

Chapter 4

The Historical City as a Critical Reference for Urban Aesthetics, History, and Climate Resilience



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Abstract The research delineates the significance of the historical city as a pivotal counter-model of urban development, particularly in the context of Italy post-World War II. It emphasizes the need for interdisciplinary approaches that intertwine architecture and urban history with public engagement, aiming to enhance decision-making in urban policy while preserving scientific integrity. The historical city is examined not just as an academic subject but as an active entity contributing to contemporary urban dynamics, navigating the transformations that have established it as a historic center amid modern urban sprawl. The chapter posits that the historical city can counteract detrimental urban policies and advocate for sustainable practices by bridging the gap between enduring historical values and the rapidly evolving identity of “modern” cities. It calls for active political engagement from historical research, promoting a collaborative framework that can enhance community socio-cultural conditions and support informed political discussions regarding urban evolution. Furthermore, the study introduces the concept of “new urban aesthetics”, highlighting the sensory and imaginative aspects of urban experiences and the shift toward aesthetic evaluations in the relationship between cities and their identities. It draws from early twentieth-century theorists and contemporary thinkers to explore how aesthetic dimensions shape urban environments and collective perceptions. The research identifies case studies to examine the intersection of new urban aesthetics with historic contexts. This comprehensive approach aims not only to create specialized knowledge but also to ensure that historical insights inform future urban development initiatives, thereby fostering community engagement and awareness

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of urban heritage. Building on this foundation, the Bologna case study demonstrates how historical insights can directly inform climate adaptation strategies. The study develops a multilayered analysis methodology to map and address Urban Heat Islands (UHIs) in the historical city's public spaces, integrating Nature-Based Solutions (NBSs) within a green infrastructure plan. By identifying vulnerable zones and simulating interventions with specific modeling, the methodology assesses improvements in microclimatic conditions. This approach provides a cross-disciplinary knowledge base that guides data-driven and long-term strategies for climate resilience, highlighting the historical city's role as both a cultural and ecological asset in the just transition toward sustainability.

Main research outputs:

- 1923 2023 Fernando Távora at 100, A. Esposito, G. Leoni, J.A. Bandeirinha, with G. Bellucci, eds., “HPA Histories of Postwar Architecture”, vol. V, n. 11 (hpa.unibo.it, Open Access, Classe A-ANVUR, SCOPUS); printed ed. Siracusa: Lettera Ventidue, 2024, HPA Series;
- Envisioning Tomorrow's Cities O.M.Ungers Urban Reflections, A. Trentin, J.H. Gleiter, eds., “HPA Histories of Postwar Architecture”, vol. VI, n. 12 (hpa.unibo.it, Open Access, Classe A-ANVUR, SCOPUS);
- The Churches and the City: European experiences between the 1950s and the 1960s, J. Alves da Cunha, A. Longhi, J. L. Marques, S. Singler with G. Bellucci, R. Maddaluno, eds., “HPA Histories of Postwar Architecture”, vol. VI, n. 14 (hpa.unibo.it, Open Access, Classe A-ANVUR, SCOPUS);
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- D. Longo, R. Roversi, M. Massari, K. Fabbri, R. Mercuri, The Green Connections: Adaptive, Integrated, and Nature-Based Solutions for Urban Historic Centres, “TECHNE—Journal of Technology for Architecture and Environment”, n. 28, 2024, pp. 181–190 (Classe A, Anvur) <https://doi.org/10.36253/techne-15868>.

Keywords Historical city · Urban development · Urban aesthetics · Community engagement · Cultural heritage · Urban Heat Islands (UHI) · Sustainability

4.1 New Urban Aesthetics and Historic City

This research aims to integrate historical perspectives on urban phenomena in historic cities with an aesthetic approach that emphasizes the sensory and imaginative impacts of new urban experiences. It briefly outlines key themes for an aesthetic reading of urban culture and references contributions that intertwine aesthetic frameworks with urban understanding.

A “new urban aesthetic” has emerged, particularly in English discourse, highlighting the relationship between cities and aesthetic evaluations. Recent studies on “rule by aesthetics” and the “aesthetic perception of urban environments” indicate that urban transformations are increasingly tied to visual identity and emotional resonance. In a competitive global economy, cities are crafted as “brandscape,” prioritizing their appeal through aesthetic identity aimed at specific social groups. This aesthetic dimension extends beyond individual perception to encompass the sensory interactions between people and their environments.

An attempt is made in the research to progressively compare this framework with historic cities, drawing insights from early twentieth-century philosophers like Georg Simmel, Sigfried Kracauer and Walter Benjamin, who explored concepts like “city as theater”, “urban landscape” and “porosity.” A subset of the research focuses on the intersection of new urban aesthetics and historical cities, establishing a philosophical base for interpreting urban phenomena. Some contemporary research trends of particular interest were then focused on for this purpose. Notably, Joe Blakey’s (Barron & Blakey, 2024) perspectives on urban dimension emphasized aesthetics as a key to understanding cities, advocating for a participatory approach that considers the collective perception of urban spaces. Richard Shusterman’s (2024) concept of somaesthetics further examined the relationship between the body and public/private spaces, highlighting the importance of democratic access and active participation in urban design. Sanna Lehtinen (2020) has investigated how contemporary urban aesthetics, particularly in historic contexts, inform the identity of cities while revealing the power dynamics at play.

