Air Quality Monitoring and Forecasting Tool: Lisbon application

Giacomo Blanco

UP2030

Ajuntament de Barcelona

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Motivation

Air Pollution threat

Air pollution poses a significant threat to public health and well-being, particularly in urban areas

Importance of Monitoring

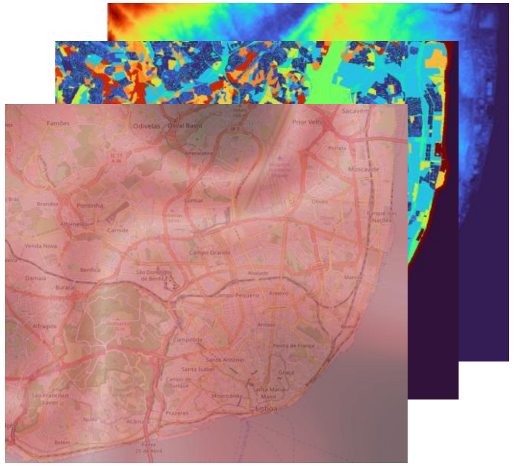
Implementing a predictive tool for air quality proves important for both citizens and policy-makers.

Remote sensing solution

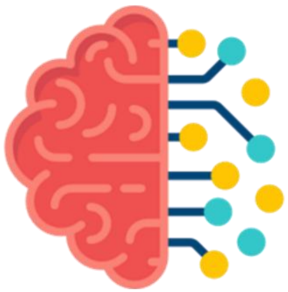
Recent advancements in remote sensing technologies made satellite imagery a cost-effective opportunity to acquire continuous measurements of air pollutant levels across vast areas

Objective

Combine several data sources

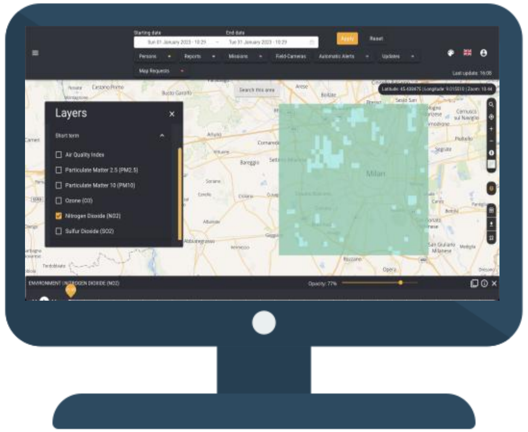


Process them with a ML-powered algorithm



To produce daily pollutant concentration maps

Offer forecasts to end users via a web-based dashboard



- Spatial Resolution: **500m**
- Temporal extent: **7 days**
- Measured pollutants: **PM25, PM10, O3, NO2, SO2**
- Estimation of Air Quality Index as defined by EEA

Data Sources

Satellite data

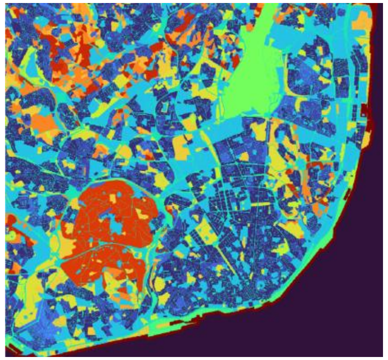
- Copernicus Sentinel 5P mission
- Atmosphere pollutant concentration
- Daily temporal resolution
- 3.5x5.5km spatial resolution
- Available from 2018

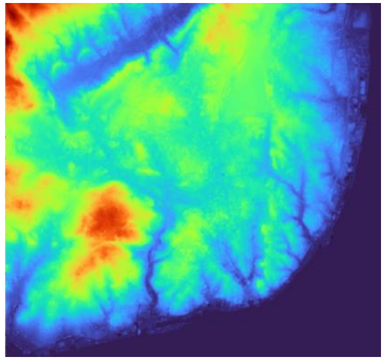
Weather data

- Solar radiation
- Humidity
- Temperature
- Precipitations
- Wind
- Cloud cover

- Visual Crossing Weather service
- Several weather variables
- Daily temporal resolution
- City spatial resolution

Morphological data





- Copernicus Urban Atlas 2018
  - land use
  - 10m spatial resolution
- Copernicus EU DEM:
  - Digital elevation model
  - 30m spatial resolution
- No temporal resolution

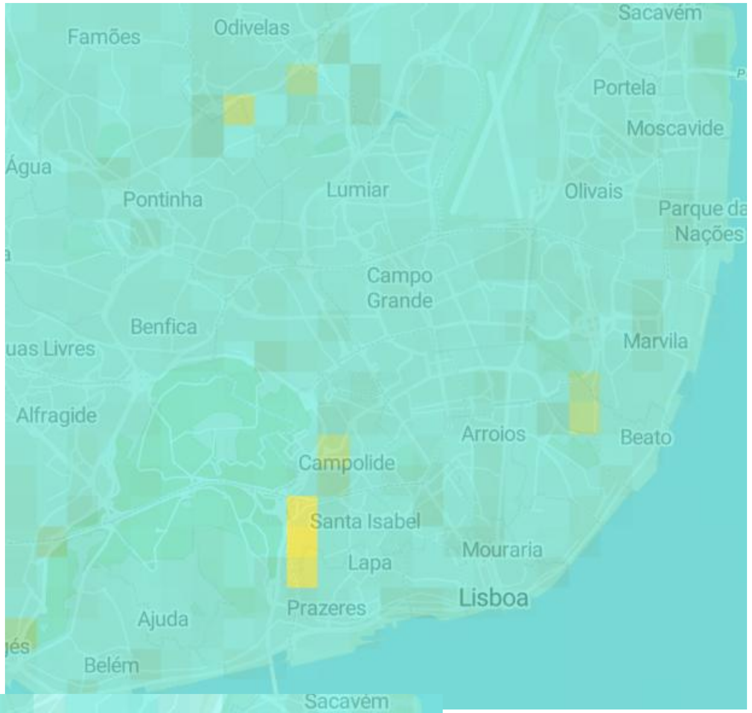
Pollution data

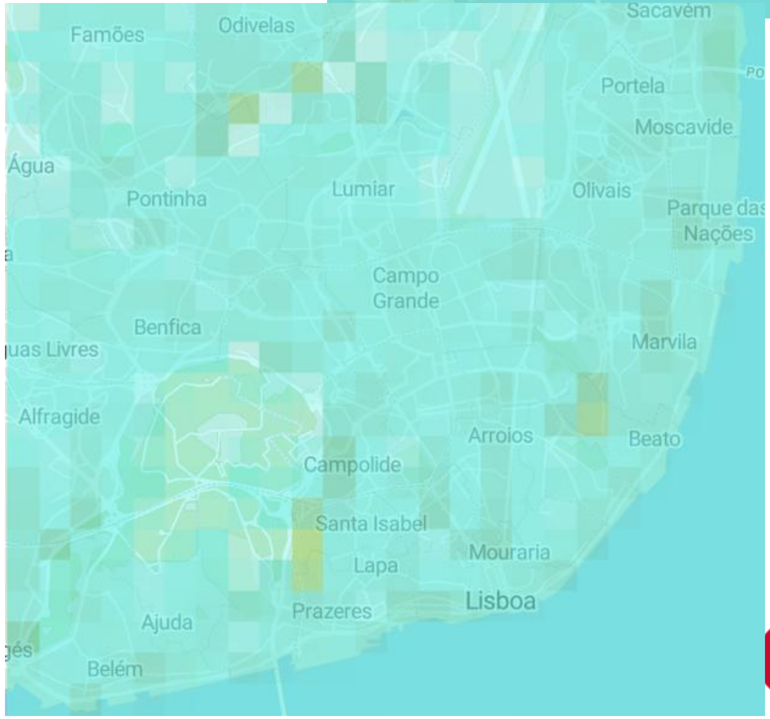
- Lisbon open data portal
- Ground pollutant concetration
- Daily temporal resolution

Results

	1 day MAE [μg/m³]	1 day MAPE [%]	Overall MAE [μg/m³]	Overall MAPE [%]
PM10	6.58	39.62	6.47	38.40
PM25	3.29	50.22	3.27	49.73
NO2	7.98	36.66	7.86	35.83
O3	10.10	23.99	10.14	23.62
SO2	0.41	26.24	0.42	26.60
Overall			**7.24**	**34.51**

*MAE : Mean Absolute Error; MAPE : Mean Absolute Percentage Error





Long Term Insights: Retrospective Analysis on Lisbon

European Environmental Agency Reference

- EEA classifies air quality according to each pollutant concentration in µg/m3
- AQI tool output relies on this classification to propose aggregated air quality index
- AQI Index is calculated as the worst air quality class considering all the pollutants

