Negotiating between the urban landscape and the domestic space: adaptive climates in Ostiense (Rome)

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Technological rationalization of recent decades has definitively dissociated the management of comfort from its context. The "passivation" and "efficiency" of spaces of everyday life have led to a technological setup capable of altering temperature, lighting, and ventilation to achieve a standard, rather than a perceptive level of comfort. This "techno-" functionalism, however, is neither neutral nor democratic. By looking at the consumption patterns in the Mediterranean area, energy consumption increases significantly during the summer due to heat waves and the Urban Heat Island (UHI) effect, caused by impermeable surfaces, limited vegetation, and poor urban ventilation. The widespread use of cooling and ventilation systems leads to high energy demand, with environmental and economic consequences. However, access

Introduction

The concept of resilience, originally associated with the resistance of materials, has gradually assumed a central role in urban and territorial debates. The literature distinguishes among engineering, ecological, and evolutionary resilience (Holling, 1973; Davoudi, 2012).

Engineering resilience is based on the idea that a system, following a disturbance, has the capacity to return to its previous state of equilibrium. When the concept intersects with the field of ecology, resilience comes to indicate the ability of a system to absorb a certain degree of shock without altering its fundamental structure.

While both of these perspectives rely on the notion of equilibrium, either to be maintained or restored, evolutionary resilience questions the very existence of such a state, acknowledging the dynamic and transformative nature of socio-ecological systems (Scheffer, 2009).

to these systems is not guaranteed for everyone, especially for those living in energy poverty, renters, or people in precarious housing conditions. Urban policies often prioritize technological models such as Positive Energy Districts and Near Zero Energy Buildings, which are frequently unsuitable for the existing building stock and more accessible in countries with greater investment capacity, thus reinforcing disparities between Northern and Southern Europe. Working with the actual capacity for renewable energy production, energy flexibility, and energy efficiency within given urban contexts is the perspective that interests PED4ALL, an European research project deeply connected to the specific context of Ostiense, a neighborhood adjacent to the city centre of Rome. Based on the recognition that current energy adaptation strategies have little room to take root in a district such as Ostiense, this contribution proposes a number of strategies for energy transition which are elaborated from the specificities of the site: analyses span from the domestic energy behaviors associated to a low-performing building stock, the quantity and quality presence of vegetation and wet areas, the geographies of paving and building materials, wind strengths and directions. The result of the design exploration offers a possible way to adapt to the changing climatic conditions and to enhance the opportunities to reduce energy use. Like the analyses, the configurations that attempt to spatialise the possibilities of energy-climate resilience work at very different scales, from the domestic space to the street, to the vacant lot, up to the level of the river park crossing the area. They are certainly not ready-made answers, but rather keys to understanding and discussing the adaptability of existing parts of the city.

Davoudi (2012) explains that evolutionary resilience promotes the understanding of urban systems as complex and interconnected socio-spatial systems, while Geddes (2003 cited in Mancuso) draws strength from the evolutionary conception of the city through the co-operation of its inhabitants.

However, the transition from theory to practice has rendered the concept increasingly ambiguous. The drive toward "resilience" has, in many cases, resulted in an acceleration of efforts to identify rapid, efficient, and economically sustainable solutions aligned with logics of performance and accountability. Yet this pursuit of efficiency has often privileged technical and administrative criteria, overlooking the actual needs of citizens and local communities (Carrosio, 2020).

In the name of resilience, adaptation strategies have frequently taken the form of top-down interventions. This has, in some instances, produced a widening gap between proposed solutions and social or territorial demands, generating unequal and sometimes counterproductive outcomes. Conceived in this way, resilience risks becoming a technical rhetoric, functional to the justification of predetermined decisions rather than an opportunity to radically rethink the relationship between planning, governance, and spatial justice (Magnani, Carrosio, Osti, 2020).

Within this framework lies the work that began as a master's thesis and then expanded within the European research project PED-4ALL, promoted by JPI Urban Europe. The research investigates the application of Positive Energy Districts (PEDs) in three European contexts: Ostiense in Rome, the Abattoir in the Cureghem district of Brussels and Kizilay Boulevard in Kartal, Istanbul.

PEDs were conceived as an integrated approach capable of combining renewable energy production, flexibility and efficiency. However, their implementation in historic and consolidated urban areas often encounters building constraints, governance short comings and an excessive focus on technical parameters (Ranzato, Vanin, Cristiano, 2022).

Specifically, the Ostiense district, located in Municipio VIII (the eighth district of Rome) in the southern area of Rome, between the Aurelian Walls and the Tiber River, belongs to the compact[1] part of the city. The morphology is predominantly characterized by a residential fabric built between the 1930s and the 1960s. It then unfolds into large, disused industrial and commercial areas. From an industrial hub to a territory in search of a new identity, Ostiense has always embodied a transformative character. The urban environment of Ostiense appears as an extremely specific and at times hostile context, marked by high temperatures, a lack of vegetation, air pollution and high population density. It constitutes a veritable ecological niche where only species (both human and non-human) adapted to such particular conditions can thrive.

Climate change, with its rapid and radical transformations challenges the resilience of these urban structures, highlighting the need to rethink these European urban models.

The aim of this article is to conduct an analysis grounded in the real conditions of the case study, questioning the standardized techno-functional approaches of the energy transition, and exposing their social and spatial limitations, while opening up possibilities for more equitable and adaptable forms of energy-climatic resilience.

The paper is structured into six main sections. The following section, *Theoretical Framework and Methodology*, explaining how the master's thesis *Ostiense Bioclimatica* was developed and how it expanded alongside the European research project PED4ALL. *Urban Heat Island and Urban System*: The Correlation between the Energy Production System and the Urban Heat Island in Rome, highlights the severity and persistence of the urban heat island phenomenon and its negative impacts on the national electricity system. *The Behaviour of Vegetation within the Urban System*, drawing on experiments conducted in the United States, Japan, and Rome, provides a qualitative overview of the effects of vegetation as the main passive cooling device. *Analysis and Design Speculation*, together with its subsections, presents a primarily climatic analysis of the Ostiense context, describing a range of devices for the implementation of passive and active solutions in the neighborhood. *Domestic Practices and the Paesaggio Elettrodomestico*, delves into the domestic sphere, linking the strongly spatial and climatic structure of Ostiense Bioclimatica with more social issues. Finally, *Conclusions*, outlines the main findings of the study, discussing both its limitations and prospects for future development.