Research interest is also shifting toward examining certain case studies that are particularly useful to compare also with the case of Bologna and its historical dimension. Such as the case of Venice, where tourism threatens local identity (Salerno, 2020), public art’s role in challenging sexual and gender norms in Amsterdam (Zembraki, 2017), community museology, emphasizing participatory narratives around urban challenges in the case of Bogotá (Góngora, 2024), pandemic-induced urban experiences and student life, illustrating how aesthetic practices can foster memory and reinterpretation in historic cities, particularly in the

Bologna case. Collectively, these case studies propose a nuanced understanding of urban aesthetics that engages with historical contexts and contemporary challenges.

4.2 Conceptual Frameworks for the Transformation of the Historic City

The research project is dedicated to the study of the conceptual frameworks for the transformation of the historic city, with a particular focus on the case of Bologna. Specifically, the research starts from the position that philosophical aesthetics is a particular tool for analysing the city, not only in terms of the temporal stratification that passes through it, but specifically for the condition of the contemporary city, namely the metropolis (*Großstadt*). Therefore, although philosophical reflection has always explored the urban reality—especially the reflection of the Greeks on the *polis*—the attention will be directed specifically to the last two centuries. For this reason, we find the main conceptual frameworks of urban aesthetics in some classical authors, who were among the first to witness and reflect on the new phenomenon of the metropolis that they observed. These include the reflections of Georg Simmel (Antonioli & Borsari, 2020), Sigfried Kracauer (Reeh, 1991; Gorzanelli, 2025) and Walter Benjamin (Gilloch, 1996; Simay, 2005). Urban sensorium, hyper- and anaesthesia, curiosity, indifference, abstraction: these authors' concepts are still relevant today. A second part of the research will be devoted to the relationship between city and form, specifically through media studies and French post-structuralism. While the reflections of Gilles Deleuze, Félix Guattari (Vilaseca, 2014; Antonioli, 2017; Boundas & Tentokali, 2017) and Michel Foucault (Amato, 2009; Catucci, 2018) on the city have already been extensively explored in critical studies—starting with the attention given by geographers to a concept like heterotopia—their German reception, especially in the work of Friedrich Kittler (1988; McQuire, 2008), has not yet been sufficiently explored. For the German media theorist, the city functions as an impersonal device whose purpose is the transmission of information, including human information. Finally, a third part of the research will be devoted specifically to the problem of temporal stratification in the city, both synchronic and diachronic. With regard to the former, our attention will be drawn to philosophical disciplines such as dromology, founded by Paul Virilio (2023) and recently revived by the sociology of Hartmut Rosa (2005), which sees society as the result of differentiations of speed. Specifically, the urban dimension is where the process of acceleration reaches its climax. With regard to the second, the reflection on the stratification of times and worlds, as found in Ernst Bloch (1923, 1954–1959) or Hans Blumenberg (1986, 1989), allows us to consider the city as a space in which several simultaneous dimensions of history become complicated, including both visions of the future and instances of the past (Ascari & Borsari, 2023). The research is also currently being developed in terms of making the framework thus drawn profitable for understanding the case of Bologna as a historic city.

4.3 Public Space and Urban Transformation in the Historic City

In the constellation of concepts and questions that traverse the realm of the historic city, the distinction between public and private space has occupied a significant place. Since the late nineteenth century, the theoretical debate has variously linked the concept of the public to notions of “space”, “sphere”, or “publicity”. This reveals a fundamental ambiguity and intertwining between the material dimensions of space and its political and symbolic ones. Public space is a space of physical and architectural structures and infrastructures, a space of practices and relationships, and a space regulated by certain institutionalized or informal norms. The idea of spatial organization as a product of power dynamics remains crucial for understanding some of the ongoing dynamics within inhabited spaces. One might consider how the aesthetic paradigm of decorum influences contemporary urban policies, fostering spatial segregation based on economic criteria. Yet, alongside the critique of these inequalities, there is also an increasing focus on the political significance of embodied subjectivities within public spaces, moving beyond institutional power to emphasize lived experiences and claims. The research aims to reconstruct the field of reflections taking shape in the concept of public space from its genealogies, definitions and interdisciplinary aspects, identifying its historical paradigms and discussing its contemporary terms and tensions. The relevance of this theoretical survey is being tested through a comparison with the analysis of the current state of public spaces in the city of Bologna, starting with municipal regulations governing urban policies and identifying key stakeholders. The study examines both the direct and indirect management of these public spaces, along with the various actors involved, including the public administration, investors, associations, and residents—whether loosely or formally organized into collectives. It also explores different architectural typologies of public spaces, analyzing specific examples within Bologna to better understand their functionality and the tensions at play. Lastly, attention is being given to practices that intentionally challenge institutional policies on the use of Bologna’s public spaces, aiming to assess their room for manoeuvre and to dissect the conflictual dynamics involved.

