



POLITECNICO
MILANO 1863

DEPARTMENT OF ELECTRONICS
INFORMATION AND BIOENGINEERING

Earth Observation-Based Screening of Illegal Waste Sites: Detection, Prioritisation, Verification

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Thomas Martinoli, Piero Fraternali

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Session 6 – ID: 114

Illegal pollution monitoring at scale

- Environmental protection agencies monitor vast territories with **limited staff and budget**
- Most effort is spent manually **scanning empty land** on satellite imagery
- This approach is slow and **does not scale** with the rising volume of crimes

Regional scale

Limited resources

Manual inspection

Empty land

Slow process

Hard to scale

Our goal: **optimize** agency resources

Who are we?



A deeply technical, multidisciplinary team from Politecnico di Milano.



Piero Fraternali

Full Professor of
Data & Web Science



Luca Morandini

Computer Vision
Specialist



Enrico Targhini

Artificial Intelligence
& Deep Learning
Specialist



Thomas Martinoli

Satellite & Earth
Observation Specialist



Mohammad
Jabbarizadegan

Artificial Intelligence
& Software
Engineering



Simona Malegori

Web & Geospatial
Software
Engineering

Yes, but... who are we?

We are the team behind the AI-based illegal landfill detection Case Study in the ***"Earth Observation against Environmental Crimes"*** report by IAI.

Colantoni, L., Scissa, C., Rinaldi, P., & Sangiorgio, A. (2026). *Earth observation against environmental crimes: A review of users and usages worldwide* (pp. 190-193). Istituto Affari Internazionali. <https://doi.org/10.82088/9788893684132>

190 // EARTH OBSERVATION AGAINST ENVIRONMENTAL CRIMES

9. AI detection of illegal landfills and solid waste in Northern Italy

Entity responsible for the analysis: Politecnico di Milano (Polimi) [academia]

Enforcement actor: ARPA Lombardia (regional agency for environmental protection)

Topic: Illegal waste disposal, waste trafficking

Status: Applied in environmental monitoring and potentially in enforcement cases

Main sources of satellite data: Copernicus Contributing Missions (WorldView 3 – Pléiades Neo)

Replicability: High

Background

PERIVALLON 

<https://perivallon-he.eu/>

Partners involved

Academic, technical, research, end-user partners from **12 EU Countries**.

24

Partners

Technology validation

The waste detection model has been evaluated during practical **on-field tests**.

6

Pilot demos

Annotated dataset

We published one of the **largest datasets** for waste detection from EO imagery.

11,700

Images

Detection performance

Our models defined the state-of-the-art on **small dumping sites** detection.

92%

F1-score

EO-based waste localization

Large-scale identification of waste sites from **VHR satellite imagery** inside an Area of Interest.

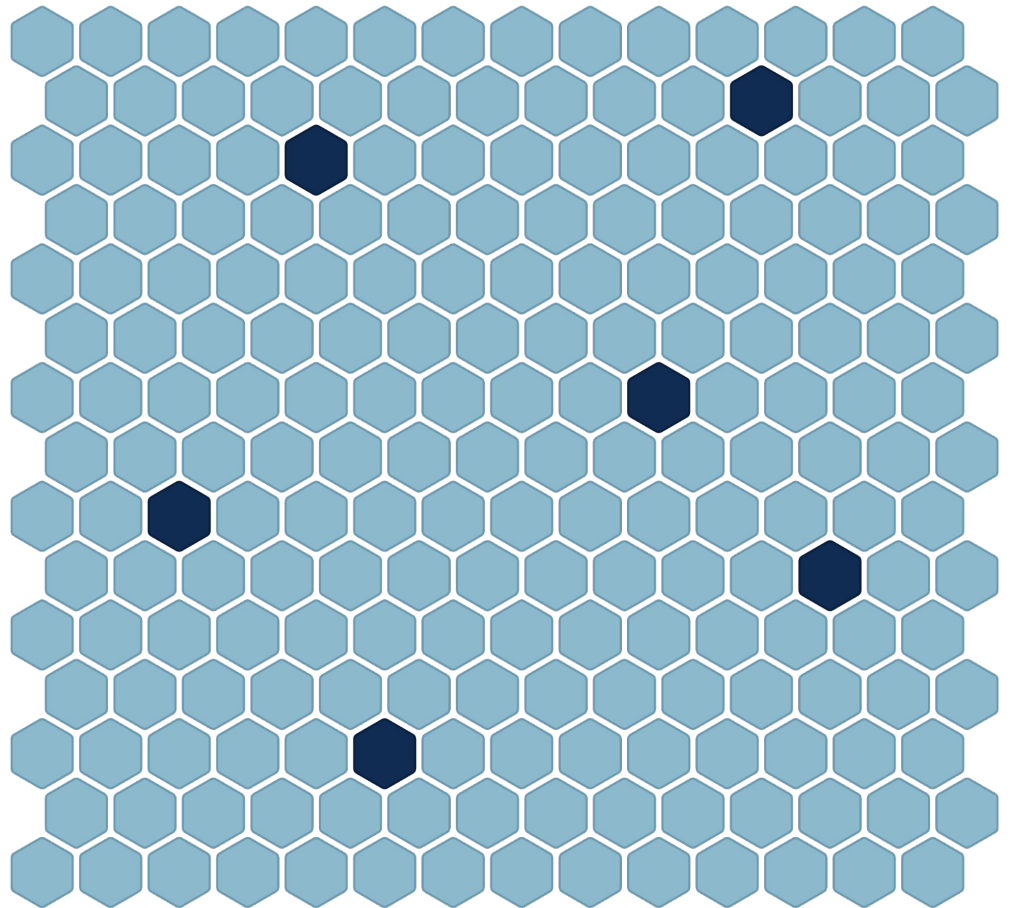
Precision	Recall	F1-Score
90.02%	94.13%	92.02%