Theoretical framework and methodology

The research originates from the master's thesis titled *Ostiense Bioclimatica*, dedicated to the Roman territory and in particular the Ostiense district, with the aim of intertwining analysis and design interpretation through maps and urban drawings. The initial study highlighted the correlation between the fatigue of the urban energy system, exacerbated by the urban heat island phenomenon, and the behavior of vegetation, which served as a basis for outlining a climatic overview of the city of Rome. To gain a deeper understanding of the context and to develop a targeted proposal for Ostiense, the investigation then focused on several factors: building performance, mobility, vegetation distribution, permeable and reflective surfaces and areas most exposed to solar radiation. Building on these observations, the research engages with the model of Positive Energy Districts (PEDs), understood as urban subsystems capable of integrating expert and local knowledge through a co-production methodology, that combine energy strategies, policies, regulatory frameworks, as well as social and spatial dimensions (Maestosi, Salvia, Pietrapertosa, Romagnoli, Pirro, 2024). Despite growing interest the implementation of PEDs faces numerous challenges. Adapting to the existing building stock and the integration of new technologies present a complex processes; in addition, the lack of established technical strategies and adequate governance models poses further obstacles. There is a risk that PEDs may be reduced to a mere techno-scientific apparatus based solely on energy parameters and unable to address the critical issues and specificities of consolidated urban contexts such as the Ostiense district.

To overcome these limitations, this work adopts a theoretical framework that interprets the territory not merely as a collection of buildings, but as a complex urban and environmental system. Through reports from Legambiente – Associazione Italiana per l'Ambiente e l'Ecologia[2], Terna – Rete Elettrica Nazionale S.p.A.[3], Areti S.p.A.[4], and other studies, it was possible to reconstruct a comprehensive overview of Rome's energy infrastructure and its energy transition highlighting its limitations and implementation challenges. It immediately emerged that many of the energy network's criticalities are exacerbated by climate change, particularly heat waves, which severely test the system's reliability. In this context, the studies by Asdrubali et al. are particularly relevant, as they analyse in detail the difficulties caused by heat waves.

In the name of resilience to these issues, various mitigation and adaptation measures have been developed in Rome, including the creation of reflective surfaces, soil permeabilization, protection of hydrogeological systems, and safeguarding of the ecological network (Rome Climate Plan, 2024). However, intervention is not straightforward: Rome's building stock is vast, heterogeneous and often subject to conservation restrictions, while territorial disparities and limited access to funding constrain the possibility of widespread and equitable action.

In this perspective, reference is also made to the studies of Sproken-Smith (1998), Oke et al. (2017) and Scudo and Ochoa de la Torre (2003), which highlight the contribution of urban morphology and vegetation to climate regulation and have allowed these aspects to be qualitatively represented across the city of Rome.

It is necessary to ask whether urbanized humanity is still capable of evolving and adapting to a rapidly changing environment, especially when the very structure of cities and the infrastructures that support them are under pressure. Is there a way in which the urban structure of our cities does not merely represent a limitation but through design and planning can actually promote and influence behavioural and social responses?

For this reason, *Ostiense Bioclimatica* seeks to propose a design alternative for public space that allows for a new vision of the territory and integrates climatic strategies, social practices and the quality of urban space. Particular attention is given to the role of passive climatic devices and the legacy of bioclimatic architecture, present in vernacular traditions that reveal traditional bioclimatic strategies transferable to contemporary architecture. Among the most renowned are the seminal works of Hassan Fathy (1986) and Paul Olivier (1997), as well as the studies of Victor and Aladar Olgyay (1963) and Baruch Givoni (1976). Contemporary reflections are also considered, such as the meteorological architecture of Philippe Rahm (2023) and the work of Kedziorek et al. (2023), which focus on creating variable comfort conditions in inhabited spaces through both low-tech and non-low-tech devices.

The design reflection drew inspiration from several international examples that have explored the creative use of urban spaces, the flexibility of street furniture and the integration of passive climatic devices. Among these are the Metropolitan Forest in Madrid (Lola. land), which combines vegetation and public spaces; the project of Philippe Rham in Taiwan "Jade Eco Park", which experiment with meteorological architecture as a form of climatic modulation; Scalo Farini in Milan (OMA), an example of converting railway spaces into multifunctional parking lots and open spaces into temporary gardens or interactive social spaces. Additional references include the projects of TVK - Trévelo & Viger-Kohler Architectes Urbanistes in Paris, such as Place de la République, Jardin Sportif Suzanne Lengles and the Michelet complex, which demonstrate how canopies, pathways and flexible spaces can foster social interaction and climate comfort. At the international level attention is also given to the Els Encants market canopy in Barcelona, the water square along the Garonne River in Bordeaux and the removable canopies at Centenary Square in Sydney illustrating how temporary or modular architecture can create multifunctional public spaces adaptable to climatic conditions and social activities.

Afterwards, by approaching the European research project PED4ALL, the investigation opened up to the socio-spatial dimension exploring everyday practices of energy consumption and comfort. Through small workshops with the inhabitants of Ostiense, called Paesaggio Elettrodomestico, it was possible to observe how the indoor conditions of buildings are closely connected to the external climatic ones. It emerges that the organization of domestic space and everyday practices can affect the thermal regulation of indoor environments, reducing dependence on electric or gas devices, in line with the studies of Shove (2007), Boni (2014), and Oskar and Hansen (1996–2020).