Pollutant	Index level (based on pollutant concentrations in µg/m^3)					
	Good	Fair	Moderate	Poor	Very poor	Extremely poor
Particles less than 2.5 µm ($PM_{2.5}$)	0-5	6-15	16-50	51-90	91-140	>140
Particles less than 10 µm (PM_{10})	0-15	16-45	46-120	121-195	196-270	>270
Ozone (O_3)	0-60	61-100	101-120	121-160	161-180	>180
Nitrogen dioxide (NO_2)	0-10	11-25	26-60	61-100	101-150	>150
Sulphur dioxide (SO_2)	0-20	21-40	41-125	126-190	191-275	>275

Hazard Index

- The Hazard Index aggregates daily air quality into a single annual indicator per station
- The index ranges from 0 (consistently good air quality) to 100 (consistently extremely poor air quality).
- It is computed for each pixel
- It allows quick comparison of pollution severity at each site, showing spatial differences and highlighting pollution hotspots within the city.
- For each day of the year a weight W_{AQ} is assigned, according to air quality level, and then normalized

$$HI = \frac{\sum_{d=1}^{365} W_{AQ}(d)}{365}$$

W_{AQ}=

- 0 if AQ = Good
- 10 if AQ = Fair
- 25 if AQ = Moderate
- 50 if AQ = Poor
- 75 if AQ = **Very Poor**
- 100 if AQ = **Extremely Poor**

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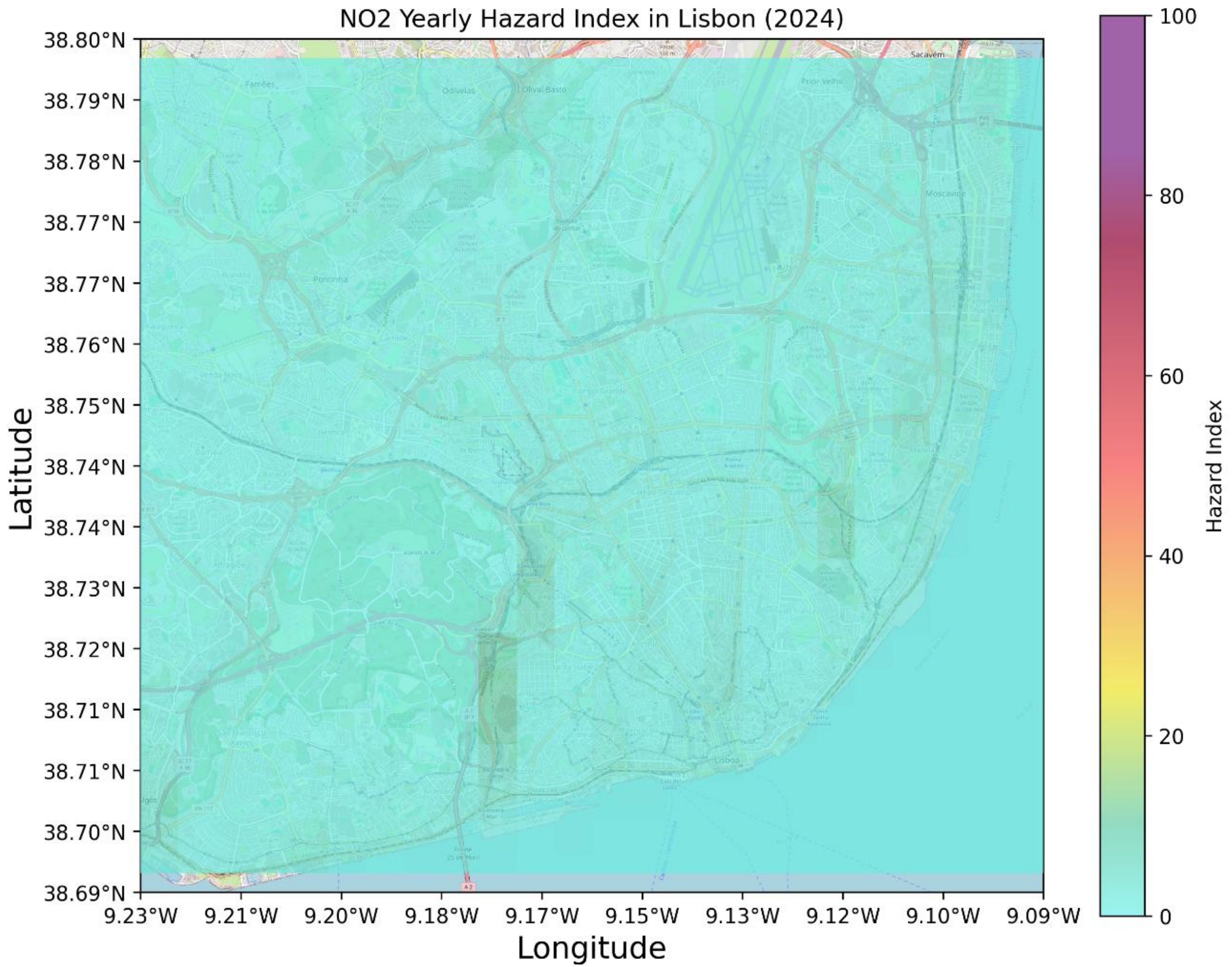
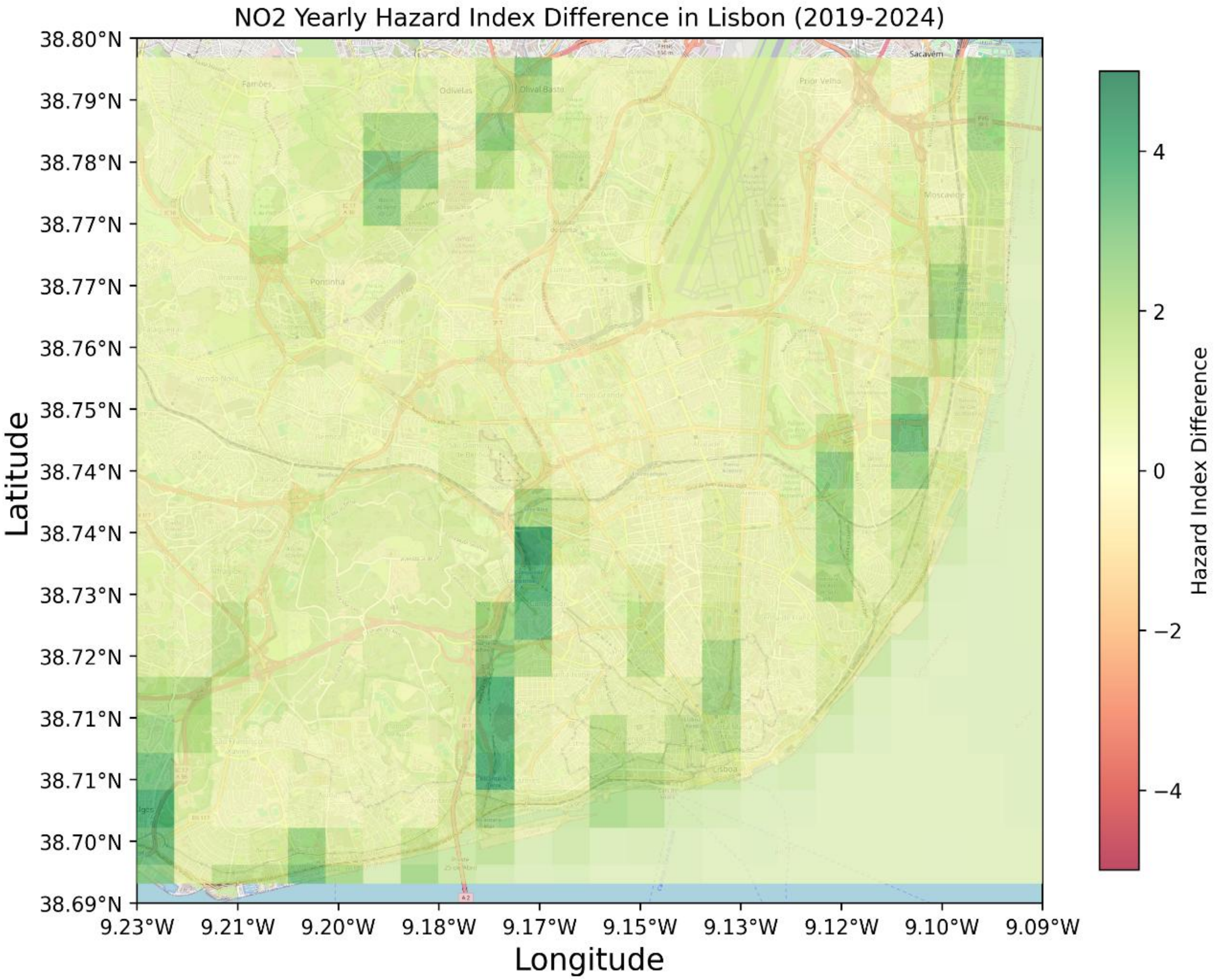
Hazard Index Results



Hazard Delta



Conclusions

Key takeaways

- Obtained results highlight the potential of AQI Tool as effective for estimating air quality within urban areas
- It can be used as either for early warning and for long term analysis, both for supporting the decision-making process

Limitations

- Coarse spatial resolution may hinder the application for sub-urban case studies
- Limited data availability can have an impact on the generalisation capabilities

Future Perspective

- Integration of other remote sensing data sources
- Explore different approaches to model the spatial relationship appropriately

This project has received funding from the Horizon Innovation Actions under the grant agreement n° 101096405.

