Nature-Based Solutions for urban microclimate regulation: the case of the Gavoglio Park project in Genoa

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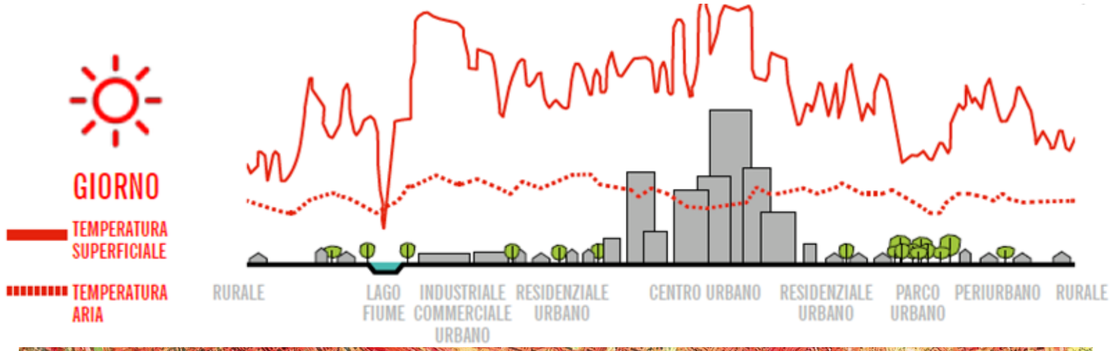
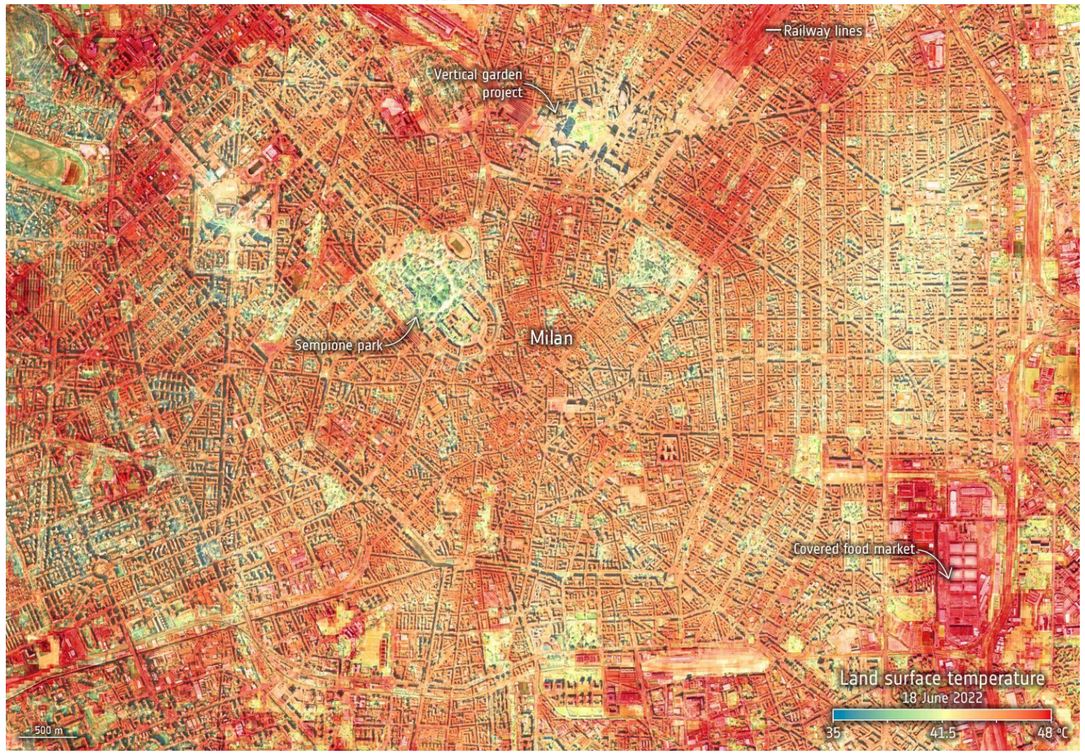
Microclimate and Urban Heat Island (UHI) phenomenon



