

FROM LAND TAKE MONITORING TO LAND TAKE MITIGATION

Michele Munafò (Italian Institute for Environmental Protection and Research)



Foto di Matteo Monzali per il concorso fotografico «Uno scatto per raccontare il cambiamento»

Land take monitoring in Italy

Artificialisation

- Soil sealing
- Soil removal
- Other

Settlement areas

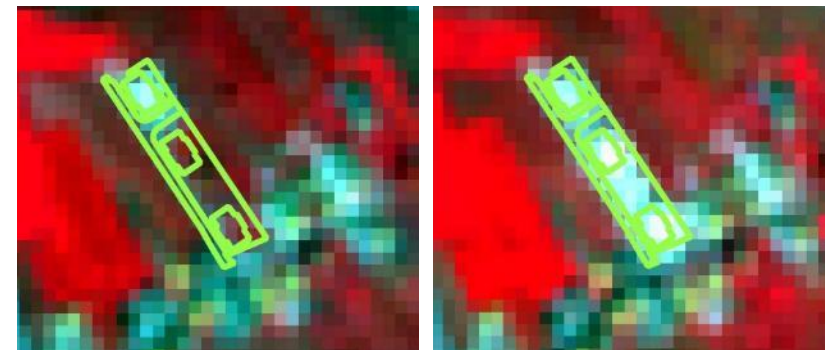
- Urban land use
- Urban-Rural continuum
- Urban ecosystems (DEGURBA)
- Planned land use (Regions)

Land Take Monitoring in Italy

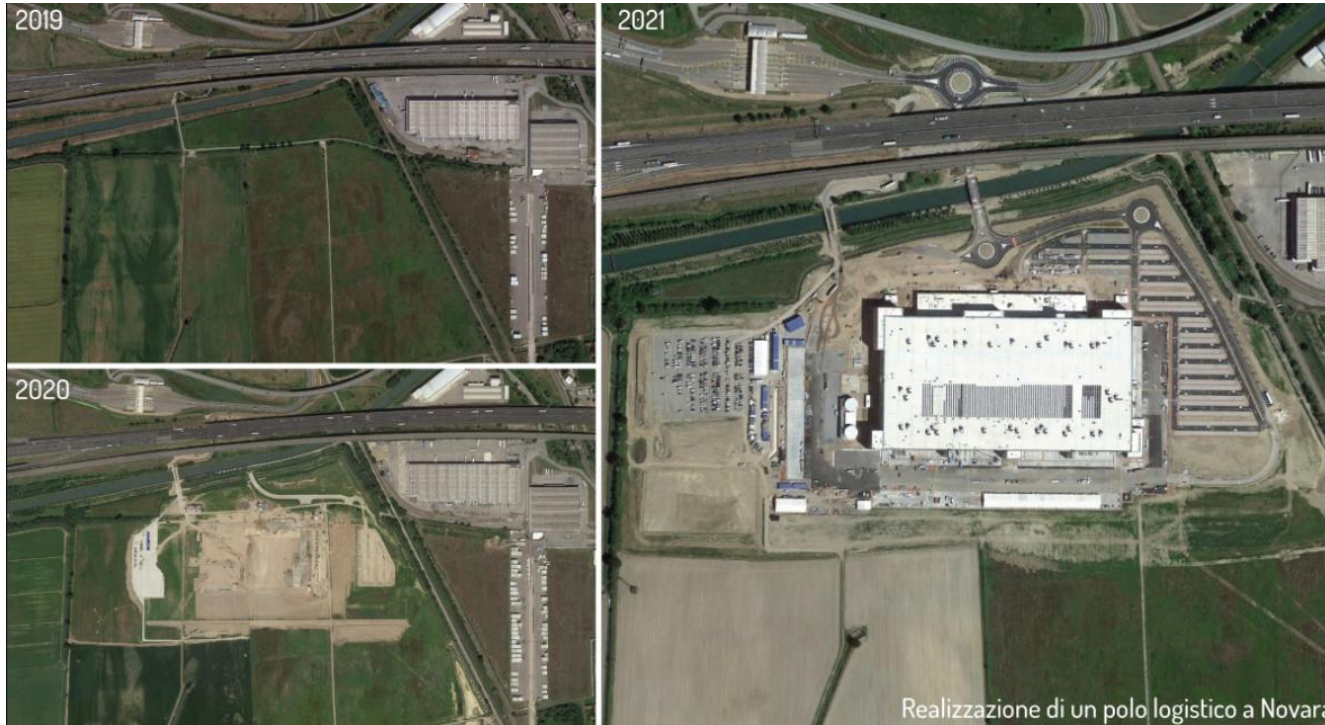
Nearly 60 photointerpreters in ISPRA and 21 Regional Agencies that, between January and February every year, map the changes of the previous year



Data sources:
Sentinel-1
Sentinel-2
VHR Images (1,5 m)
Ortophotos (0,2 m)



Land Take Monitoring in Italy (artificialisation)



IT: Reversible land take

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EU: soil removal

IT: Permanent land take

~

EU: soil sealing

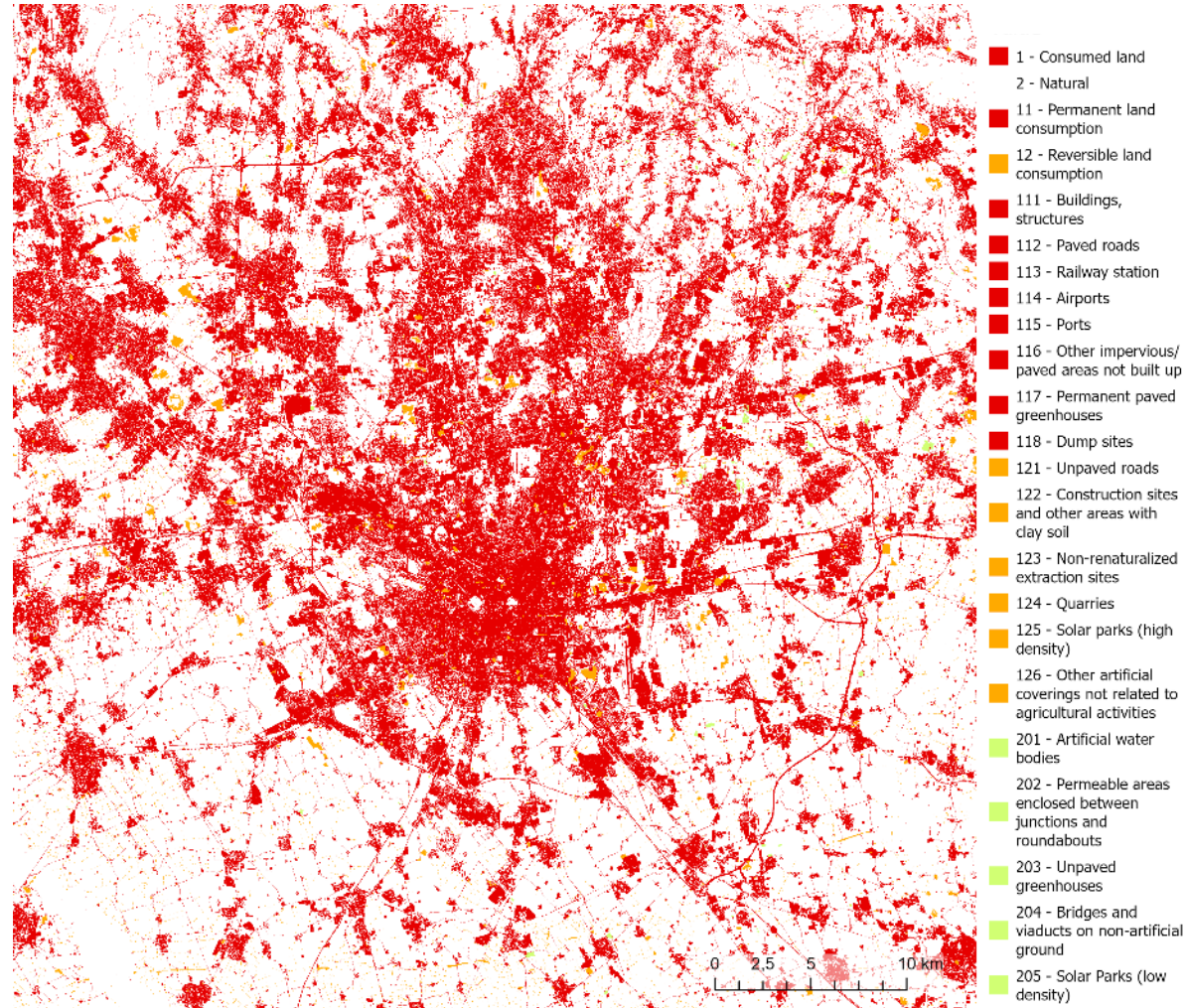
A change from non-artificial land cover to artificial land cover due to new “**Artificial surfaces and constructions**” -> All surfaces where natural landscape has been changed by or is under influence of human construction activities by replacing natural surfaces with artificial 2D/3D constructions or abiotic artificial materials. Artificial parts of urban and rural areas, where mankind has built settlement infrastructures. It includes sealed areas (buildings, other constructions and sealed flat surfaces) and non-sealed areas* (artificial but unsealed). Urban green and natural surfaces are excluded.

(EEA, 2021, Explanatory Documentation of the EAGLE Concept)

* EAGLE LCC-1_1_2 Non-Sealed Artificial Surfaces

Italian National Land Take map (artificialisation)

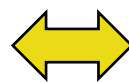
Produced annually through photo interpretation carried out by the National System for Environmental Protection, coordinated by the Institute for Environmental Protection and Research.



Artificialisation refers to the portion of land covered by sealed and other artificial surfaces. The map produced by ISPRA-SNPA describes these surfaces in **14 thematic classes**: **8 sealed surfaces (permanent land take)** and **6 other artificial not sealed surfaces (reversible land take)**. Other **5 classes monitor other types of land cover that do not result in land take (other artificialised surfaces)**.

Land take is defined as the change over a given period **from non-artificial cover (non-consumed land) to artificial cover (consumed land)**, distinguishing between **permanent land take** (due to the presence of permanent artificial cover resulting in soil sealing) and **reversible land take** (due to the presence of reversible artificial cover with removal of the soil or loss of its functions).

The classification system adopted in ITALY



DIRECTIVE (EU) 2025/2360 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 12 November 2025

1. LAND TAKE (SOIL ARTIFICIALISATION)

11 – Soil Sealing

111.	Buildings
112.	Paved roads
113.	Railways
114.	Airport installations (including their associated access infrastructures)
115.	Sea port installations
116.	Other non-build up/paved areas (squares, parking lots, sports fields, concrete or asphalt surfaces, etc.)
117.	Permanent paved greenhouses
118.	Dump sites

12 - Soil Removal

121.	Unpaved roads
122.	Construction sites and other clayey areas
123.	Not-renaturalized extractive areas
124.	Groundwater extractive areas
125.	Ground mounted photovoltaic fields
126.	Other artificial coverage not connected to agricultural activities (if removed, the initial condition of soil is retored)

OTHER ARTIFICIALISATION

201.	Artificial water bodies
202.	Permeable interlocking areas between road interchanges and traffic circles
203.	Unpaved greenhouses
204.	Bridges on non-artificial ground
205.	Low-density photovoltaic fields

‘artificialisation’: durable alteration of the soil components and soil characteristics, resulting in a loss of the capacity of soils to provide ecosystem services

‘sealed soil’: soil that underwent soil sealing - covering of soil with completely or partially impermeable material (Buildings, roads, train tracks, paved areas, waste disposal and dumping grounds...)

‘soil removal’: temporary or long-term total or partial removal of soil in an area (construction sites, open-pit mining and quarrying...)

‘other soil artificialisation’: soil that does not fall under the definition of sealed soil and soil removal (intentional stabilisation and compaction of soil, modification of layers of soil or subsoil with the inclusion of artificial materials or the partial covering of soil with composite materials...)

“Concerning renewable energies, Member States can qualify the soil as sealed, removed or neither sealed nor removed, depending on the type of construction: solar parks could either be considered as soil sealing or not, depending on what is done with the soil at their base....”