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Ecosystem Services Assessment: Application in Milan with InVEST

Giulia Melis

LINKS Foundation

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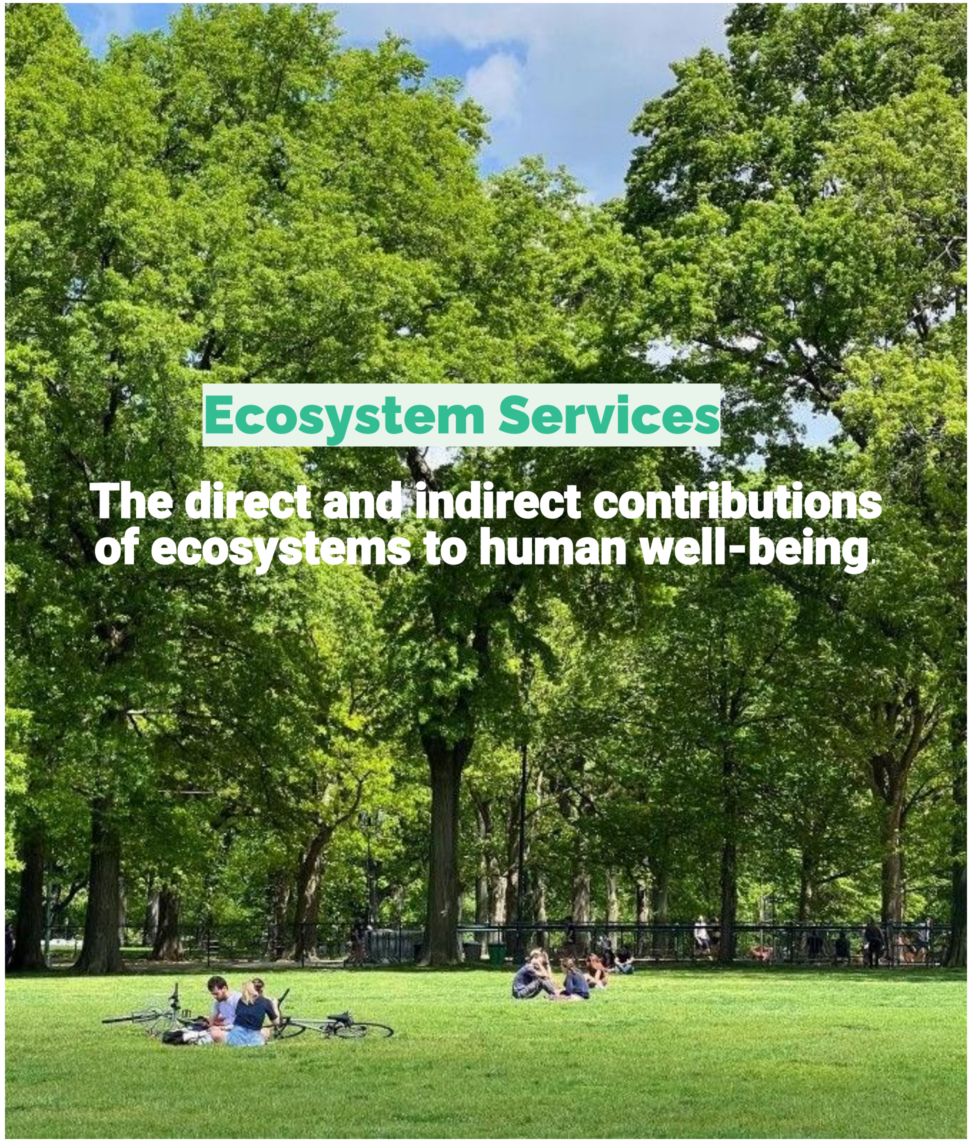
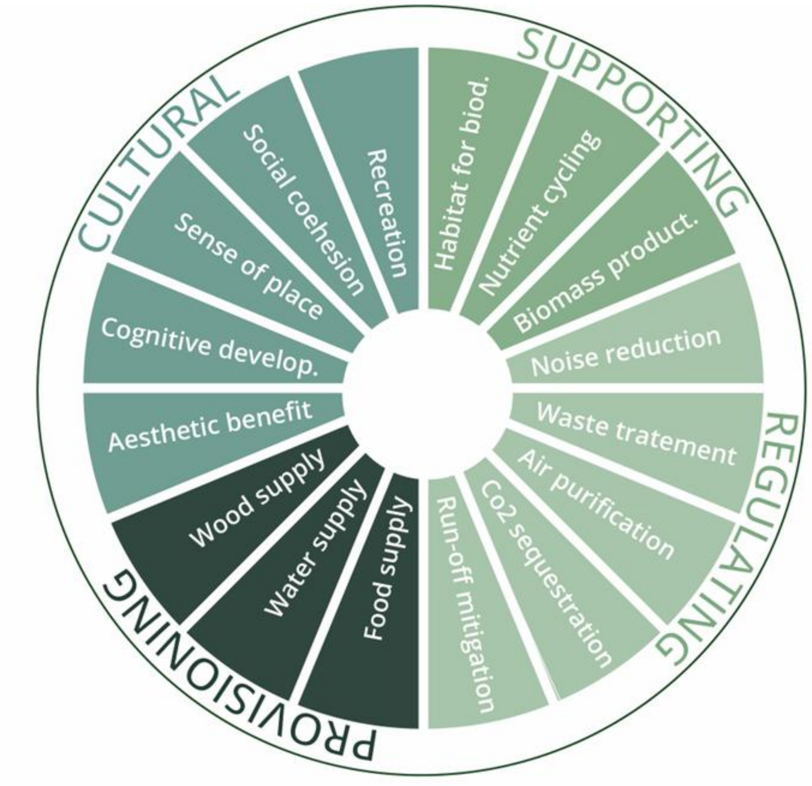
Intro: What are Ecosystem Services?



Urban Ecosystem Services

The range of ecosystem services provided by **green and blue infrastructures** that help address **city challenges** such as climate adaptation or socio-spatial inequalities.



Intro: InVEST a model to map and assess ES

Advantages ✓

- Open source, easily accessible and user-friendly
- Basic GIS skills required
- Comparative analysis of future scenarios
- Both Biophysical and Economic assessment