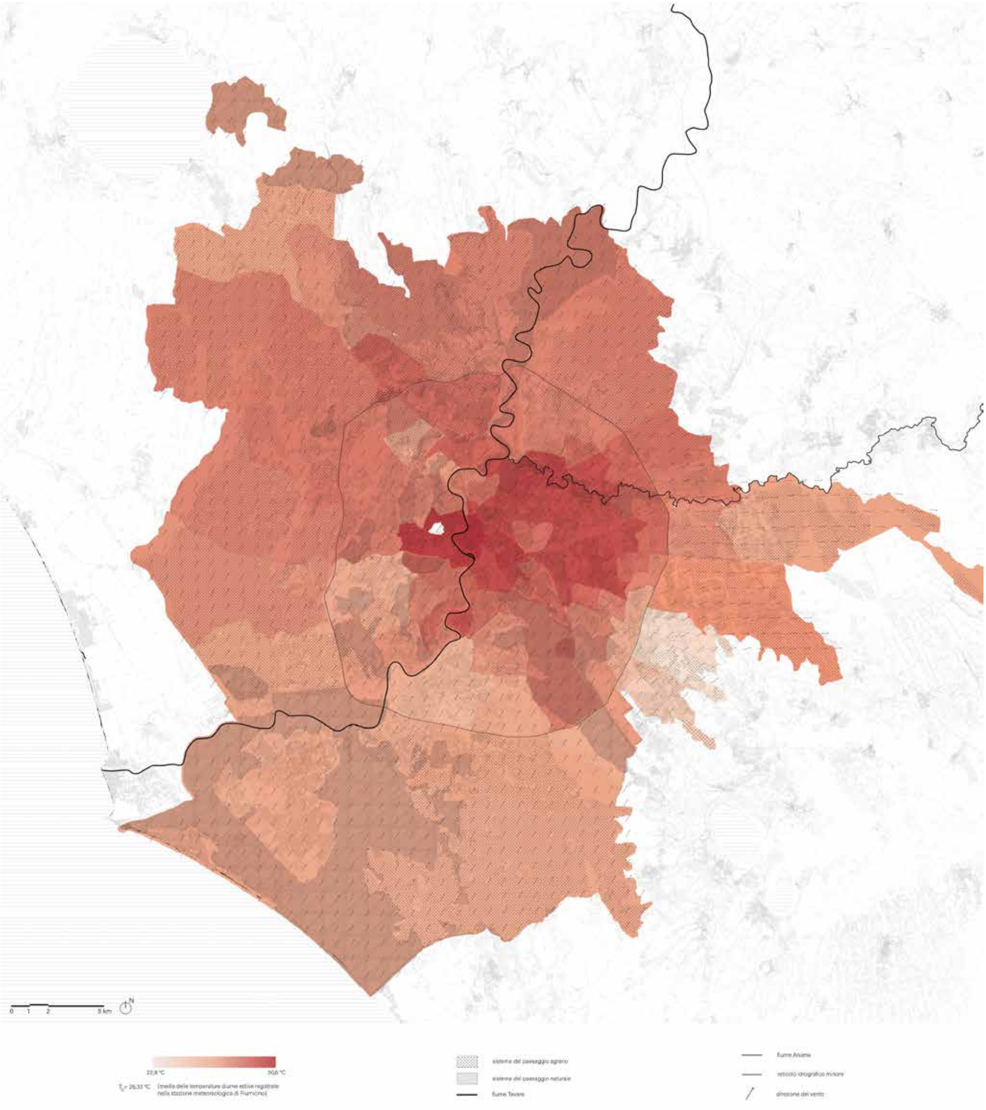
Urban heat island and urban system: the correlation between the energy production system and the urban heat island in Rome

The significant temperature difference between city and countryside was a phenomenon already observed in the 19th century by the London pharmacist Luke Howard, who was a pioneer in identifying what is now known as the Urban Heat Island (UHI) effect. This effect consists of the formation of warmer microclimates within urbanized areas compared to the surrounding rural zones. The intensity of this phenomenon is currently measured by the Urban Heat Island Intensity (UHII) indicator, which expresses the difference between average, maximum or minimum temperatures recorded by urban microclimate stations and those recorded in reference rural areas.

The causes are multiple: the morphology of the territory which hinders natural ventila-

Urban heat island and urban system: the correlation between the energy production system and the urban heat island in Rome.
Source: Asdrubali et al., 2022, reworked by Giordana Panella and Giancarlo Scarascia Mugnozza
Fig 1

tion; high levels of air pollution; soil impermeabilization and the limited presence of vegetation (Fawzi Arrar et al., 2024). In Rome, the urban heat island effect manifests particularly strongly, and forecast data indicate a constant worsening of the phenomenon. It is estimated that the number of extreme heat events will increase from an average of 2 to 28 days per year, with an overall temperature rise of +3.65°C compared to 1960 (Legambiente, 2020). Quantifying the urban heat island phenomenon has become fundamentally important, both for design and forecasting purposes. Francesco Asdrubali, Full Professor of Technical and Environmental Physics, and Marta Roncone, PhD student in Technical Physics at the Department of Industrial, Electronic, and Mechanical Engineering of the University of Roma Tre, calculated the UHII in Rome's neighbourhoods using data from 35 urban microclimatic stations and the rural station at Fiumicino airport. The resulting map spatializes and makes legible the temperature differences within the city compared to the rural reference station, calculated by urban zones (Fig. 1). It is evident that the most pronounced phenomenon occurs in the central neighbourhoods and the eastern quadrant. The impacts of the intensification of the heat island effect are numerous and profound. Beyond the health risks, especially for the most vulnerable populations during heat waves, the phenomenon has direct implications on energy infrastructures. The national electricity system, mainly based on centralized production , reveals a series of structural vulnerabilities. The Resilience Plan by the company Areti highlighted a significant correlation between rising ambient temperatures and increased electrical power demand. Analysing data from 2012 to 2022, critical stress thresholds on the grid were identified: high temperatures lead to higher energy demand precisely when the grid is more vulnerable, as heat impedes thermal dissipation along power lines, causing increased cable temperatures and raising the risk of infrastructure failure. In addition to structural problems, there are inequalities in energy consumption. Again, Asdrubali and Roncone (2023), together with De Lieto Vollaro and in collaboration with the collective #mapparoma (Keti Lelo, Salvatore Monni, and Federico Tomassi), presented maps of domestic consumption based on data provided by Areti for urban zones in 2021. They show that the lowest consumption is in the compact city, due to its dense fabric and medium-small housing, but also linked to social groups with limited economic resources. However, the largest percentage increase in domestic consumption during the summer months, when air conditioning peaks occur, is also observed in the compact city. In light of this morphological, climatic, infrastructural and social complexity, an integrated design approach becomes increasingly urgent, one capable of connecting the urban landscape, techno-



