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What Space Tells Us.

Reading spatial traces through a computational-participatory
framework for public housing governance

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Key Definitions

LL	Living Lab : <i>a user-centred, open innovation approach that brings together different stakeholders to co-create, test, and evaluate solutions in real-life contexts.</i>
ULL	Urban Living Lab : <i>a Living Lab applied to the urban context, where citizens, researchers, public authorities, and other stakeholders collaboratively address urban challenges through experimentation and knowledge exchange.</i>
Human trace	<i>The physical and spatial evidence left by everyday practices, through which inhabitants appropriate, adapt, and negotiate space over time.</i>
Spatial error	<i>A specific type of human trace that reveals a discrepancy between the intended function or design of a space and its actual use, highlighting potential mismatches between planning assumptions and lived realities.</i>
AI	Artificial Intelligence: <i>a field of computer science focused on developing systems capable of performing tasks that typically require human intelligence, such as perception, reasoning, learning, and decision-making.</i>
DL	Deep Learning : <i>a subset of machine learning based on artificial neural networks with multiple layers, capable of learning complex patterns from large amounts of data, including images, text, and other forms of information.</i>
VLM	Vision-Language Model : <i>an AI model capable of processing and understanding both visual and textual information by learning relationships between images and language, enabling tasks such as image interpretation, description, and semantic analysis.</i>
MML	Multimodal Machine Learning : <i>a machine learning approach that integrates and analyses multiple data modalities to identify patterns and relationships across different sources of information.</i>
AOB	Area of the Building : <i>the spatial extent considered for the analysis, corresponding to the area directly associated with the selected building or case study.</i>
AOI	Area of Interest: <i>the geographical extent considered relevant for the research.</i>

00.

INTRODUCTION

Human intelligence is often compared to that of a machine, frequently proving less efficient in terms of performance and more prone to producing errors. However, while we are normally inclined to associate a negative meaning with error itself — as it may not always be useful to the task at hand (e.g., solving a mathematical equation) — an error can also be read differently: not merely as a failure, but as a first trace of human presence, an indicator of the factors that led to its occurrence. The question thus shifts to: why did this happen?

More broadly, this question can be raised not only in relation to errors but also to the most mundane human behaviours. Why do we dress in a certain way? Why do we move in a certain way? Why do we occupy the left side of the street rather than the right?

Determining all the factors that produce these human traces would obviously be an impossible task, and perhaps even a pointless one, given the subjectivity of the individual. Nevertheless, analysing large-scale patterns can help us identify primary factors that are useful to our understanding.

Space is the first medium in which the human being leaves such traces. It is used, adapted and shaped according to behaviours, needs or emotions. Our brain is trained to recognise automatically the phenomena that produced them (Figure 1). Today, given the growing possibilities for exploring and training digital systems — AI in particular, due to its capabilities of “understanding” images and reality — translating this theory into a technology is possible. Moreover it allows us to systematically map spacial traces on a large scale.

It is possible to identify at least two key characteristics of this defining the representation of spatial evidences:

VISIBILITY: it becomes possible to translate normally invisible dimensions (typically qualitative and intangible aspects such as culture, social relations, and behaviours) into something visible, such as data, visualisations, or maps.

COMPLEXITY: this approach seeks to overcome the flattened narrative produced by socio-economic data, which often fails to capture the invisible layers across economic, social, and cultural conditions. This is a particularly relevant aspect in peripheral and often marginalised areas, marked by strong heterogeneity across economic, social and cultural conditions which is normally not fully captured by vulnerability indices or statistical data.

Both of these aspects find direct application in public governance, where a comprehensive view is necessary in order to make large-scale decisions capable of accounting for the intertwined socio-economic and cultural factors at play. More specifically, this holds true in public housing governance, where the relationship between public institutions and residents has always been complex, and where various approaches, from top-down to bottom-up, have often proven ineffective to improve the management of these complex situations.

Today, and especially in the future, the decision-making process will increasingly rely on tools such as digital twins, which are increasingly supported by the European Union itself, in order to manage a growing level of complexity aimed at improving the effectiveness and sustainability of proposed solutions. However, relying primarily on quantitative data (economic, environmental, demographic, and so on) risks producing partial solutions, or effects that go unnoticed or remain invisible to the mapping process itself. It is therefore worth investigating how these tools could be adopted as alternative means of representing reality — ones that do not measure the object of observation solely in terms of efficiency, but that can also directly inform and influence the decision-making process.

We can add a third criterion:

MEANINGFULNESS: assuming spatial traces can be helpful in representing human aspects, and provided the two criteria of visibility and complexity are respected, we can hypothesise that such a representation becomes *meaningful* for the decision-making process. In other words, a complete mapping of spatial traces, applied directly to the public social housing sector, could help reconstruct a more complex image of the realities experienced by residents, placing them back at the centre of the decision-making process.

Against this background, this research proposes a conceptual framework that combines computational and participatory methodologies to identify, validate, and interpret spatial '*human traces*' within public housing environments. Rather than replacing human knowledge, the framework aims to integrate computational observation with residents' lived experiences, supporting public authorities in managing housing estates and neighbourhoods through a continuous, evidence-based, and context-sensitive decision-making process.

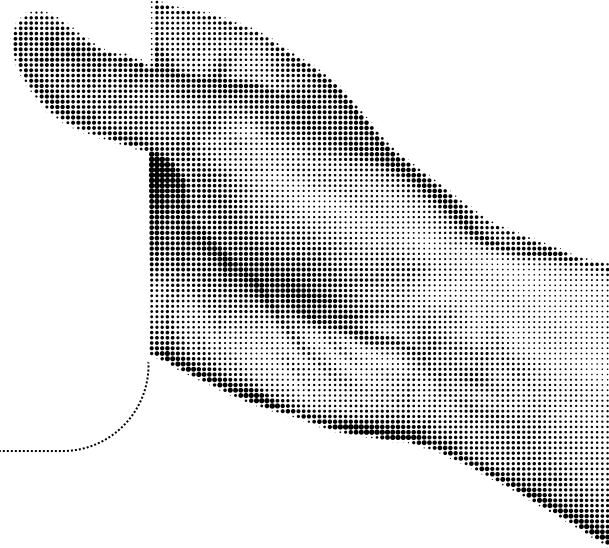


Figure 1. Humans can intuitively recognise the motivations behind this “spatial anomaly”—the placement of two chairs next to a formal bench. By contrast, a machine must learn to infer the logical relationships that explain this behaviour.



RESEARCH QUESTION

How can visible spatial traces in public housing be translated into decision-support knowledge for more situated, inclusive, and adaptive renovation strategies?



PROBLEM FRAMING

01

Why Is a New Approach Needed?

HUMAN TRACES

02

What Can Human Traces Reveal?

TECHNOLOGICAL TOOLS

03

How Can These Phenomena Be Mapped?

THE PROCESS

04

A participatory-computational BDMF

CASE STUDY

05

Simulating the Framework in Pilastro, Bologna

GOAL:

The research aims to develop a Building Data Management Framework (BDMF) capable of collecting, integrating, interpreting, and translating spatial and social data into decision-support strategies for public housing governance.

RESEARCH OUTPUTS:

- A theoretical framework defining the relationship between spatial traces, human behaviour, and decision-making.
- A methodological framework describing the proposed computational-participatory workflow.
- An indicator-data-interpretation matrix linking observed phenomena to measurable indicators and planning implications.
- A decision-support dashboard prototype for public authorities, integrating spatial data, participatory findings, and intervention scenarios.
- A case study application demonstrating and validating the framework through the Pilastro neighbourhood in Bologna.

RESEARCH METHODS:

The research follows a five-stage methodological process that combines theoretical investigation, computational analysis, and participatory validation to develop and test the proposed Building Data Management Framework.

00. Contextual Validation

The research begins with preliminary interviews and direct engagement with experts to gain an initial understanding of the study context, identify local challenges, and ground the research within real community needs.

01. Literature Review

A comprehensive review of the relevant literature is conducted to establish a solid theoretical foundation. This phase explores public housing, spatial analysis, human-centred urban planning, computational methods, AI applications, and participatory approaches.

02. Identification of Relevant Spatial Elements

Based on the literature and preliminary fieldwork, the research identifies the spatial characteristics and human traces that are considered meaningful for understanding everyday life in public housing environments.