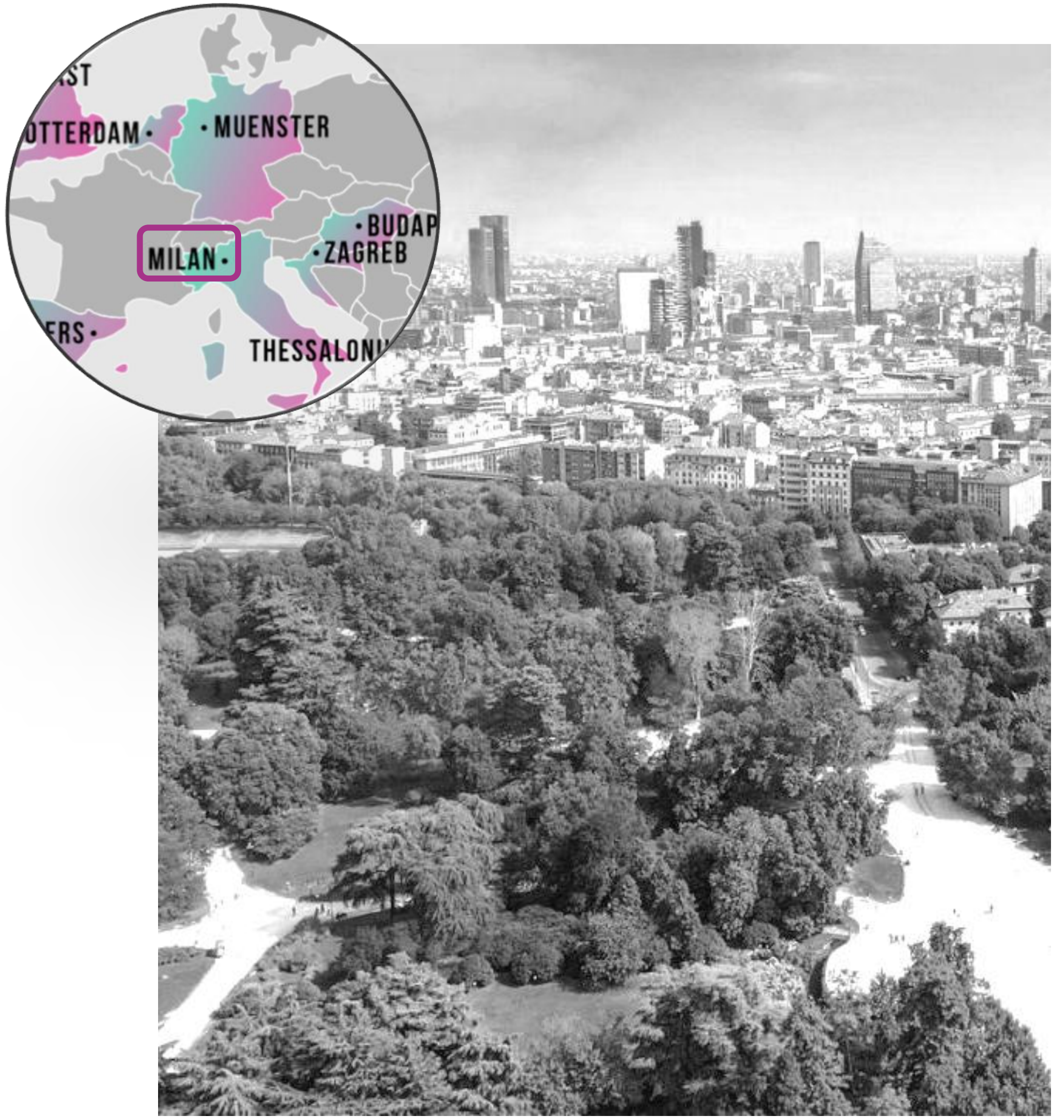
InVEST

Integrated Valuation of Ecosystem Services and Tradeoffs

Type of Ecosystem Services

Annual Water Yield	RouteDEM
Carbon Storage and Sequestration	Scenario Generator: Proximity Based
Coastal Blue Carbon Preprocessor	Scenic Quality
Coastal Blue Carbon	Seasonal Water Yield
Coastal Vulnerability	Sediment Delivery Ratio
Crop Pollination	Urban Cooling
Crop Production: Percentile	Urban Flood Risk Mitigation
Crop Production: Regression	Urban Nature Access
DelineateIt	Urban Stormwater Retention
Forest Carbon Edge Effect	Visitation: Recreation and Tourism
Habitat Quality	Wave Energy Production
Habitat Risk Assessment	Wind Energy Production

Case study: InVEST application in Milan



Goals

1

Planning and Design Support

- assess future project scenario vs current state
- inform urban plans (Urban Green Plan, Climate Plan, Climate City Contract)
- prioritize Nature-based Solutions interventions

2

Model Testing and Scaling

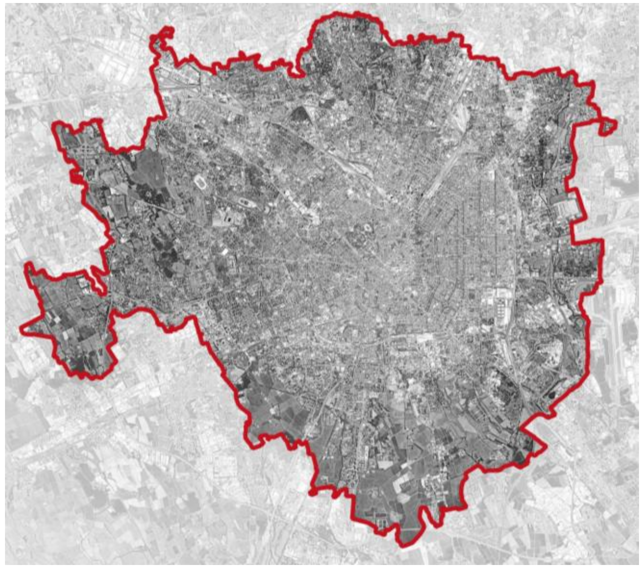
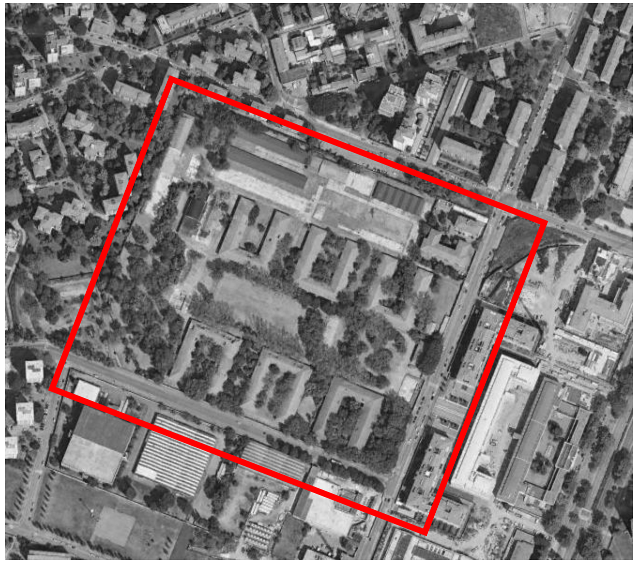
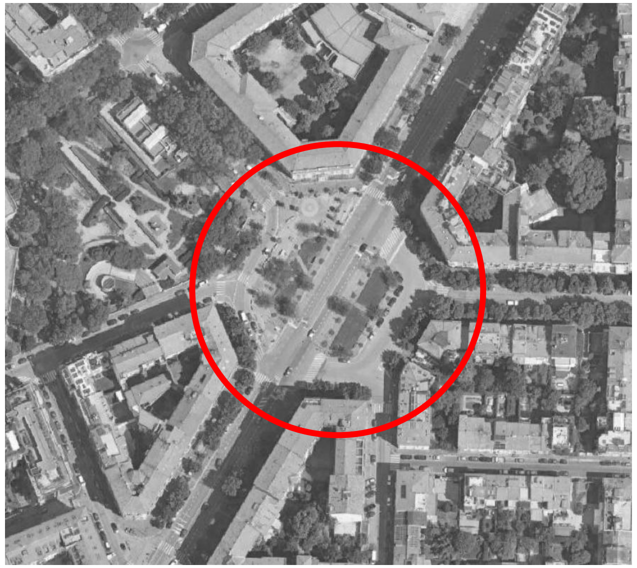
- test the InVEST model on multiple spatial scales to identify its strengths and limitations and assess its future use and replicability within the Municipality.