4.4 Cinema and the City: Everyday Metropolitan Life in Amateur Cinema

Cinema and city have always had a privileged and, at the same time, multifaceted relationship. As has often been noted, cinema is historically born as an urban phenomenon since city constitutes the first subject of its images and it is within cities that cinema spreads in a sort of *mise en abime* that sees a new type of urban space, the movie theatre, filled by inhabitants intent on watching images of the city and its inhabitants (Bruno, 2008). On the one hand, many authors—Walter Benjamin and

Sigfried Kracauer in primis—have noted in cinema the privileged art of modernity capable of both showing and implementing—and perhaps even reversing (Bratu-Hansen, 2011)—those aesthetic-perceptual, social, political and economic changes that occurred during the nineteenth and twentieth centuries (Casetti, 2005) and inscribed in city and its life. On the other hand, there is an increasing urgency to think about cinema and city in their productive imbrication considering cinema as one of the actors within the processes of construction, perception, conception and change of cities (Shiel & Fitzmaurice, 2001, 2003). If there is no city without its (mental and filmic) imaginaries, it is important to consider how retrospectively these imaginaries contribute to the redefinition of the city itself by focusing on the role of cinema in the physical, social, cultural, and economic development of cities, considering visual mediation as a non-secondary part of urban processes.

In this context, my research proposes to reconsider this complex relationship between city and cinema by relocating it within a particular and little-studied film genre: home movies. Images of these films are the result of a primarily social practice that sees the entry, after photography, of cinematic devices into ordinary people everyday life. Once these films have left the primary circuit of domestic fruition becoming - in many ways - public, they allow us to reflect as much on the memorial role that cinema (in its non-professional side) played in everyday urban life as on some properly aesthetic aspects regarding the role of technical intermediation in the perception of places. Through these images it becomes possible to reflect on the affective relationship between dwellers and city—mediated and implemented through film images—as on the urban imaginaries that these images both show and generate. The research is conducted from archive material from various family collections of the city of Bologna and it is on this city that it primarily focuses. The aim is to retrace the many theoretical positions that have dealt with the delicate interconnections between city and images—especially cinematographical ones—by involving a new object of study capable of broadening the reflection beyond the cinema realised and experienced in a professional contexts.

4.5 ‘Historical City’ as a Counter-Model of Urban Development

The research focuses on the role of the History of Architecture and Urban History in public engagement rather than on specialized methodological aspects. The intention is to explore how these disciplines can enhance decision-making processes in urban policy without compromising their scientific integrity.

The research advocates for a defined research-action field centered on the “historical city” from the post-World War II era to the present, particularly in Italy, while also considering broader geographic contexts. This approach aims to scrutinize the historical city not only as a subject of study but as an active participant in contemporary urban dynamics.

The historical city has undergone significant transformations, particularly after the war, where it evolved into a ‘historic center’ amidst a rapidly changing urban landscape. This development creates a dichotomy between the enduring values of the historical city and the sprawling identity of the ‘second city’, which often neglects its heritage. By analyzing these dynamics, the volume posits that the historical city can serve as a model for resisting detrimental urban policies and promoting sustainable practices.

The volume emphasizes the need for historical architectural research to engage with the political dimension of urban development actively. It suggests a collaborative, multidisciplinary approach that can transcend traditional disciplinary boundaries. The aim is to foster a shared vision that enhances the socio-cultural conditions of communities, moving beyond mere academic discourse to impactful, community-oriented research.

Moreover, it argues for a shift towards ‘community history’, where historical research becomes accessible and relevant to citizens involved in urban transformation. By leveraging digital tools and participatory practices, historians can maintain rigorous scholarly standards while contributing to public understanding of urban heritage.

In conclusion, establishing a defined field of research-action focused on the historical city is presented as a strategic response to contemporary urban challenges. This field not only aspires to produce specialized knowledge but also aims to facilitate informed political dialogue about the city’s evolution, ensuring that the historical context informs future urban development initiatives.

4.6 Urban Policies and the Transformation of the Historic City in Bologna

The research aims at analyzing the work of architect Pier Luigi Cervellati and his activity as a councillor of the municipal administration of Bologna, which led, under his guidance, to the elaboration of the “Plan for the Historic Centre” of Bologna in 1969, later implemented through the PEEP/Centro Storico of 1973.

The process that led to the elaboration of the 1969 Plan is part of the theoretical and design research, carried out in the academic and professional spheres, that actually oriented the administrative activity of the Municipality of Bologna and that had as its main instance that of constituting itself as a cultural act.