03. Development of the Indicator Framework

The selected spatial elements are translated into a structured system of measurable indicators. These indicators define how qualitative observations can be systematically collected, interpreted, and transformed into spatial knowledge.

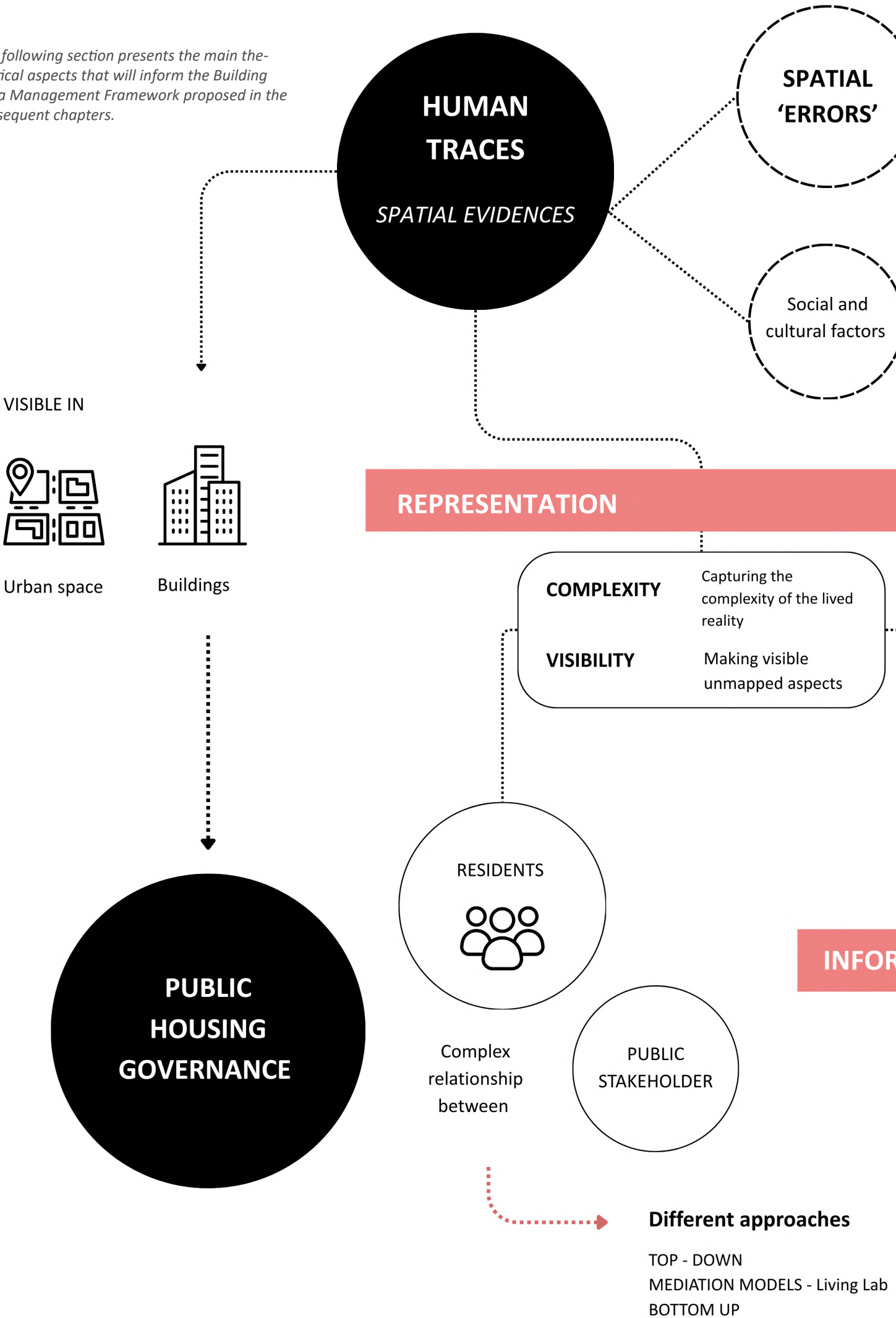
04. Design of the Building Data Management Framework

The research develops a participatory-computational workflow integrating AI-supported spatial analysis, open datasets, field observations, and participatory validation into a coherent decision-support framework for public housing governance.

05. Framework Application and Simulation

Finally, the proposed framework is applied to the Pilastro neighbourhood in Bologna. The simulation evaluates its ability to identify spatial phenomena, validate findings through community engagement, and generate intervention strategies that support more informed and adaptive decision-making process.

The following section presents the main theoretical aspects that will inform the Building Data Management Framework proposed in the subsequent chapters.



They are signs of:

NEEDS

BEHAVIOURS

EMOTIONS

Building Data
Management Framework

MEANINGFULNESS

FORMING GOVERNANCE

Representational tools

AI - BIM

VLM

DIGITAL TWIN

AI - CITY

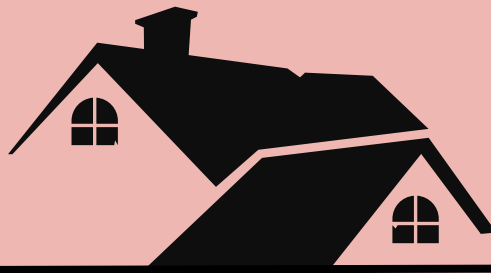
Decision making support Tools

DIGITAL TWIN

**DIGITAL
TOOLS**

01.

BEYOND FOUR WALLS AND A ROOF



According to the UN Committee on Economic, Social and Cultural Rights, housing goes beyond the mere possession of one's 'own four walls' and 'a roof over one's head' (UNHabitat, 2009). It is to be regarded as being able to live at a certain place in security and dignity while being able to express one's own cultural identity. The right to adequate housing defined by the Committee's general recognises freedoms and entitlements in housing (United Nations Committee on Economic, Social and Cultural Rights, 1991) (CESCR United Nations, 1997):

- Protection against forced evictions and demolition of one's home;
- The right to be free from arbitrary interference with one's home, privacy and family;
- The right to determine where to live and to freedom of movement
- Equal and non-discriminatory access to adequate housing
- Participation in housing-related decision-making at the national and community levels.

Strategies that do not just providing housing but also addressing gaps and inequalities in existing systems and reviewing and modifying existing housing policies and programmes in order to challenge possible stigmatisation, marginalisation and discrimination and bringing housing back to his "social use" and the "diverse set of social relationships that give it meaning" (Human Rights Council, 2017: 10).

In fact, housing should not be understood merely as a commodity or a basic good to be supplied but as a condition that enables individuals to achieve forms of **social participation, stability, and wellbeing**. Governments are required to take all necessary and possible measures to ensure that the housing situation grants security, privacy, health and social embeddedness (UN Habitat, 2009: 9).

Housing is defined by 4 domains (Drilling, Negash, & Wagaw, 2021).

- the quality of housing
- the stability of housing (free from forced displacement)
- affordability (balanced increase in rent and wages, funding of programs)
- the embedding in a neighbourhood (staple, safe outdoor spaces, access to transportation and jobs, community, social services).

The problem arises when, particularly in moments of crisis and in already complex contexts, housing is treated purely as a matter of provision — losing sight of the other dimensions that have, over time, shaped the social fabric of the population it is meant to serve. The following sections will therefore trace how the theme of housing has been addressed historically, and how the various approaches to it have shifted over time.

1.1 The Socio-Economic Role of Housing

Historically, the housing sector has always been deeply intertwined with broader social, economic, and political dimensions that extend far beyond the mere provision of a dwelling. Nevertheless, housing is often approached as a purely technical issue, in which the role of the architect, planner, or designer is reduced to delivering physical solutions through the construction of buildings. It is therefore not surprising that, for a long time the urban planner/designer has increasingly been portrayed—both in public discourse and institutional practice— as a depoliticised professional producing objective and technical solutions for complex urban problems (Pacchi, 2018). According to Moroni, these technocratic planners:

“believe themselves able to gather and analyse a priori and in quantitative terms the relevant information regarding the city. They consider themselves able to rely on specific predictions of future events. Thanks to this kind of competence, planners presume that they are able to design the desired urban end-state and to define, as precisely as feasible, target sites for particular uses.”