logical innovation and microclimatic resilience. Philippe Rahm (2023) proposes defining this approach as the "Anthropocene Style": a way of designing that acknowledges the interdependence between the built environment and climatic phenomena, between daily comfort and urban energy metabolism. In a city like Rome, strongly marked by its historical layering but also subject to new climatic vulnerabilities, planning sensitive to territorial specificities appears not only desirable but necessary to face the challenges of the present. Improving housing comfort, reducing energy consumption and limiting CO_2 emissions can no longer be pursued as separate objectives but must be achieved through a unified and situated vision capable of reading and transforming the city starting from its climate.

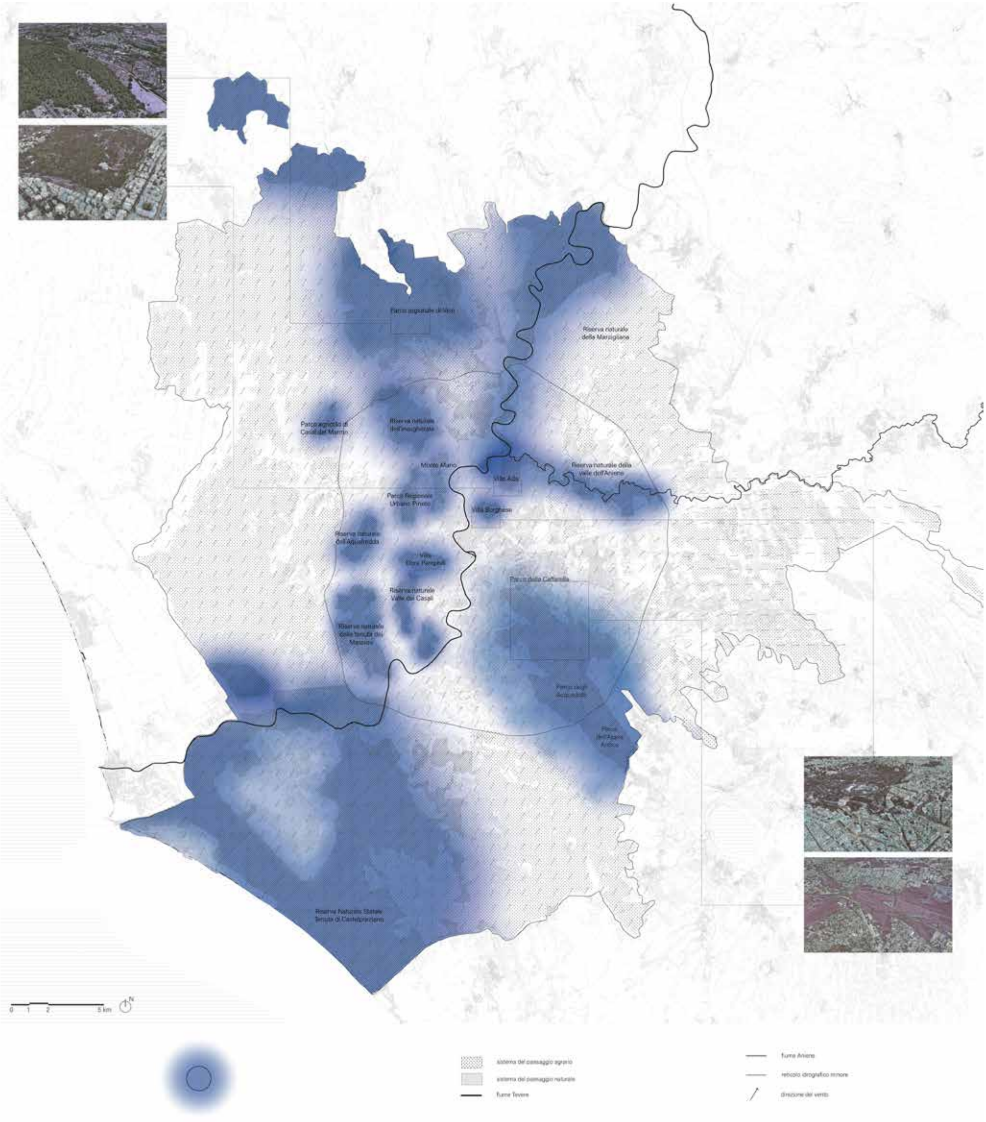
The behaviour of vegetation within the urban system.
Source: author's elaboration
Fig 2

The behaviour of vegetation within the urban system

The literature highlights the crucial role of urban vegetation as a tool for climate mitigation. It has been estimated that a 10% increase in green surface area would lead to a 2°C reduction in air temperature, with an energy saving for summer cooling of 8-11%. In particular, thanks to the shading provided by trees, depending on their position, species and canopy size, energy consumption for the air conditioning of residential and commercial buildings can be reduced by 15-50% (Akbari et al., 2001), as they generate a natural low-tech cooling effect. Unlike other types of surfaces, grassy areas remove heat from the environment through the process of evapotranspiration (Scudo, Ochoa De la Torre, 2003). Experiments by Sproken-Smith (1994), Brundl et al. (1986), Oke (1989), Jouregui (1975 and 1990), and Seito et al. (1990 and 1991) confirm that shading and evapotranspiration are the two main factors in lowering temperatures. In particular, Sproken-Smith states that the effect called the "cooling effect," i.e., the positive thermal influence of parks, is often noticeable within a distance approximately equal to the width of the park itself. Moreover, Marando et al. (2019) specifically studied this effect of vegetation in the Metropolitan City of Rome. By analysing different elements of Green Infrastructure during the summer period, they found that the Periurban Forest (Tenuta Presidenziale di Castelporziano) extends this effect up to about 170 meters beyond its boundary; for the Urban Forest (Villa Ada Savoia) it extends beyond the urban forest area up to a maximum of 100 meters; for the street trees of Quercus ilex L. along Viale Mazzini, the mitigation of local surface temperature, about 1.3°C, extends up to 30 meters from the row of holm oaks.