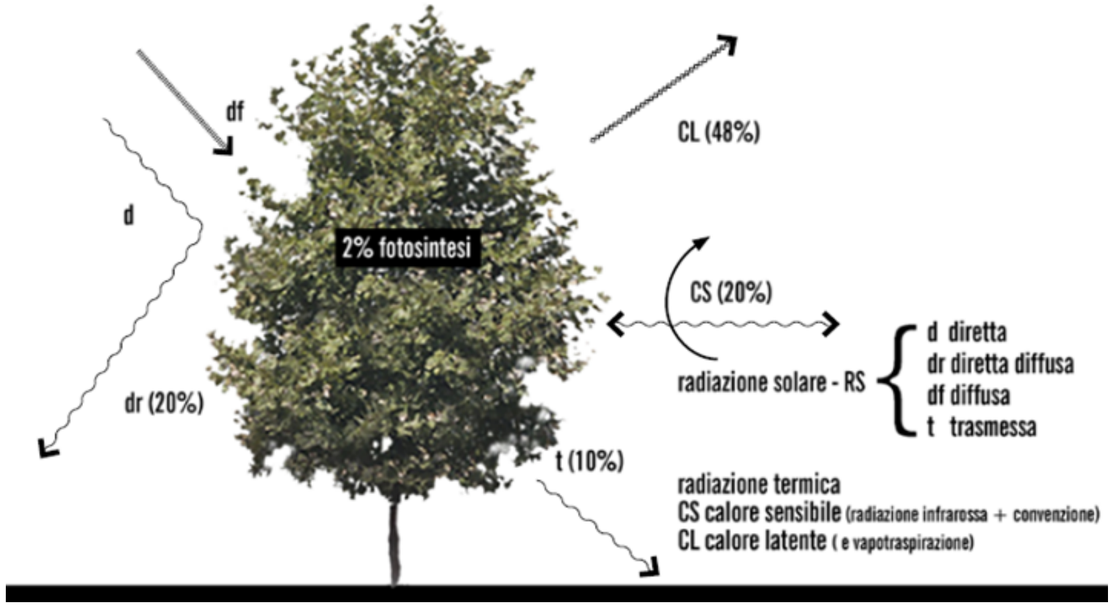
Progetto REBUS, 2015)



ESA, 2022

An **Urban Heat Island** is an area that is significantly warmer than surrounding natural areas.
This temperature difference is **up to a 5-10 °C increase** depending on the **size, density** and **structure** of the city (Desiato, 2014).

The role of ecosystems in urban microclimate regulation



(M. T. Salomoni, 2018)

ESA, 2022

Urban vegetation can reduce air temperatures and heat islands through three processes:

- **Shading**
- **Evapotranspiration**
- **Reflection (albedo)**

A mature tree can transpire up to **450 liters of water per day**, producing a major temperature drop, as it takes 633 calories for every gram of water evaporated (M.T. Salomoni, 2018)

LAND Italia

The Gavoglio Park project in Genoa, a laboratory for NBS experimentation

LAND Italia

The adopted NBS for climate resilience

The project is structured around 3 axes of development:

- Increasing green areas
- Improvement of soil permeability
- Use of "fresh" pavements

Key project improvements:

+ 4500 m^2 of de-impermeabilized soil
+ 130 trees
+ 6400 m^2 of green areas
+ 154 m^2 of green wall
+ 117 m^2 of rain gardens
+ 109 m^2 of infiltration basin
+ 123 m^2 of vegetated channels
+ 4750 m^2 of permeable pavements
+ 30 m^2 of cistern

Microclimatic performance of trees

The power of trees to regulate the microclimate depends on their botanical characteristics such as (M. T. Salomoni, 2018):

- **Canopy density**
- **Height at maturity**
- **Leaf type**

Nome botanico	Nome comune	Ord. di grandezza	Tipo di foglia	Chioma	Performance microclimatica
Cinnamonum camphora	Canfora	II	sempreverde	Densa	Alta
Quercus ilex	Leccio	II	sempreverde	Densa	Alta
Quercus cerris	Cerro	I	decidua	Semi-aperta	Alta
Ceratonia siliqua	Carrubo	III	sempreverde	Densa	Alta

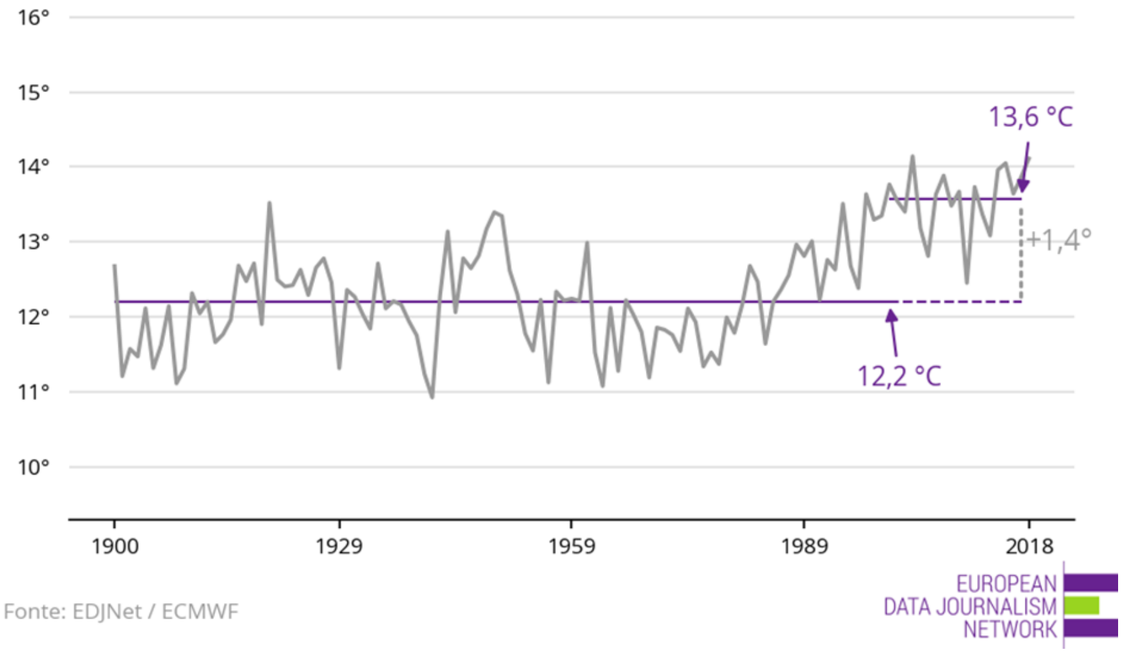
Thermal anomalies and impacts of heat waves in Genoa