This vision was already rooted at the beginning of the 20th century, when authors such as Frederick C. Howe argued that cities should be designed and governed by “experts”¹. This optimistic and simplified belief in technical expertise as a neutral and superior form of decision-making ultimately led to very different outcomes in practice. Throughout the 20th century, it justified a wide range of urban interventions in which public control over private development was framed as necessary, given the perception of private construction as driven primarily by financial and economic interests. However, this approach often remained distant from the complexity of urban reality, reinforcing a technocratic model in which architecture and expert knowledge were positioned as self-evident solutions to inherently political and social problems. (Howe, 1912).

Authors such as Jane Jacobs², Paul Davidoff and Giancarlo De Carlo, in the 1960s, challenge the idea that planning and policy-making can be understood as neutral or purely technical processes. In fact, every planning decision embeds a political choice (Davidoff, 2007) about whose needs are prioritised, whose knowledge is consulted, whose presence in the city is facilitated or obstructed. However, the claim to technical neutrality in urban planning has frequently served to insulate politically consequential decisions from democratic accountability (Fainstein, 2010).

Moreover, urban space has always been a site of political, ideological and social contestation and the real estate sector has historically been one of the primary mechanisms through which economic and political power has been exercised over territory. As Henri Lefebvre argued³ in *“The Production of Space”*, space is not a passive container for social life but is itself produced by political and economic relations and reproduces them in turn. In *“Rebel Cities”* (2012), David Harvey extending this argument, argues that urbanisation has never been a neutral process of city-building but has functioned historically as a mechanism for absorbing surplus capital and surplus labour in moments of economic crisis. This happened in 1848, when the crisis in Paris left surplus capital and surplus labour side to which Napoleon III’s response was a vast programme of state-funded infrastructural investment lead by Baron Haussmann. However, this not as isolated case but as a recurrent strategy in history. In the post-Depression United States, where Robert Moses absorbed enormous quantities of capital and potentially volatile labour through debt-financed highways, large-scale suburbanisation and infrastructural transformation.

The same phenomenon happened again in 2007–2008, when the housing sector underwent a profound transformation. Although the crisis originated in the United States through the collapse of the subprime mortgage market, its effects rapidly spread across Europe, exposing the growing financialization of housing and the fragility of housing systems increasingly dependent on real-estate speculation and private investment. Across Europe, the crisis triggered a combination of austerity measures, reductions in public expenditure and a progressive withdrawal of the state from social housing provision.

1 “City planning, in a comprehensive sense, is only possible where the city has authority to control private property in the interest of the community” (The City as a Socializing Agency, Frederic C. Howe, 1912).

2 Jane Jacobs defines “modern, orthodox city planning” the oversimplifying epistemological approaches that had been characterising planning in the first half of the twentieth century (Jacobs, 1969).

3 “Urbanization has played a particularly active role alongside phenomena such as military expenditures in attempts to absorb the surplus product that capitalists perpetually produce in their search for profits.” (Rebel Cities, 2012)

Figure 2: A slum in Paris in 1877-78, showing the squalid conditions in parts of Haussmann's Belle Époque Paris (Charles Marville, Haut de la rue Champlain (vue prise à droite), 1877-1878. Musée Carnavalet, Histoire de Paris)



Within this context, homeownership has progressively been framed as the only viable path toward dignified housing and property ownership has been normalized as both a personal aspiration and an individual responsibility (Betavatz & Toussaint, 2021). In Italy in particular, housing represents a key pillar of family security, traditionally transmitted across generations. For 87.2% of Italians, the home is perceived as a safe investment. This perception is shared across age groups, including 83.8% of young people, 86% of adults, and 91.8% of older generations.

Even if, this system of housing privatisation has been a dominant model since the post-war period, enabling many households to access homeownership, today, it appears increasingly unsustainable. For example, In Italy, wealth is becoming progressively concentrated in older generations: households headed by individuals born between the post-war period and the early 1960s hold on average over €360,000 in wealth, whereas those belonging to generations born between 1981–1996 and 1997–2012 possess significantly less, around €150,000 on average (CENSIS, 2025). Moreover, according to a survey conducted by mUp Research, more than one million young Italian adults, between 29 and 39, report a desire to leave the parental home but are unable to do so due to insufficient economic resources. Young adults aged between 29 and 39 face significant barriers to accessing homeownership. 69% of buyers in this age group had to rely on a mortgage to complete the purchase, while 62% have not yet been able to buy their first home. Among those who did manage to purchase a property in the last five years, nearly one in three did so with financial support from their family (Franzosi, 2025).

PUBLIC SOCIAL HOUSING SECTOR

Today overlapping crises, including geopolitical conflicts and reconstruction processes, reinforce the concentration of population and capital in selected metropolitan areas, while accelerating internal and international migration toward cities, where housing increasingly becomes a central site of both economic accumulation and social tension. It is estimated that Europe's urbanisation rate will reach approximately 83.7% by 2050, with cities generating around 80% of total economic growth (UN DESA United Nations, 2025). Additionally, more than 3,000 cities experienced population decline between 2015 and 2025, confirming the simultaneous presence of expansion and contraction processes within the global urban system.

Moreover, it is important to recognise that, while temporary responses can be provided through social services, the management of housing distress ultimately requires long-term housing policies and structural measures, as highlighted in the *“Piano nazionale per gli interventi e i servizi sociali di contrasto alla povertà 2021-2023”*¹. In this scenario there is a growing need to identify and implement housing interventions in a faster and more effective way (fio.PSD ETS, 2022), moving beyond uniform approaches in favour of more adaptive and context-sensitive strategies.

In this scenario, the public sector holds both the responsibility and the authority to ensure adequate housing provision, particularly for vulnerable populations. Its role goes beyond simply providing shelter, extending to the delivery of housing solutions that actively promote social inclusion, dignity, and long-term well-being.

Unfortunately, this sector often suffers from the absence of shared operational protocols and relies on planning instruments whose effectiveness is weakened by higher-level national legislation (OECD, 2023). For example, in Italy, municipalities lack the technical and administrative resources to implement their urban plans effectively, particularly in smaller or more peripheral areas, where responsibilities for land use decisions often exceed the institutional capacity to fulfil them. The result is a decision-making landscape in which planning choices are shaped as much by electoral cycles and coalition politics as by any systematic analysis of need. This leads to leaving the market to operate in a regulatory environment that has been insufficiently equipped to contain its most damaging effects.

1 “Where social services can take responsibility for immediate housing emergencies, particularly in relation to individuals in conditions of severe vulnerability or specific situations, they are not able on their own to provide a long-term solution where social policies are not supported by coherent housing policies capable of offering a natural pathway for care processes aimed at achieving autonomy for individuals and families in need.”

THE NEED FOR AN EVIDENCE-BASED APPROACH:

Moreover, these processes raise critical questions about the effectiveness of contemporary decision-making. Some publicly supported interventions appear to fail in addressing their stated objectives, as illustrated by the case of the Scalo di Porta Romana student housing development in Milan. Conceived within the broader regeneration of the former Porta Romana railway yard and initially developed as the Olympic Village for the Milano-Cortina 2026 Winter Games, the project was later presented as a strategic response to the city's severe student housing shortage, due to the high presence of students in the city.¹ However, the final rental levels failed to meet the affordability needs it was originally intended to address. As a result, civic associations and student organisations have strongly criticised the scheme and calling for a revision of the agreement with the developer.

The Scalo Romana case raises questions about the effectiveness of the decision-making system in delivering transparent projects that genuinely respond to the needs of the territory. These concerns become even more central in a context of limited resources, where public intervention is expected to prioritise their allocation toward the most vulnerable segments of the population. Unfortunately, this is not an isolated case of mismanagement of resources have systematically penetrated the governance of public housing itself. In Lombardy, the public housing sector has revealed flawed and highly controversial practices in the allocation and governance of public resources.

In the past decades, a combination of fiscal constraints, institutional fragmentation, and repeated reorganisations of regional housing governance has contributed to chronic underinvestment in the public housing stock (OECD, 2020; Federcasa, 2024).

Investigations and administrative reports have repeatedly highlighted critical issues within ALER, including financial fragility, maintenance backlogs and uneven conditions across the housing stock. Regional audits have shown that a significant share of buildings requires extraordinary maintenance, with persistent concerns regarding building safety and energy efficiency. At the same time, the broader Lombardy housing governance system has also been affected by judicial inquiries involving political and administrative actors.