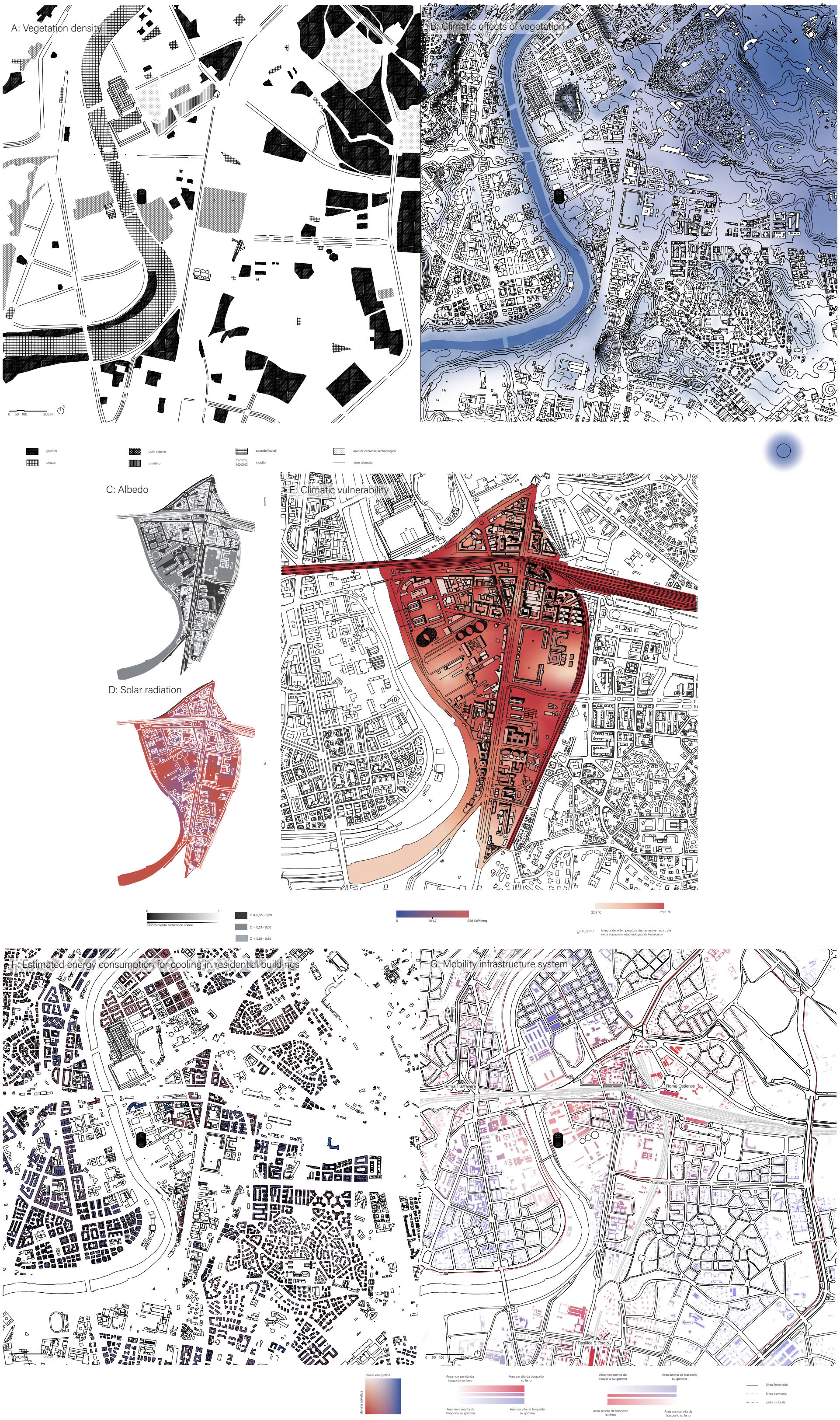
Although the mapping is qualitative (Fig. 2), it roughly proposes an offset of the average park width. However, as Sproken-Smith's research emphasizes, the surrounding urban context is essential for the irradiation of the climatic effect. Therefore, care was taken to limit the spread of the vegetation effect where the context is heavily built. In essence, this provides an indication of the effect that urban parks produce at the local scale, i.e. at the level of an urban district. When compared with the urban heat island map, it is evident how vegetation density and its effect are influenced positively or negatively depending on the urban context.

Villa Doria Pamphili, Villa Ada and Villa Borghese being surrounded by a continuous and dense residential fabric, struggle to produce a climatic resonance effect on a larger scale, similarly to what occurs in the eastern portion of the city. In contrast, the pine forest of Castel Porziano, the parks of the Appia Antica and the Veio Regional Park, characterized by extensive vegetated surfaces and a less compact



urban fabric, show a greater capacity to mitigate the urban heat island.
Rome is one of the largest urban systems, where different types of urban fabrics, a remarkable variety of landscape and environmental systems, a rich agricultural heritage characterized by a mix of intensive, rural and high-natural-value areas are intertwined.

Focusing on the parks highlights the lack of a coherent ecological network: the park system appears fragmented and the lack functional connections with both the consolidated urban fabric and with the surrounding agricultural landscape. This discontinuity undermines the systemic potential of vegetated spaces and reduces their overall impact on the city's climate resilience.



