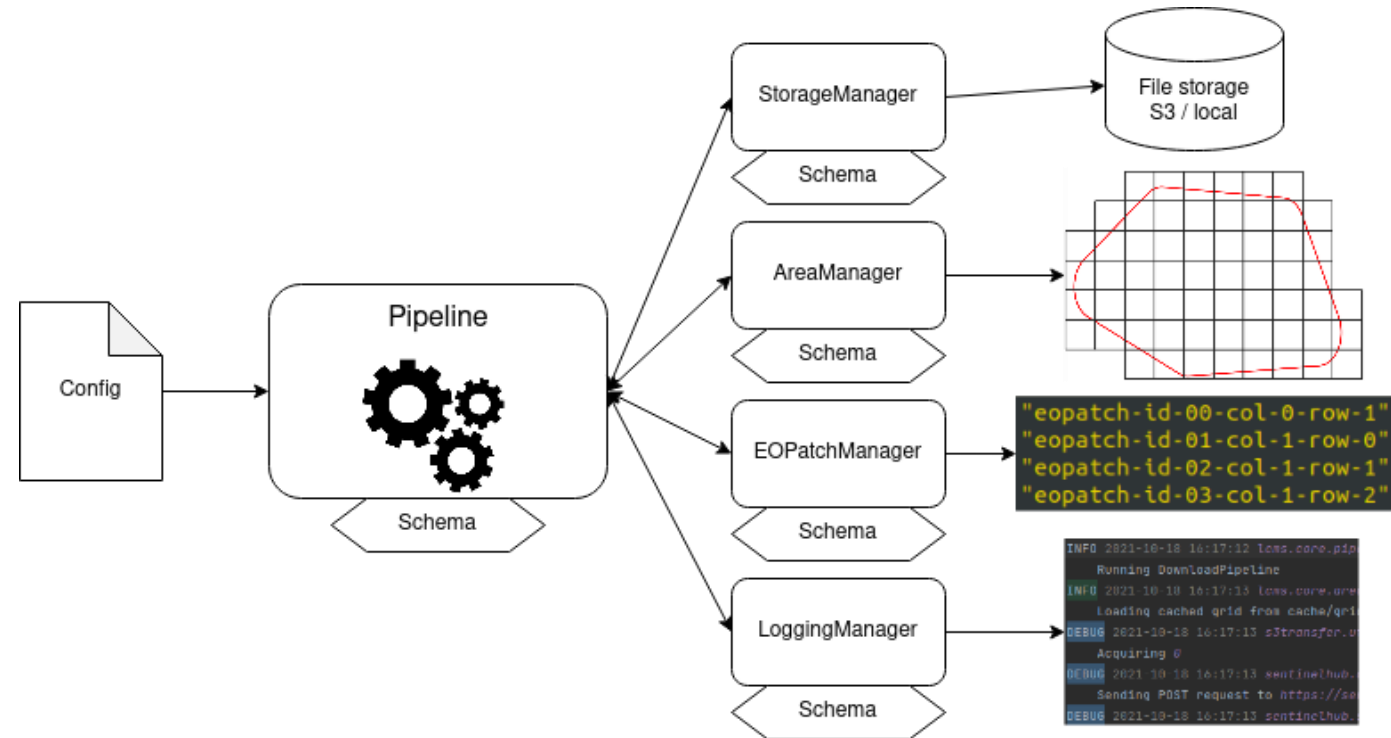
Different experiments were done:

- training models with different datasets (changing ratio of negative vs positive samples),
- changing learning rate (from 0.001 to 0.0001),
- changing precision (from 16 to 32) and
- changing epochs (from 75 to 150).
- **The best model achieved IoU 0.82 and accuracy 0.93** on the evaluation dataset which was done on 1200 locations distributed across the country.
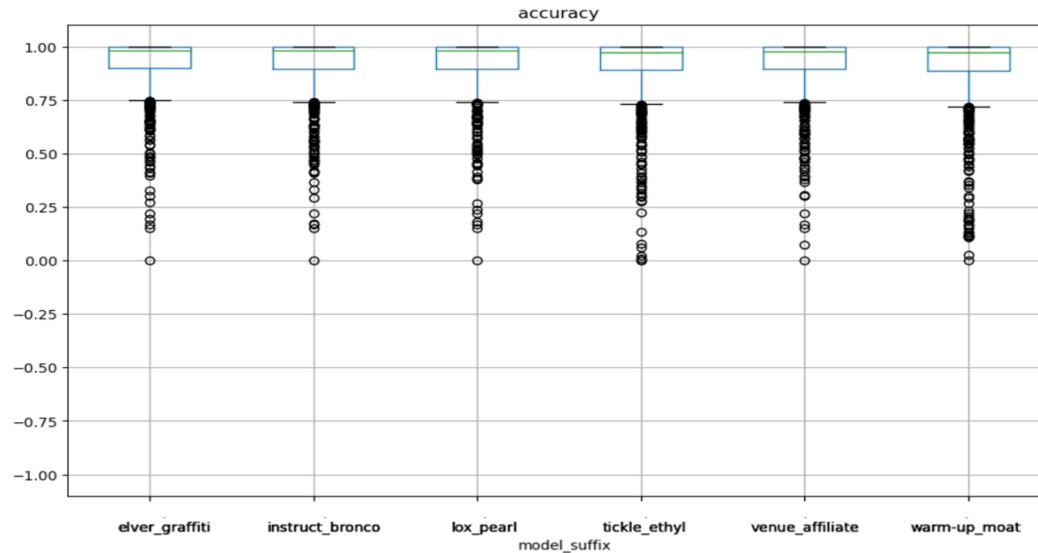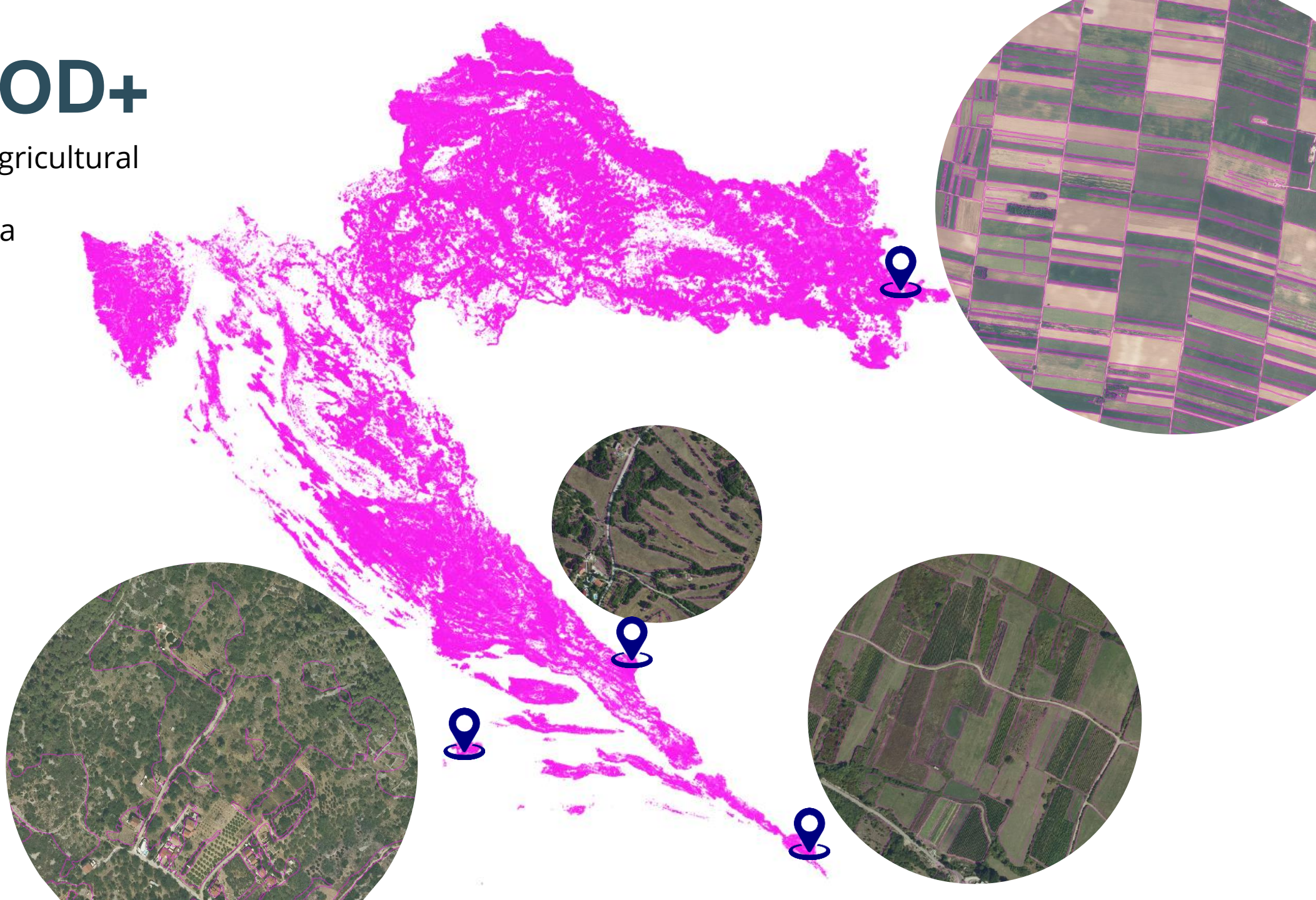