2023

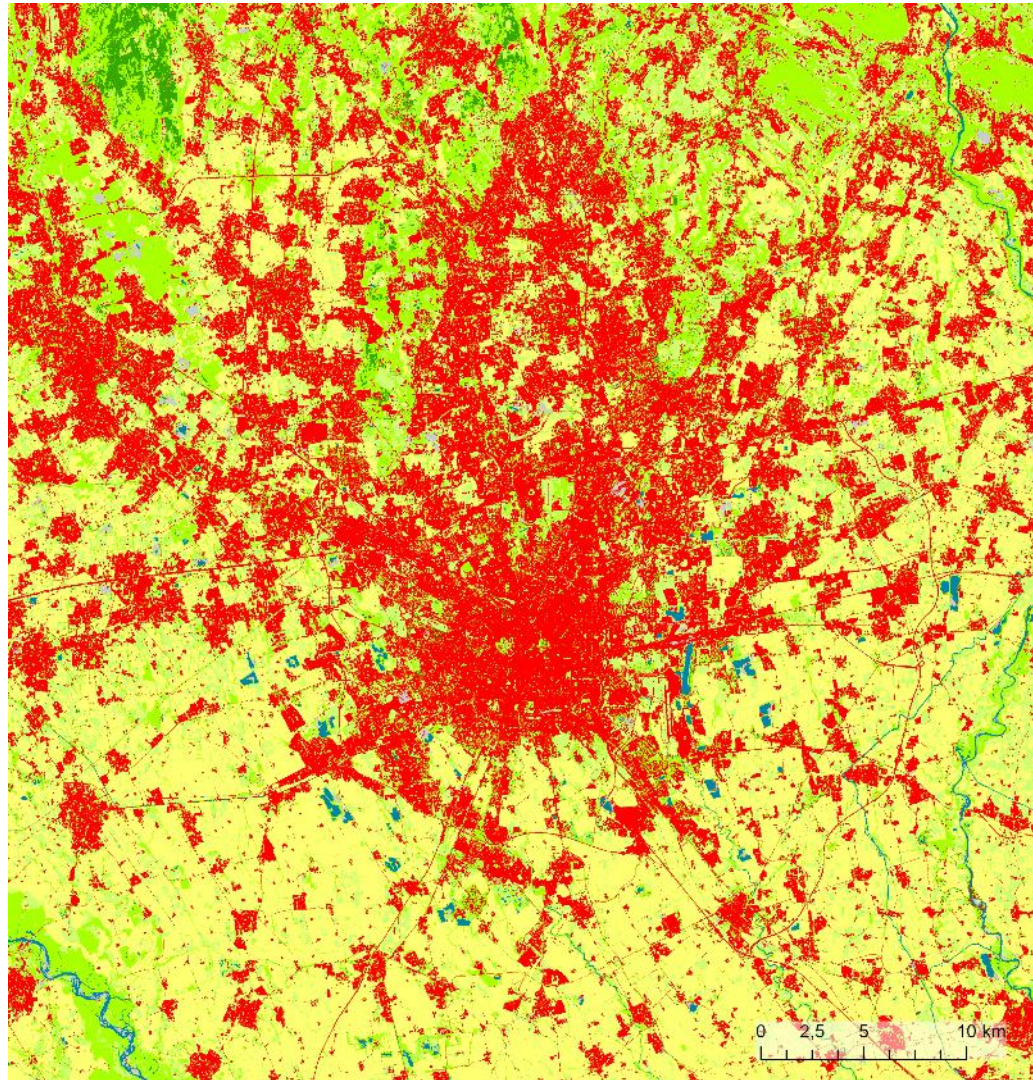
Soil Sealing

2024



Cittadella (PD) - ITALY

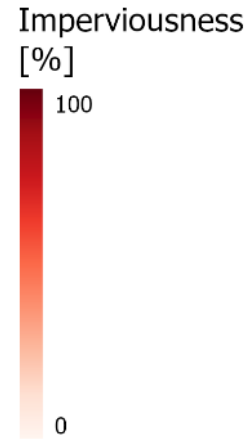
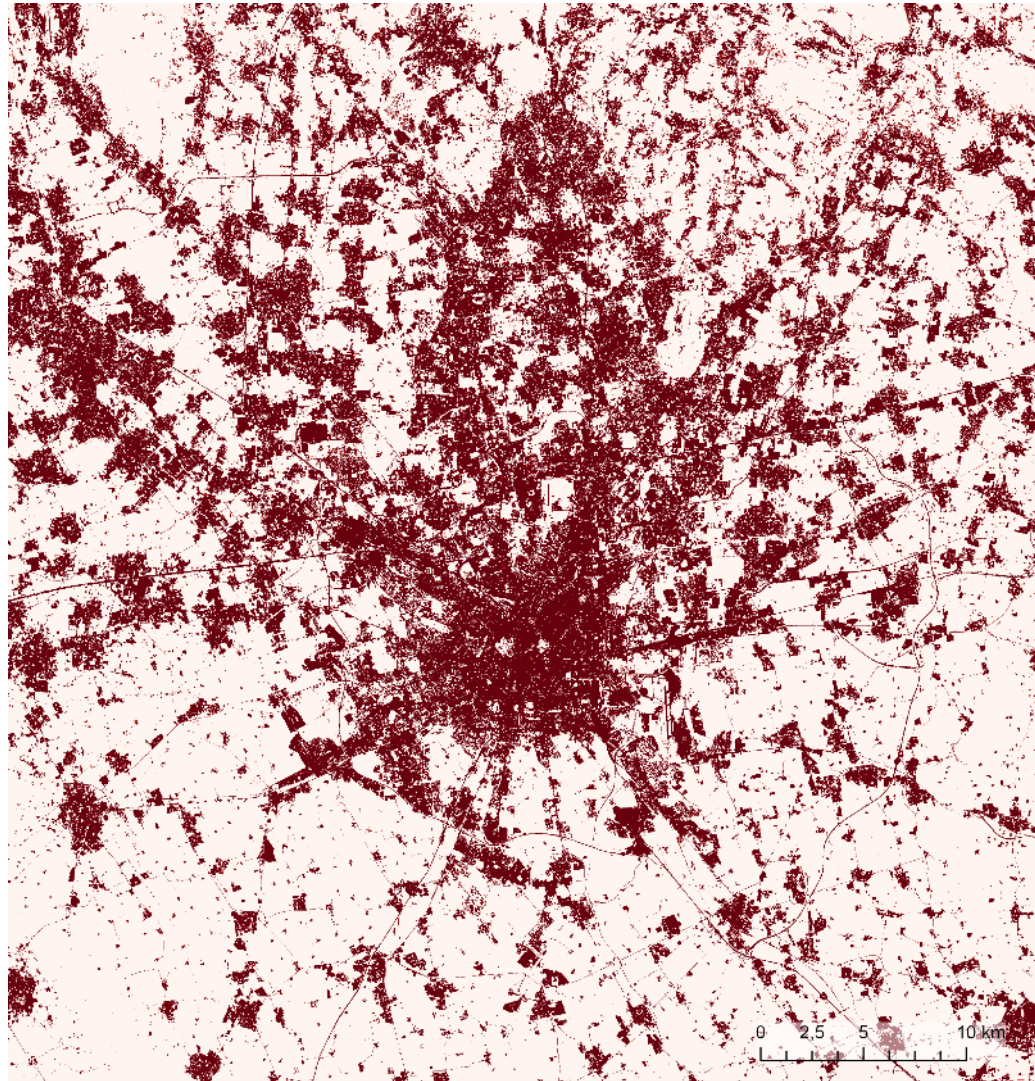
CORINE Land Cover Plus Backbone



- Sealed
- Woody needle leaved tree
- Woody broadleaved deciduous tree
- Woody broadleaved evergreen tree
- Low-growing woody plants
- Permanent herbaceous
- Periodically herbaceous
- Lichens and mosses
- Non and sparsely vegetated
- Water
- Snow and ice

Class 1 “Sealed” includes all impervious and sealed surfaces, such as buildings, structures, any type of flat surface covered with artificial impervious materials. Vegetated rooftops and **solar parks** are also included.

HRL Imperviousness



HRL Imperviousness focuses on impervious areas that are characterized by the substitution of the original (semi-) natural cover or water surface with an artificial, often impervious cover.

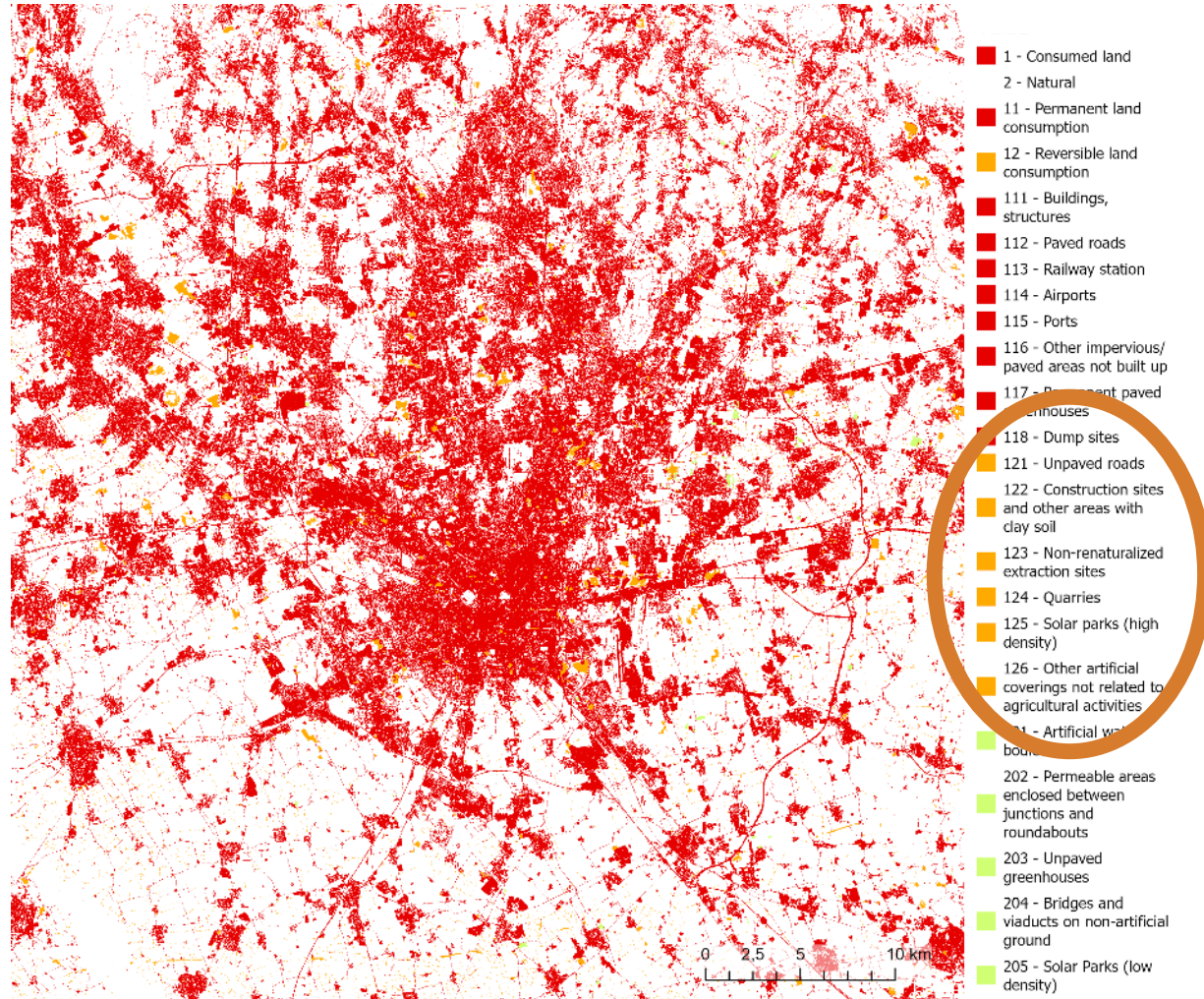
There is agreement between Imperviousness Density (IMD) and CLCplus BB class 1.

Other non-vegetated land covers, such as non-sealed artificial or bare surfaces of natural origin are currently not covered within HRL Imperviousness.