Case study: InVEST application in Milan

Two Ecosystem Services

- Microclimate regulation (urban cooling)
- Carbon Storage and Sequestration

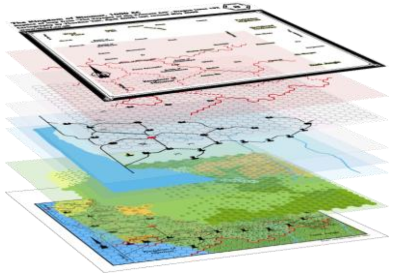
Three Level of Application

Urban level	Neighbourhood level *Caserma Mameli*	Plot level *Piazza Sicilia*
		

Method: InVEST model overview and workflow (*biophysical assessment*)

Input

- Land Use and Land Cover Maps



- Table of Biophysical Value

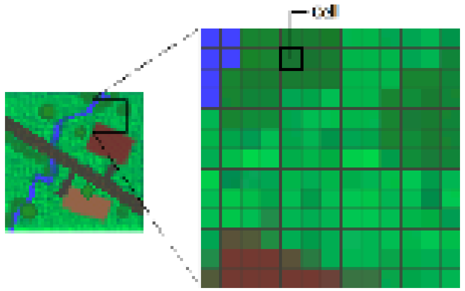
CSV

InVEST

Integrated Valuation of Ecosystem Services and Tradeoffs

Output

- Ecosystem Services Maps



- Activities Report

Method: Improving input data

1. Land Use and Land Cover Maps

DUSAF + DBT *(Green Surfaces)* + Google EIE *(Canopy Cover)*

2. Table of Biophysical Value (carbon storage & sequestration)

Land Use Class	*C_above*	*C_below*	*C_soil*	*C_dead*
Airports	0,5	0,1	5	1
Landfills	0,1	0,05	2	0,5
Construction site	0,1	0,05	2	0,5
Land without current use	1	0,2	10	2
Permanent crops	30	20	60	15
Forest Canopy Cover	150	50	80	20
Natural meadows	20	15	50	10
Water	0	0	0	0
Continus urban fabric	0,2	0,1	3	0,7
Urban fabric with medium density	1	0,5	10	2
Urban fabric with low density	5	2	20	5
Detached buildings	10	5	30	8
Industrial or commercial areas	0,1	0,05	2	0,5
Highways	0,2	0,1	3	0,7
Streets	0,1	0,05	2	0,5
Railways	1	0,2	10	2
Green urban areas Green Surf.	15	8	40	10
Pastures	15	10	40	8
Sports and recreation facilities	2	1	15	3
Arable land	5	2	25	5

Method: Improving input data

1. Land Use and Land Cover Maps

DUSAF + DBT *(Green Surfaces)* + Google EIE *(Canopy Cover)*

Urban level: scenarios assessed

Carbon Storage & Seq.	Urban Cooling
Input Data	**Input Data**

2023 Scenario

Current land use including all green surfaces and existing tree cover

Carbon Storage & Seq. – Input Data

Spatial Data
Land Use and Land Cover

Urban Cooling – Input Data

Spatial Data
Land Use and Land Cover Evapotranspiration Potential
Climate Data
Reference Air Temperature UHI Effect (max-mean)

2050 Scenario

Future land use considering a **3% increase** of **green surfaces** and **tree cover**

Carbon Storage & Seq. – Input Data

Spatial Data
Land Use and Land Cover **+ 3% green surf. and tree c.**

Urban Cooling – Input Data

Spatial Data
Land Use and Land Cover **+ 3% green surf. and tree c.** Evapotranspiration Potential
Climate Data
Reference Air Temperature **+2°C** UHI Effect (max-mean)

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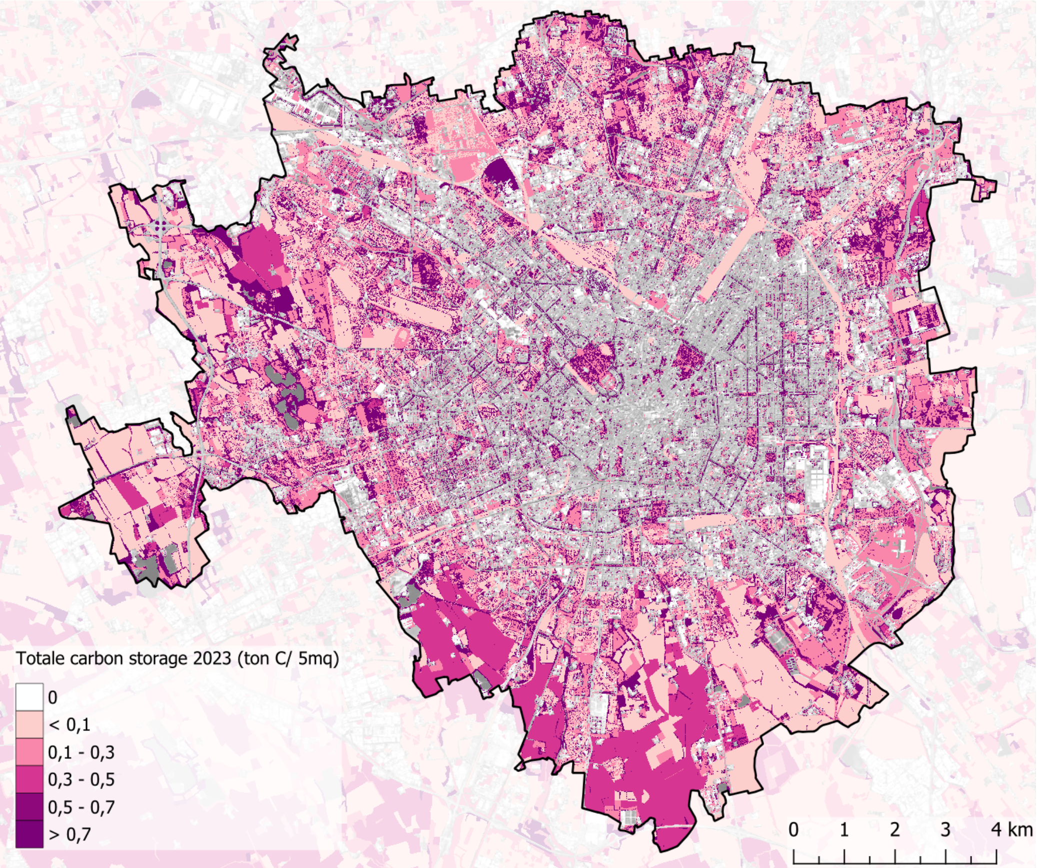
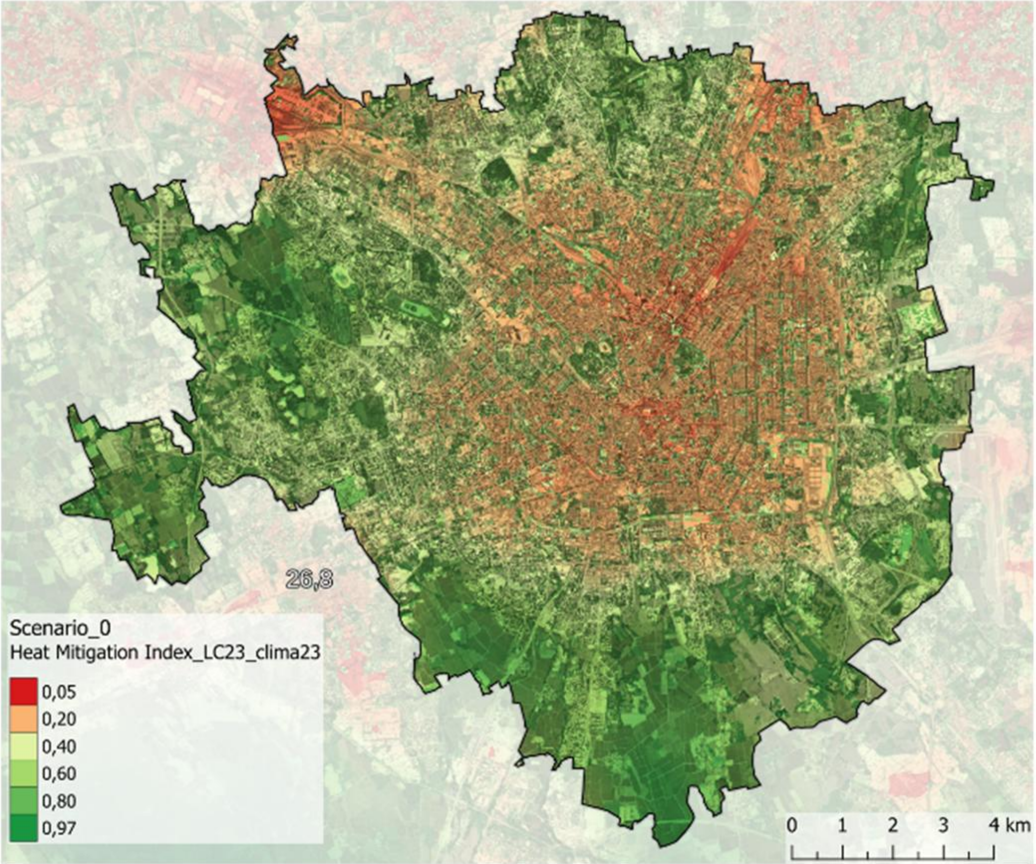
Urban level: outputs current state