Accuracy of different model results
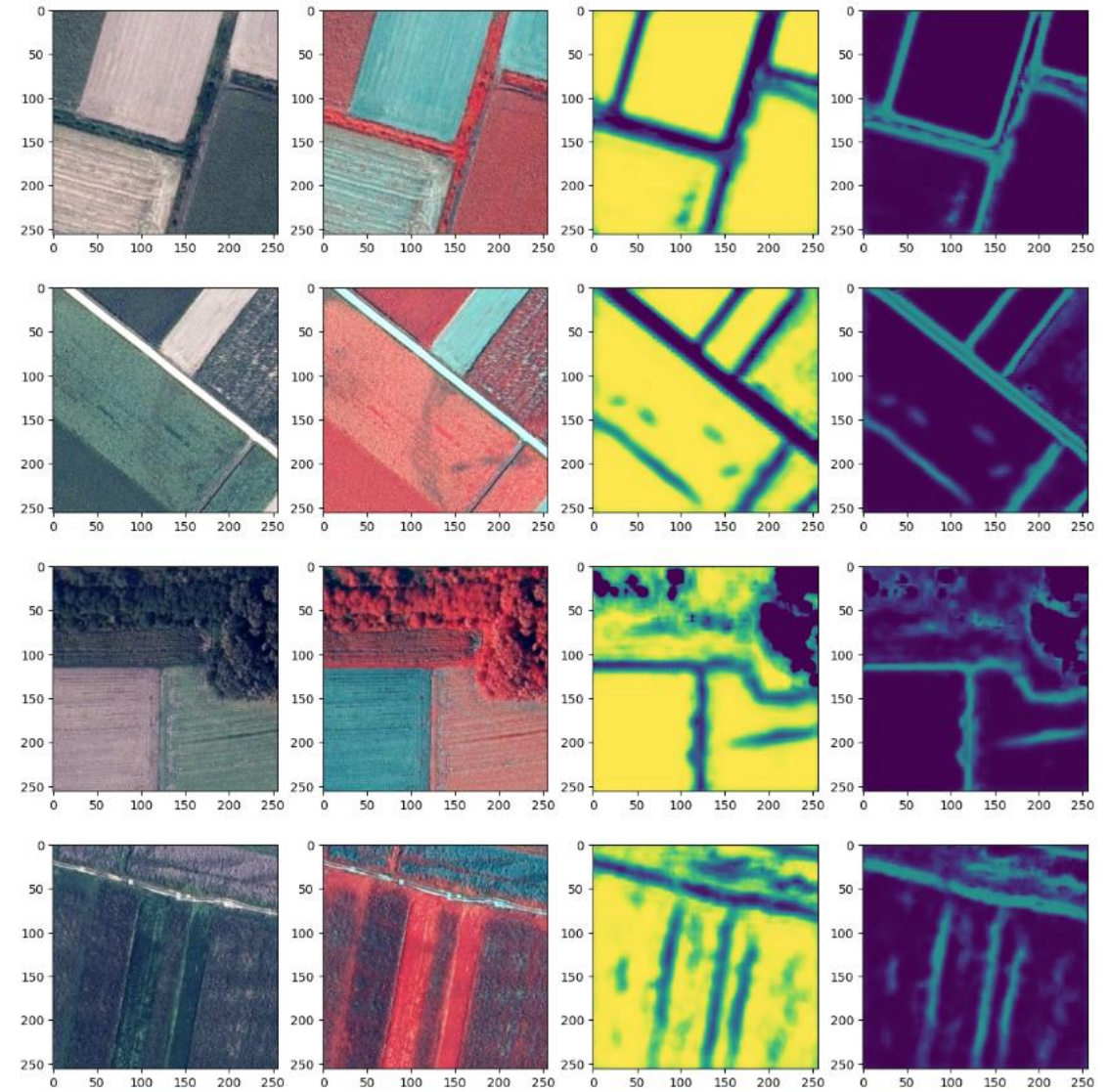
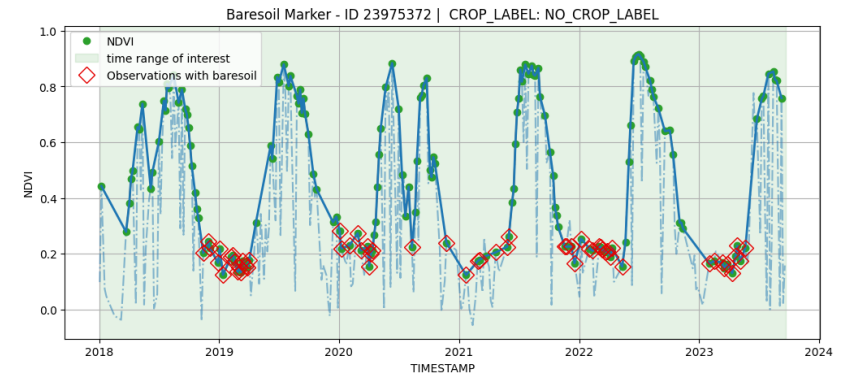*Predictions of agricultural parcel borders.*