Soil Removal



Italian National Land Take map (other artificial not sealed surfaces)

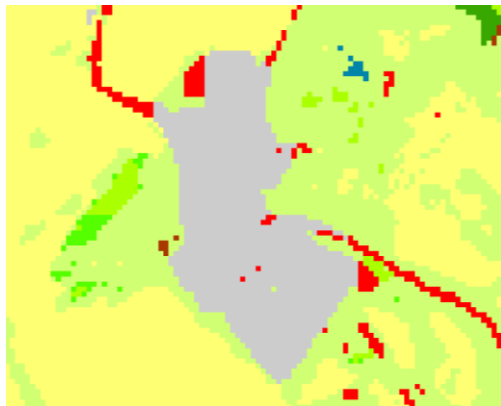


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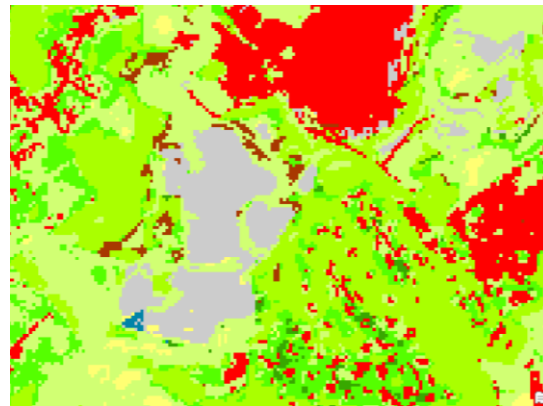
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CORINE Land Cover Plus Backbone

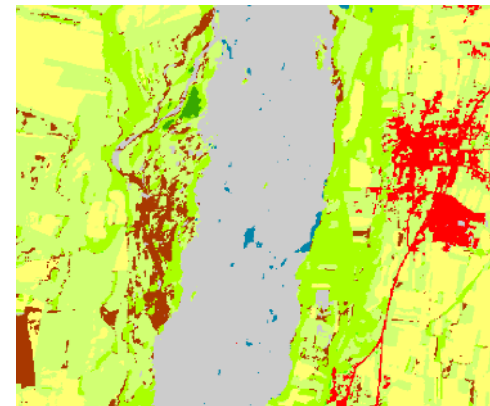
Quarries and mines



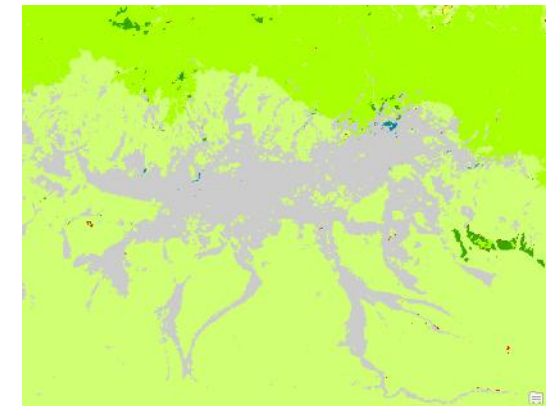
Construction sites



Riverbed

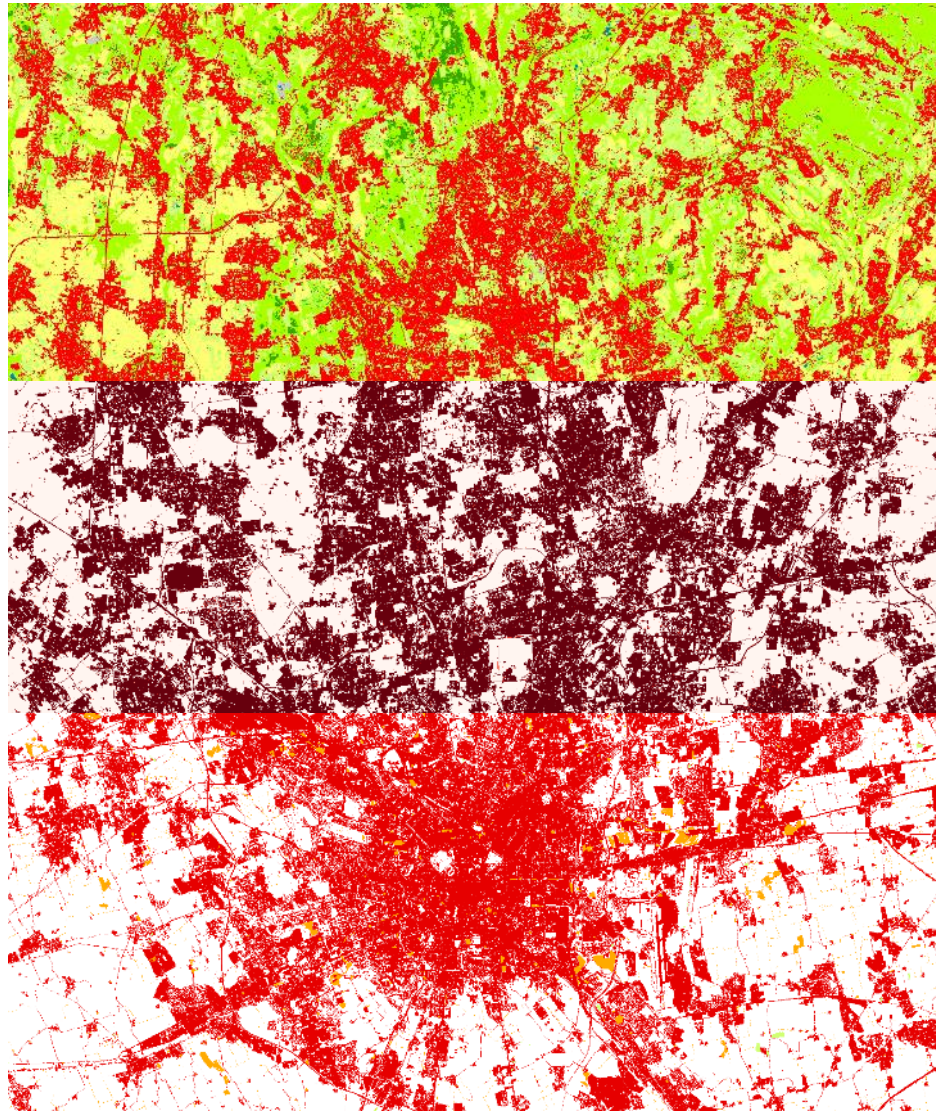


Bare rock



Unsealed artificial surfaces are included in the class “Non-and sparsely vegetated” but it is not possible to distinguish natural abiotic surfaces from areas where the surface layer of soil has been removed or other types of artificialization have occurred.

Land Take in Italy: Copernicus vs Italian National data



Layers	Status		Changes			
	[ha]	[%]	2018 - 2021		2021 - 2023	
	[ha]	[%]	[ha]	[%*]	[ha]	[%*]
CORINE land Cover Plus Backbone (2023) (Sealed)	1 690 489 (**)	5,57	15 044	+0,91	28 577	+1,71
Imperviousness (2021) (Sealed)	1 915 745 (***)	6,28	51 098 (****)	-	-	-
Italian National Land Consumption map (2023)	2 149 610	7,14	21 480	+ 1,01	15 292	+0,71
– Sealed		6,56				
– Removed		0,61				

(*) Percentage increase calculated with respect to the artificial land in the starting year

(**) Calculated considering every pixel with values >50 as sealed

(***) Calculated considering every pixel with values >0 as sealed

(****) The data refers only to the “**New cover**” class of the IMCC layer

Increased imperviousness density, no imperviousness at first reference date

$$\text{IMD}(n-1) = 0, \text{IMD}(n) > 0$$

Land Take in Italy: Copernicus vs Italian National data



Example of change identified by all three layers

CLC Plus Backbone

IMCC

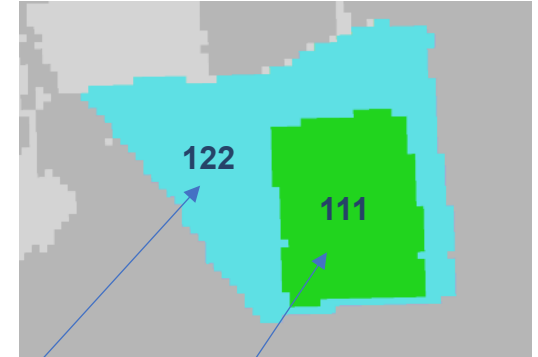
IT

2018

2018-2021

2018-2021

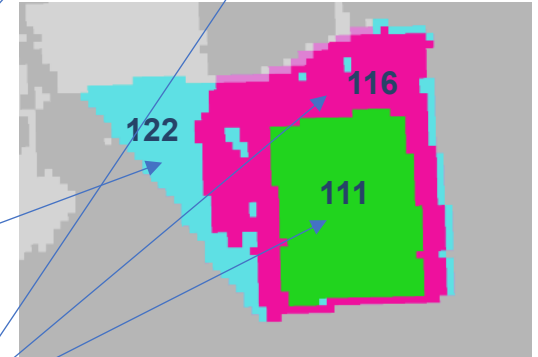
2018-2021



2021

2021-2023

2021-2023



2023

Removal

Sealing

111 Buildings, Structures, 116 Other impervious paved area not built up, 122 Construction sites

Land Take in Italy: Copernicus vs Italian National data

Example of change mapped by IT and only in minimum part by Copernicus

New road infrastructure

2018



2021



CLC Plus Backbone

2018-2021



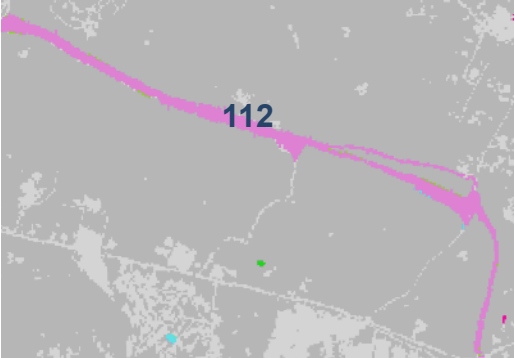
IMCC

2018-2021



IT

2018-2021

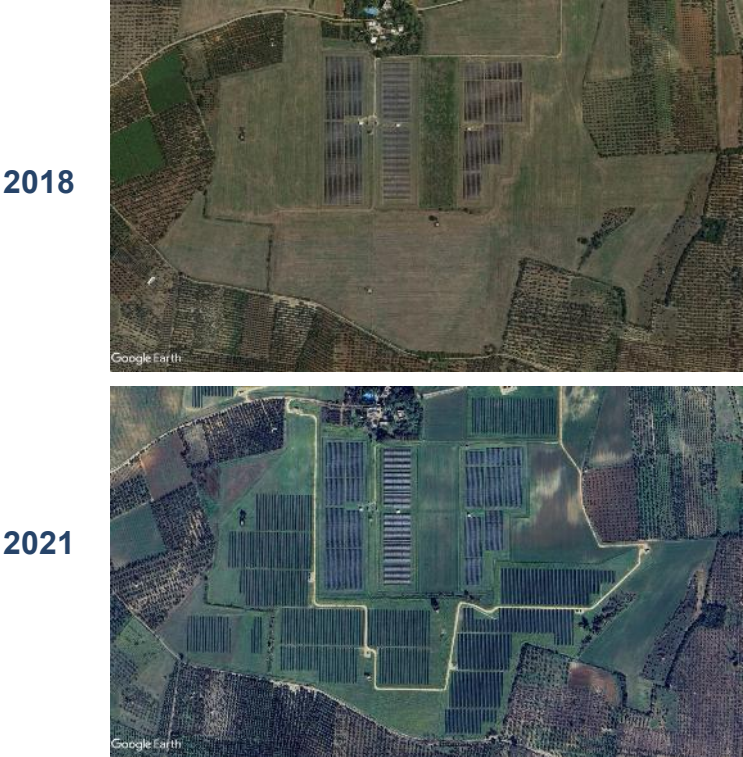


112 Paved roads

Land Take in Italy: Copernicus vs Italian National data

Example of change mapped by IT and only partially by Copernicus data

New solar park



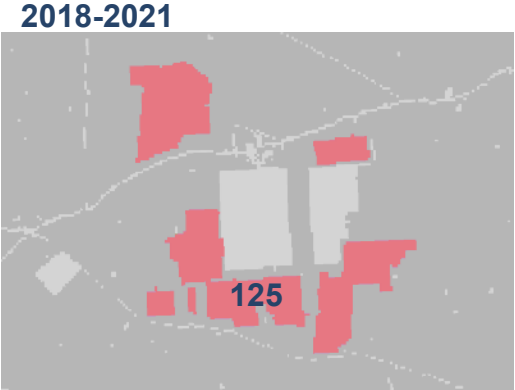
CLC Plus Backbone



IMCC



IT



1: Consumed land; 125: solar parks

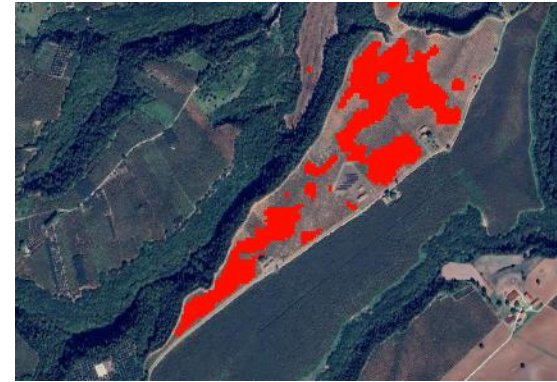
Land Take in Italy: Copernicus vs Italian National data