More recently, investigations into urban planning processes in Milan (2024–2025) have raised concerns about potential conflicts of interest and opaque decision-making in planning approvals, involving members of advisory or technical commissions. According to judicial authorities, the inquiry examined possible links between private developers, consultants and administrative figures in the approval of building projects. At the time of ongoing investigations, more than seventy individuals were reported as under scrutiny by prosecutors, although legal proceedings remain ongoing and conclusions have not yet been formally established.

What connects the governance challenges in ALER and the broader Milan urban planning system is the fragility of the institutional mechanisms. Administrative systems, designed to translate priorities and needs of the people and of the territory into policy outcomes, operate within a context where competing economic interests and fragmented governance structures can significantly affect decision-making processes. As a result, ensuring a transparent decision-making process based on accessible and reliable data remains a critical challenge.

Moreover, the absence of unified data infrastructures and standardised tools and the limited availability of resources, make it difficult the decision making process itself and the evaluation of it. This means that policies often depends on the discretionary capacity of regional authorities rather than constituting a shared and systematic governance asset that would enable comparison across territorial contexts. These structural gaps contribute to conditions in which inefficiencies and cases of mismanagement can emerge.

¹ In Milan, rental housing prices increased by nearly 12% in a single year between 2022 and 2023

Figure 3: Public social housing estates in Rome illustrating the scale and physical condition of the Italian ERP stock.



PUBLIC SOCIAL HOUSING IN ITALY

The ALER case showed us the effect of the fragmented governance in terms of public social housing. In Italy, the State does not directly intervene in the construction or management of social housing infrastructure, but it retains control over housing policies, funding frameworks, and national programmes. However, the implementation of these policies has progressively been delegated to regions and municipalities, particularly through local land-use planning systems whose complexity often limits the effective delivery of housing programmes. These areas are often characterised by physical decay, social vulnerability, and infrastructural deterioration, yet they also hold considerable potential for urban regeneration, rehabilitation, demolition, and reconstruction processes capable of redefining their role within contemporary cities.

Today, Italy counts approximately one million publicly owned housing units. Around 75% of this stock—roughly 800,000 dwellings—is still managed by the former IACP (Istituti Autonomi Case Popolari), later transformed into regionally controlled housing agencies, while the remaining share belongs to municipalities. More specifically, only 2.3% of the Italian housing stock is managed by public entities associated with Federcasa, within what is described as a context marked by a “*chronic shortage of housing for low-income households*” (Chiodelli, Coppola, Belotti, & Ber-ruti, 2021). According to the CENSIS, not only is the share of public social housing insufficient to meet the growing demand, but the sector itself is also affected by severe structural inefficiencies:

Insufficient building stock and unused vacant buildings : the Italian housing system is marked by a structurally constrained and inelastic supply. While demographic growth remains limited, the increasing prevalence of single-person households is expected to sustain housing demand in the coming years. However, the social housing sector continues to face chronic shortages, long waiting lists, insufficient investment in renovation, and a progressive reduction of available stock. In addition, approximately 7.7% of the total ERP stock remains vacant due to the need for extraordinary maintenance, while a further 2.8% is estimated to be illegally occupied (CENSIS, 2025).

A system not financially sustainable: public rents are often set at very low levels, which discourages turnover. While low rents are essential to ensure the social function of public housing, their regulatory rigidity, combined with insufficient public subsidies, often undermines the financial sustainability of housing providers and limits their capacity to maintain and expand the existing stock. The average ERP rent is approximately €130 per month, compared to around €600 in the private rental market. Therefore, consolidated rent arrears had reached approximately €3.2 billion by 2023, averaging around €4,200 per dwelling. (OECD, 2023)

Allocation criteria and risk of segregation : the allocation criteria directly shape the social composition of public housing estates. In Italy, access to social housing is regulated through a selective point-based system based on income, household composition, housing conditions, disability, and length of waiting time. This mechanism allows for the targeting of a significant share of low-income households (approximately 58%) but at the same time it raises concerns regarding the potential risks of exclusion and socio-spatial segregation that such concentration may produce (Poggio & Boreiko, 2017).

Maintenance Deficits and the Need for Renewal Strategies : a lack of investments in the sector has led to bad conditions of the buildings, affected by dampness, inadequate insulation, safety deficiencies, and years of insufficient maintenance, leading in some cases to the complete abandonment of dwellings. In fact, as reported by OECD, Italy's has one of the oldest housing stocks: the average age reached 47 years, while only 13.9% of units had been built after 1991. This ageing condition represents a major challenge for the ecological transition, requiring substantial public investment in deep renovation and energy retrofitting. Only 3.3% of the ERP stock has undergone major renovation or extraordinary maintenance, while only around 12% has been subject to energy efficiency upgrades (Federcasa, 2026).

In Italy, in response to the European Green Deal, the PNRR and the Superbonus scheme have accelerated renovation activities and improved the energy performance of the housing stock (GRINS Foundation, 2024) mainly particularly among households with sufficient financial capacity to co-finance the interventions. By contrast, the public housing stock remains structurally underfunded and in a condition of progressive deterioration, while fragmented governance arrangements continue to limit the effectiveness of public interventions in producing systemic and long-term improvements (Della Spina, Galati Casmiro, & Giorno, 2026)

However, the resources allocated under the National Recovery and Resilience Plan (PNRR) were significantly reduced, from approximately €7 billion originally dedicated to housing-related measures and urban regeneration to around €4.1 billion, corresponding to a reduction of more than 40%. This contraction of financial resources is particularly relevant when contrasted with the growing urgency of the housing crisis, especially in urban areas where housing costs and social inequalities continue to rise.

In parallel, the ongoing debate on the *“Piano Casa”* in Italy highlights how the housing issue is primarily addressed through a set of policy proposals focused on simplifying planning and building procedures, regenerating public housing stock, and restructuring the housing market.

However, the issue clearly extends beyond national boundaries, as also emphasised in Ursula von der Leyen’s political discourse, housing is positioned as a central priority within the European agenda. The growing attention and intervention of the European Union underline how housing has become an increasingly strategic policy priority, with rising levels of investment expected in the coming years. In this regard, it is necessary to effectively manage both existing and future resources through transparent and traceable processes, from their initial conception through to their final outcomes.

HOUSING AS A PROBLEM OF REPRESENTATION

However, the issue at stake is not only one of socio-economic and managerial dynamics operating at a broad scale. This research chooses to focus on one specific dimension of that larger picture: **the representation of these problems within the decision-making process**. Certainly, this question is not confined to housing alone but it applies to any field in which a process must decide which aspects of a phenomenon to privilege, and how to narrate it. In the housing sector, and particularly in the marginalized areas of the city, the stakes of this question become especially high. When housing is flattened into a mere matter of provision and material conditions, the realities it is meant to describe are flattened along with it, reduced to numbers. This happens for at least three interrelated reasons.

First, certain dimensions of housing are inherently difficult to represent. Vulnerability is a case in point: even where composite indices exist, such as the IDISE index produced by ISTAT, they operate at a level of aggregation that cannot capture the specificity of a single place.

Second, the very people meant to be represented are sometimes invisible to the systems doing the representing. Informal subletting, undocumented cohabitation, elderly residents living in isolation, or migrants without stable registration are all realities that housing registries and municipal datasets frequently fail to record.

Third, the positive dimensions of fragile areas are rarely told. Representation tends to concentrate on vulnerability while overlooking the informal support networks, shared caretaking practices, and forms of everyday solidarity that may also characterise these same places. This emphasis is, to an extent, necessary: it is often what secures attention and resources, but it also risks locking vulnerable areas into a permanent association with poverty, danger and decay, feeding a continuous process of exclusion and stigma.

Representation, then, is ultimately a question of choice — of what one decides to see, and what one decides to show. This calls for an investment in methods capable of capturing a more complex, layered account of reality. Representation, however, cannot be discussed in isolation from the approach that underlies it, discussed in the following section.