The research examines Cervellati’s involvement in the elaboration of the plan for his hometown from the very beginning, that is, from his convocation in the research group gathered around Leonardo Benevolo at the Faculty of Architecture in Florence from 1962 to 1965. The group carried out a fundamental study for the historic centre of Bologna, commissioned by the Bolognese administration, a little-known chapter of Bolognese town planning, especially if one compares it with the subsequent PEEP Centro Storico, which highlights the greatest experience carried out on the

city's historic centre in the second half of the twentieth century. The subsequent use by the municipal administration of Bologna of that study for the elaboration of the mentioned plans shows how these studies were necessary for the subsequent urban and social policies promoted by the municipality. The narratives of the creators and promoters of the plans and the following historiography have placed the Bolognese experience on an international level, qualifying it as a political act, but, thanks to actors as Benevolo and Cervellati, it should be considered more than a mere technical act aimed at conservative restoration: a cultural, social, anthropological, and critical operation.

The research also delves into the report on the main vectors and themes that the plan addressed, as well as on the upstream objectives of the plan, aimed at drawing up a variant to the General Regulatory Plan signed by Giuseppe Campos Venuti, another important figure for the proposed theme. This is necessary to clarify to what extent Cervellati was able to take action and what areas he was most interested in, which tools he used, such as the typological and structural study of pre-existing architectural artefacts.

A significant part of Cervellati's work was centred on the communication of the plan to citizens. It mainly aimed at tracing and re-proposing the identity value of the historic centre to its residents and to all the citizens of Bologna. Indeed, thanks to the cultural impulse that Cervellati was able to give to the communication of the plan, it was recognised on the international scene and taken as a model by many foreign delegations, who visited Bologna to study and 'export' the plan, especially after the UNESCO Symposium held in Bologna in 1975. Therefore, the research illustrates which aspects of the plan in particular were considered 'exportable' cornerstones abroad as well as the reasons for this.

4.7 A Diachronic Analysis of the Political and Social Role of Large Containers Starting with the 'Plan for the Historic Centre' of Bologna (1969–2022)

The research project aims to reconstruct and analyse the processes of identification, acquisition, recovery, and adaptation to new social and cultural functions of the disused or little-used public monumental heritage of the city of Bologna. The rehabilitation of the so-called "large containers" (monumental complexes, large palaces, convents, etc.), starting from the first studies conducted during the drafting phase of the 1969 Plan for the Historic Centre (Major variant to the 1958 PRG), became the instrument for the reorganization, restructuring, and new distribution of collective services for the neighbourhoods during a phase of great social, cultural and economic changes in the city. The adoption of a public policy of services to support the housing policy thus became one of the most relevant aspects of the 1973–75 municipal programme plan.

The research project follows two main directions: the first is aimed at analysing the criteria and methods adopted during the analytical—survey phase and the realization one of the interventions on the large containers; the second is focused, on the one hand, on the study of the methods of communication and participation in the project and its realization and, on the other hand, on a diachronic analysis of the transformations that occurred over time following the intervention. For the first direction, based on the historical method, the research is founded on the identification of the archival sources kept in the archives of public institutions (Archivio storico del Comune di Bologna; Archivio della Regione Emilia-Romagna; Comitato per Bologna Storica Artistica etc.) and in the archival of the architects and town planners who played a central role in this path. At the same time, a study of the bibliographic sources produced by the public administration and by chroniclers and scholars is conducted.

While the first part focuses more on the study of bibliographic and archival sources, the second part is aimed at analyzing the data collected and at identifying experiences and criteria that can still be used in today's debate. The reconstruction and analysis of the close links between architecture, town planning, and the cultural, social, and political history of Bologna in the second half of the twentieth century provide the basis for defining operational models of intervention useful for the recovery of disused buildings and areas to host collective services.

4.8 The Churches and the City 1955–1968. Cardinal Giacomo Lercaro's Contribution to the Urban and Cultural History of Bologna

The cultural, political and social life that saw the city of Bologna as a protagonist between the 1950s and 1960s involved public figures from both the world of politics, which in those years was experiencing the bitter confrontation between the centre and the left, and the world of planners and technicians engaged in defining the lines of intervention and management of the city and the territory. Cardinal Giacomo Lercaro (1891–1976) was added to this extremely complex and varied context from April 19, 1952, who was to lead the archdiocese of Bologna until 12 February 1968. From the time of his arrival in the city, Lercaro saw a marked difference between the historical part, which was within the antique walls until the early twentieth century, and the new suburbs that, particularly after the Second World War, had experienced rapid and almost uncontrolled development. The cardinal promoted and guided a planning and cultural research on the relationship between the city and sacred space that led to the identification of new parishes and the construction of churches and parish centres intended as nodal points for the future social and cultural activities of the new neighbourhoods. Fundamental in this sense was the creation of the “Ufficio Nuove Chiese di Periferia” (New Suburban Churches Office), a body formed for the most part by young architects who had recently

graduated mainly in Florence (among them were Giorgio Trebbi, Glauco and Giuliano Gresleri, Luciano Lullini, etc.) called upon in the first instance to read the critical issues and then to promote, in concert with the population concerned and the authorities, suitable design solutions.