Notti tropicali TR20			Notti calde TN90P		
valore climatico 1971-2000	valore medio 2006-2015	Variazione	valore climatico 1971-2000	valore medio 2006-2015	Variazione
55	66	**+20%**	33	61	**+82%**

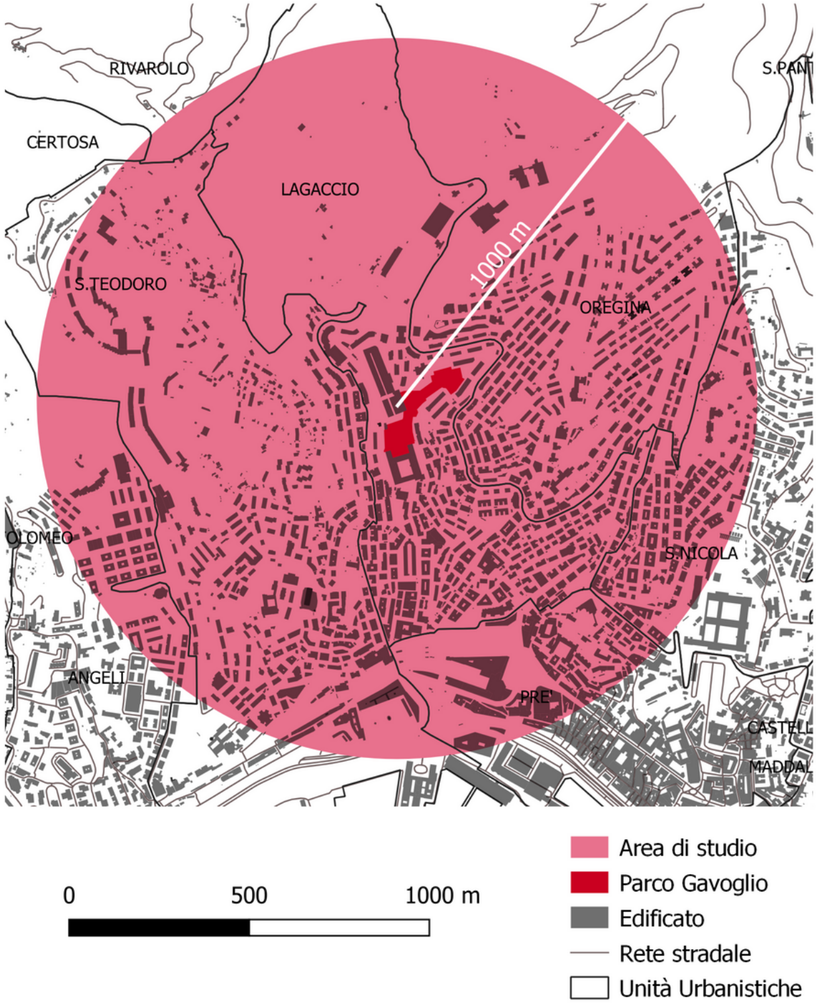
Giorni caldi TX90P			Giorni estivi SU25		
valore climatico 1971-2000	valore medio 2006-2015	Variazione	valore climatico 1971-2000	valore medio 2006-2015	Variazione
33	53	**+59%**	74	78	**+5%**

Indice di durata dei periodi di caldo WSDI			Massimo delle temperature massime TXx		
valore climatico 1971-2000	valore medio 2006-2015	Variazione	valore climatico 1971-2000	valore medio 2006-2015	Variazione
7	12	**+82%**	33	34	**+3%**

Istat, rilevazione dati meteo-climatici, 2020



Fonte: EDJNet / ECMWF



Evaluation of Gavoglio Park's contribution to local climate regulation

Using the Urban Cooling model of the InVEST software to estimate the microclimate benefits generated by adopted NBS.

The aim is to create a model of the study area at the previous state and another at the project state to estimate the microclimate improvement generated by the Gavoglio Park.