Examples of false changes on natural soils

2018



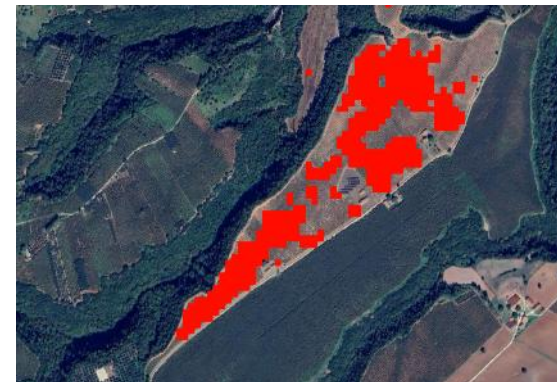
CLC Plus Backbone
2018-2021



2021



IMCC
2018-2021

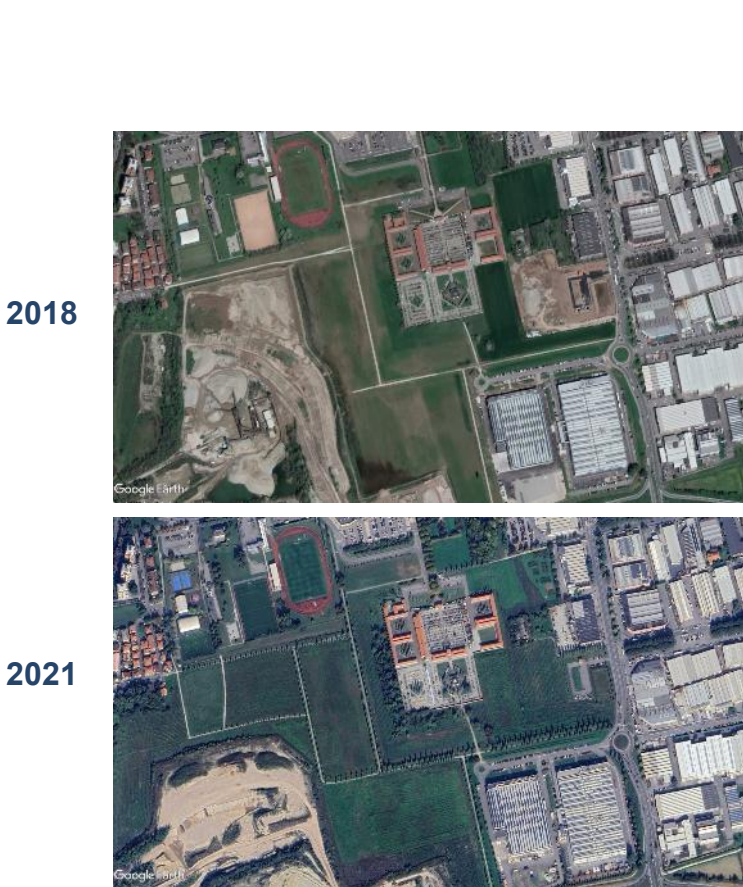


IT
2018-2021



Land Take in Italy: Copernicus vs Italian National data

Example of restoration mapped only by the IT map



CLC Plus Backbone



IMCC

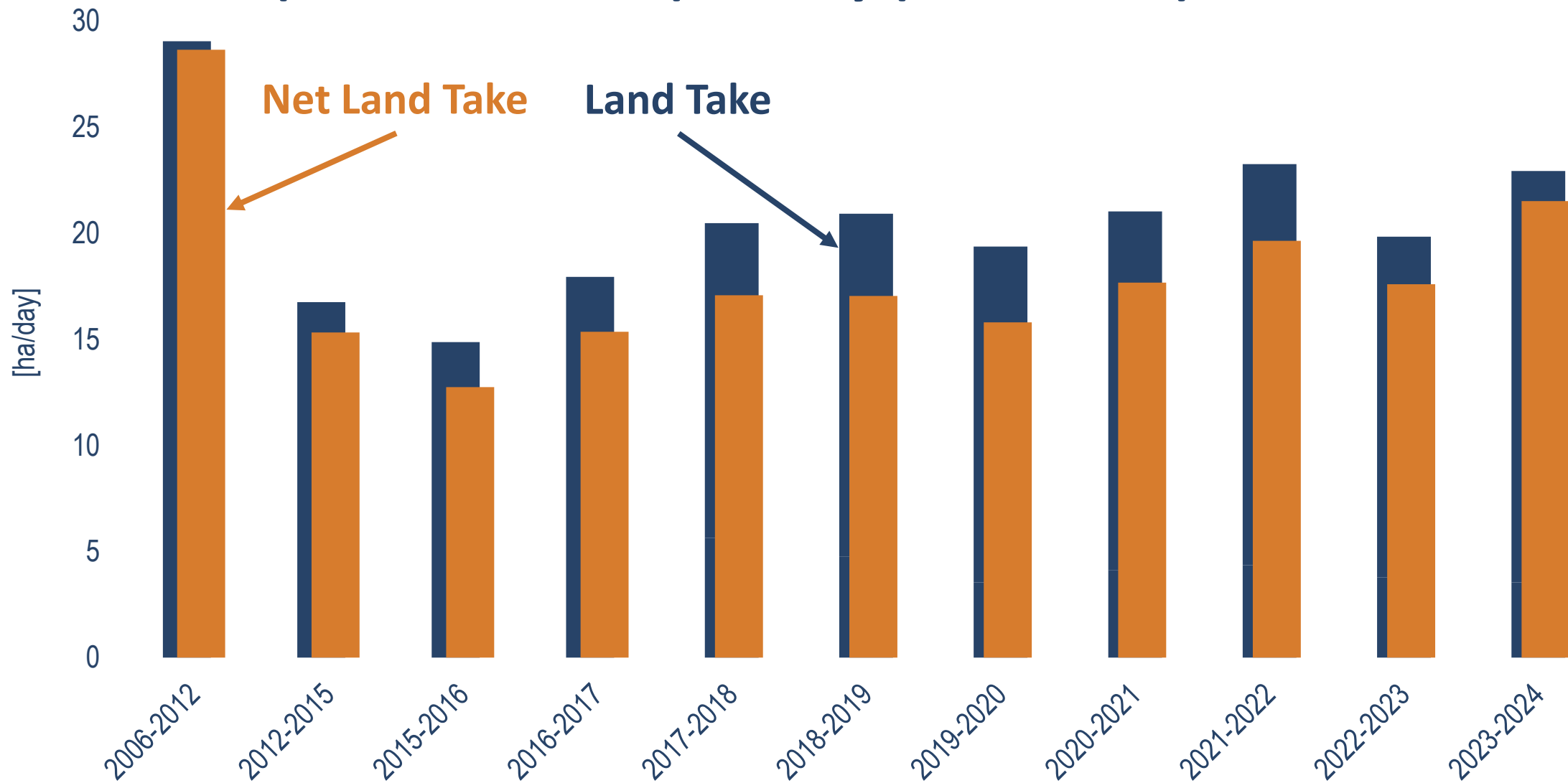


IT

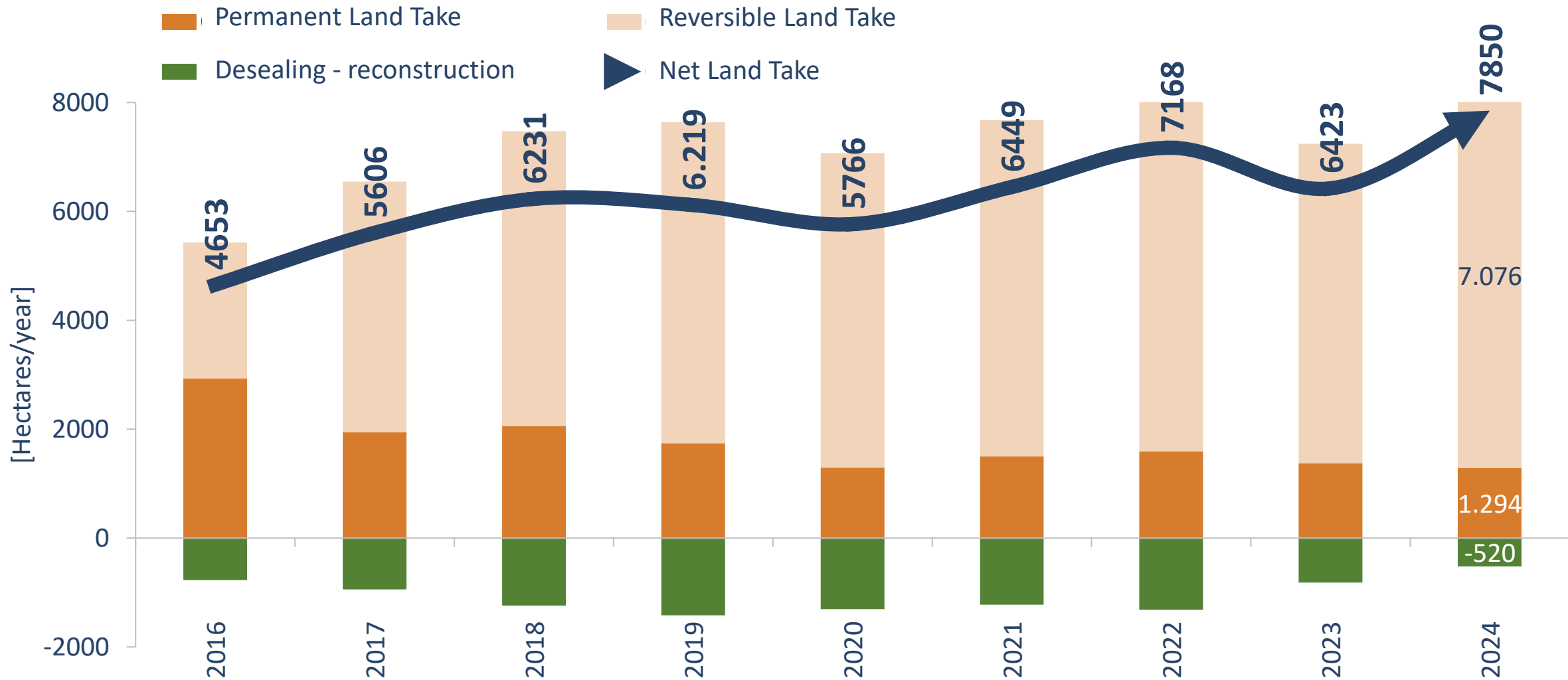


2: natural

Land take (artificialisation) in Italy (2006-2024)



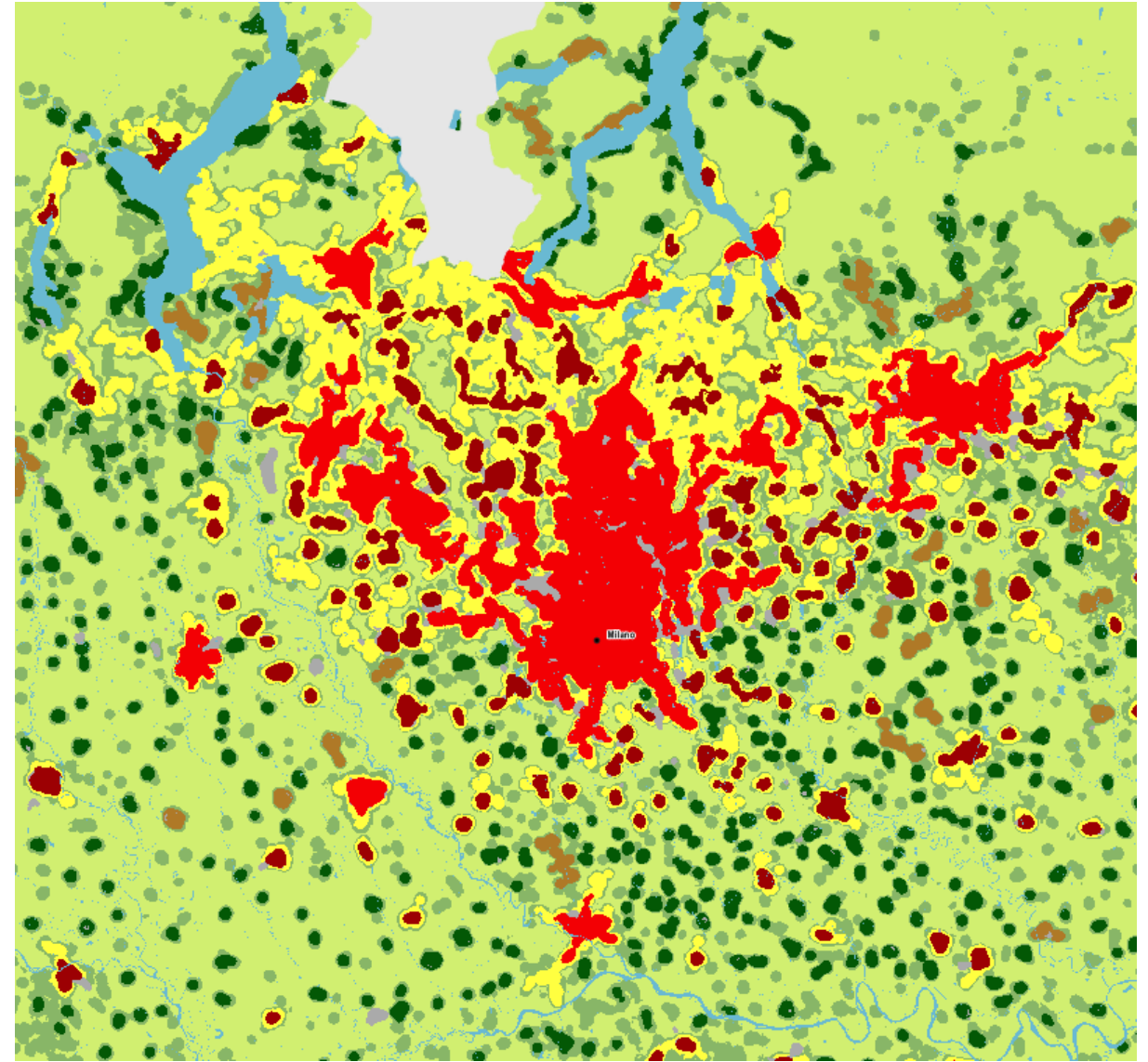
Land take (artificialisation) in Italy (2016-2024)