Is this enough?

Time saving: photo-interpretation



 Empty territory scanned  Manually evaluated waste site

Territory scanning

Manual

Site evaluation

Manual

Manual baseline

Area inspected	100%
Inspection time	—
Sites identified	—

Operator time per phase

Territory scanning

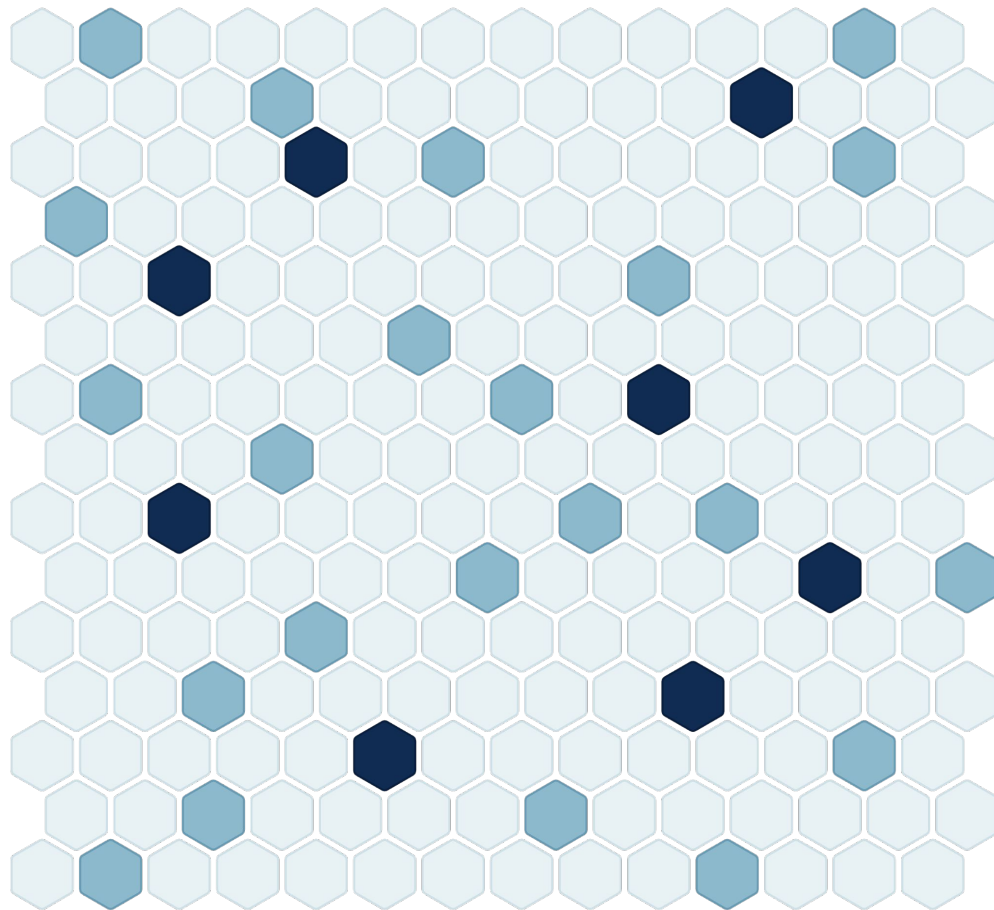
Site evaluation

47%

53%

Test area: 125 km², 12 municipalities

Time saving: AI-assisted analysis



AI-detected, triaged and discarded



Manually evaluated waste site

Territory scanning

Automated

Site evaluation

Manual

Compared to the manual baseline

Area inspected	14%	-86%
Inspection time	-21%	
Sites identified	+11%	vs manual

Operator time per phase

Site triage

Site evaluation

26%

74%

▼ 21% time saved

Test area: 125 km², 12 municipalities

Lessons learned

High manual workload using a plain AI detector:

- Many candidate sites **need to be reviewed**
- **No automated assessment** of the site environmental risk
- **A large fraction of time** is spent to manually evaluate all candidate sites

The constraint remains manual review time and it **scales linearly with the number of sites**

Operator time per phase

Site triage

Site evaluation



26%

74%

▼ 21% time saved

Active research

ALP-AI<https://alp-ai.org>

Partners involved

Academic, environmental agencies, end-user partners from **Italy and Switzerland**.

6

Partners

Project duration

Technology development, field testing, **environmental policies** formulation.

30

Months

Research work

Multiple environmental protection **AI-based projects** on different areas.

4

Work Packages

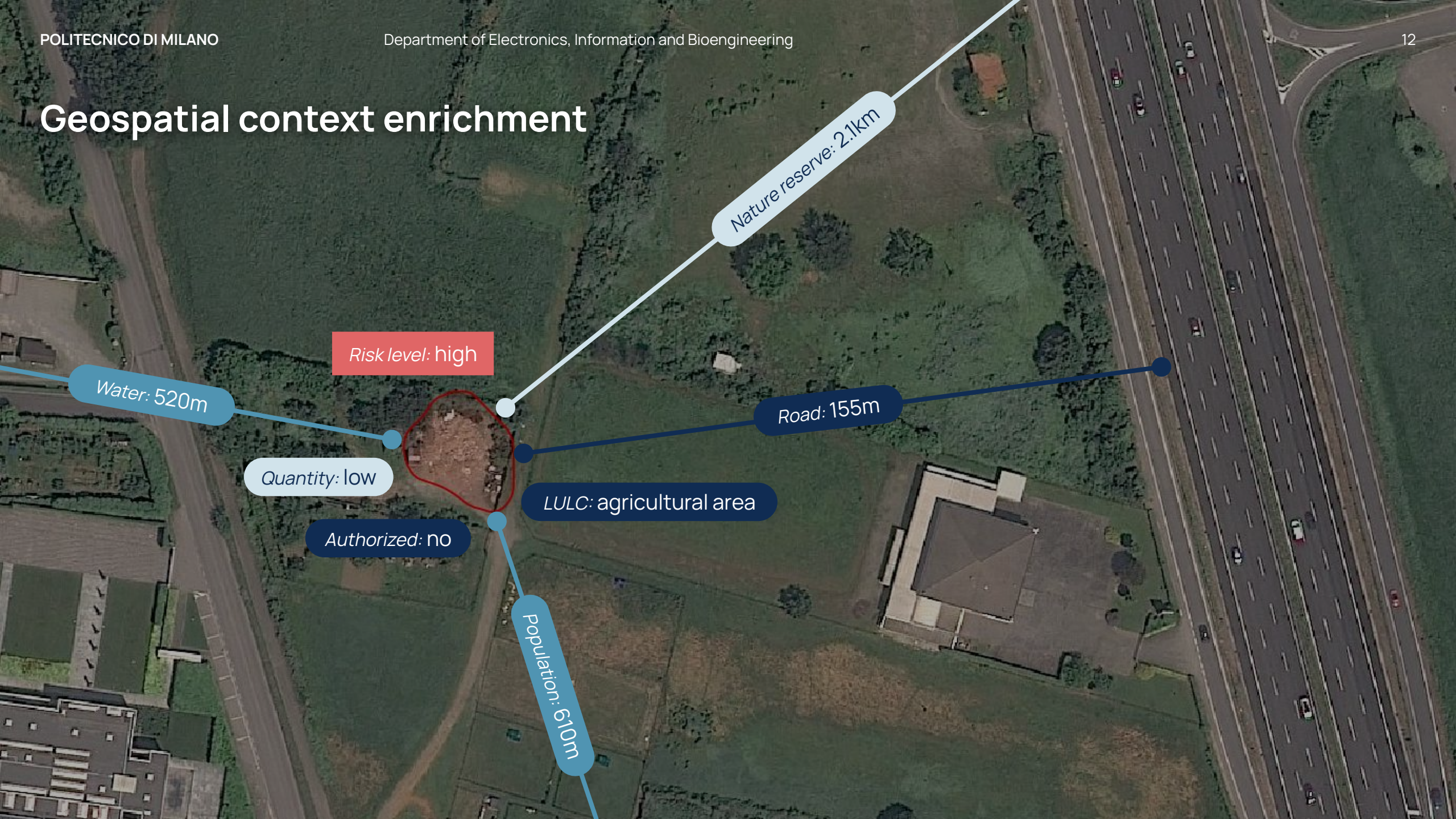
Follow-up project

Risk assessment of waste dumping sites that pollute the surrounding environment.

risk

Research direction

Geospatial context enrichment

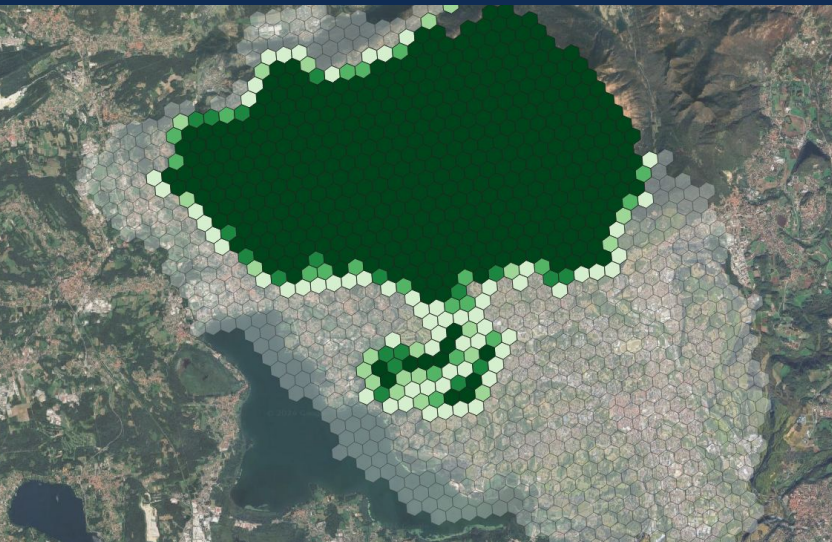


Automated environmental risk evaluation

Automatic **environmental risk assessment** and site ranking:

- Built on **18 risk criteria** defined together with environmental agency experts
- Dumping site **risk scoring** and classification (consistent across regions)
- Critical **site ranking** for intervention prioritization