InVEST Urban Cooling model input data

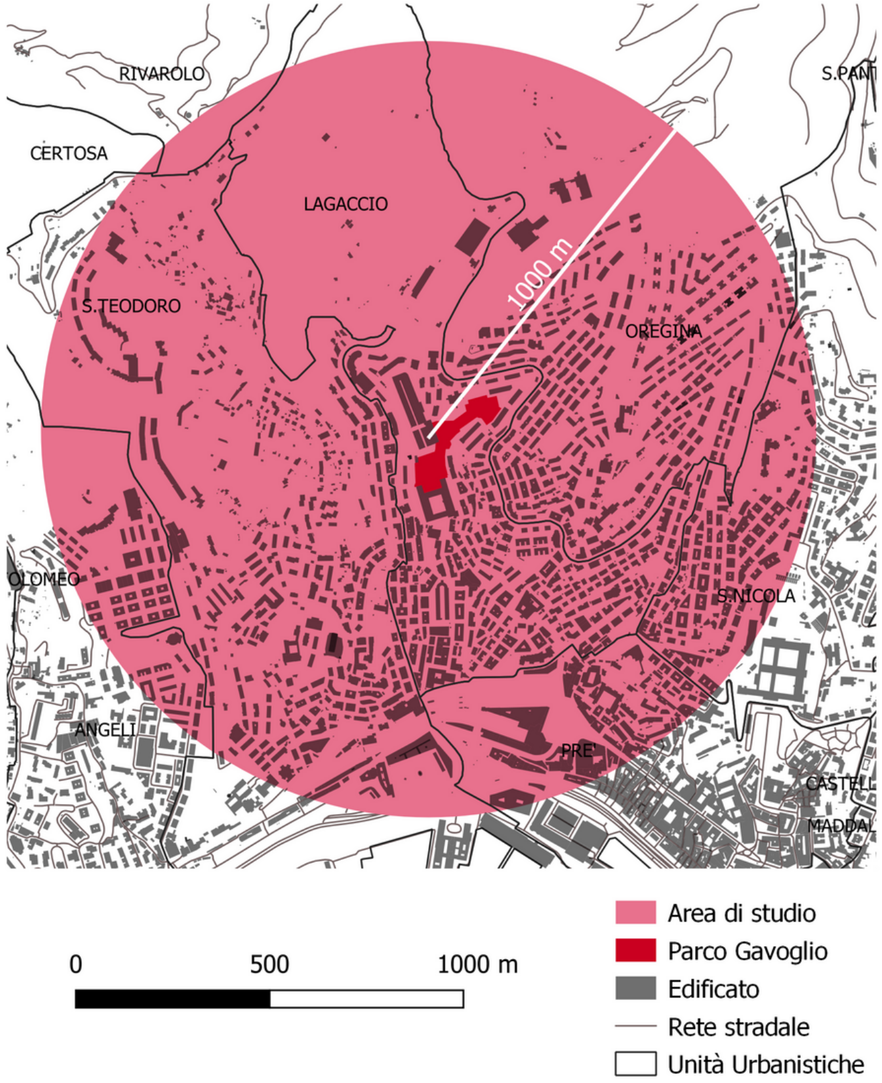
Dataset	Tipo	Risoluzione	Fonte	Note
Uso del suolo 2018	Vettoriale	Aree > 0,25 ha	Copernicus Land Monitoring Service, 2018	Layer rasterizzato ai fini della compatibilità
Evapotraspirazione mensile media (mm)	Raster	100 m	Consortium for Spatial Information (CGIAR-CSI), 2019	Media dei valori di luglio (2008-2015)
Area di interesse	Vettoriale	/	Elaborazione propria	Area buffer di 1000m intorno al perimetro di progetto

Meteorological reference data for the model:

Dato		Fonte
Temperatura di riferimento media per il mese di luglio 2015 (Stazione Genova Sant'Ilario)	25.6 °C	Centro Funzionale Meteoldrologico di Protezione Civile della Regione Liguria
Intensità dell'effetto isola di calore media sul periodo 2008-2015 riferita al perimetro del compendio Gavoglio	4.25 °C	European Environment Agency, 2017

Parameters included in the biophysical table:

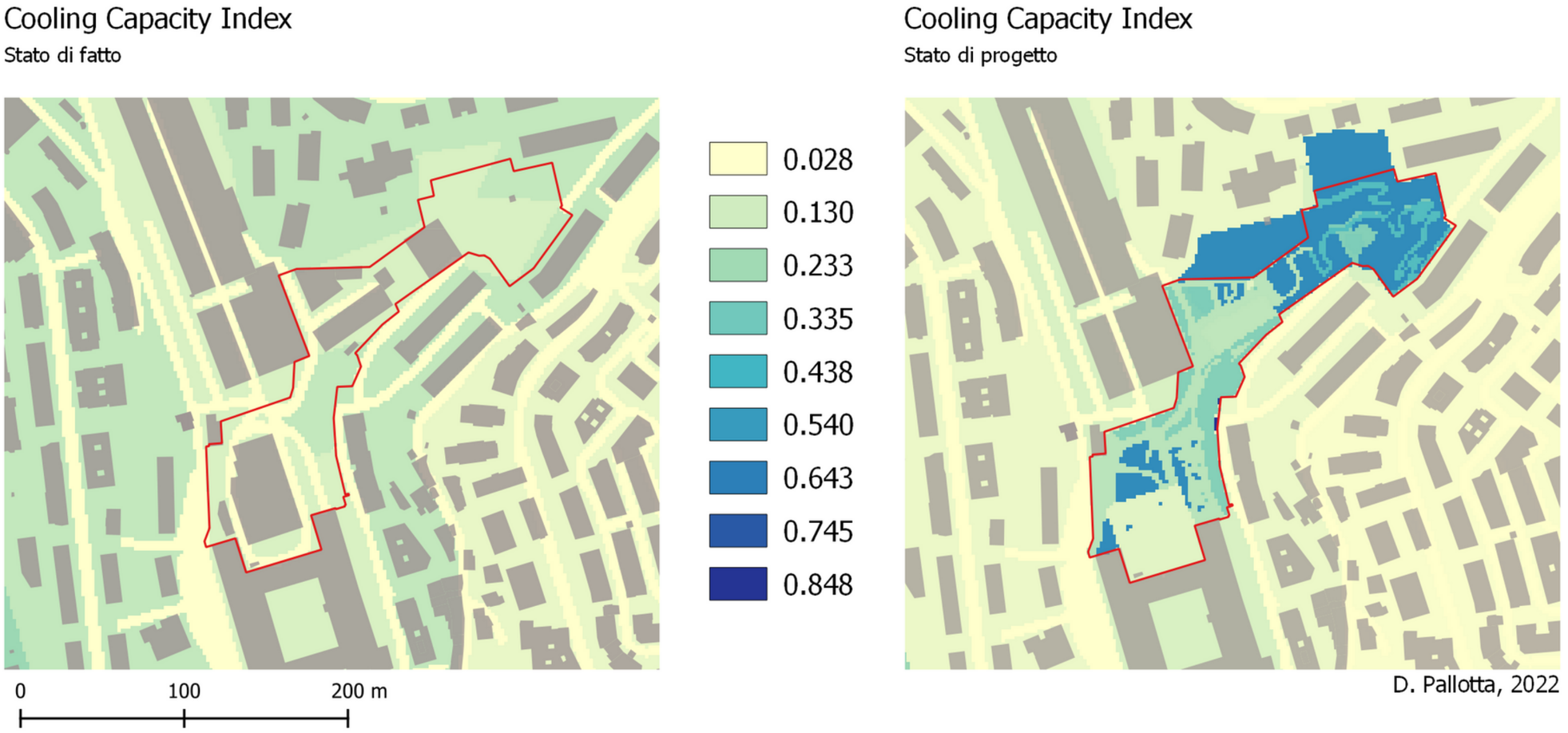
Dato	Fonte
Classi di uso del suolo	Corine Land Cover, 2018
Crop coefficient (Kc)	FAO Irrigation and drainage paper 56, 1998
Albedo	I. D. Stewart and T. R. Oke, 2012
Ombreggiamento (%)	Fotointerpretazione su QGIS