Carbon Storage



Urban Cooling



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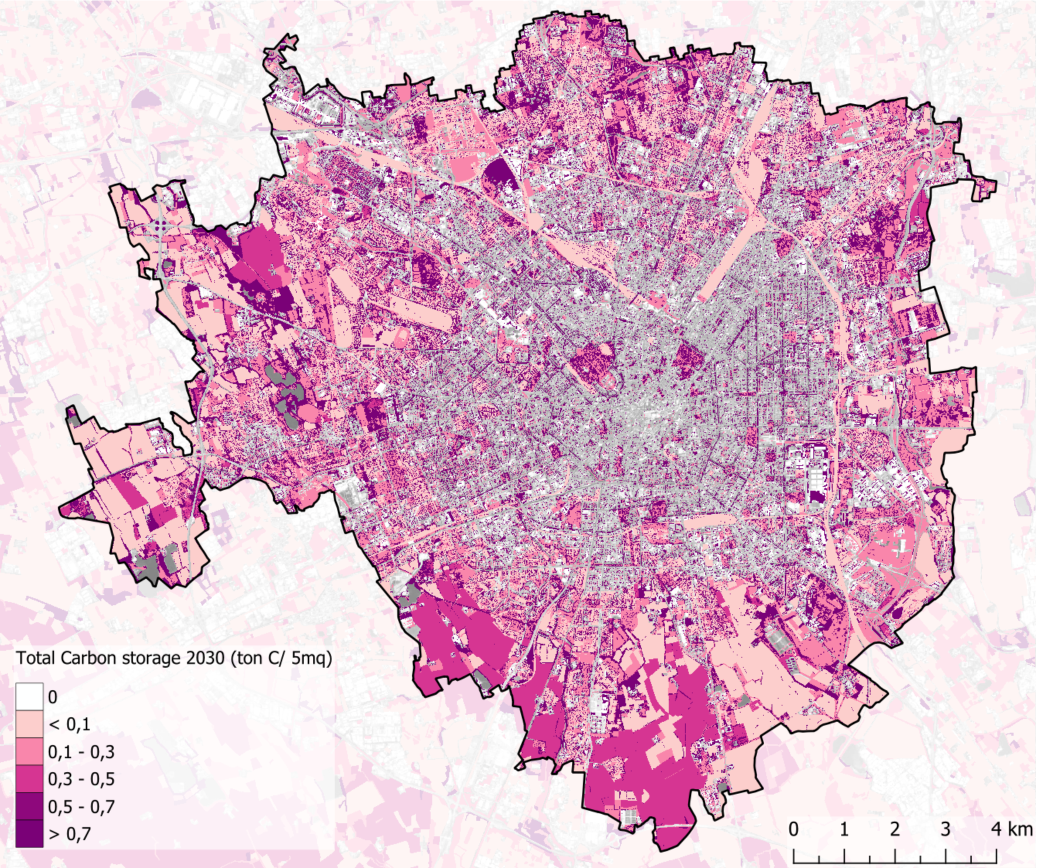
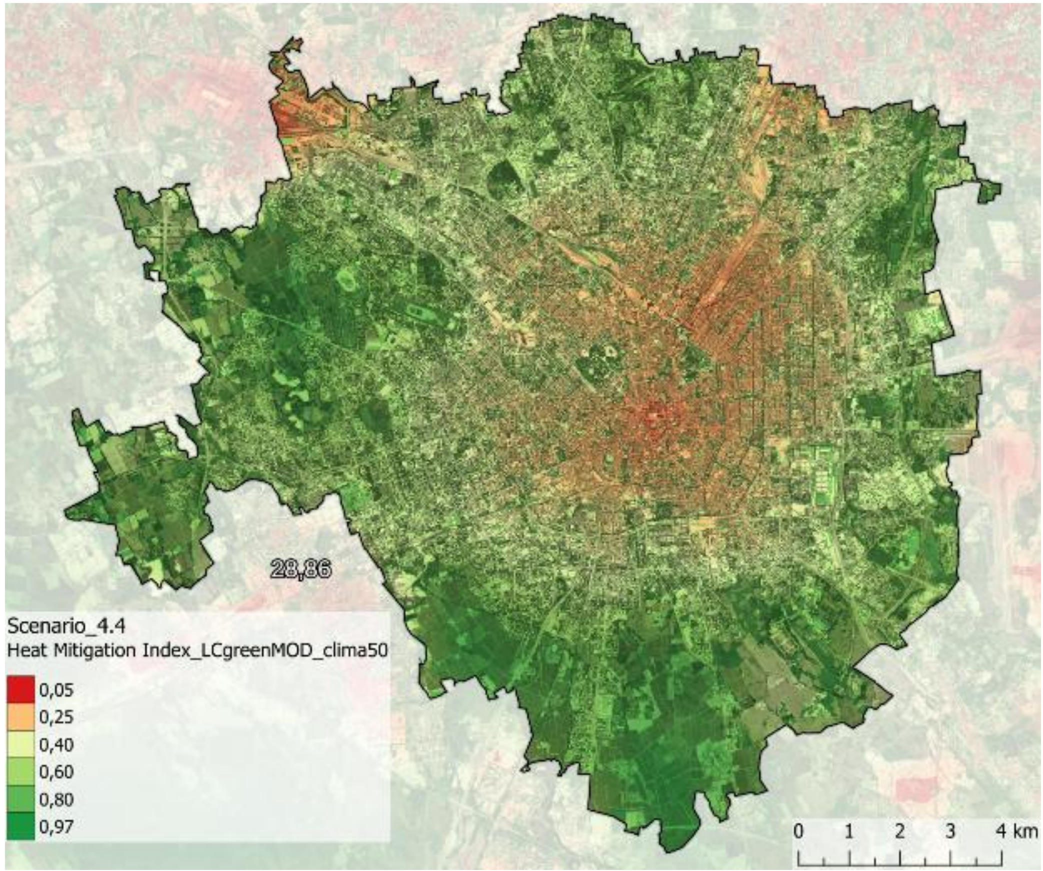
Urban level: outputs future scenario

Carbon Storage



Tot. Carbon Sequestred (2023-2030): **+220.340 Ton**

Urban Cooling



The future scenario keeps temperature rise **≤2 °C**

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Neighborhood level: scenarios assessed

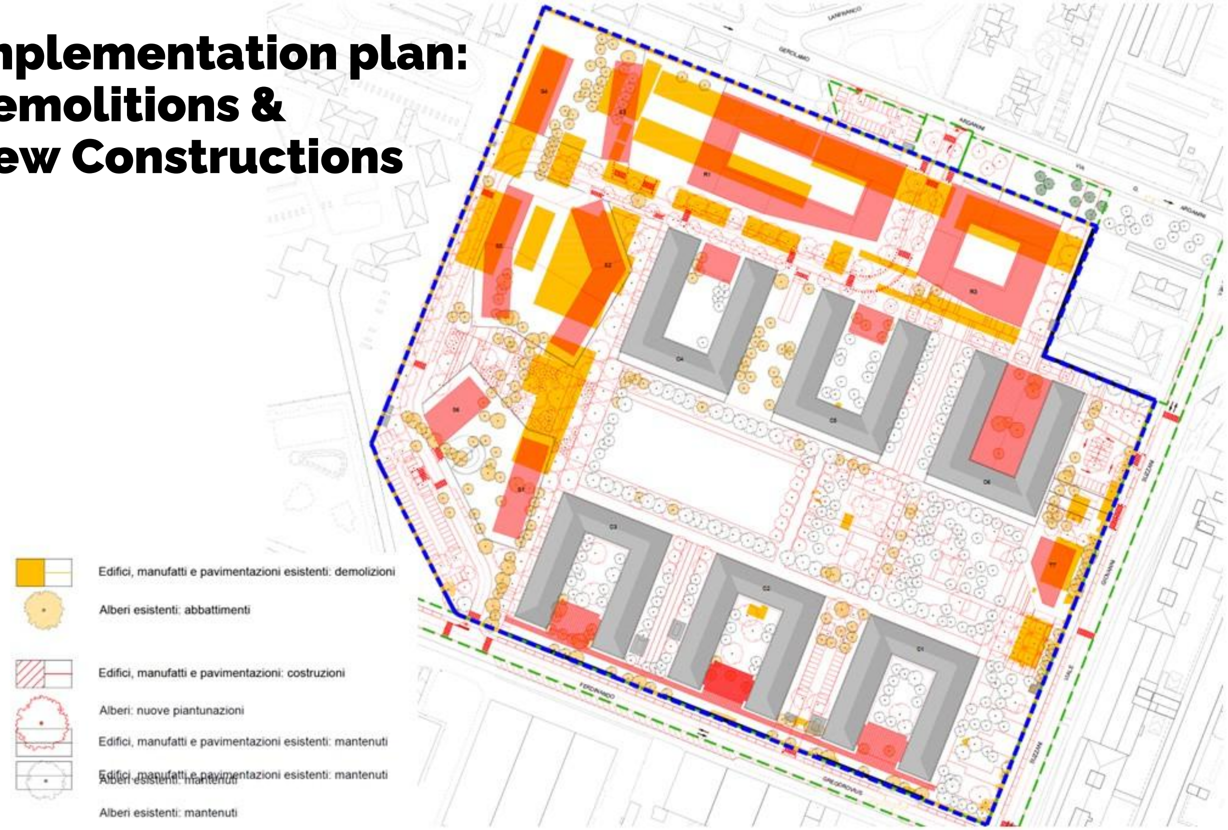
Scenario 0: Current State

Land Use update to 2020
(with Green Surfaces and Tree Canopy Cover)