In the summer of 1955, two key episodes took place that kick-started this operational process of “reconstruction” of the new suburbs. On June 26, from Porta Saragozza, Lercaro led the symbolic procession of the “peaceful conquest of the suburbs”, an itinerary that would touch in the following hours the areas where the 44 new parish centres would be built. In the following September 23–25, Lercaro presided over the work of the first National Congress of Sacred Architecture, an event that included both moments of confrontation and the organisation of several exhibitions and, above all, supported an international confrontation with personalities from the ecclesiastical world and planners from many European countries. Lercaro had already initiated an important contact with many counterparts, including Cardinal Josef Frings (1887–1978) in Cologne and Manuel Gonçalves Cerejeira (1888–1977) in Lisbon, which would lead to the establishment of fundamental relationships especially among young designers of new churches.

The premises, the critical and methodological analyses, the results obtained, sometimes contradictory and not always fully satisfactory according to Lercaro’s high expectations, are for the most part contained in the review “Chiesa e quartiere” edited by the same operators of the Ufficio Nuove Chiese between November 1955 and September 1968, and where one can read all the salient moments included in the 13 years under study and in which Giacomo Lercaro’s activity in Bologna was most incisive.

4.9 Urban Heat Island Mitigation in Historic Cities: Multi-layer Analysis, Software Simulations and Modelling as Supportive Planning Tools

Historic cities, due to their cultural and architectural value, represent not only a tangible heritage, but also a symbolic repository of the memory and identity of the communities that inhabit them. These urban areas are increasingly vulnerable to threats related to climate change, including rising temperatures, coastal erosion, extreme weather events, and sea level rise. These challenges pose significant risks, not only to the preservation of built heritage but also to the overall quality of life within these cities (IPCC, 2023; Nicolini, 2024).

Historic city centers, because of their unique characteristics and morphology, are particularly vulnerable to the urban heat island (UHI) effect, which leads to significantly elevated surface temperatures in urban areas compared to surrounding rural regions. Contributing factors include high building density, extensive use of impervious materials (e.g., stone, brick, and asphalt), and narrow streets that restrict air-flow, thereby limiting the dissipation of accumulated heat. Furthermore, the scarcity

of green spaces exacerbates the severity of the UHI phenomenon (Zhao et al., 2014; Pappalardo et al., 2023). In addition to compromising outdoor comfort in public spaces—directly impacting their usability—the UHI effect significantly affects the daily lives of residents. It increases health risks (e.g., metabolic disorders, dehydration, cardiovascular disease), raises energy consumption, worsens air quality, and diminishes biodiversity (Oudin Åström et al., 2011).

In response to this condition, UNESCO has developed a series of policies and strategies to mitigate the impacts of climate change on world heritage, focusing specifically on historic cities. The 2011 landmark document, *Recommendation on the Historic Urban Landscape*, including a *Glossary of Definitions Preamble* (UNESCO, 2011), provides guidelines for the conservation and management of historic cities, emphasising the importance of heritage knowledge, the protection and preservation of historic sites, and the need to involve local communities in the preservation process. This document highlights the urgent need for policies that consider the specific requirements of historic cities in the context of climate change and adaptation following an integrated approach. Recently, the 2023 *Climate Action for World Heritage* paper further reinforced these indications, drawing attention to specific risks that threaten cultural heritage and historic urban fabric (including infrastructure and local communities), such as sea-level rise and extreme heat waves (IPCC, 2022).

Addressing the challenges posed by climate change in historic cities, as outlined in UNESCO recommendations, necessitates a comprehensive, knowledge-driven methodology that takes into account the multifaceted environmental, social, and regulatory complexities inherent to these urban areas. Within this framework, multi-layer mapping serves as an essential tool, enabling a systematic analysis of various thematic layers, uncovering their interconnections, and supporting the planning of targeted mitigation strategies.

In this context, Nature-Based Solutions (NBSs)—defined by the European Commission (2017) as strategies inspired and sustained by natural processes that enhance the resilience of territories—offer an effective and adaptable approach to mitigating the UHI phenomenon. Owing to their characteristics, typologies, and potential applications, NBSs can enhance the comfort and accessibility of public spaces, particularly during periods of elevated temperatures (Alves et al., 2024).

This section presents the integrated approach developed within the PNRR CHANGES—Cultural Heritage Active Innovation for Sustainable Society research project, applied to the historic city of Bologna for analyzing and planning potential interventions in public spaces aimed at mitigating the impacts of the urban heat island (UHI) effect. The methodology integrates multilevel mapping with ENVI-met software modelling and simulation. The mapped data categories—environmental, social, and built-environmental—provided a comprehensive information framework that guided the identification of sample areas for targeted interventions, primarily through the application of Nature-Based Solutions (NBSs).