A: Vegetation density
0 50 100 250 m
N
B: Climatic effects of vegetation
giardini
piazza
corti interne
cimitero
sponde fluviali
incolto
area di interesse archeologico
viale alberato
C: Albedo
D: Solar radiation
E: Climatic vulnerability
0
1
assorbimento radiazione solare
C = 0,05 - 0,20
C = 0,21 - 0,50
C = 0,51 - 0,80
0
864,7
1729 kWh/mq
22,9 °C
29,3 °C
T_0 = 26,33 °C
(media delle temperature diurne estive registrate nella stazione meteoreologica di Fiumicino)
F: Estimated energy consumption for cooling in residential buildings
G: Mobility infrastructure system
Piramide
Roma Trastevere
Roma Ostiense
Garbatella
Basilica S. Paolo
0 50 100 250 m
N
classe energetica
densità abitativa
Area non servita da trasporto su ferro
Area servita da trasporto su ferro
Area non servita da trasporto su gomma
Area servita da trasporto su gomma
Area non servita da trasporto su gomma
Area servita da trasporto su gomma
Area servita da trasporto su ferro
Area non servita da trasporto su ferro
linea ferroviaria
linea tranviaria
pista ciclabile

Climatic and Morphological Analysis of the Ostiense District.
Source: maps designed by Giordana Panella and Giancarlo Scarascia Mugnozza
Fig 3

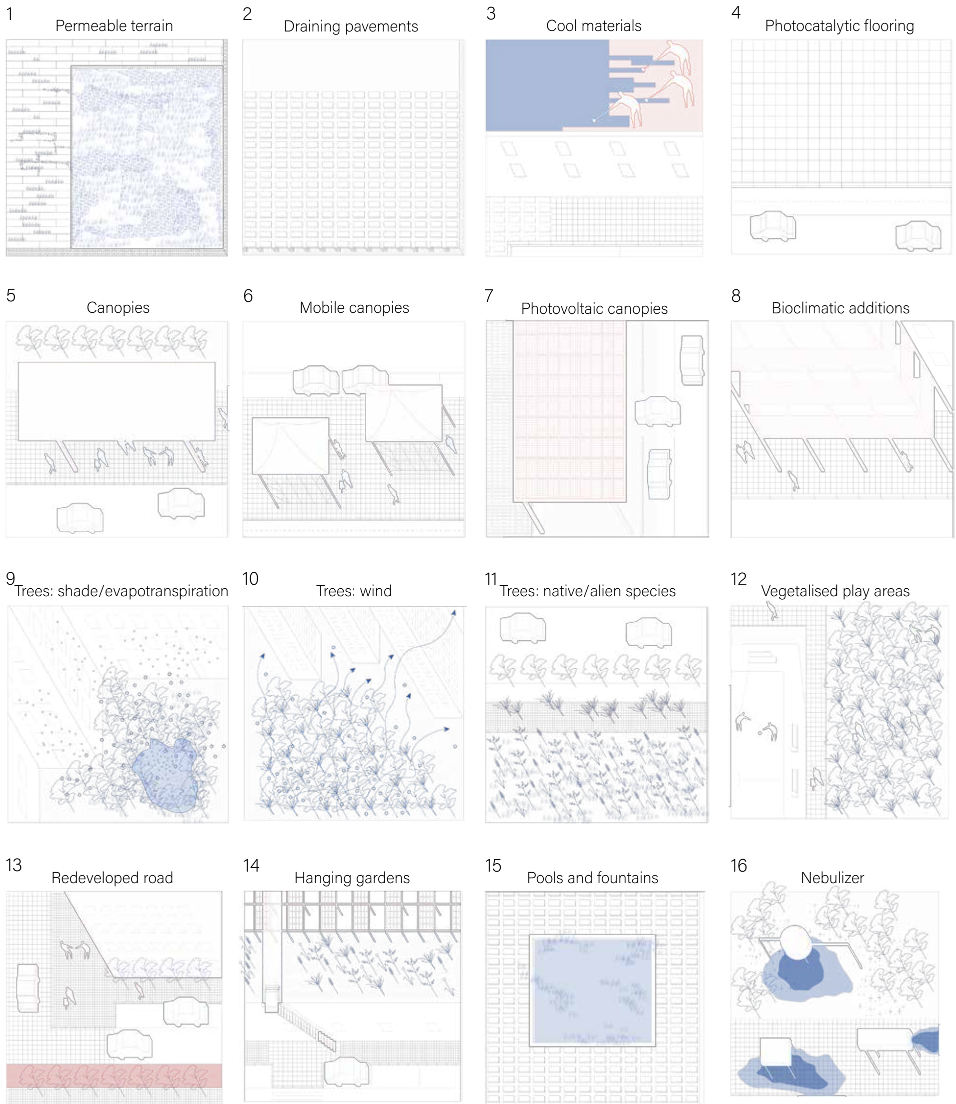
Analysis and Design Speculation

Climatic and Morphological Analysis of the Ostiense District

The analyses conducted for the study area highlight the main causes of increasing temperatures in the urban environment. These include the extent of paved and impermeable surfaces, which absorb solar radiation due to their low reflectance. The geometries of the urban fabric, which hinder natural ventilation and the diffusion of the positive effects of vegetation, and finally, the effects related to vehicle traffic and the use of air conditioners during the summer season in the residential context.

The Ostiense district (Fig. 3), in its densest part, is characterized by a predominantly compact block morphology with narrow streets bordered by continuous building fronts that are poorly permeable to ventilation. The analyses conducted on vegetation aim to make visible how its configuration (A), distinguishing between gardens, squares, inner courtyards, cemeteries, riverbanks and uncultivated areas, interacts with the urban morphology. By comparing these elements, the intensity of the blue areas defines the limits of the vegetation's capacity to act as a bioclimatic device (B). The urban system of Ostiense presents a high incidence of impermeable surfaces. The black and darker grey are areas that are highly irradiated and have a low albedo coefficient[5](C) (ranging between 0.05 and 0.50) (Fabian, 2019). As shown by the purple colour in the following diagram, this results in significant heat absorption. Using Autodesk Formit software, the most critical thermal zones correspond to surfaces combining high heat storage capacity, constant sun exposure and vegetation inconsistent with the climatic needs of the area (D). The most critical areas are those near the railway to the north and east, the two intermodal hubs of Piramide and Garbatella and Via Ostiense in its less vegetated section, (E).