Scenario 1: Project State

Land Use update to 2020 +
Project Regeneration Area

**Implementation plan:
Demolitions &
New Constructions**



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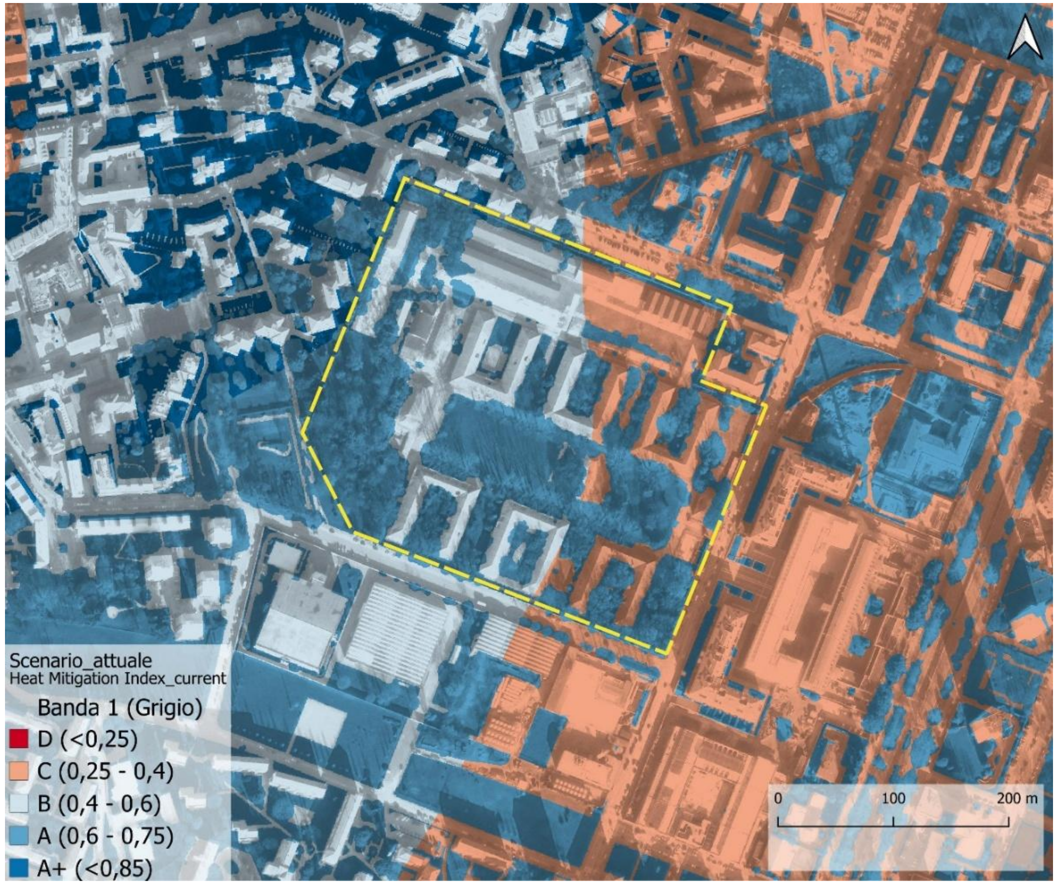
Neighborhood level: outputs current state

Carbon Storage

Urban Cooling



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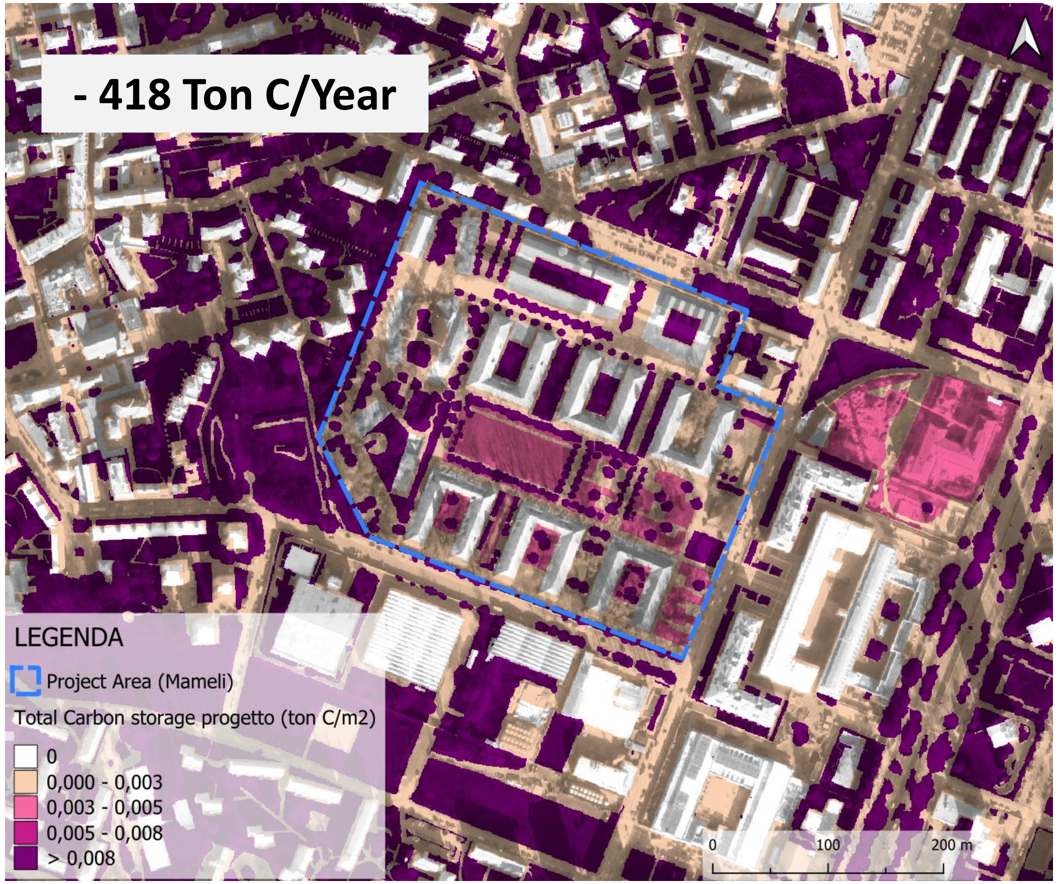
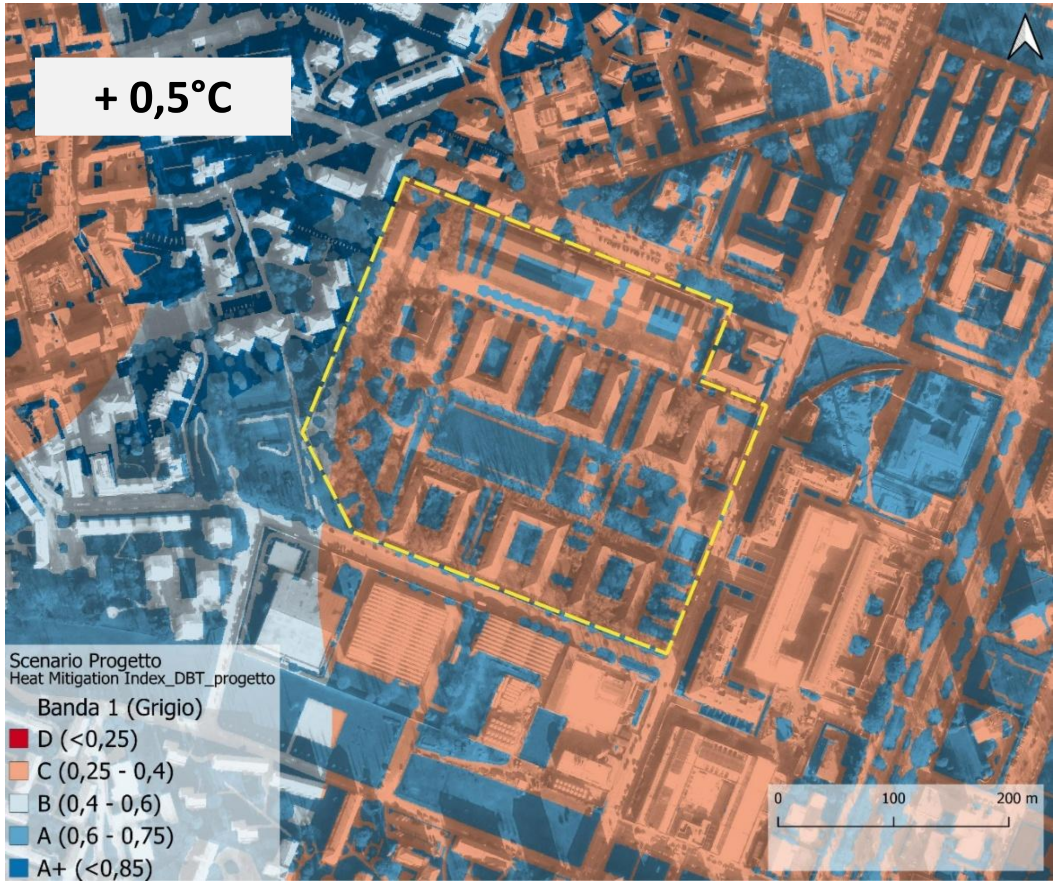
Neighborhood level: outputs project state