4.9.1 *The Bologna Case Study: Strategies for Climate Adaptation*

Bologna has consistently demonstrated a systematic commitment to addressing the challenges posed by climate change, implementing numerous policies and projects aimed at reducing environmental impacts and enhancing urban resilience. These efforts align with global sustainability goals and international climate agreements. One of the city's key initiatives, the Urban Climate Green Strategy (Municipality of Bologna, 2022a), emphasizes urban greening as a central measure to mitigate the effects of heatwaves, enhance CO₂ absorption, and improve biodiversity. Additionally, the Urban Local Environmental Adaptation Plan, developed within the framework of the LIFE BlueAp project (Municipality of Bologna, 2015), outlines concrete actions to protect the city from the impacts of extreme climate events, such as sustainable water resource management, the promotion of green infrastructure, and innovative urban mobility solutions. Another key pillar of Bologna's climate strategy is the Sustainable Energy and Climate Action Plan—PAESC (Municipality of Bologna, 2021a), which sets ambitious goals for reducing greenhouse gas emissions and improving the energy efficiency of buildings. The plan promotes the adoption of renewable energy sources and the development of sustainable public transport systems. Complementing these strategies, the *Impronta Verde* (Green Footprint) project (Municipality of Bologna, 2021–2027) focuses on urban resilience and environmental protection through urban agriculture, the regeneration of green spaces, and the creation of ecological corridors. Furthermore, the city's General Urban Plan (Municipality of Bologna, 2021b) incorporates sustainability and climate adaptation goals into spatial planning, with a focus on creating resilient neighborhoods, redeveloping degraded urban areas, and adopting eco-friendly architectural solutions.

In addition to public planning initiatives, it is noteworthy that in 2022 Bologna was selected by the European Commission as one of the 100 cities committed to achieving climate neutrality by 2030. The city's goal is to reduce CO₂ emissions to zero, following a roadmap that includes actions on mobility, waste reduction, urban greening, and education. This ambition is further supported by the Climate Contract approved in 2024, (Municipality of Bologna, 2024) which outlines a program of commitments and investments, involving businesses, economic operators, institutional partners, the third sector, and citizens. Bologna's commitment to climate action also involves significant citizen engagement. In 2023 the city established the Citizens' Climate Assembly (Municipality of Bologna, 2023), a deliberative body composed of 100 randomly selected citizens who collaborated on drafting a document of recommendations for the municipality. Additionally, the city's collaborative approach to tackling climate challenges is reflected in its role as coordinator of the LET'SGOV project (2023–2025), funded by the European Union under the NetZeroCities program. This project focuses on reducing energy consumption and developing a model for enhanced multi-level governance.

4.9.2 Multi-layer Analysis to Support UHI Mitigation Planning

The risks and impacts of climate change are reflected in urban contexts in complex ways, compounding other crises, such as social challenges, that affect contemporary cities globally. Adopting a comprehensive approach capable of observing and analyzing urban environments—particularly historic ones—across multiple scales and levels of complexity is crucial for understanding how various factors and thematic domains interact.

The multilevel mapping methodology developed within the CHANGES project has proven to be an essential tool for planning interventions in Bologna's urban context. By leveraging available databases and thematic maps, and through the overlaying of multiple data layers—including climatic, social, and architectural information—it was possible to identify spaces most vulnerable to the urban heat island (UHI) effect.

The collected data focused on three main categories of inputs: the distribution of green spaces, the density of historic buildings, and demographic vulnerabilities. Specifically, the data included: new urban ecological corridors, green areas and public spaces envisioned in ongoing projects; proposals for the redevelopment of public spaces as part of the Participatory Budget (Municipality of Bologna, 2024b); public greenery, trees, and street furniture; the potential fragility index (Municipality of Bologna, 2022b); micro-climatic vulnerability data; proximity services and spaces (e.g., gardens, public parks, squares, socio-cultural, healthcare, and neighborhood services); sustainable mobility infrastructure (e.g., pedestrian zones, cycling paths, public transport); and historical-architectural constraints on buildings or portions of the urban fabric (Fig. 4.1).

The analysis of this data enabled the identification of priority areas for climate adaptation measures, such as the redevelopment of public spaces and the introduction of new green infrastructure. This integrated approach supported the development of targeted strategies to improve the urban microclimate while ensuring the preservation of historical heritage and the promotion of social well-being, in alignment with the Impronta Verde project, which served as the overarching framework (Fig. 4.2). The maps generated through this methodology facilitated the visualization and evaluation of the relationships between various factors, aiding in the identification of potential areas for sample interventions, which were further explored through detailed analyses (Fig. 4.3).