The estimate of energy consumption for cooling, based on energy class and population density, focused on residential buildings, shows that low-efficiency buildings tend to overheat more quickly during hot periods, requiring greater use of air conditioners and fans to maintain comfort conditions. Residential density accentuates this effect, as more occupants generate higher internal loads, making it difficult to maintain thermal comfort. The intersection between low energy efficiency and high density identifies areas of greatest energy and climate vulnerability, characterized by high summer electricity consumption, which are shown on the map as dark purple buildings (F). The mobility system also represents a critical element for the environmental resilience of the area. Despite its strategic location between two intermodal hubs, the northern part of Ostiense, as highlighted by the colour intensity (F), is well served by public transport, both rail and bus. However, private road mo-



Bioclimatic devices and strategies.
Source: elaboration by Giordana Panella and Giancarlo Scarascia Mugnozza
Fig 4

bility continues to dominate, contributing to air pollution and the overheating of urban surfaces. The district's configuration as a "pass-through place", rather than as an integrated system of public spaces and sustainable mobility strengthens the conditions of microclimatic stress and complicates the implementation of adaptation strategies.

Bioclimatic devices and strategies

In relation to the analyses carried out, a matrix of devices was defined that engages with a dense and historically layered urban fabric, characterized by spatial and social complexity that limits the application of purely technological or economically burdensome solutions. In these contexts, the design challenge does not lie solely in energy efficiency or the technical performance of the devices, but in their ability to adapt to a heterogeneous built environment. The matrix thus becomes a non-prescriptive but interpretative tool, capable of mediating between material conditions, local resources and everyday practices (Fig. 4)

Masterplan and climate regeneration

In continuity, the masterplan (Fig. 5) proposed for the Ostiense area is conceived as a coherent set of interconnected actions aimed at reclaiming urban spatiality capable of generating climatic comfort and social transformation. The strategies developed based on the placement of devices in relation to the morphological and climatic criticalities identified in the neighborhood analysis aim at an equitable redistribution of environmental well-being.

Vegetation assumes a central role in the construction of local microclimates and in redefining the relationship between open space and urban density. In consolidated contexts such as Ostiense, its function is not only technical—shading and evapotranspiration—but also spatial and social, as it restores access to thermal comfort and the collective enjoyment of spaces that are currently marginal or impermeable. Trees are uniformly distributed throughout the territory, paying particular attention to streets and public spaces, where the selection of species resistant to pollution, favourably positioned for urban breeze circulation and with wide trees canopies (height over 18m) becomes essential for the creation of climatic corridors. A dense mass of trees is placed as close as possible to the railway to the north and east, to reduce the heat hotspot and along Via Ostiense one of the busiest streets.

To enhance the cooling effect through evapotranspiration on a small scale, it is important to place vegetation in relatively "enclosed" conditions, within almost continuous vertical limits (Scudo, De la Torre, 2003). From this perspective, the courtyards of large residential complexes become vegetated islands, which in some cases are further enhanced by the inclusion of water basins that amplify the cooling effect. The insertion of vegetation in inter-

Masterplan and climate regeneration.
Source: elaboration by
Giordana Panella and Giancarlo Scarascia Mugnozza
Fig. 5

nal courtyards not only improves microclimatic conditions but it promotes collective management of the microclimate, turning thermal comfort into a common good.

The large areas currently awaiting transformation, such as the former Mercati Generali and former Ex Italgas sites, are considered as potential spaces for temporary climate mitigation interventions, in connection with the uncultivated area near Teatro India on the opposite bank of the Tiber, strengthening the ecological continuity of the neighbourhood (Fig. 6).

At the same time, interventions target materials and pavements to counteract heat accumulation in areas that are heavily irradiated and characterized by low albedo, such as the intermodal hubs of Piramide and Garbatella. The aim is to act simultaneously on the environmental and morphological levels, through: a) depavement, which restores permeability to surfaces and their capacity to absorb rainwater; b) the use of permeable pavements, to implement eco-friendly solutions for the environment; c) the introduction of cool materials, capable of reflecting solar radiation and reducing heat absorption; d) the use of photocatalytic pavements, which contribute to air purification. These actions help to reconnect the urban fragments of the neighbourhood and improve local microclimatic conditions.

In areas where streets widen, the installation of light-fabric movable canopies, fixed shelters and photovoltaic coverings is planned, providing shade and producing energy, but above all redefining these spaces as new places for social interaction and urban rest. Building rooftops also take on a new role: they host photovoltaic panels and collective functions, with a view to energy redistribution and the regeneration of urban surfaces.

Alongside strategies for public space, interventions are planned within domestic spaces, such as in the two blocks near Piazza Porto Fluviale owned by ATER[6]. Bioclimatic greenhouses are added to the façades; these elements enhance the mitigating effect of vegetation and restore access to thermal comfort even for people experiencing energy and economic vulnerability (Fig. 7).

Domestic practices and Paesaggio Elettrodomestico

The continuation of the research within the PED4ALL research allowed the analysis to extend from the urban and morphological level to the dimension of everyday practices related to energy use and domestic comfort.