ARKOD+

2,848,790 agricultural parcels
1,822,550 ha

Trend of agricultural activities on delineated parcels

Baresoil Marker - ID 23975372 | CROP_LABEL: NO_CROP_LABEL

Analysis results

- Mowing marker analysis revealed a negative trend in the number of mowed parcels. On both Sentinel-2 and PlanetScope Fusion, the number of mowed parcels decreased.

- Bare-soil marker did not show significant trend changes with around 8,000-11,000 parcels having at least 1 bare-soil observation through the year.

- On 27% of parcels monitoring of agricultural trend was possible only with PlanetScope Fusion
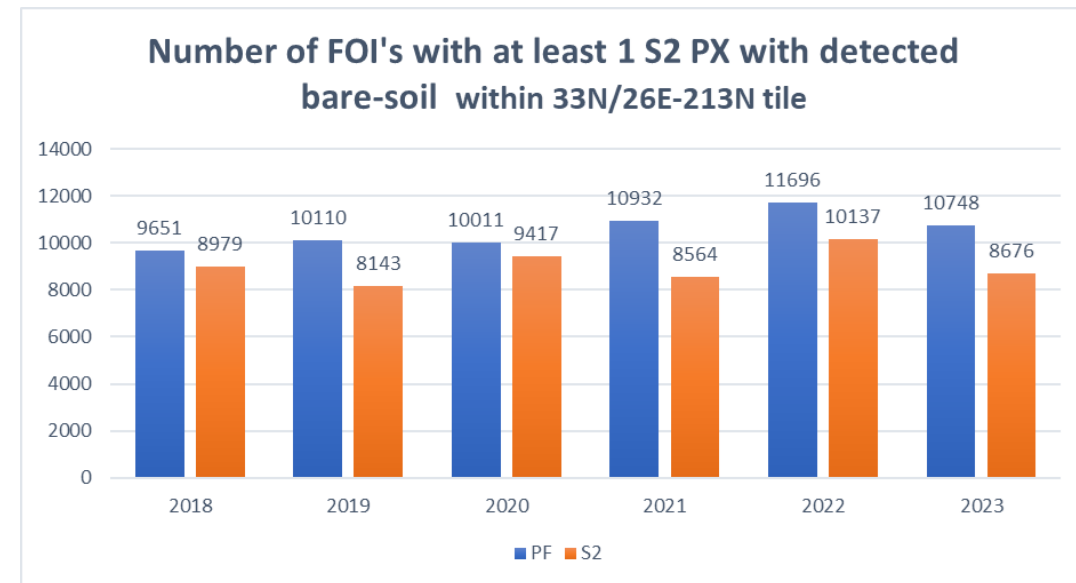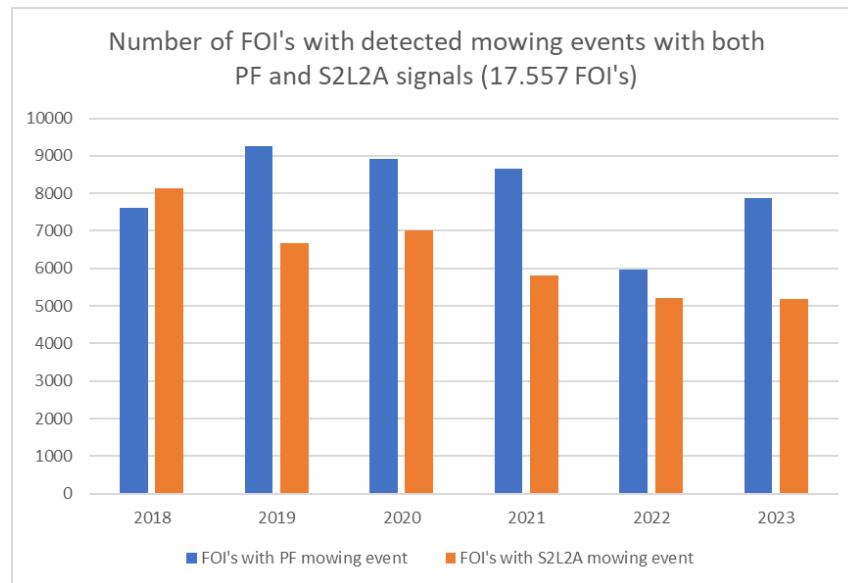
Conclusion

- Climate policy planning is more important than ever! CROLIS data will provide precise and timely delivered information about LU/LC changes and trends.

- Initial pilot results are promising. Improvement in all use-cases is possible - training data is highly significant.

- PlanetScope Fusion showcased as advantageous compared to Sentinel-2 on small and narrow parcels.

Acknowledgment: LIFE CROLIS Project is co-financed by the LIFE Programme of the EU.

Thank you for your attention!