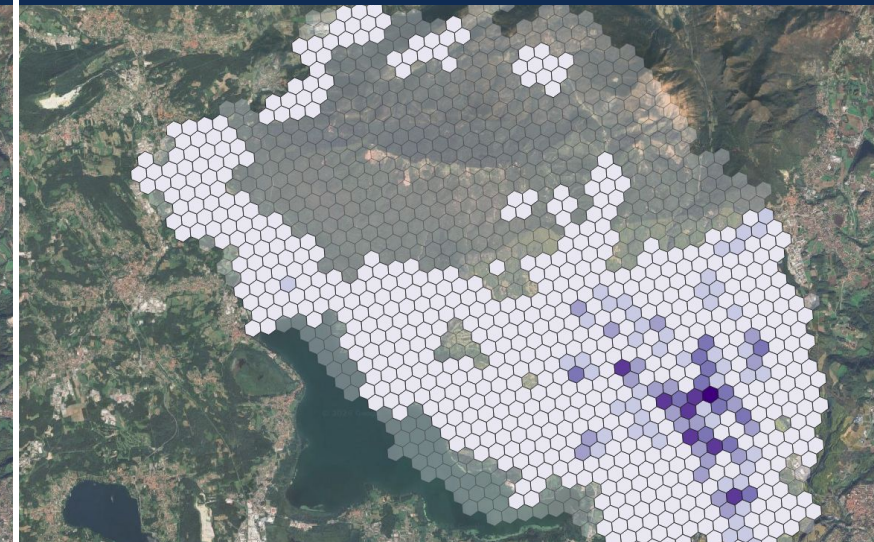
Nature reserve



Water bodies



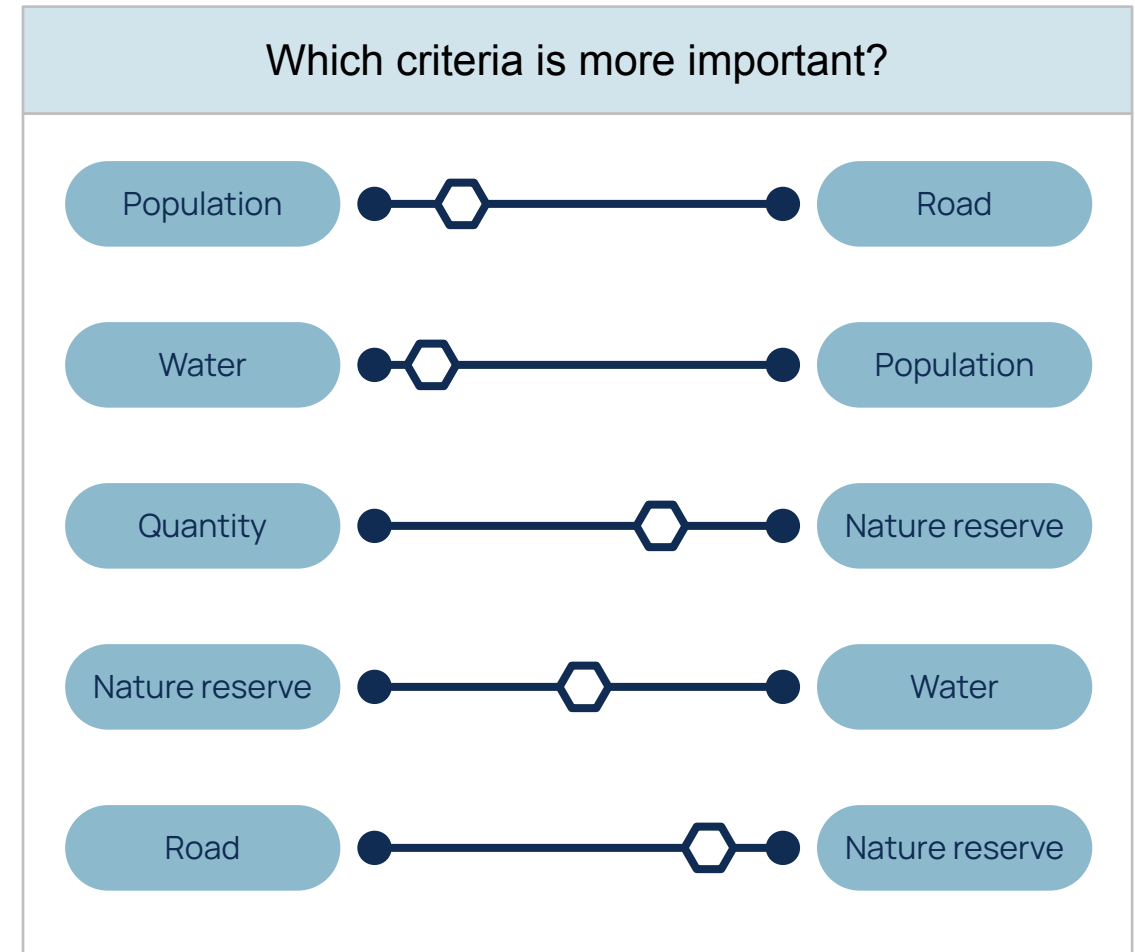
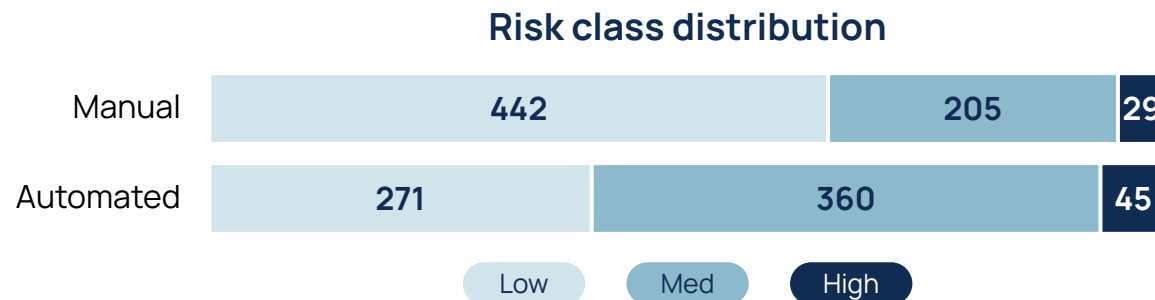
Population



Risk engine calibration

Three-step calibration procedure:

1. Experts define the **importance of each risk criteria**
2. The engine **calibrates the parameters** based on the expert decisions
3. The algorithm is fine-tuned on a reference dataset of **~700 sites evaluated manually** by experts



Manual vs automated risk scoring

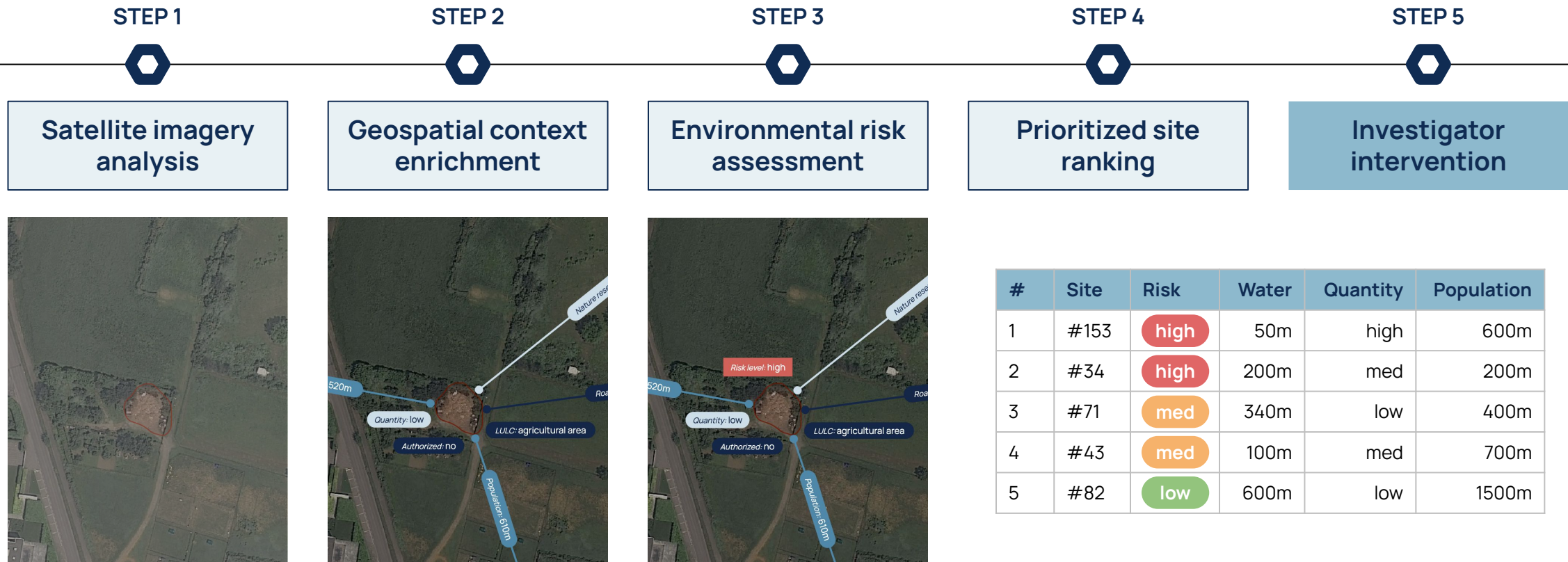
The manual rating is a valuable but **heuristic judgment**.

The automated engine systematically applies the **same expert-calibrated criteria** to every site.