Settlement areas monitoring in Italy

- Urban land use (e.g. CLC class 1)
- Urban-Rural continuum
- Urban ecosystems (DEGURBA)
- Planned land use (useful for land take mitigation measures)

URBAN-RURAL CONTINUUM 2021

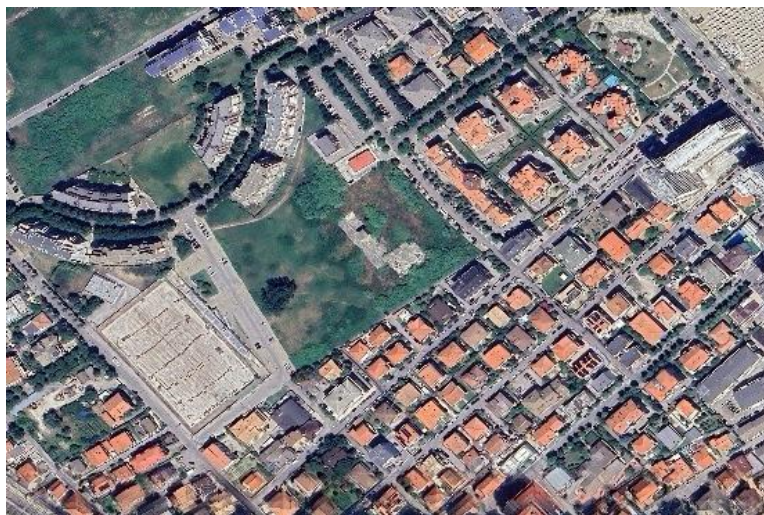


Urban soils artificialisation (cfr. Nature Restoration Regulation)

Construction of a new supermarket and parking lot in the urban area of the municipality of Livorno



Construction of a new skating rink in the urban area of the municipality of Montesilvano, in an area with medium flood risk.



Land Take (hectares per year) in 2024 in Italy



Urban

+552
ha



Suburban

+1 717
ha



Industrial

+1 277
ha

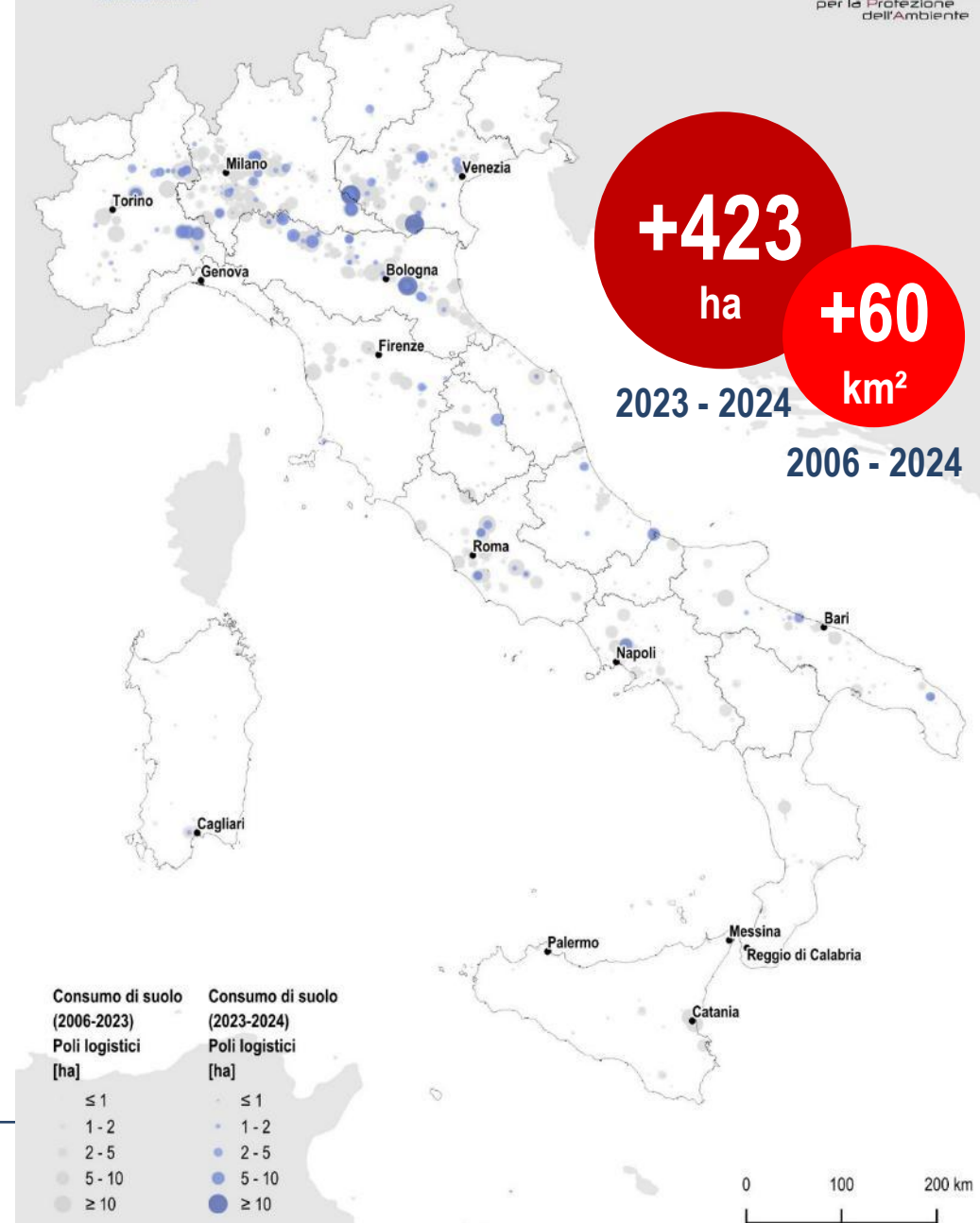


Rural

+4 789
ha

Densification

Optional Indicators in Italy: Land taken for logistic hubs

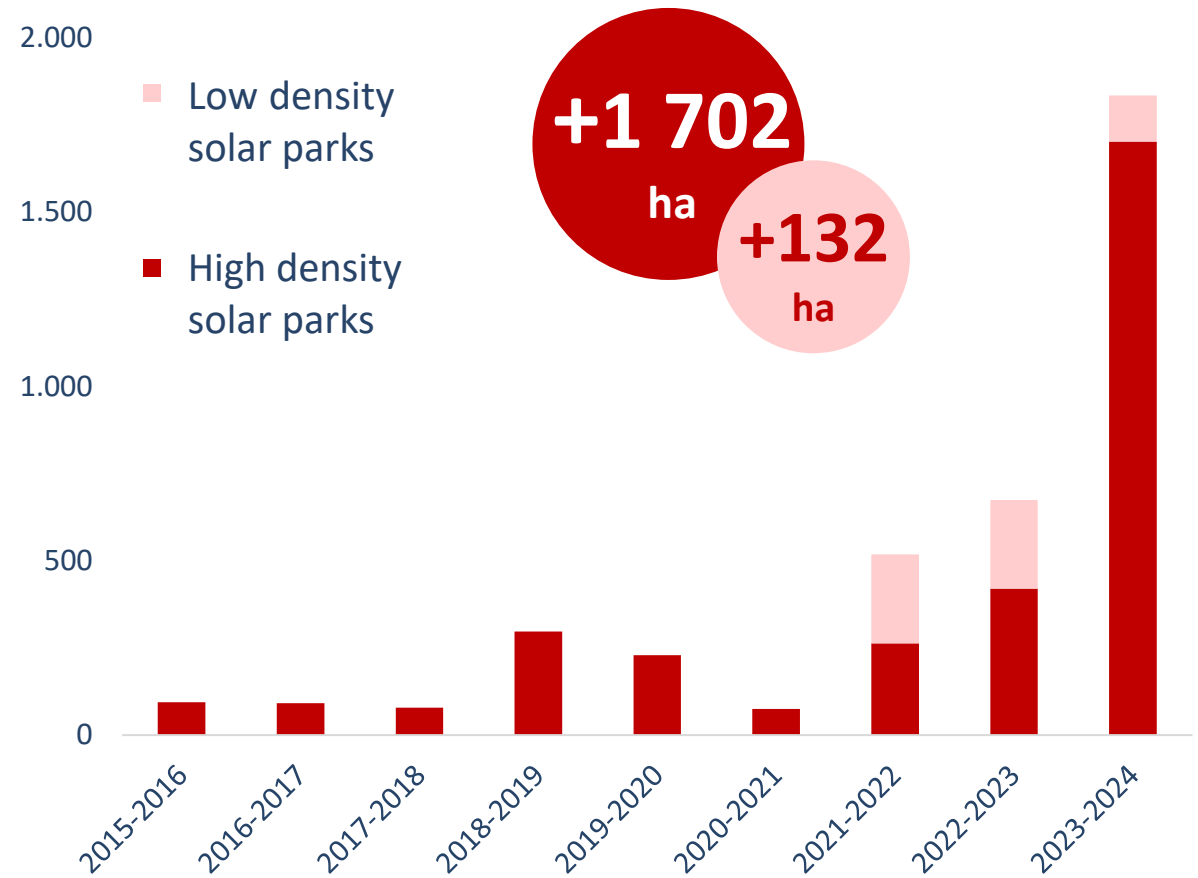


Optional Indicators in Italy: Land taken for solar panels

New ground-mounted photovoltaic systems covering an area of approximately 21 hectares in the municipality of Manzano (UD)

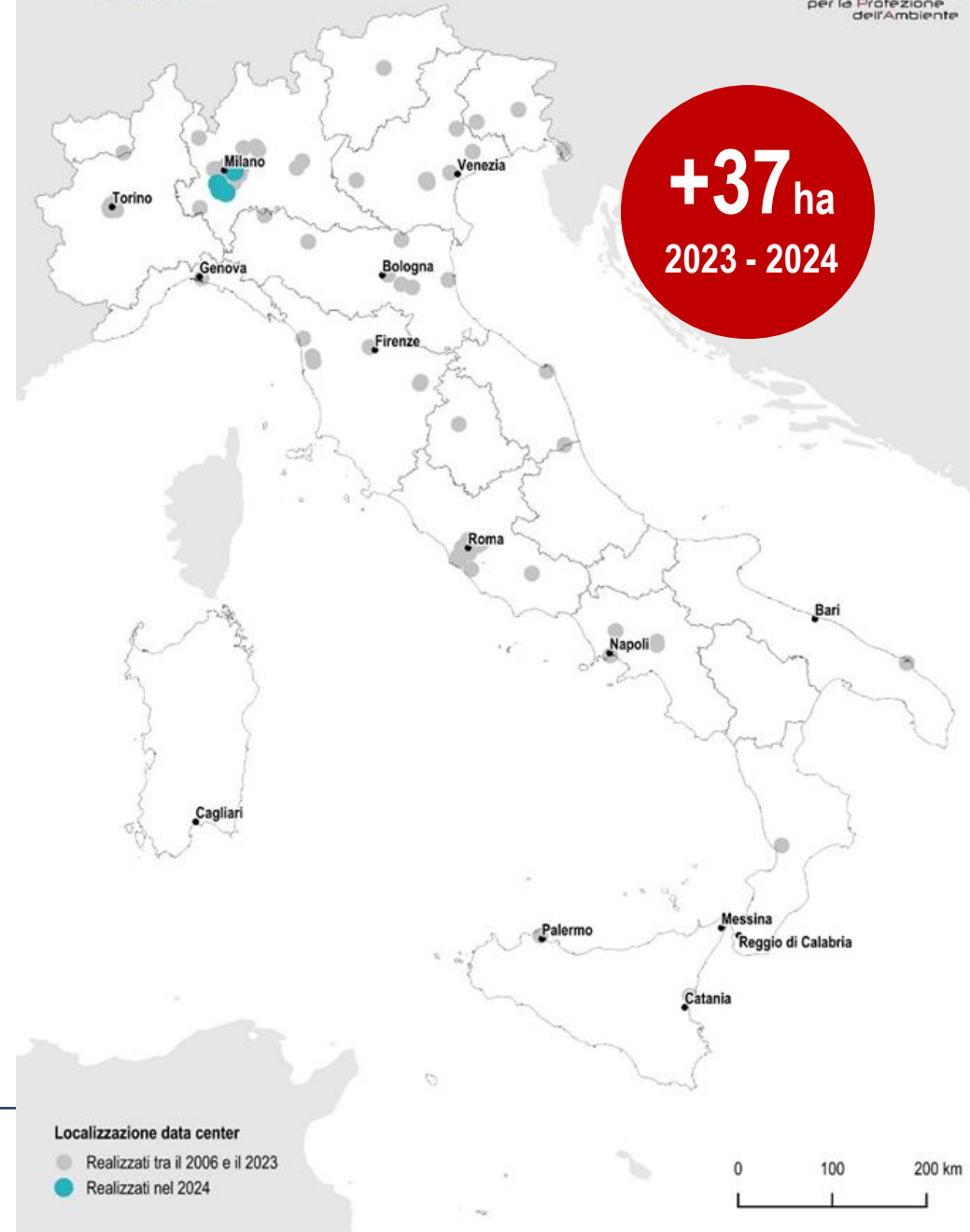


New ground-mounted photovoltaic systems covering an area of approximately 17 hectares in the municipality of Sarmato (PC)