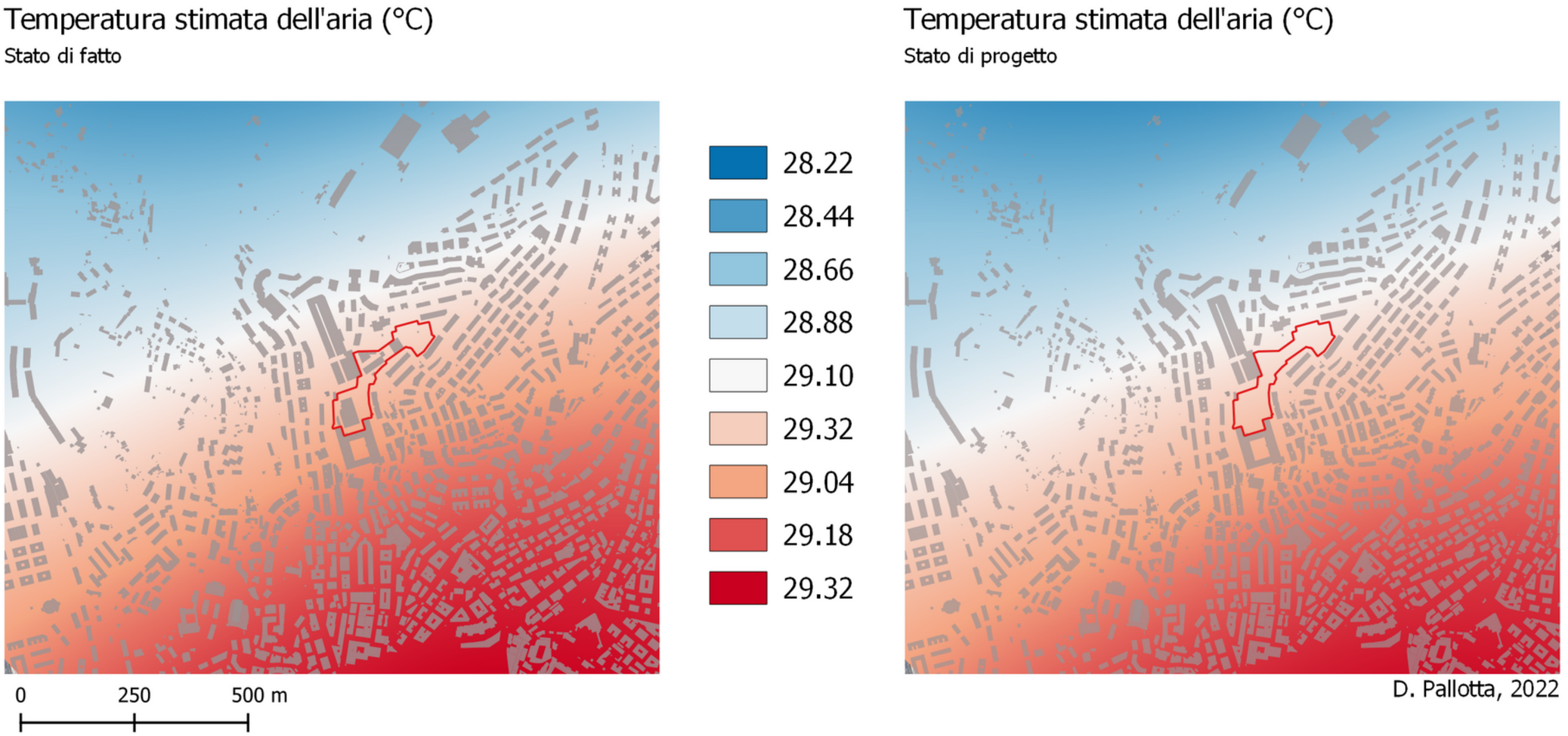
Urban Cooling model output

- **Cooling Capacity Index (0-1):** estimate for each pixel based on local shading, evapotranspiration and albedo.
- **Estimation of air temperature (°C):** calculation based on reference temperature, heat island intensity and CCi
- **Estimation of air temperature change (°C):** obtained by subtracting previous state estimated temperatures from actual state estimated temperatures.