1.2 Approaches to Housing

In the field of housing, a range of approaches has been developed and tested over time in order to produce solutions aimed at improving people's living conditions — some in a formalised and institutionalised manner (top-down), designed to manage an extensive housing stock on a large scale; others emerging as a reaction to inadequate living conditions, unexpressed needs, or as a means of mediating between a range of factors and actors (Living Labs). Many of these approaches, however, have revealed significant limitations and structural weaknesses. This section examines the main approaches to housing, namely the bottom-up approach, the top-down approach, and the intermediary approach.

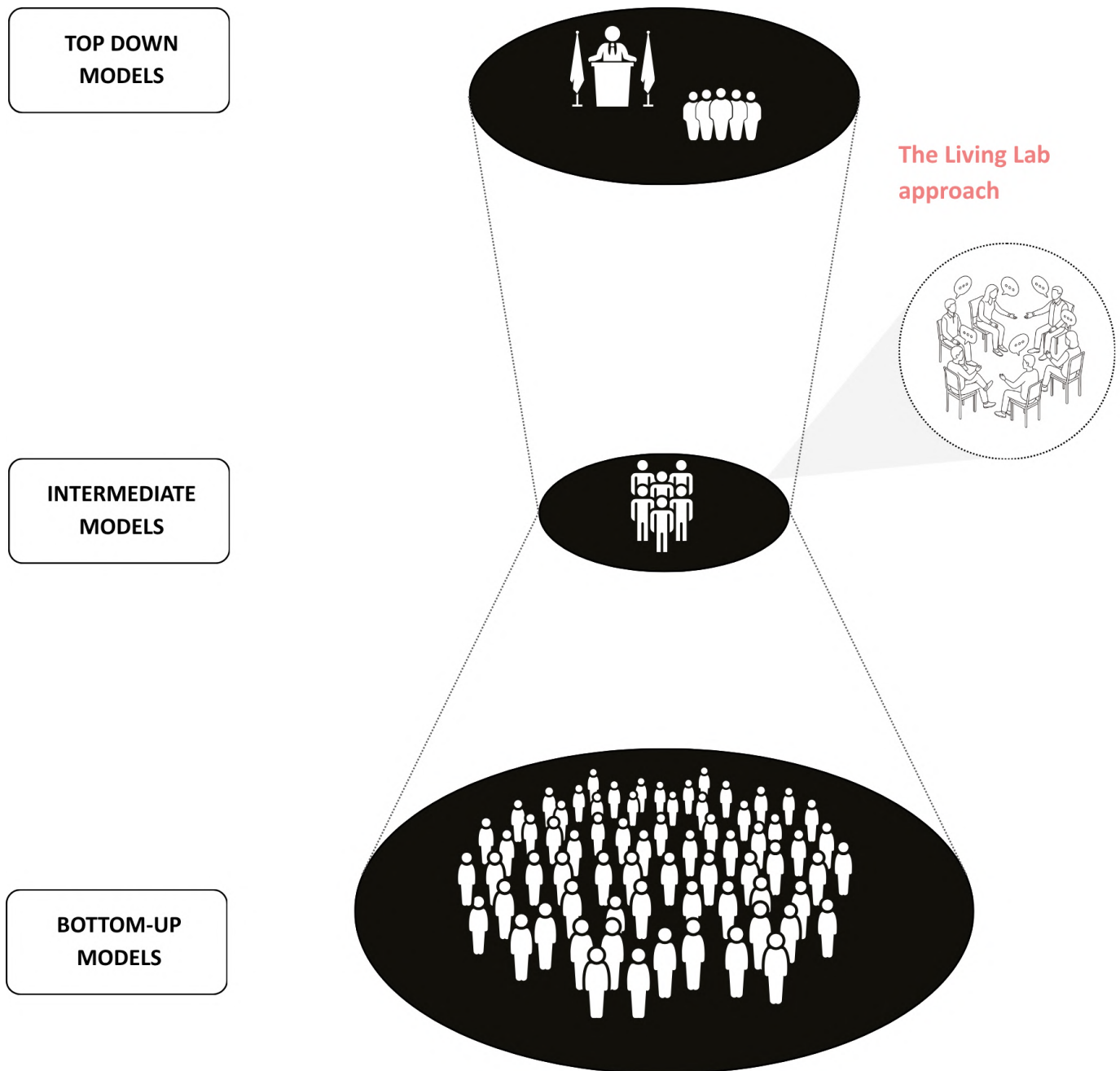


Figure 4. Overview of the different housing approaches presented in the following sections.

THE FAILURE OF TOP-DOWN HOUSING MODELS

What do many large-scale housing projects in the peripheries of our cities have in common? They emerged from a historical moment (between the 1960s and 1970s) in which architecture was believed to possess the power to resolve social conflict through form alone. During this period, the architect was often perceived as a visionary figure capable of shaping society from above: through the design of buildings and urban structures, it was thought possible to regulate social relations, collective life, and even individual behavior.

This modernist ambition was rooted in the belief that architecture, guided by a limited group of enlightened designers, could provide universal solutions to complex social and economic challenges. Housing estates, megastructures, and large-scale collective developments were conceived as tools of social reform, based on the assumption that spatial order could directly produce social order. In this framework, the architect acquired an almost political role, shaping how people were expected to live and inhabit the city. Architecture was also understood as a universal and transferable language, largely detached from local cultural specificities and site conditions, which often resulted in design responses that remained disconnected from the contexts in which they were implemented.

However, this radically optimistic idea collided with reality. Many of these projects remained unfinished, were heavily modified over time or proved unable to adapt to changing social conditions. The rigidity and monumentality of their architectural language often contrasted with the evolving and flexible needs of everyday life. Moreover, many of these complexes struggled to establish meaningful relationships with their surrounding urban contexts, becoming isolated enclaves rather than integrated parts of the city.

Across different geographical and political contexts, the top-down approach that characterized much postwar modernist housing, repeatedly demonstrated its limitations. In many cases, these projects failed to integrate with the socio-economic realities they were intended to improve, revealing the gap between architectural idealism and the complexity of lived urban experience. The following 5 case studies illustrate this phenomenon.

Figure 5: Demolition of Pruitt Igoe



01 - PRUITT-IGOE

St. Louis (USA), 1956 - 1972

Across 57 acres of inner-city St. Louis, Pruitt-Igoe was conceived as a vertical utopia for 10,000 residents — a rational answer to urban poverty, equipped with skip-stop elevators, communal green spaces, and long corridors intended to foster neighbourly life. Yet the project was built on a set of assumptions that the city itself would rapidly invalidate. As St. Louis lost nearly a third of its population to suburbanization and white flight and the complex found itself stranded in an economic and demographic void its planners had never imagined. By 1972, the vacancy rate had reached 27%, the highest of any public housing project in the United States and only 600 residents remained of the 10,000 originally expected. The same year, the building started to be demolished, with the last towers razed by 1976.

02 - UNITÉ D'HABITATION

Marseille (France), 1952

When Le Corbusier completed the Unité d'Habitation in Marseille in 1952, he presented it as a manifesto — an attempt to compress the entirety of urban life into a single self-sufficient structure. The “machine for living” contained 337 apartments across 18 floors, along with shops, a hotel, a gymnasium, a nursery and a rooftop terrace, all designed to make the city redundant. Every dimension, every proportion, every relationship between spaces was calibrated according to the Modulor, Le Corbusier's anthropometric system derived from an idealised human body. The social programme, however, unravelled almost immediately — not from within, but from above. Originally conceived as social housing of HLM status, the government began selling off apartments soon after construction to recuperate funds. By 1954, the building was under multiple private ownership, with a population that had become predominantly middle-class and bourgeois failing as a social housing for lower income households. Today the building it has become an object of architectural pilgrimage, celebrated globally as a masterpiece of modernism.

The Unité d'Habitation demonstrates that architecture alone cannot determine the social and political conditions of its own inhabitation.