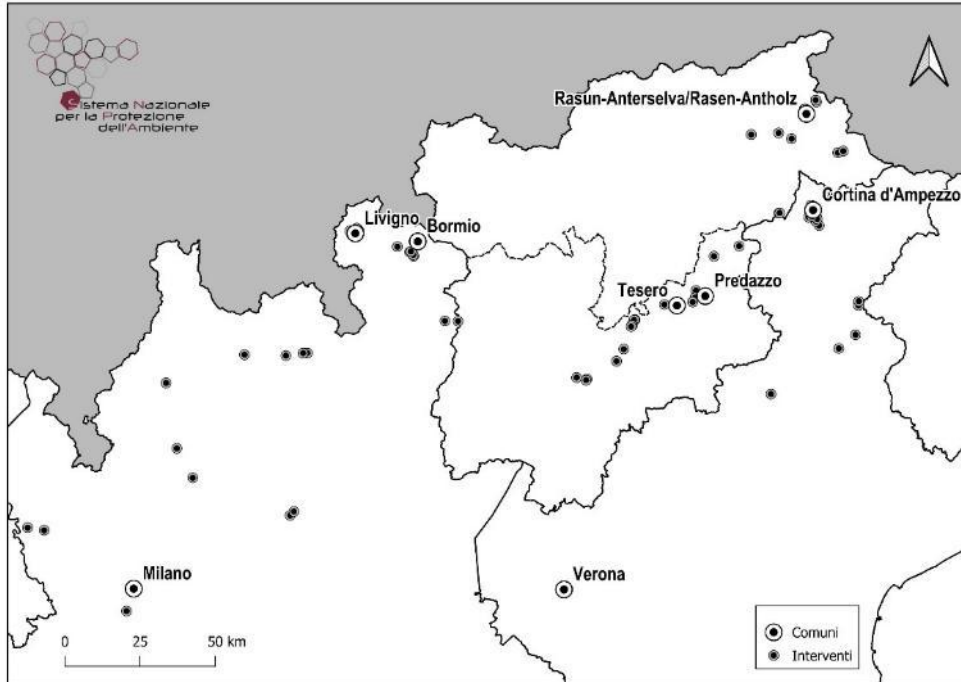
Land taken for data center in Italy

Vellezzo Bellini (Pavia) 6 hectares. 2021 - 2024

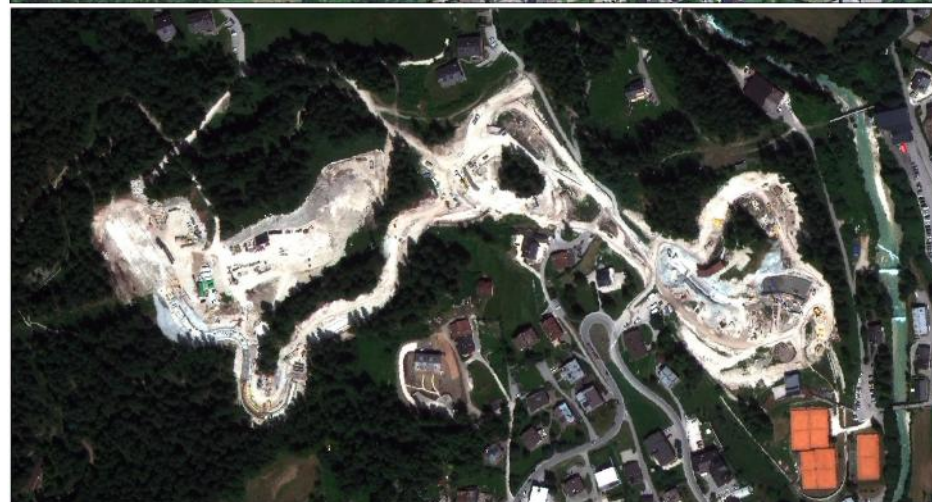


Land taken for winter olympic games in Italy

Map of the key municipalities involved in the Olympic Games interventions and the precise location of the planned works



The state of the area before the intervention and, below, the corresponding construction site area, equal to approximately 5 hectares of surface area.



2022 - 2023



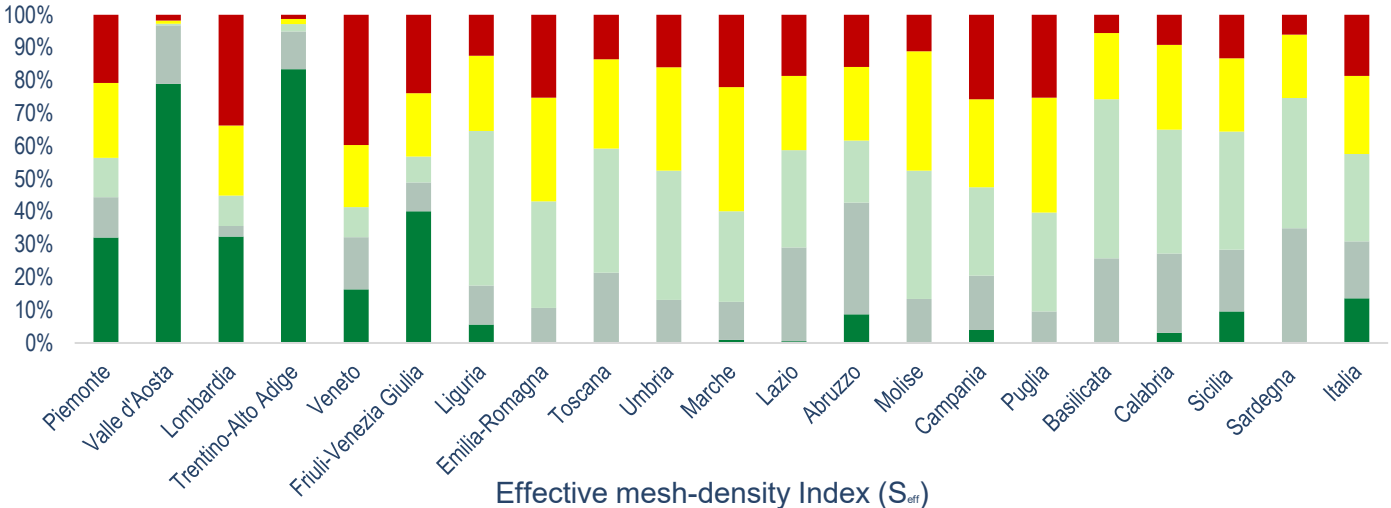
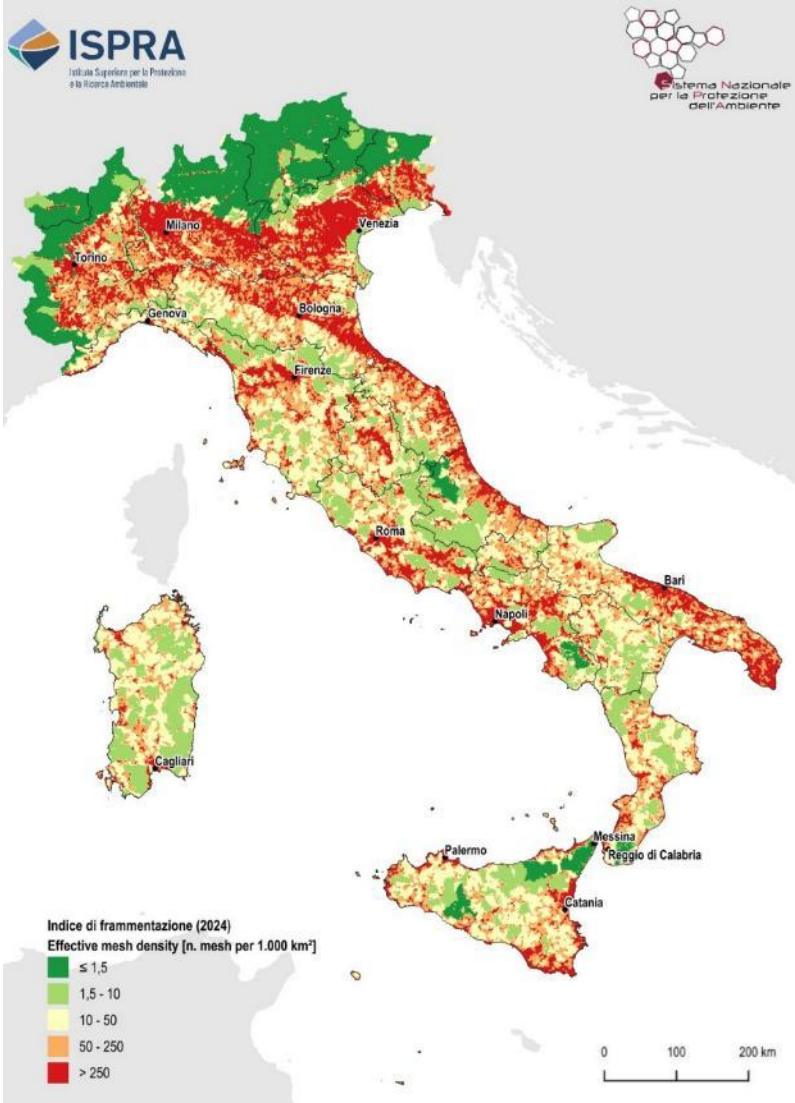
2023 - 2024



Geographic distribution of changes

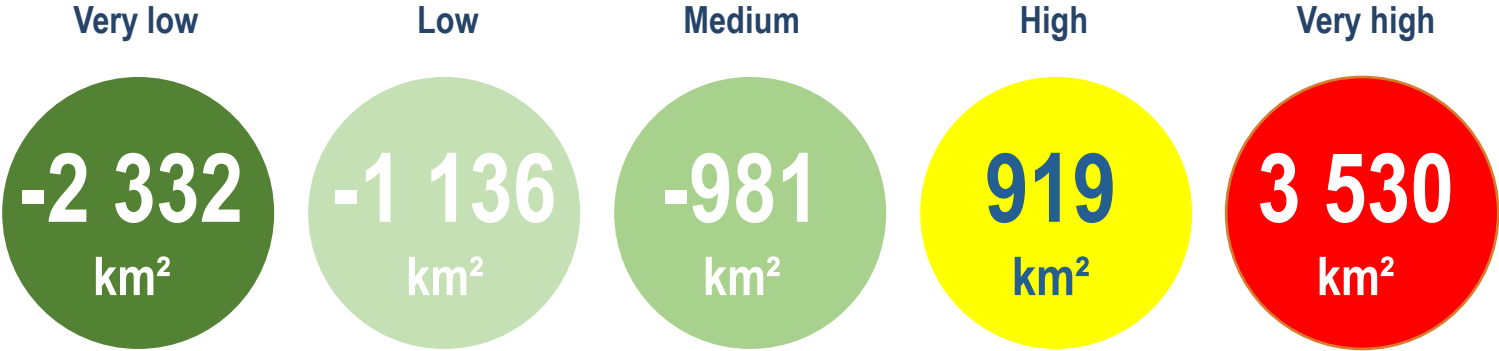
Area Dolomitica - Bolzano	15%
Area Dolomitica - Trento	32%
Area Dolomitica - Veneto	22%
Lombardia	31%