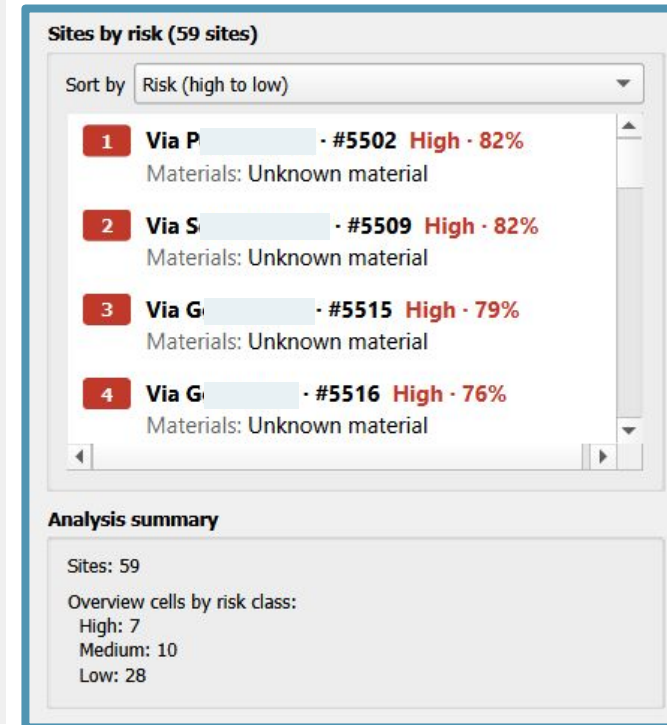
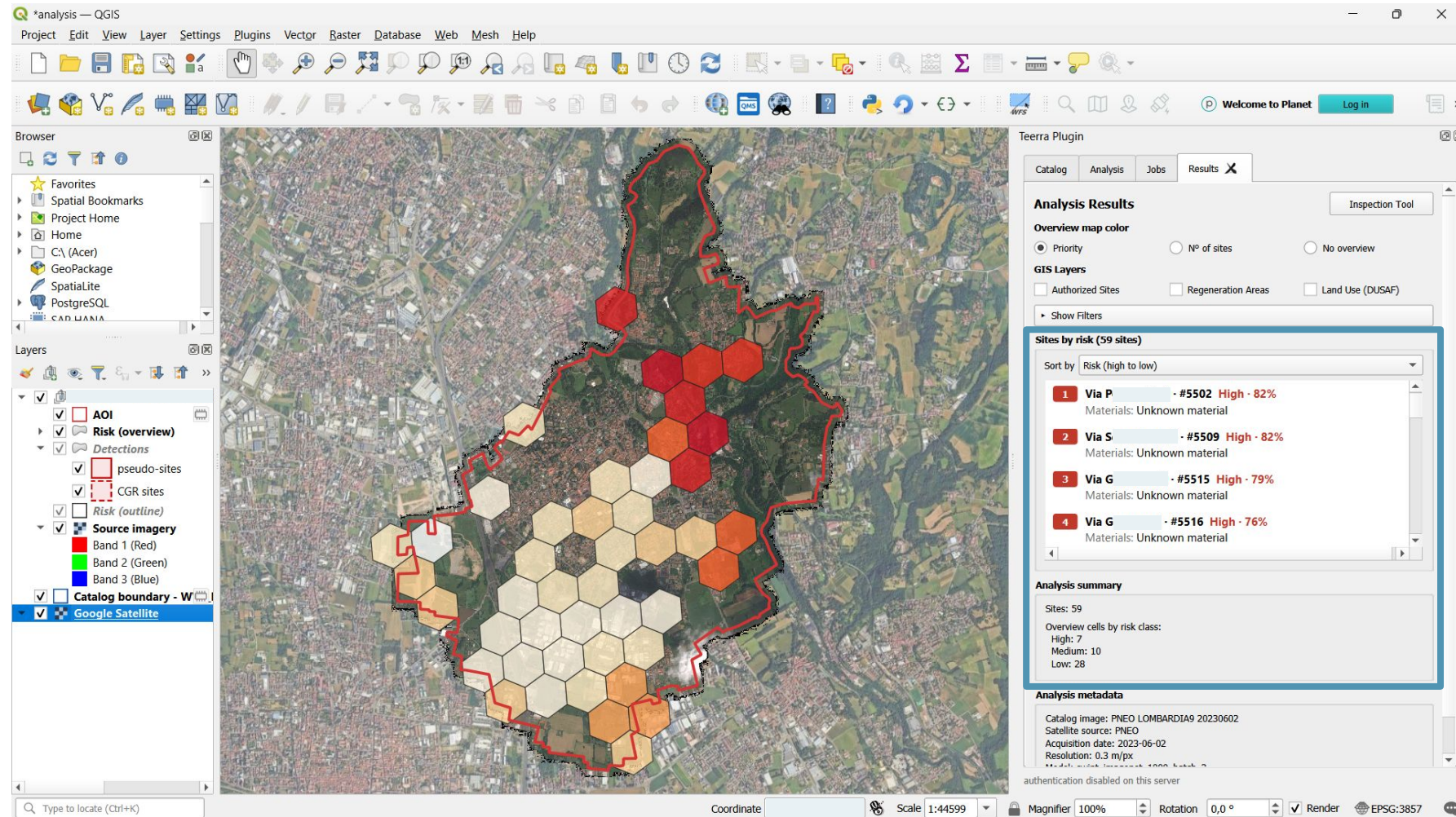
	Manual assessment	Automated engine
Approach	Heuristic	Systematic
Manual effort	High (site by site)	Low (one-time calibration)
Consistency	Analyst-dependent	Same criteria for all sites
Comparability	Case-based evaluation	Fair across regions
Expert knowledge	Applied case by case	Distilled, applied systematically

End-to-end operational pipeline

From satellite imagery to **actionable intelligence**: engine detect and prioritizes, **experts decide**.