03 - LA GRANDE BORNE

Paris (France), 1967

In the decades following the II World War, France faced a catastrophic housing shortage driven by rural migration, demographic growth and decades of neglected maintenance. The state's response was the grands ensembles, vast housing estates of towers and slabs built on the peripheries of major cities, conceived as rational, hygienic, modern alternatives to the insalubrious conditions of inner-city neighbourhoods. Intended as stepping-stone housing for a growing working and middle class, they became instead concentrations of poverty, racial segregation and social isolation, cut off from the city by inadequate transport, absent services and the sheer scale of their monotonous environments. One of this large housing estates is the “La Grande Borne”, designed by Émile Aillaud, producing 3,775 homes organised across seven distinct sectors, each with its own architectural identity. The architect, Aillaud explicitly positioned the project against the monotony of the conventional grands ensembles creating curved buildings, pedestrian-only interiors, low-rise scale, forty shades of coloured glass on the facades. It was, in his own words, “a painter's estate as much as an architect's.” Unfortunately, by 1982, more than 750 of La Grande Borne's apartments had already been deemed uninhabitable, due to the lack of infrastructure, amenities, services and above all employment. Today La Grande Borne registers: unemployment rate at 22.5% (over twice the national rate), poverty rate of 45% and it is a Zone de Sécurité Prioritaire (ZSP), targeting persistent violent offenses. Despite extensive urban renewal efforts and new transportation links, core socioeconomic challenges in La Grande Borne have shown limited improvement.

Meanwhile, the grands ensembles are known to be the backdrop for some of France's most significant social ruptures¹ and the data show the failure of a project, what is not visible is the resilience that grew within it. The spatial disobedience of their inhabitants like the appropriations, informal economies, informal support services can be seen as a collective refusal to disappear. This is a symptom of failure but an expression of need that the project had never provided a legitimate channel for.

Figure 6: Unité d'Habitation, Marseille

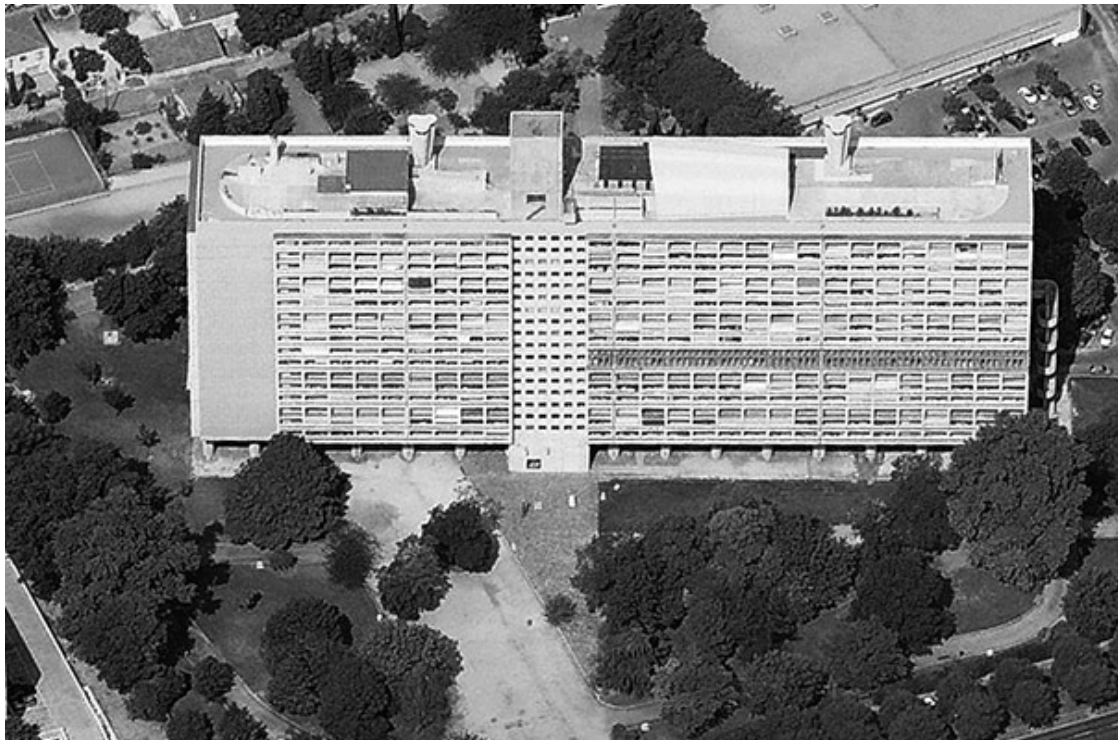


Figure 7: La Grande Borne, Paris



04 - CORVIALE

Rome (Italy), 1972

Commissioned in 1972 and completed a decade later on the south-western outskirts of Rome, Corviale stands as one of the most radical and contested experiments in Italian social housing. Designed by Mario Fiorentino under the influence of Le Corbusier's Radiant City, the building stretches for nearly a kilometre in a single unbroken concrete mass, housing approximately 6,000 residents in what its architect conceived as a city-within-a-building: a self-sufficient urban organism in which collective life would prevail over individual atomisation. Central to this vision was the "*Quarto Piano*" reserved entirely for services, communal spaces and professional studios intended to animate the building with public life from within.

Within years of its completion, the fourth floor had been entirely occupied by families who had converted it into informal housing. The census counted 135 households living there but the regeneration project that followed could formalise only 103 of them. The project's most ambitious collective space had become its most vivid act of spatial disobedience. What Corviale reveals is not the failure of its inhabitants, but the failure of a programme that had designed collective life without consulting those who would live it.

Participatory initiatives have since attempted to address what the original project ignored. The Laboratorio di Città Corviale, run in partnership with Roma Tre University, has for years worked to build a different relationship between the building, its residents and the institutions responsible for it, fostering cultural programming for reactivating the neighbourhood. These efforts have a renewed sense of collective identity and a body of knowledge about the place that no planning document had previously captured, but their contributions has remained structurally limited.

The socio-economic conditions that shape daily life, unemployment, inadequate services, bad quality of the structure, lie beyond the reach of participatory culture alone.

05 - ROBIN HOOD GARDENS

London (UK), 1972 - 2008 (demolished)

Completed in 1972 in Poplar, East London, Robin Hood Gardens was Alison and Peter Smithson's only opportunity to realise at full scale their longstanding interest in what they called "*human facts*", developed within the Independent Group¹ and Team X.¹ The Smithsons' ambition was explicit: "*Sometimes inhabitants treat their direct properties differently from the common spaces. We suppose the issue here is to understand how to design behaviour, meaning how to bring people to respond in a certain way to the built space*" (Domus, 2018).

The project was, in this sense, not merely a housing estate but a social experiment. The scheme consisted of two long curved concrete blocks facing each other across a central landscaped garden, conceived as a stress-free zone protected from the noise, pollution and vehicular traffic of the surrounding city. At every third floor, the "*streets in the sky*", wide elevated walkways ran the full length of each block acted as genuine public space.

Unfortunately, architects had not imagined that the concrete would be severely deteriorated and that the public spaces and circulation areas, sheltered from natural surveillance and poorly connected with the urban fabric, could provide a series of blind spots linked to a sense of insecurity and isolation. When the demolition was announced in 2008, the official consultation process carried out by public authorities reported that approximately 80% of residents supported demolition². However, this figure stands in sharp contrast with unofficial surveys and independent accounts, which instead indicated a stronger preference among residents for refurbishment and the retention of the existing estate. This data resonates with what has been reported as a vibrant community, that emerged precisely within the spatial and programmatic constraints of the building. The demolition of the estate must therefore be understood not as an isolated architectural event but as part of a broader urban process. The site is now being redeveloped through the Blackwall Reach project, a large-scale regeneration scheme targeting middle- and upper-income residents, further accelerating the gentrification of East London and displacing the original working-class community. In this transition, the architecture itself gradually shifted into an object of aesthetic and heritage debate, while the lived realities of its inhabitants were increasingly marginalised.

2 According to an unofficial survey conducted by a group of residents, among 140 households, at least 130 families expressed a preference for refurbishment rather than demolition. This stands in stark contrast to the official consultation process. Moreover, the "Statement of Community Participation" accompanying the 2007 consultants' report noted that the figure of "80%" in favour of demolition should be treated with caution, as it included a significant proportion of residents described as "highly illiterate," and raised concerns that participants were not fully informed that demolition would entail the loss of their "secure council tenancies."

The demolition of a building risks erasing its human and material dimensions, reducing a complex socio-spatial reality to a purely physical object. Moreover, it disrupts the continuity of collective memory embedded in places, often transforming living communities into objects of preservation or abstraction rather than recognising them as active social actors within the urban fabric.