Urban Cooling model results



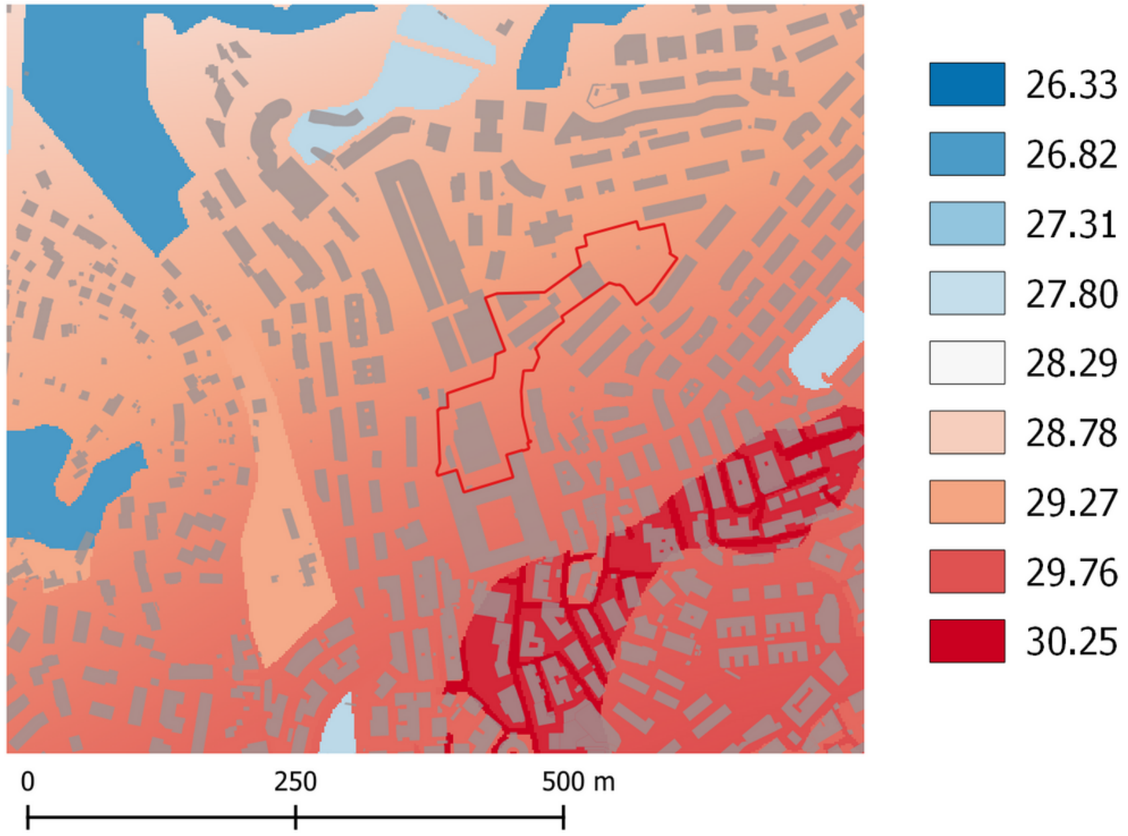
Urban Cooling model results



Urban Cooling model results

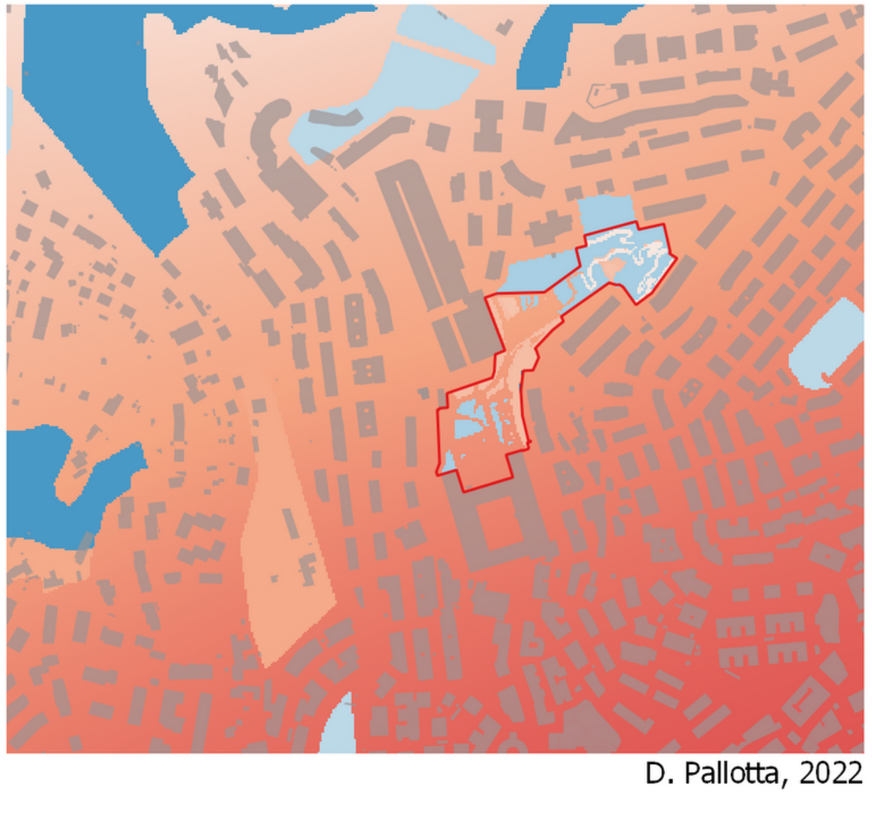
Temperatura stimata senza miscelazione dell'aria (°C)

Stato di fatto



Temperatura stimata senza miscelazione dell'aria (°C)