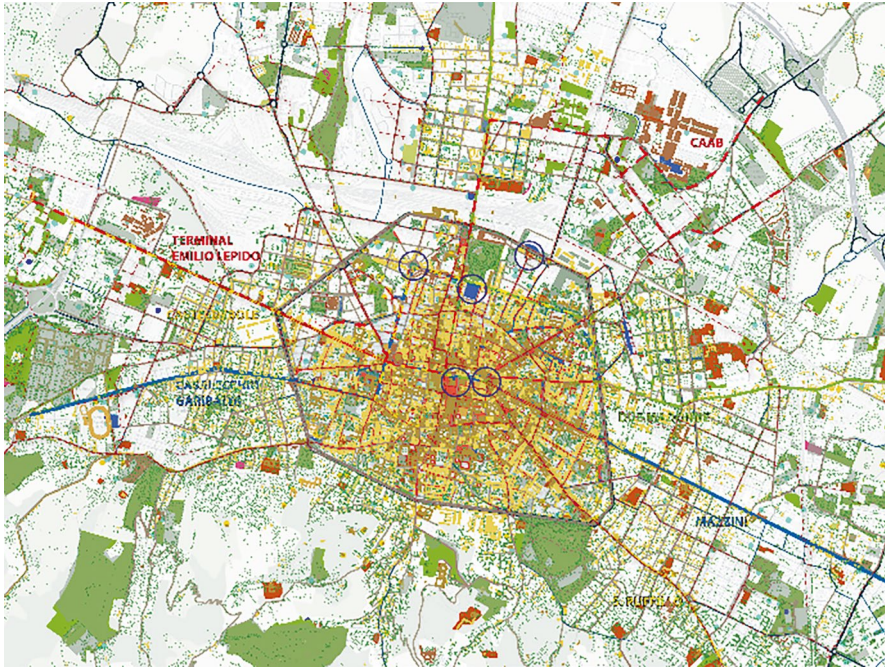


Fig. 4.1 Historic Centre of Bologna, multi-layer analysis. (Elaboration by Federica Lecci)

4.9.3 Software Modelling and Simulation to Test the Use of NBS

The multi-level analysis described in the previous section provided a comprehensive overview of Bologna’s historic center, which was instrumental in identifying a series of sample areas. These areas represent typical urban open spaces—including public and private courtyards, urban parks, streets, parking lots, squares, and residual spaces—where the application of Nature-Based Solutions (NBSs) was virtually tested through software simulations.

The software ENVI-met v.5.6.1 (www.envi-met.com) has been used to obtain a series of maps—Outdoor Microclimate Maps (OMM) (Gaspari & Fabbri, 2017)—of the pre- and post-intervention state of the study areas, through which to observe the transformations, paying particular attention to the possible enhancement of the UHI effect, parameterised through three classes of environmental data.

The microclimatic conditions generated by the simulations were based on a specific set of variables: the location (Bologna), the date (27th July 2021), chosen as representative of typical summer climatic conditions, and the time (11:00 AM), selected to reflect peak usage of public open spaces. The reference subject was modeled using a pre-set software profile: a 35-year-old man, 1.75 m in height, weighing 75 kg, standing, with a metabolic rate of 141.32 W. Additionally, the software



Fig. 4.2 The areas identified (green dots) for the sample interventions in the framework of the *Impronta Verde* project. (Elaboration by Federica Lecci)



Fig. 4.3 Detailed map of analysis, aerial photo of the current status and ENVI-met modelling of the application of NBSs (i.e., raingardens, street trees and permeable paving systems) on one of the sample areas. (Elaboration by Federica Lecci)

required the definition of cell dimensions, which establish the grid for constructing the model. Each cell represents a portion of the simulated area, to which specific attributes are assigned: materials for surfaces or height for building portions.

The simulation output includes detailed maps that provide microclimatic data, such as air temperature (T_a), surface temperature (T_s), physiological equivalent temperature (PET)—an indicator used to assess thermal stress on individuals,

measured hourly—and the Universal Thermal Climate Index (UTCI), which quantifies the physiological response of humans to weather conditions.

For research purposes, and to assess the mitigation effectiveness of Nature-Based Solutions (NBSs), a catalog of solutions tailored for application in historic urban contexts was developed. This catalog includes the following categories: rain gardens, street trees, community gardens, permeable paving systems, eco-friendly urban furniture (e.g., integrated planter and seating systems), urban fruit trees, noise barriers in the form of freestanding green walls, and islands of coolness (e.g., greenery and shading elements). These categories have been selected basing on literature and main available catalogues review (DG RTD, 2021; UNaLab, 2019), the analysis of some case studies, and based on the scale and characteristics of the areas identified for experimentation. The types of NBSs have been then modelled—simplifying their characteristics—and imported into the ENVI-met software (Fig. 4.3) to proceed with simulations, and to obtain a series of maps of the different types of temperatures which allowed the impact evaluation of the adopted solutions on the UHI effect for comparison between the pre- and post-intervention state (Fig. 4.4).