Optional Indicators: Land Fragmentation in Italy



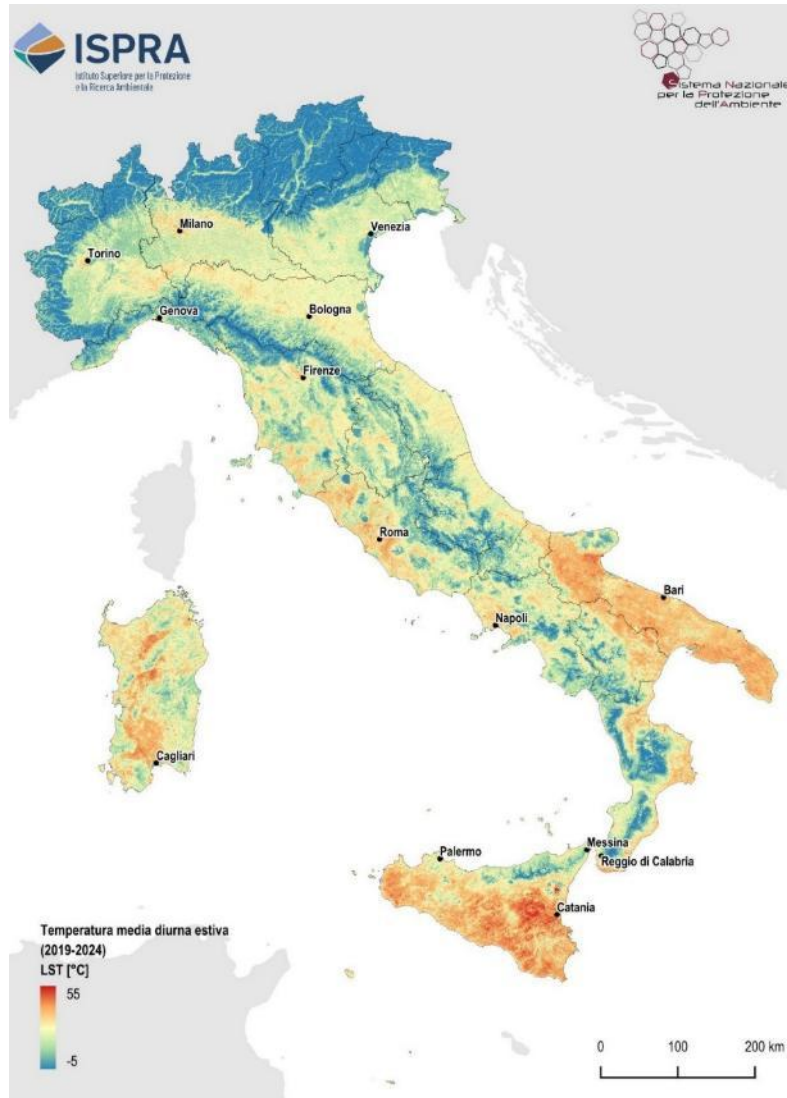
Percentage composition of regional territories with respect to the five fragmentation classes

Differences between 2006 and 2024

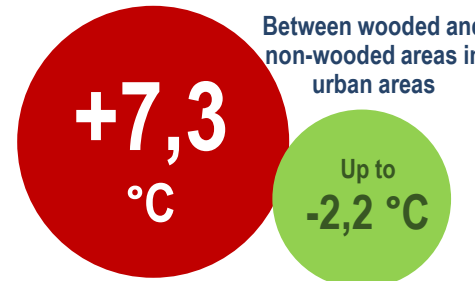


Source: ISPRA-SNPA 2025

Surface Urban Heat Island



Difference in average summer daytime land surface temperature



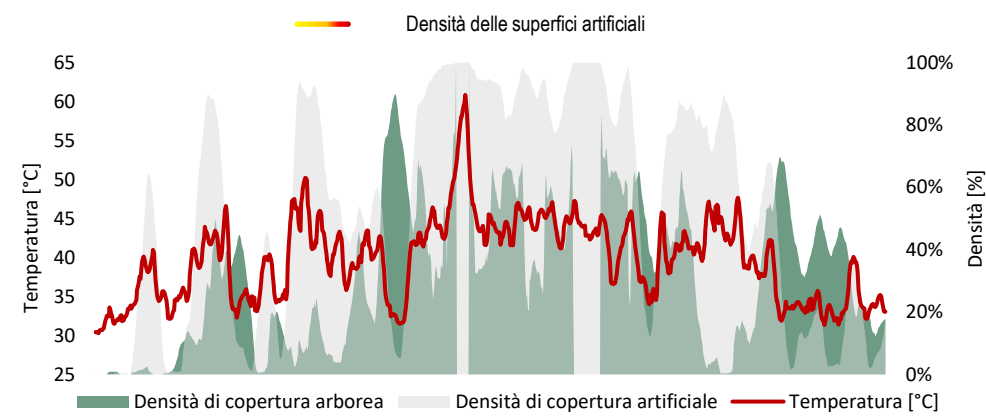
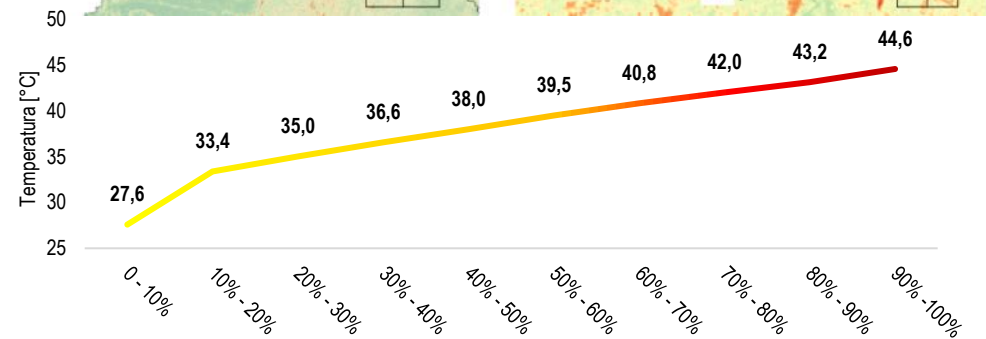
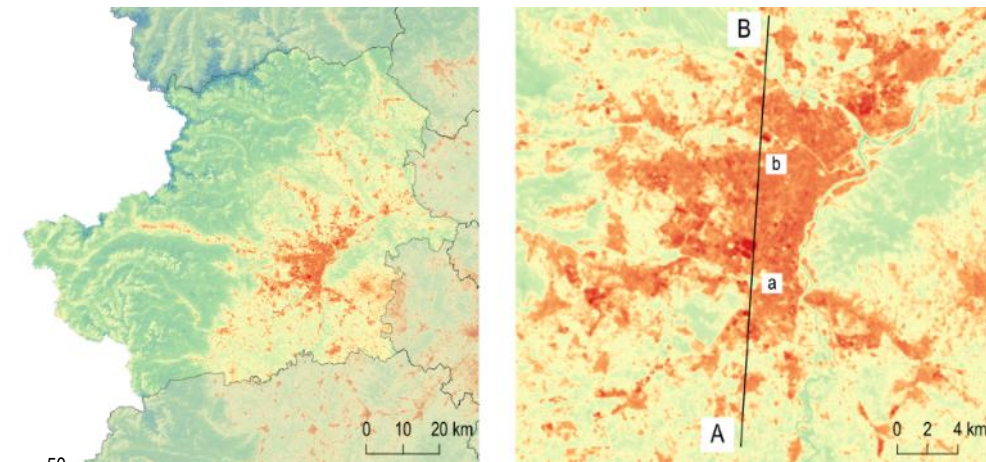
Between wooded and non-wooded areas in urban areas

Urban-rural National Average

Population exposed to temperatures > 40°C



National Average for Urban Areas



Source: ISPRA-SNPA 2025

Loss of Ecosystem Services in Italy



Ecosystem Services (Flow)	Minimum (€/year)	Average (€/year)	Maximum (€/year)
Carbon storage and sequestration	-51 587	-161 995	-272 401
Habitat quality	-3 103 783	-3 103 783	-3 103 783
Crop production	-23 482 015	-23 482 015	-23 482 015
Timber production	-6 911 945	-6 911 945	-6 911 945
Pollination	-1 484 498	-1 733 293	-1 982 089
Local climate regulation	-728 607	-1 821 518	-2 914 429
Particulate matter and ozone removal	-321 536	-649 238	-976 938
Water availability	-468 424	-5 855 287	-11 242 151
Regulation of the hydrological cycle	-463 875 158	-502 222 170	-540 569 183
Purifying water from contaminants	-70 863	-10 143 317	-20 215 769
Total	-500 498 415	-556 084 558	-611 670 702



9 624 730 379 €

Ecosystem services loss (€ per year) due to new land take (artificialisation) between 2006 and 2024

Source: ISPRA-SNPA 2025

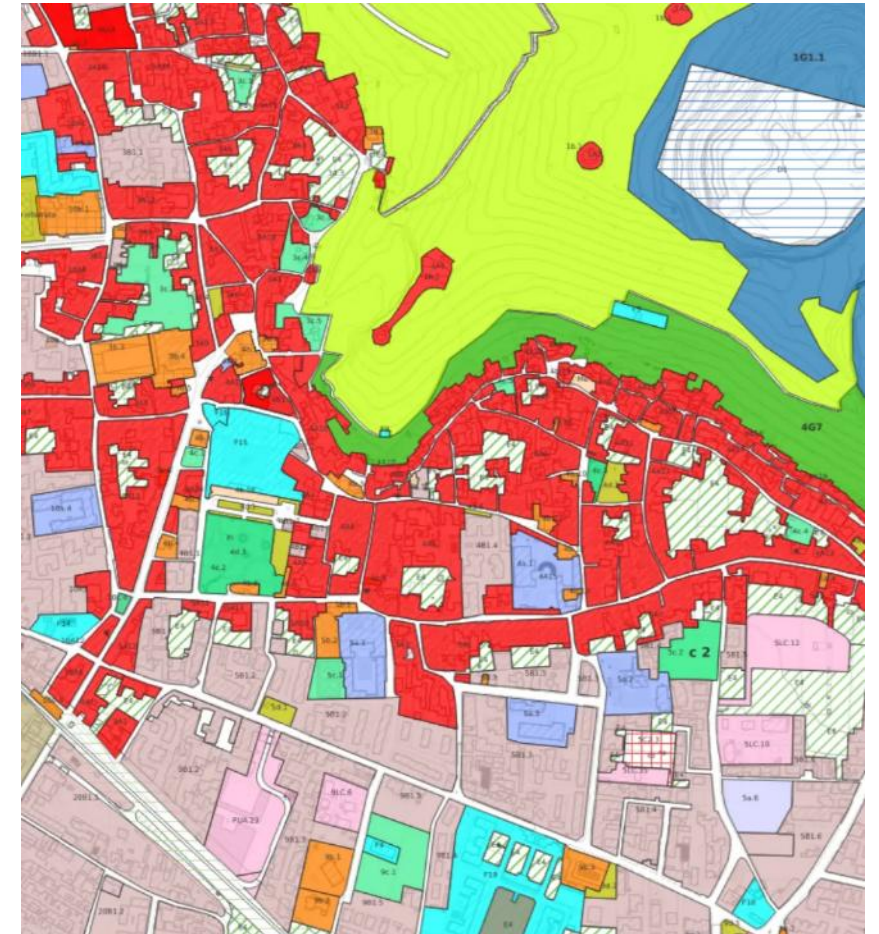
Planned land use and Regional Laws for Land Take Mitigation in Italy

Article 12

Land take mitigation principles

Without impinging on the autonomy of the Member States with regard to spatial planning, Member States shall ensure that the following principles are taken into consideration in the event of new soil sealing or new soil removal as part of land take, at the **appropriate spatial level within their territory**:

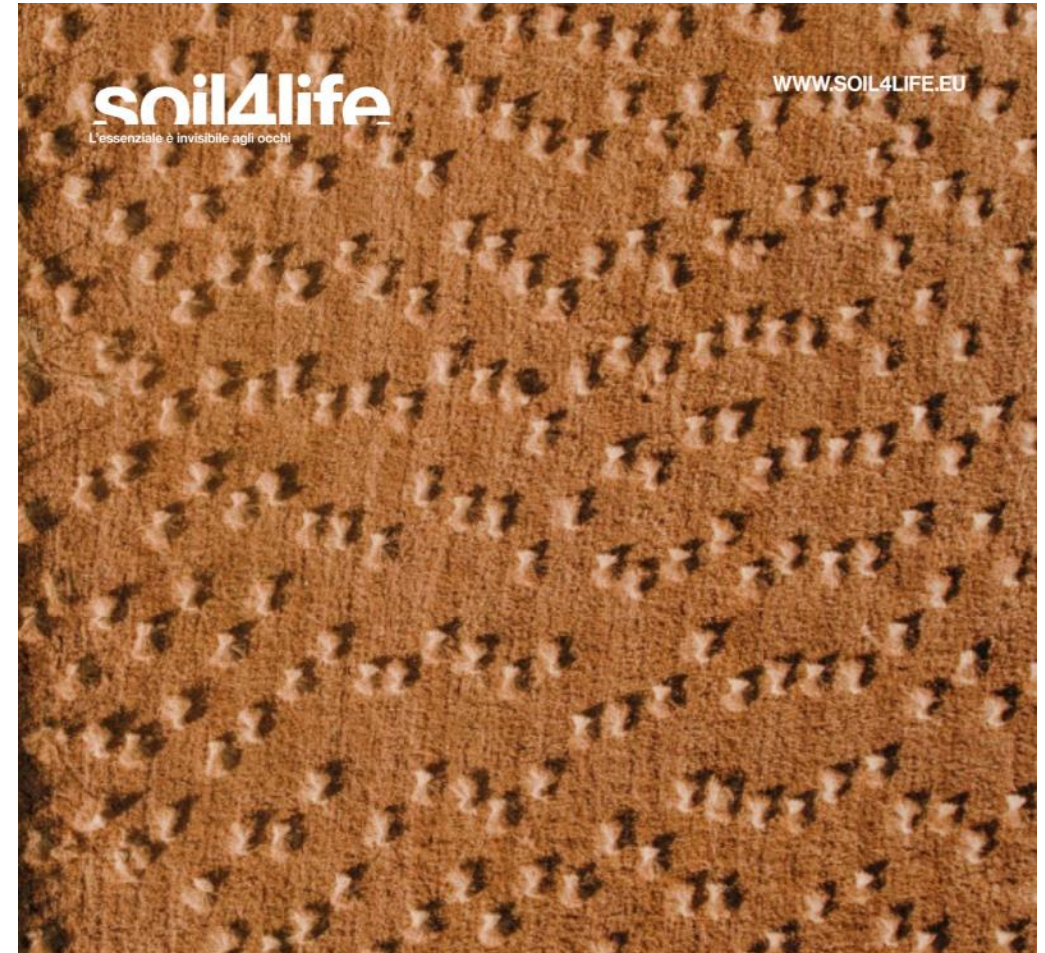
- (a) avoiding or reducing as much as possible the loss of the capacity of the soil to provide multiple ecosystem services, including food production, by:
 - (i) **reducing**, as much as possible, the area of soil affected by soil sealing and soil removal, in particular by encouraging the reuse and repurposing of sealed soils, such as existing buildings;
 - (ii) **selecting** areas where the loss of ecosystem services would be minimal, in particular areas with severely degraded soils, such as brownfields; and
 - (iii) carrying out the soil sealing and soil removal in a way that **minimises** the negative impact on soil, in particular by protecting the surrounding soils or by keeping the soil sealing as reversible as possible;
- (b) aiming to offset to a reasonable extent the loss of the capacity of the soil to provide multiple ecosystem services, including through returning ecosystem services by encouraging the **de-sealing** of sealed soils and the **reconstruction** of areas that underwent soil removal.



National network for land take monitoring and sustainable use of soil in Italy

(with national and regional representatives)

Statement of principles on sustainable use of soil (2021)



**Carta nazionale dei principi
sull'uso sostenibile del
suolo.**



Ministero dell'Ambiente e della Sicurezza Energetica

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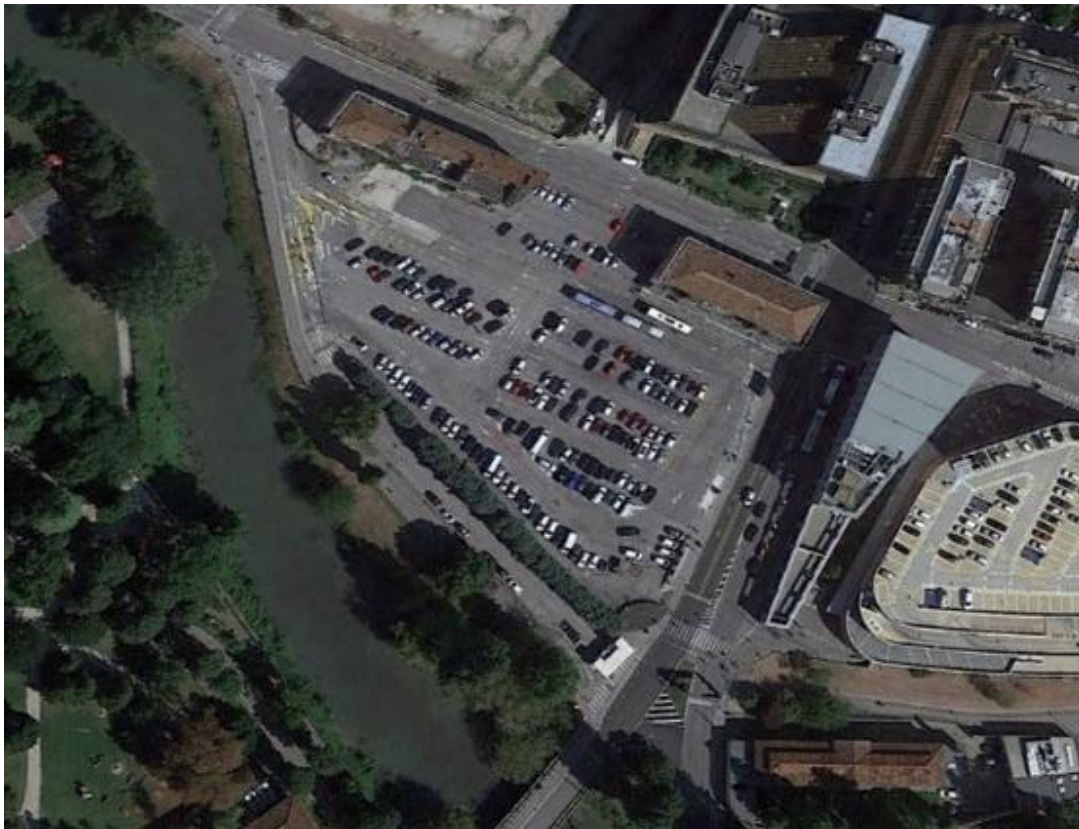
Iniziative

Fondo per il Contrasto al consumo di suolo



Il Fondo per il contrasto al consumo del suolo è stato istituito con legge 29 dicembre 2022, n. 197 "Bilancio di previsione dello Stato per l'anno finanziario 2023 e bilancio pluriennale per il triennio 2023-2025" pubblicata in G.U. n. 303 del 29 dicembre 2022. Il Fondo per il contrasto al consumo del suolo potrà finanziare interventi di rinaturalizzazione dei suoli degradati o in via di degrado in ambito urbano e periurbano tesi a contrastare il consumo del suolo con la finalità di avviare azioni di "ripristino" delle superfici di suolo "consumato", invertendo così il fenomeno verso un bilancio neutro sul consumo di suolo. Gli interventi di recupero all'interno dei perimetri cittadini hanno l'obiettivo principale di "rinaturalizzare" suoli degradati, per restituire loro le funzioni naturali che erano anche quelle di contenimento ed equilibrio dei sistemi di deflusso delle acque meteoriche la cui compromissione può produrre tragedie legate al dissesto idrogeologico. Tale fondo sarà indispensabile per programmare, finanziare e monitorare azioni ed interventi che possano contribuire alla salvaguardia del suolo e al contrasto dei fenomeni di degrado di suolo, compreso il consumo di suolo.

2022 Parking




Piazzale Boschetti (Padova)

~ 4 500 m²

2023 Urban green



Nature Restoration Regulation for Urban Ecosystems


EUROPEAN UNION

THE EUROPEAN PARLIAMENT THE COUNCIL

Brussels, 15 March 2024
(OR. en)

2022/0195(COD) PE-CONS 74/23

ENV 1402
CLIMA 605
FORETS 193
AGRI 758
POLMAR 60
CODEC 2314

LEGISLATIVE ACTS AND OTHER INSTRUMENTS

Subject: REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on nature restoration and amending Regulation (EU) 2022/869

PE-CONS 74/23 TREE.1.A LS/JGC/di EN

SPECIFIC TARGETS

- Pollinating insects
- Forest ecosystems
- **URBAN ECOSYSTEMS**
- Agricultural ecosystems
- Marine ecosystems
- River ecosystems

Article 8: Restoration of urban ecosystems

No net loss of green urban space and tree cover by 2030, and a steady increase in their total area from 2050

Article 14: Preparation of the national restoration plan

4. Member States shall determine and map urban ecosystem areas as referred to in Article 8 for all their cities and towns and suburbs.

The urban ecosystem area of a city or of a town and suburb shall include:

- (a) the entire city or town and suburb; or
- (b) parts of the city or of the town and suburb, including at least its urban centres, urban clusters and, if deemed appropriate by the Member State concerned, peri-urban areas.

Member States may aggregate the urban ecosystem areas of two or more adjacent cities, or two or more adjacent towns and suburbs, or both, into one urban ecosystem area common to those cities, or towns and suburbs, respectively.

Article 3: Definitions

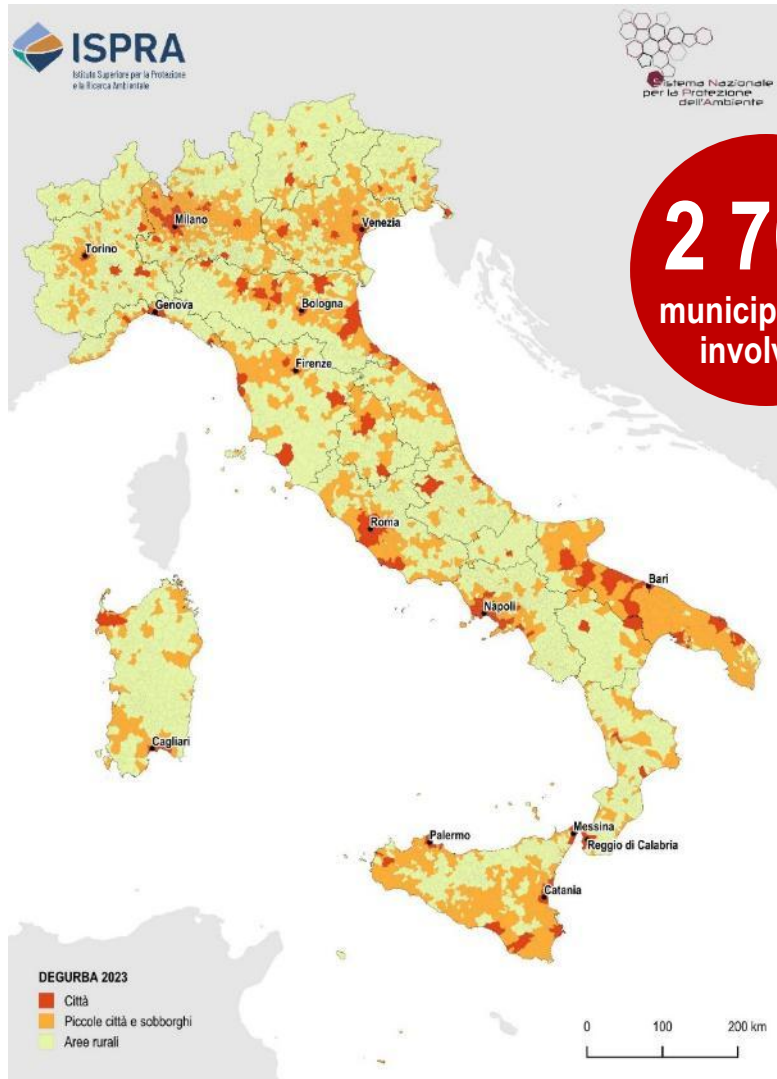
Local Administrative Units (LAU - Regulation EC 1059/2003) classified as city, town or suburbs

Sub-municipal areas classified as city, town or suburbs

➔ According to the Eurostat classification system DEGURBA

➔ Using data available at national level or from the European Copernicus programme

Nature Restoration Regulation for Urban Ecosystems



2 763
municipalities
involved



+5 377
ha

Net Land Take per year
(2024)

595
ha

Net Land Take in Tree
Cover Areas

**~
4 000**
ha

Net Land Take in Green
Areas

Source:
ISPRA-
SNPA 2025

Thank you

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