Stato di progetto



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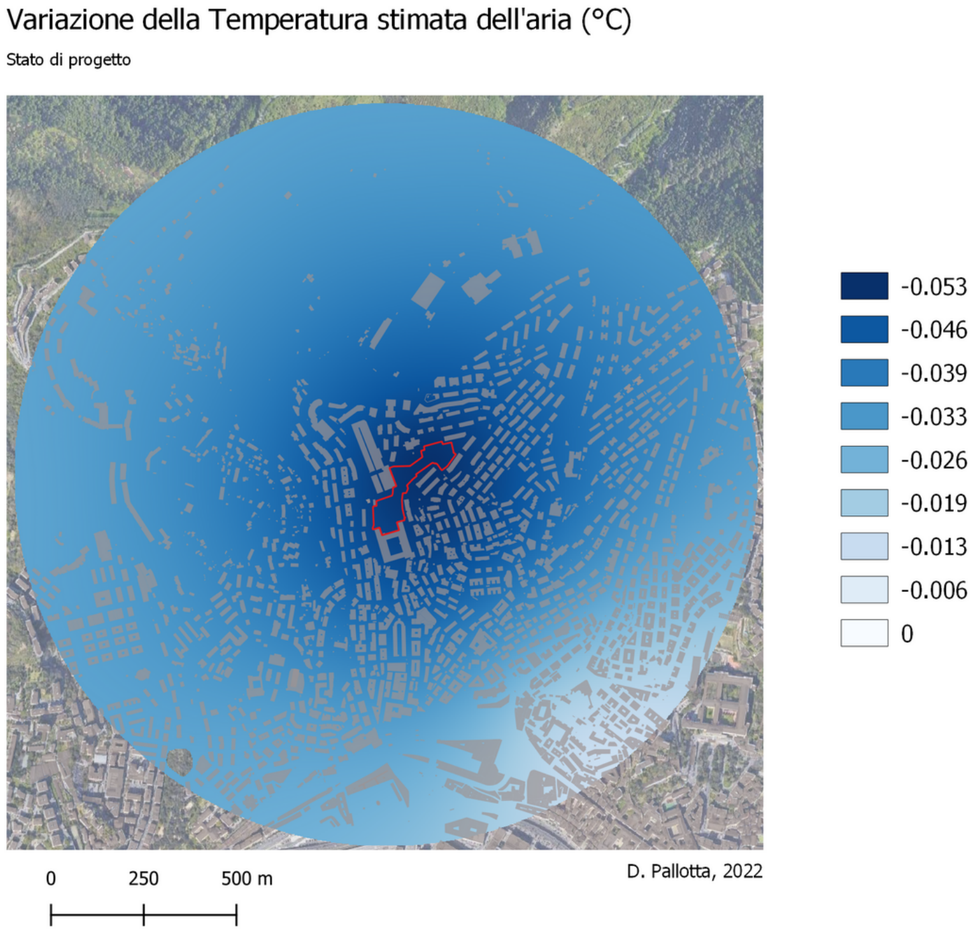
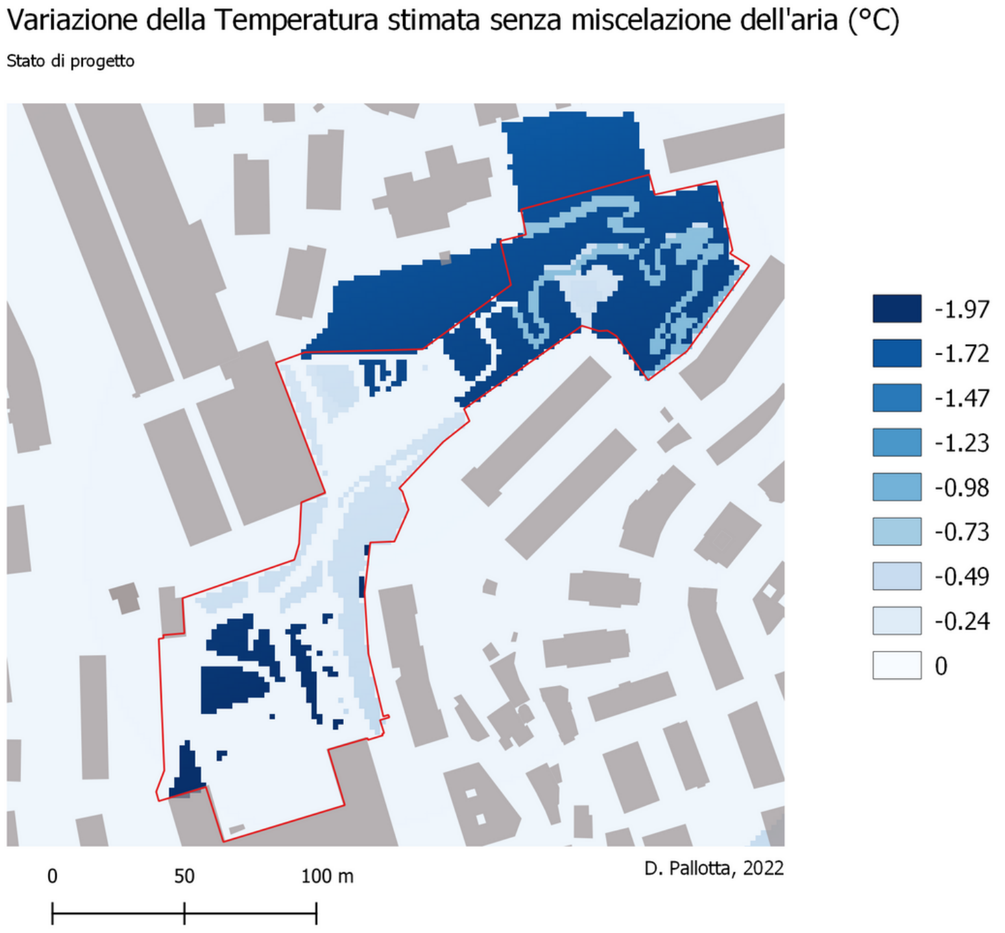
Urban Cooling model results





Limits and opportunities of the Urban Cooling model

Limits:

- Urban microclimate is a very complex system to study
- The model does not take into account topography or built-up area (just the intensity of buildings for each land cover class)
- Some input parameters are studied in a limited number of researches and countries

Opportunities:

- According to a 2021 study by Zawadzka, the model has been shown to be able to estimate the distribution of air temperatures with a large degree of statistical determination
- Data available on a global scale
- Open source software still under development
- Simplicity compared to traditional models
- Interoperability of GIS systems

Conclusion

The inclusion of these solutions in a widespread way in the metropolitan area represents the first step toward climate-efficient design. Nature, in fact, thanks to the multiple ecosystem services it provides, must become the protagonist of public spaces, ensuring better thermal comfort for citizens and reducing health risks related to extreme heat waves in the city.