Figure 8: Façade of Corviale, Rome



Figure 9: Robin Hood Gardens



These experiences converge on a single, unavoidable conclusion: **the top-down model of architectural planning and construction has failed** across every scale at which it has been attempted. These examples led us to these conclusions:

A) **Architecture alone cannot determine human behaviour.** People do not inhabit buildings as their designers intended but they transform them, appropriate them, and rewrite them through the accumulated pressure of daily life. Space becomes a silent record of unexpressed needs: every sealed balcony, every occupied fourth floor, every desire path worn into the grass a form of testimony that the official project was never designed to read.

B) The very processes of exclusion, caused by the peripheral locations, the severed connections, the absence of services, paradoxically **strengthened the internal bonds of the communities.** Forms of solidarity, mutual support and collective resilience emerged precisely where the planning logic had assumed they would not be needed, because everything had been provided. The system, however, proved structurally incapable of narrating these informal expressions of community life. The result was a partial and distorted representation of peripheral areas.

C) **The architecture is not the solution and not the cause to the problem**, even if it is often blamed to have the main role in this story as in the Robin Hood Gardens. As Marcuse states: "most problems have a spatial aspect, but their origins lie in economic, social, political arenas, the spatial being a partial cause and an aggravation" (Marcuse, *From critical urban theory to the right to the city*, 2009)

D) **Demolition** has been, historically, the institution's answer to this misreading. It represents the most drastic possible response to the perceived failure of a project: the erasure not only of an architectural vision but of the community that had grown within it. The cases of Pruitt-Igoe, the Robin Hood Gardens, and many other examples like the Vele di Scampia in Naples all point to the same logic: when the gap between the planned and the lived becomes undeniable, **the building is destroyed rather than understood.** This logic is the substitution of one top-down decision with another, and it repeats the original error in a more permanent form.

What is needed instead is a fundamentally different approach: one that treats the existing built heritage not as a problem to be demolished but as a territory to be read. The modernist legacy of the 1960s and 1970s remains present, often like a ghost, in the urban fabric. In Italy, much of this inheritance is managed as public residential housing, placing on the state a formal obligation of maintenance, management and care that has been systematically neglected. These are not abstract architectural objects, but they are living communities, whose spatial conditions of isolation and neglect are the direct consequence of political decisions made decades ago and never reversed.

The question is how to intervene on these inherited contexts, while the housing crisis makes it an urgency impossible to deny. In residential architecture, no technical or formal solution is sufficient on its own. The complexity of social housing demands an approach grounded in the specific reality of each place: the people who inhabit it, the environmental and cultural heritage embedded in it, and the social, economic and urban dynamics that surround it. A housing project cannot be conceived as an autonomous object, but it must enter continuous dialogue with the territory in which it is embedded. For this reason, it is necessary to find tools capable of listening to what the space is already trying to say.

ARE BOTTOM- UP SOLUTIONS ENOUGH?

The results, as the cases of Corviale and Robin Hood Gardens make clear, were projects that knew everything about form and almost nothing about life. Yet these same cases reveal something that their architects had not planned for and what Marcuse describes as movements that *“are not after profit, but seek a decent and supportive living environment”* (Marcuse, *From critical urban theory to the right to the city*, 2009).

This observation has a substantial theoretical grounding. In her foundational work *“The Death and Life of Great American Cities”* (1961), Jane Jacobs argued that urban vitality emerges not from masterplans but from the participatory logic of communities who understand their own streets. Decades later, the work of Nabeel Hamdi (2004) developed this argument into an explicit methodology, demonstrating that small-scale community-led interventions can generate significant spatial and social change from below. Moreover, communities can produce, manage and defend shared resources and spaces in ways that formal planning systems are structurally incapable of recognising or replicating (Bollier & Helfrich, 2019).

However, we cannot ignore the significant limits of bottom-up initiatives. The socioeconomic dynamics that produce exclusion, isolation and poverty in peripheral housing estates operate at a scale that localised community-led responses are not equipped to dismantle. In fact, *“participatory urbanism, without redistributive power risks becoming a frustrating process”*³ (Arnstein, 1969) and form of self-management of scarcity, asking residents to solve, with their own problems produced by political and economic decisions made far above their heads. This tension is made explicit in the work of Isabelle Anguelovski, whose research on community resilience in marginalised urban neighbourhoods consistently finds that bottom-up initiatives improve quality of life and strengthen social bonds without altering the structural conditions of inequality that generated those neighbourhoods in the first place (Anguelovski, 2013).

PILASTRO

Bologna (Italy), 1964

The case of the Pilastro neighbourhood in Bologna offers one of the most instructive Italian examples of what community-led mobilisation can achieve. The Villaggio del Pilastro was a public housing complex built from 1964 onwards on the north-eastern periphery of Bologna, commissioned by the Istituto Autonomo Case Popolari to house the wave of workers and families arriving in the city during the industrial boom of the 1950s and 1960s, under the coordination of architect Giorgio Trebbi. Its ambition was to reproduce something of the city of Bologna elsewhere — a self-sufficient neighbourhood with its own civic life, green spaces, and collective infrastructure. The reality its first residents encountered was radically different. There was no reliable running water, no heating, no paved roads, no public transport. The isolation deepened in 1967, when the construction of the ring road physically severed the neighbourhood from the rest of the city. The gap between intention and execution was the measure of insufficient resources, of priorities that yielded to the first pressures of the market of the structural distance between those who decided and those who lived.

To bridge that gap that, in September 1966, the residents founded the Comitato Inquilini: a structured collective organism formed by any type of resident, despite any type of political belief, culture. The Committee was cross-party, politically active but non-partisan, and it engaged the municipal administration with a combination of direct action and institutional negotiation. The results were concrete and significant: bus connections, schools, heating, health-care services, sports facilities and, in 1972, a neighbourhood library. One nucleus of residents went further, inserting themselves directly into the management of the district’s central heating plant, generating real economic savings for the community in the process. From this experience grew the first nucleus of what would become SUNIA, today a national tenants’ union.

Around these political battles, a community life formed that was vivid and deliberate. Residents inhabited the park, the courtyards, the common areas, in ways that the project had anticipated but not guaranteed. They fought to defend the central park from a development plan that had originally earmarked it for construction, an early act of spatial resistance that would prefigure later struggles. The neighbourhood developed a local television channel, cultural associations and a collective identity that actively contested the stereotyped external image of Pilastro as a dangerous, degraded, peripheral “other” to the virtuous city of Bologna.

This period of community vitality, documented in Roberto Beani's documentary, did not survive unchanged into the following decades. The 1980s brought a shift in the demographic composition of the neighbourhood, a decline in the collective political engagement that had characterised the earlier period and a gradual retreat from shared life toward more individualised modes of inhabitation and the political climate that had sustained the Comitato Inquilini cooled.

The images of residents gathered for communal meals in the park or assemblies, produce a particular kind of melancholy but they let us understand that this forms of engagement appears to have dissipated or at least changed. It would be tempting to ask what has changed but that question leads into a tangle of socioeconomic, cultural and political transformations so deeply intertwined that no single cause can be isolated. Instead, the more productive question, and the one this research takes as its starting point, is different: in a historical moment in which the most fragile communities struggle to organise and mobilise to articulate their own needs, how can we identify and recognise those needs that often go unexpressed? The forms of collective communication and political mobilisation have changed. The will or capacity to unite around shared demands may have weakened. But the needs themselves have not disappeared. They have simply become harder to read and the tools available to public governance for reading them have not kept pace. As David Harvey argues in *Rebel Cities* (2012), the right to the city⁴ cannot be exercised individually: it is necessarily a collective right, one that requires both the capacity to organise and the institutional structures capable of receiving and acting on what communities know about their own lives (Harvey, 2012). Questioning these dynamics is legitimate, as the surrounding social conditions have profoundly changed.

- **Lower levels of politicisation** and civic engagement have weakened traditional forms of collective participation and neighbourhood activism (Putnam, 2000)
- Contemporary urban societies have become increasingly **multicultural and linguistically fragmented**, making shared forms of representation and participation more complex. (Sandercock, 1998).
- **The rise of digital and virtual forms of social interaction** has transformed the way communities are formed and experienced in physical space.
- **Greater residential mobility and housing precarity** have reduced long-term attachment to the home environment, weakening both the expectation and the willingness to invest care and identity in one's dwelling.

