URBIS24: Urban Insights from Space
ESA-ESRIN (ITALY) 16-17-18 SEPTEMBER 2024

# Enhancing Infrastructure Resilience: Leveraging Machine Learning for Urban Land Use Change Monitoring

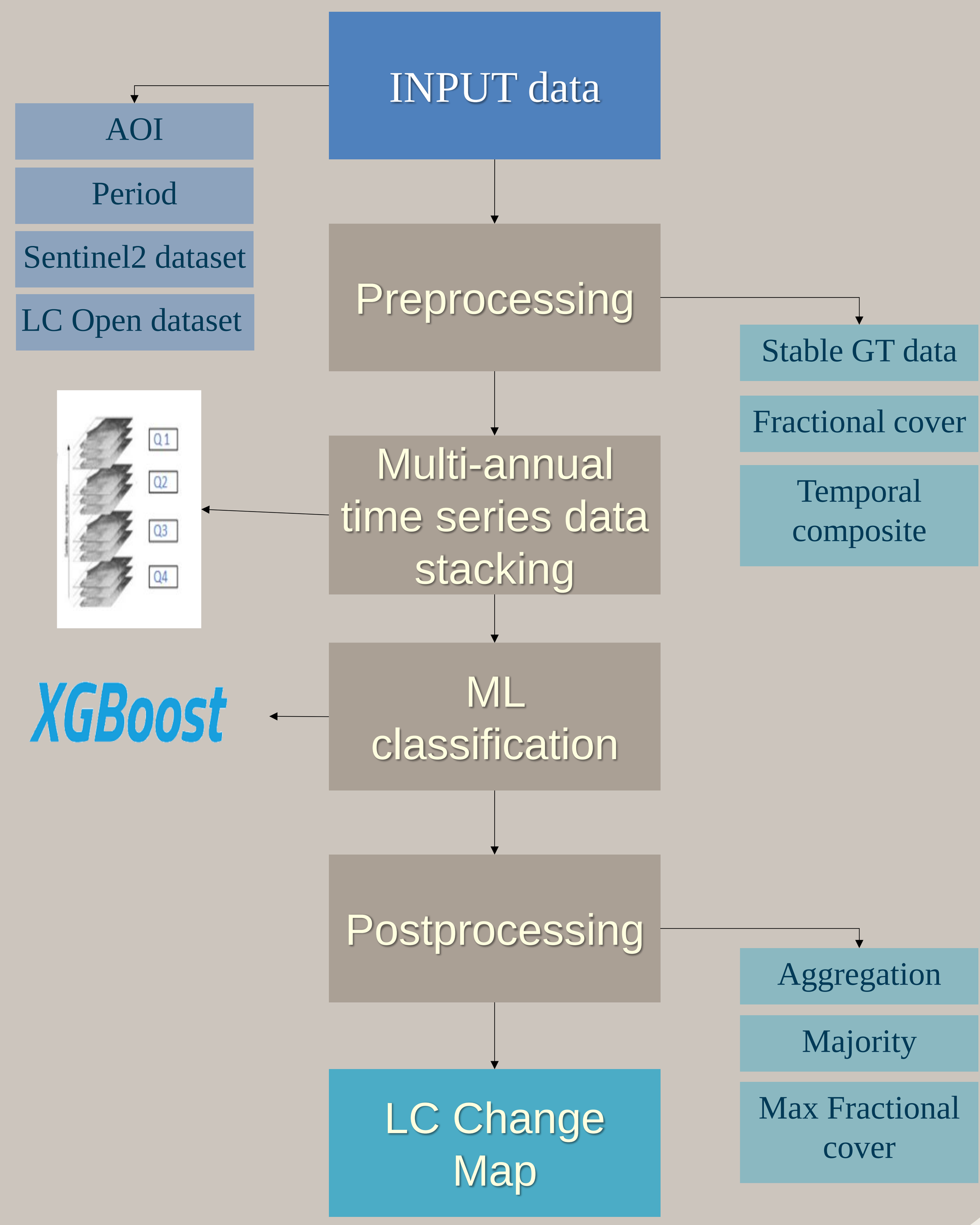
M. Simone, N. Taggio, V. Massimi, D. Drimaco, R. Nutricato, D.O. Nitti


## ABSTRACT

The study of land cover and land use (LCLU) changes in urban areas is crucial for understanding city dynamics. Activities such as deforestation, mining, and agriculture can significantly impact the landscape and soil, potentially leading to erosion or instability. These threats increase the risk of landslides or soil subsidence, which can damage infrastructure such as roads and railways.