Prototype: analysis overview



Prototype: site inspection

QGIS *analysis — QGIS

Project Edit View Layer Settings Plugins Vector Raster Database Web Mesh Help

Browser

- Favorites
- Spatial Bookmarks
- Project Home
- Home
- C:\ (Acer)
- GeoPackage
- Spatialite
- PostgreSQL
- SAR MANA

Layers

- ☒ AOI
- ☒ Risk (overview)
- ☒ Detections
 - ☒ pseudo-sites
 - ☒ CGR sites
- ☒ Risk (outline)
- ☒ Source imagery
 - ☒ Band 1 (Red)
 - ☒ Band 2 (Green)
 - ☒ Band 3 (Blue)
- ☒ Catalog boundary - W
- ☒ Google Satellite

Teerra Plugin

Catalog Analysis Jobs Results

Site details

Via P . Italia

Site ID: 5502

Classification score: 99.90%

Recognized materials: Unknown material

Authorizations

Authorized site (CGR): ---

Authorization registry (0)

Risk assessment

Overall: High (82%)

Contribution to overall:

Territory: 77.83%

Waste management: 3.92%

Site characteristics: 0.70%

Criteria coverage: 75.06%

Risk criteria · ranked by contribution to overall

#	Factor	Value
1.	Protected areas	Inside (Nature park, Regional park)
2.	Water	53 m
3.	Population	2,635 inh/km ²
4.	Agricultural land	30 m
5.	Road	7 m
6.	Inside CGR	No
7.	Natura 2000	3,311 m
	Slope	6.5°

Analysis metadata

Catalog image: PNEO LOMBARDIA9 20230602

Satellite source: PNEO

Acquisition date: 2023-06-02

Resolution: 0.3 m/px

Model: swint_imagenet_1000_batch_3

Risk weights: 1.4-fuzzy-reweighted

authentication disabled on this server

Coordinate Scale 1:1008 Magnifier 100% Rotation 0,0 ° Render EPSG:3857

Risk criteria · ranked by contribution to overall

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Future works

Lower resolution imagery

Large-scale territory screening
using **IRIDE** imagery

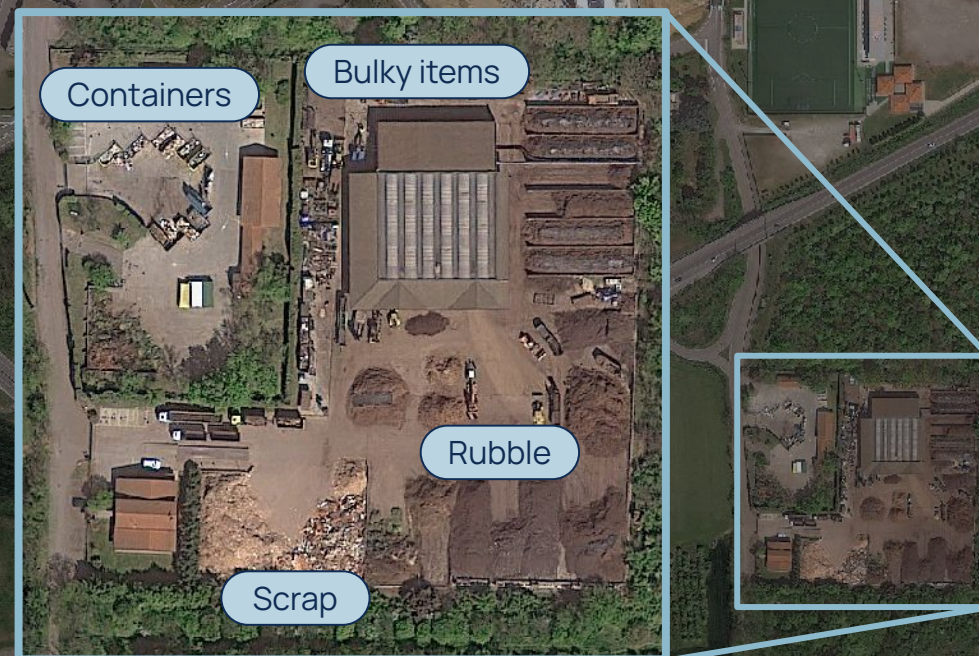
HEO: 2.5 m/px

Nimbus VHR: ~1 m/px



Material recognition

Material classification to
enhance risk assessment





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Thank you for your attention

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