The investigation involved the residents of three housing units located in different areas of the neighbourhood (Fig. 8), through two co-analysis sessions. The first, dedicated to reconstructing the Paesaggio Elettrodomestico, was conducted using a maquette, revealing the daily use of household appliances. The second session consisted of analysing three climatic conditions, in order to reconstruct the

1. Spazi permeabili
calore specifico 879 J/kgK,
densità 1460 kg/mc,
albedo 0,15-0,20;
2. Pavimentazioni drenanti
grigliato di calcestruzzo vibro compresso 50x25 cm,
permeabilità 40/60% in base alla tipologia,
albedo 0,20-0,30;

3. Materiali freddi
albedo 0.90-1,00;
4. Pavimentazioni fotocatalitiche
conglomerato bituminoso contenente malta cementizia 50x50cm,
albedo 0,20-0,30;
5. Coperture/pensiline
acciaio composte da lame frangisole e opache,
albedo 0,70-1,00;

6. Coperture removibili
tessuto acrilico, impermeabile e autopulente;
7. Coperture fotovoltaiche:
fonte energetica,
albedo 0,05-0,1;
8. Addizioni bioclimatiche:
fonte energetica passiva;

9. Alberi:
ombra ed evapotraspirazione,
albedo 0,20-0,30;
10. Alberi:
brezze urbane con il passaggio del vento,
albedo 0,20-0,30;

11. Alberi:
specie autoctone aliene,
alberature stradali > 18m,
verde urbano 12-18m,
piccoli giardini < 12m;
12. Aree gioco vegetalizzate:
alberi < 12m,
albedo 0,20-0,30;

13. Sezioni stradali riqualificate: s
pecie resistenti all'inquinamento,
alberi > 18m o tra i 12-18m;
14. Giardini pensili:
albedo 0,20-0,30;
15. Vasche e fontane:
calore specifico 4180 J/kgK,
albedo 0,05-0,10 sole allo zenit,
50-0,80 sole all'orizzonte;

Cooling core Ex Italgas.
Source: elaboration by Giordana Panella and Giancarlo Scarascia Mugnozza
Fig. 6

Bioclimatic additions in Via del Commercio.
Source: elaboration by Giordana Panella and Giancarlo Scarascia Mugnozza
Fig. 7

Placement of the various apartments in the transect.
Source: author's elaboration
Fig. 8

practices adopted by residents within the domestic space to achieve a state of comfort.
One couple lives in dwelling A. This is in a six floors modern building with high energy performances. The 80 square meter apartment is located at the fourth floor. One person lives in dwelling B, a 50 square meter flat, which is in an historic building at the top floor. Dwelling C, 70 square meter, is at the top floor of a 60s courtyard building. Two people live in this one. From the three situations analysed, a strong interdependence between energy consumption and urban configuration emerges. The apartment C is closest to the railway

Reconstruction of the context in which apartment C is located.
Source: author's elaboration
Fig. 9

tracks is strongly affected by the urban heat island, while the one near the Tiber (apartment A) benefits from more favourable microclimatic conditions.
During the intermediate season dual exposure can generate cold drafts. Dwelling B has a free view, so that it can benefit more. Dwelling C, instead, is closely surrounded by high buildings that neglect the effect (Fig.9).
In the winter period, the efficient heating system and the good envelope insulation of apartment A are essential. Where this is not possible, conscious use of clothing becomes relevant.
Recognizing these relationships forms the basis of a situated energy transition, capable of integrating comfort, spatial justice and collective transformation.

Conclusions

The study shows how the definition of resilience proposed by the Intergovernmental Panel on Climate Change (2007), understood as "the amount of change a system can undergo without changing state", proves inadequate when applied to complex systems such as cities. The spatial analyses conducted show, in fact, that Rome presents a marked problem of summer heat island, constantly worsening over time, which puts pressure on the electrical grid and amplifies social inequalities, particularly affecting the most vulnerable groups. It is a systemic phenomenon involving infrastructures everyday practices and housing conditions and one that seems destined to persist. In this context, the Ostiense district represents an emblematic case with an urban fabric in continuous transformation, where social, environmental and spatial dynamics intertwine. Rather than thinking of resilience as the ability to return to an original state, it is necessary to consider an evolutionary resilience, understood as a succession of mutable and transitory states, capable of generating new conditions of equilibrium in response to regime changes and the potential cascading effects deriving from them. The PED4ALL research confirms and deepens the intuition of Ostiense Bioclimatica, highlighting the social and spatial limits of dominant technological strategies. Urban warming, in fact, cannot be reduced to a purely climatic issue: it intertwines with social practices and with the city's energy organization, contributing to the formation of new spatial vulnerabilities. As Shove (2002) observes, energy consumption is not an abstract fact, but is closely linked to everyday practices. It is the search for an ideal thermal condition that has radically transformed our behaviours and our perception of comfort. Technological evolution has certainly increased levels of well-being, but at the price of a progressive detachment from natural processes and from the direct control of our living conditions. We have delegated to technology and to fossil fuels the regulation of our living environment, constructing an apparent comfort that has progressively eroded our perceptive and critical awareness. The proposed approach aims to reactivate this awareness, bringing energy, climate and comfort back within a spatial and somatic horizon, in which urban design becomes a tool of relation between bodies, matter and environment. On the theoretical bases addressed, the identified strategies can be translated into flexible and adaptive urban planning tools, such as climate action plans, local building regulations or guidelines for urban regeneration, inspired by experiences already initiated in cities such as Pavia, Venice and Milan (Legambiente, 2020). Interventions such as de-paving, the use of reflective materials, the creation of vegetated courtyards or the activation of threshold spaces could be integrated into municipal policies for the mitigation of urban heat, promoting an energy transition rooted in local contexts.

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Notes

[1] According to Monni, Lelo and Tomassi (2021), the compact city consists of a set of high-density neighbourhoods forming the semi-central ring around the historic core, developed throughout the twentieth century and the post-war period. These urban settlements now accommodate the majority of Rome's population, within a building stock that is generally low-performing and often lacks adequate public spaces and infrastructures.

[2] Legambiente is the leading environmental association in Italy, founded in 1980. It is a non-profit organization, recognized as a public-interest body, operating at both national and local levels through a network of local branches, regional committees, and a national headquarters.

[3] Terna – Rete Elettrica Nazionale S.p.A. is an Italian joint-stock company that manages the transmission and dispatching of electricity throughout the national territory. It is one of the largest Transmission System Operators (TSOs) in Europe.

[4] Areti is the company of the ACEA Group responsible for the distribution and metering of electricity in the city of Rome and part of its metropolitan area.

[5] The albedo coefficient is the ratio between the solar radiation reflected and the incoming radiation. A white surface has an albedo coefficient of 1, while a black surface has an albedo coefficient of 0.

[6] The Territorial Agency for Residential Housing is the entity that manages public real estate assets intended for people facing housing or economic difficulties

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