Remote sensing data, particularly from multispectral and multitemporal optical imagery, plays a key role in monitoring these changes. Automated approaches using artificial intelligence and machine learning have been effective in identifying LCLU classes, aiding in global change studies.

Planetek Italia is developing an infrastructure monitoring service aimed at predictive maintenance of roads, railways, and bridges. This service uses supervised machine learning to analyse LCLU changes with time-series Sentinel-2 data. Supported by the Italian Space Agency under the I4DP Market project, the initiative aligns with guidelines from the Italian Ministry of Infrastructure and Transport for risk classification and safety assessment of bridges. It builds on the Rheticus® Safeway service, developed under the Horizon 2020 Safeway project, and aims to scale the service for broader European and global use. This monitoring service represents a significant advancement in proactive maintenance strategies, leveraging satellite-based geo-analytics to enhance the safety and resilience of infrastructure networks.



REFERENCES

[RD01]

https://land.copernicus.eu/

[RD02]

https://worldcover2020.esa.int/

[RD03]

Chen, Tianqi, and Carlos Guestrin. "Xgboost: A scalable tree boosting system." Proceedings of the 22nd acm sigkdd international conference on knowledge discovery and data mining. 2016.


## GROUND TRUTH DATA GENERATION

The input data needed to generate the training mask are:

1) CGLC [RD01] at 100m resolution from 2015 to 2019;

2) ESA WorldCover [RD02] at 10m resolution by ESA .

The stack of CGLC layers from 2015 to 2019, is analysed to derive a preliminary mask containing all the CGLC stable pixels, unchanged through the entire stack (i.e., areas where the land cover has not changed). This set of CGLC stable pixels are then intersected with the ESA WorldCover Layer to produce the reference for the training process.

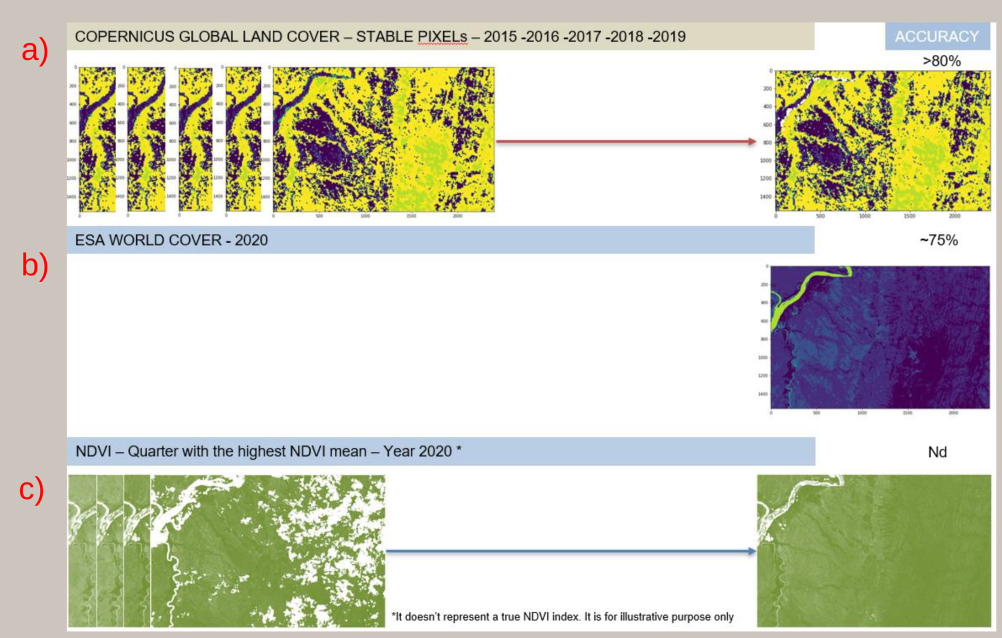



*Figure 1 – a) Creation of stable map from the Copernicus Global Land Cover classification; b) Esa Word cover representation; c) Use of NDVI to improve the accuracy;*

## PREDICTION

Once the datacube is ready, it is possible to configure the AI algorithm. Due to the availability of the reference dataset, the eXtreme Gradient Boosting Model (XGboost) [RD03], a supervised ML method, is used for pixel-based classification.