4.9.4 Results

The development of effective strategies and tools that support concrete actions to mitigate the urban heat island (UHI) effect in historic city centers has been a primary goal of the integrated methodology applied to the Bologna case study. By building a robust knowledge base that integrates multiple thematic layers—environmental, social, and built environment—the methodology offers a comprehensive framework for identifying pilot areas. These areas, representative of diverse urban open spaces typical of historic centers and consolidated urban environments, were used to assess the effectiveness of Nature-Based Solutions (NBSs) in reducing UHI

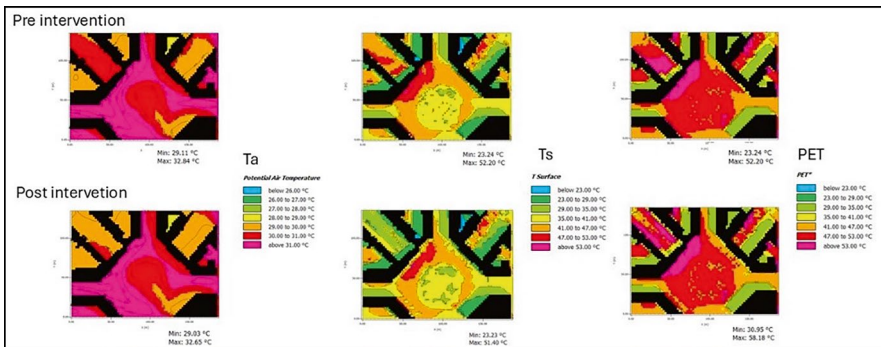


Fig. 4.4 Outdoor microclimate maps (T_a air temperature, T_s surface temperature, PET physiological equivalent temperature) of the pre and post-intervention state developed for one of the sample areas. (Elaboration by Federica Lecci)

impacts through pre- and post-intervention simulations of outdoor microclimatic conditions. Beyond the specific outcomes of the Bologna case study, the methodology demonstrated its strengths and potential for replication.

Multi-layer mapping proved to be a crucial tool for planning interventions. The integrated approach in Bologna facilitated the identification of complex interactions between environmental, social, and cultural variables, providing a solid foundation for informed decision-making. The analysis revealed how temperature distribution, land use, green space availability, and reflective surfaces help pinpoint areas most vulnerable to the UHI phenomenon. Assessing the climatic impacts on vulnerable populations—especially the elderly and children—underscored the direct link between thermal comfort and the accessibility of public spaces. Moreover, the synergy between ongoing or planned redevelopment projects and citizen proposals in the Participatory Budget process highlighted how urban adaptation efforts can align with both political priorities and community involvement. The methodology also successfully navigated the regulatory constraints associated with preserving historical and architectural heritage, ensuring that adaptation measures enhance, rather than compromise, the integrity and cultural value of these assets.

The integration of climate data, along with social and cultural characteristics, proved vital for the development of effective adaptation strategies. The ability to overlay these thematic layers allowed for the precise identification of priority intervention areas, guiding local policies toward sustainable and inclusive solutions.

Regarding the NBS application in pilot areas, the methodology enabled the detailed analysis of the benefits brought by various interventions, such as greening, depaving, and shading elements. The microclimatic simulations, created through ENVI-met software, offered a representative scenario for different types of urban open spaces, complementing traditional satellite data used for measuring climate change impacts in cities. By subdividing open spaces into smaller cells, the case study obtained more precise data, revealing a nuanced mosaic of micro-scale temperatures that vary even within closely located areas. This modeling, along with the NBS catalog tailored for historical contexts, facilitated both the planning and evaluation of transformations aimed at enhancing microclimatic comfort while improving public space quality and accessibility.

The use of ENVI-met, a 3D microscale modeling software for simulating complex urban environments, proved to be a highly valuable tool for urban planning efforts related to climate adaptation, outdoor comfort, and public health improvement. Its open-source nature and user-friendly interface make it accessible for broader use, offering significant potential for future applications. Additionally, the visual representation of results in map form made it easier to communicate the comparison between current conditions and projected outcomes, enhancing understanding for both experts and non-experts. This also opens the door for participatory co-design processes involving local communities, further reinforcing the relevance of NBS interventions in urban planning.

In conclusion, the integrated methodology tested in Bologna's historic city center—combining multilayer analysis with NBS simulation—holds significant potential for replication in other urban contexts. It can serve as a valuable resource for

administrators, policymakers, and urban planners to develop data-driven strategies that promote a fair transition while preserving the unique identity of historic centers. Future research could explore the further application of this methodology in other cities, expanding the knowledge base for more resilient, inclusive, and sustainable urban environments. This approach not only addresses immediate climatic challenges but also supports long-term urban sustainability, ensuring that historic cities can thrive in a changing climate.

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