Carbon Storage



Urban Cooling



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Plot level: scenario assessed

Scenario 0: Current State

Land Use update to 2020
(with Green Surfaces and Tree Canopy Cover)

Scenario 1: Project State

Land Use update to 2020 +

De-paving project

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Plot level: outputs current state

Carbon Storage

Urban Cooling

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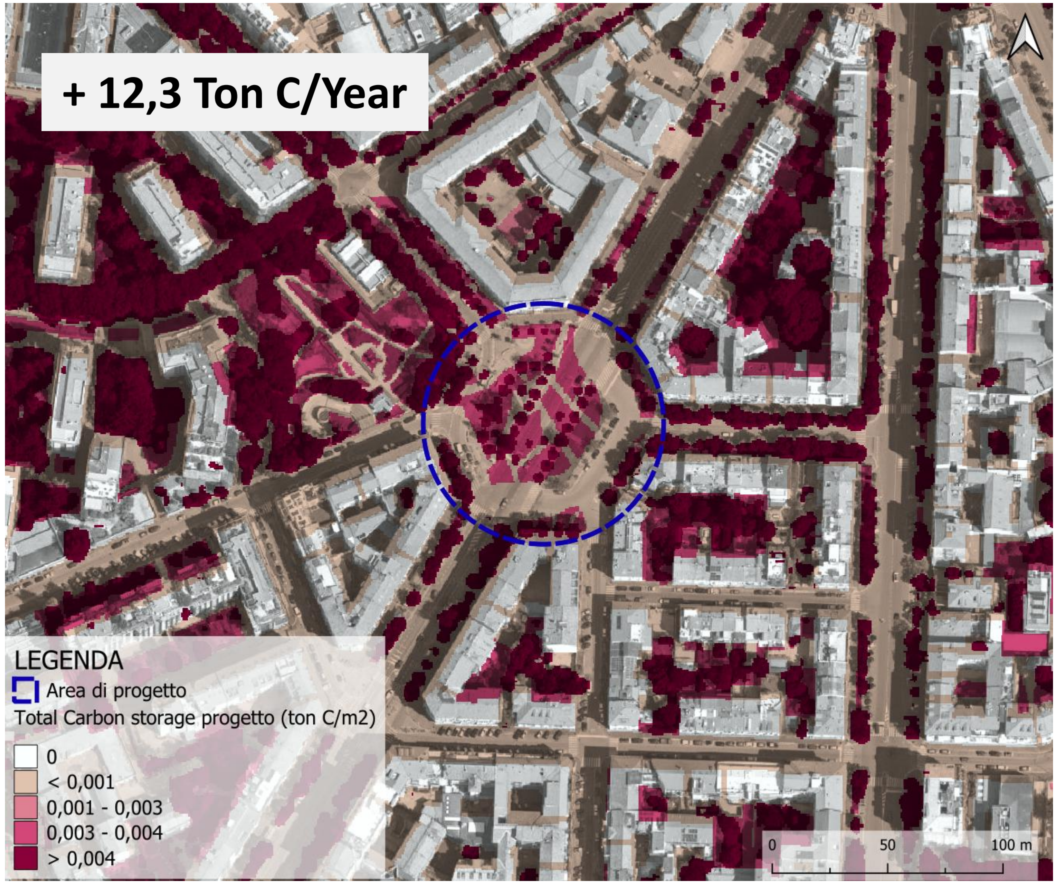
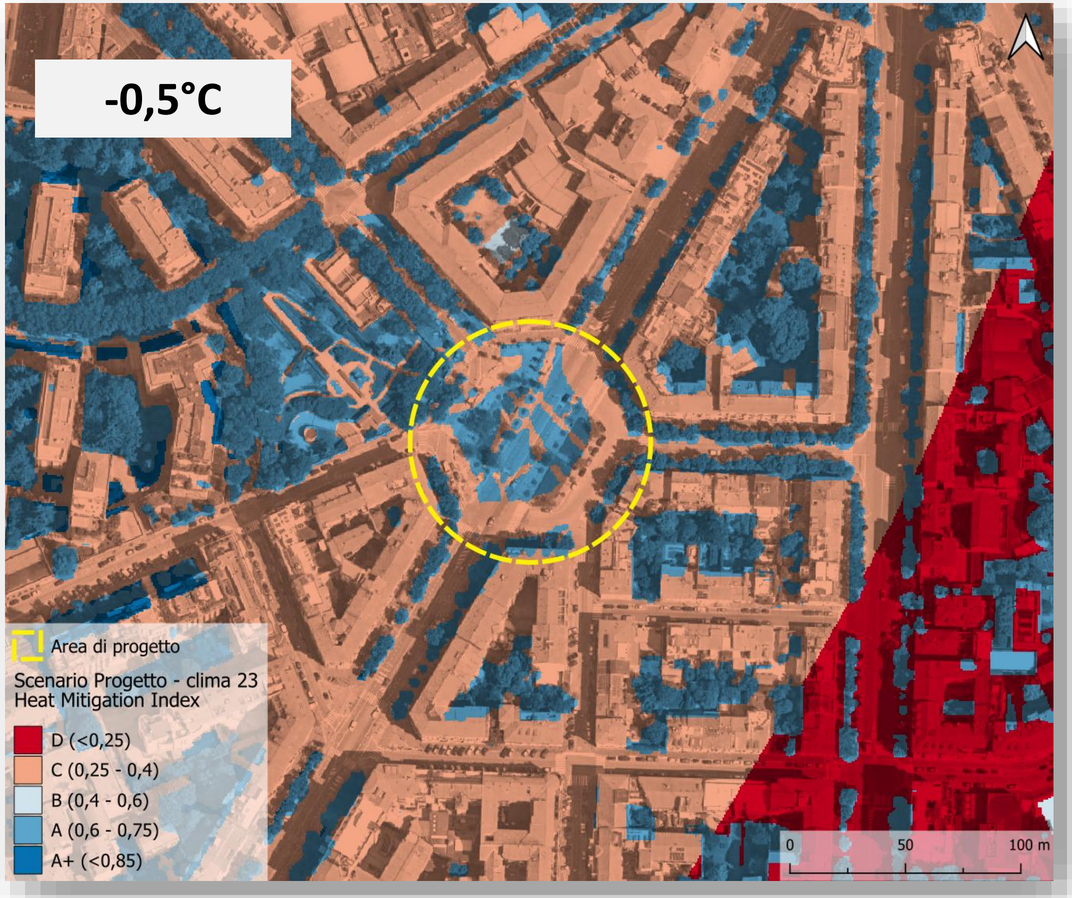
Plot level: outputs project state

Carbon Storage



Urban Cooling



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Conclusion

Key takeaways

- The reliability of InVEST depends critically on input data quality and consistency
- InVEST is useful for large-scale assessments, but without accurate, high-resolution inputs it cannot reliably capture plot-scale environmental change

Limitations

- Simplified vegetation data about density or ecological condition and no seasonality or grow dynamics
- Local variability of soil characteristics is not captured

Future Perspective

- Improvement of vegetation data with remote sensing products
- Development and integration with datasets specific to detailed urban scale

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