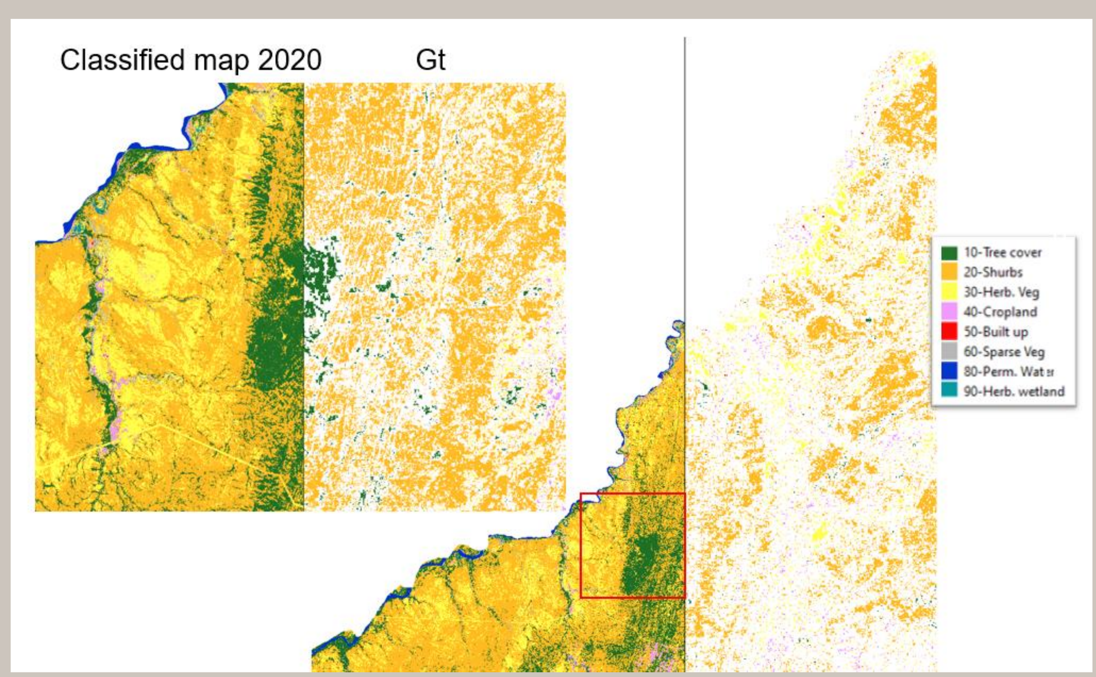



*Figure 2: A zoom related to the ground truth data generated by the procedure and the classified map*

## LAND COVER CHANGE

Differences between predicted yearly maps create the temporary land cover change maps. As final step, a majority aggregation is performed to accomplish the Minimum Mapping Unit defined by the user.

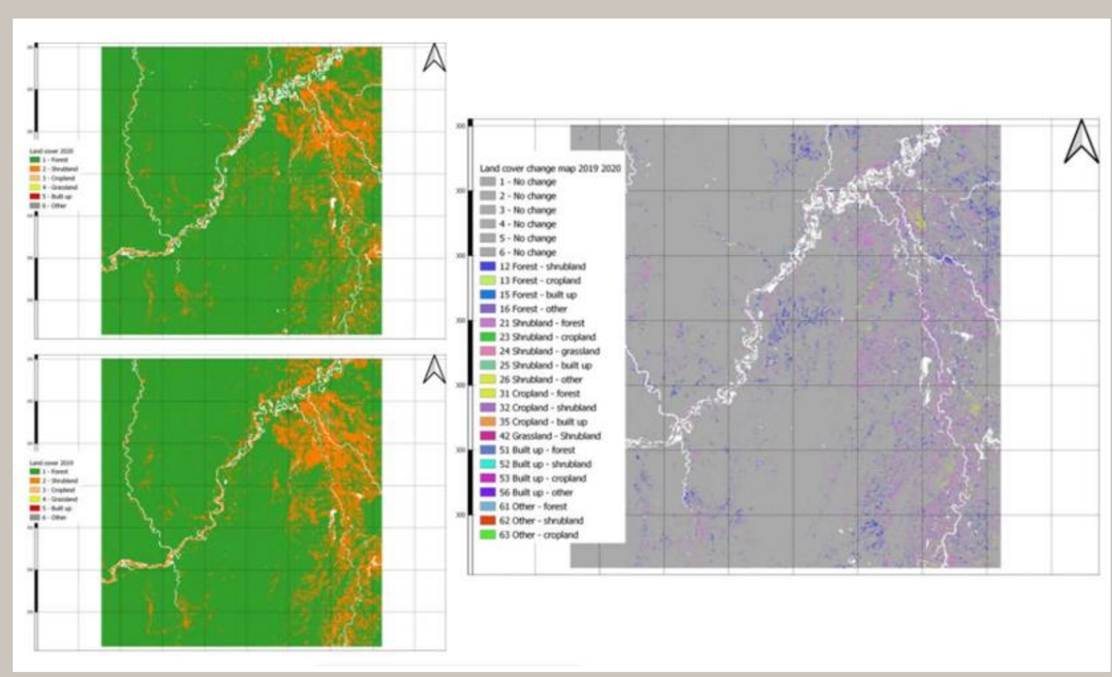


*Figure 3: left - An example of two classified maps; right – An example of land cover change map*

## SERVICE OVERVIEW

*Figure 4: An overview of the service output in Campania Region*

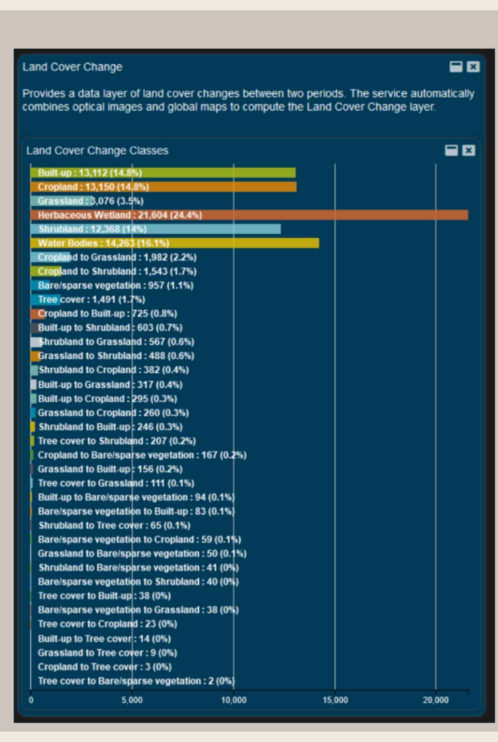


*Figure 5: An overview of the analytics extracted from the service*

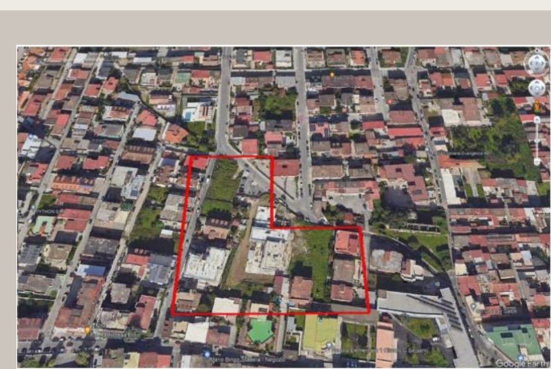


*Figure 6: A zoom in the pre-event LCC*

*Figure 7: A zoom in the post-event LCC*


## Authors

**Matteo Simone**
**simone@planetek.it**

**Nicolò Taggio**
taggio@planetek.it

**Vincenzo Massimi**
massimi@planetek.it

**Daniela Drimaco**
drimaco@planetek.it

**Raffele Nutricato**
raffaele.nutricato@gapsrl.eu

**Davide Oscar Nitti**
davide.nitti@gapsrl.eu

**Planetek Italia s.r.l. Società Benefit**
https://www.planetek.it


P22S1943-43-v0