Figures 10-13: Photos of life in Pilastro during the '70s



A MEDIATION MODEL: THE LIVING LAB

Not only community-led initiatives often struggle to deliver structural, long-term, and scalable solutions, but they also tend to operate in opposition to public institutions, limiting their capacity to generate systemic change. In response to these challenges, **intermediary models have emerged with the aim of bridging the gap between the different actors involved in housing provision.** Among the most prominent of these are Living Labs, a well-established theoretical and operational framework developed by the European Network of Living Labs (ENoLL). **Living Labs are conceived as open innovation ecosystems in which multiple stakeholders collaboratively co-create, test, and refine solutions in real-life settings.**

The Living Lab model is based on the Quadruple Helix framework, which promotes collaboration among citizens, academia, industry, and public authorities. Unlike traditional laboratory settings characterised by hierarchical structures and controlled environments, Living Labs adopt a horizontal and participatory governance model that encourages knowledge exchange and shared decision-making among all participants. This collaborative structure makes the approach particularly valuable in contexts characterised by power imbalances or by the underrepresentation of certain stakeholder groups in decision-making processes. The selection of stakeholders defines the operational scale of a Living Lab, which functions across three interconnected and often complementary levels:

Micro Level: This level focuses on daily operations and the methodologies applied within individual projects. It involves the practical execution of co-creation workshops, field tests, and direct engagement with end-users through specific tools to gather insights and validate prototypes.

Meso Level: This level oversees the implementation of specific projects within the Living Lab. Each initiative is dedicated to a thematic vertical with clearly defined objectives, dedicated budgets, and specific timelines.

Macro Level: This level manages the big picture and long-term strategy. It focuses on systemic orchestration and the consolidation of high-level partnerships, ensuring the overall sustainability and strategic direction of the ecosystem.

When applied to urban contexts, the Living Lab evolves into the concept of the Urban Living Lab (ULL), defined as a collaborative governance framework that brings together public authorities, citizens, researchers, businesses, and civil society to co-create, test, and implement innovative solutions in real-life urban environments (Steen & van Bueren, 2017). Rather than being a single project or a physical place, an Urban Living Lab is conceived as an **experimental process** in which innovation is generated through continuous interaction among stakeholders.

Urban Living Labs are distinguished by four defining characteristics:

- they operate in real-life settings,
- they actively involve multiple stakeholders in co-creation, using an horizontal approach
- they adopt an experimental and iterative approach to innovation
- they aim to generate tangible societal impact beyond the duration of individual projects.

The key strength of this approach lies in the absence of predetermined solutions, allowing outcomes to emerge through collaboration. This characteristic represents, on the one hand, a major advantage in addressing complex urban challenges, which require cross-sector coordination and the meaningful involvement of local communities while simultaneously enabling the production of new knowledge.

At the same time, the lack of ex-ante control over the solutions developed may entail **the investment of significant resources without certainty regarding the final outcomes or their feasibility of implementation.** However, one of the main advantages of this methodology is that solutions tend to be more closely aligned with local needs and realities. As a result, they may require fewer corrective interventions during implementation and can prove more effective and efficient once scaled or integrated into broader policy frameworks.

HouseInc Project

The HouseInc project adopts an innovative transdisciplinary methodology to investigate the complex and interconnected dimensions of housing inequality within marginalised communities across 4 european case studies in Romania, Italy, Czech Republic and Germany. It focuses on analysing the economic, social, ecological and digital drivers of inequality, with particular attention to issues such as energy and mobility poverty, employment conditions, health, and socio-demographic factors across micro-, meso- and macro-levels.

Through a combination of mixed methods—including modelling, GIS-based spatial analysis and multinational surveys—the project examines how recent crises, such as the COVID-19 pandemic and geopolitical instability, have intensified existing housing disparities. HouseInc brings together universities, research institutes, policy organisations, NGOs and practitioners in direct engagement with vulnerable communities.

The findings are processed, mapped and translated through Living Lab methodologies, with the aim of scaling up results and informing policy recommendations at local, national and European levels, ultimately contributing to more inclusive and sustainable housing strategies. Within this framework, the Living Lab component of HouseInc is oriented towards fostering awareness and understanding within communities, rather than focusing exclusively on the production of tangible outputs or immediate solutions.

Figure 14: Off-Campus, San Siro, Milan



Figure 17: Participants of the Cahors LL



Figure 15-16: Participants of the QuiCasa LL



01 - HOUSEINC LIVING LAB

LOCATION: Darvari (Romania), Karvina & Ostrava (Czech Republic), Vogelstang (Germany), Turin (Italy)
FOCUS: Energy Poverty

ACTIVITY: The Living Lab activities were defined in subsequent phases of the research, building a structured process and on analysing the results produced at each stage. The process included:

- framing the research scope and defining the analytical focus, with experts from each case study;
- capacity building and the exploration of potential solutions, involving local communities and field experts such as social operators;
- the development and refinement of solutions, carried out with experts for each case study;
- additional focus groups aimed at further defining and assessing implementation pathways.

MAIN FINDINGS: The HouseInc process demonstrated that the LL approach was particularly effective in fostering awareness and mutual understanding among communities and partners involved, rather than primarily generating concrete solutions. In fact, at the end of the project, only one solution was effectively implemented, and this was mainly for informational purposes. As a result, the LL approach did not substantially translate into structural interventions capable of improving housing conditions within the communities involved.

02 - QUICASA

LOCATION: Campinas, Brazil
FOCUS: Affordable Housing

ACTIVITY: The QuiCASA LL, set in a low-income urban area (Quilombo housing complex), where residents face infrastructural and environmental challenges, aimed at improving a housing conditions through combining research, design, and on-site experimentation. The process aimed:

- To understand the context and challenges: a brainstorming session, followed by field-based investigations and a series of ideation workshops, supported by participatory tools.
- To turn ideas in feasible solutions: a design phase, involving students, professionals and residents and a second workshop, using also interactive tools (such as maps, augmented reality, games, and children-oriented activities).

Throughout the Living Lab, participation gradually increases and trust between actors strengthens, with some ideas even being spontaneously implemented by residents. At the same time, the main challenge of the LL was managing expectations and trust: combining long-term participation with the difficulty of implementing solutions.

MAIN FINDINGS: This experience shows that one of the main challenges of Living Labs remains the establishment of trust between the community and the actual implementation of the proposed solutions. At the same time, the process revealed a gradual increase in participation and a shift in residents' attitudes, moving from an initially complaint-driven and confrontational stance towards public stakeholders to a more constructive approach that enabled the collective design of ideas and feasible interventions. However, despite this positive evolution in community engagement and co-creation capacities, the proposed solutions were ultimately not implemented.

03 - STEP-IN LIVING LAB

LOCATION: Hungary, UK, Greece
FOCUS: Energy Poverty

ACTIVITY: This project was launched during the pandemic of Covid-19, tackling energy poverty as a social and economic issue. The LL engaged with households in rural (Nyírbátor), mountaneos (Metsovo) and urban areas (Manchester). The core part of the project consists in the home visits by experts and technicians that assessed energy consumption patterns and installed low-cost efficiency measures in the houses. Moreover, households received customized recommendations on energy consumption at the Energy Cafés (virtual or physical community meetings with experts). The majority of participants at the cafés affirmed that they received useful information on energy saving measures.

04 - OFF-CAMPUS SAN SIRO

LOCATION: Milan, Italy
FOCUS: Inclusion, Innovation

ACTIVITY: The LL (Grassi & Alessandri, 2025) operates as a long-term, socially engaged university initiative embedded in one of the Milan's largest public housing districts. Four research groups, from different universities, collaboratively develop research, and action-oriented projects in close interaction with residents, associations, and local institutions. Within this framework, the activity is structured as an open and accessible "intermediate space", enabling co-produced forms of knowledge while critically reflecting on the role of universities and the territory. The Living Lab focused on main 5 dimensions:

- Developing competencies: as practical, relational and institutional skills.
- Creating relationships on the territory, by connecting engaged stakeholders.
- Producing new narratives of an often stigmatised urban environment
- Encouraging transformative practices, participation and supporting local initiatives
- Influencing policies

MAIN FINDINGS: The academic sector can be an effective mediator between local realities, residents, and institutions. However, scaling up and translating these processes into solutions to inform policymaking, remains a challenging step to achieve.

05 - CAHORS LIVING LAB

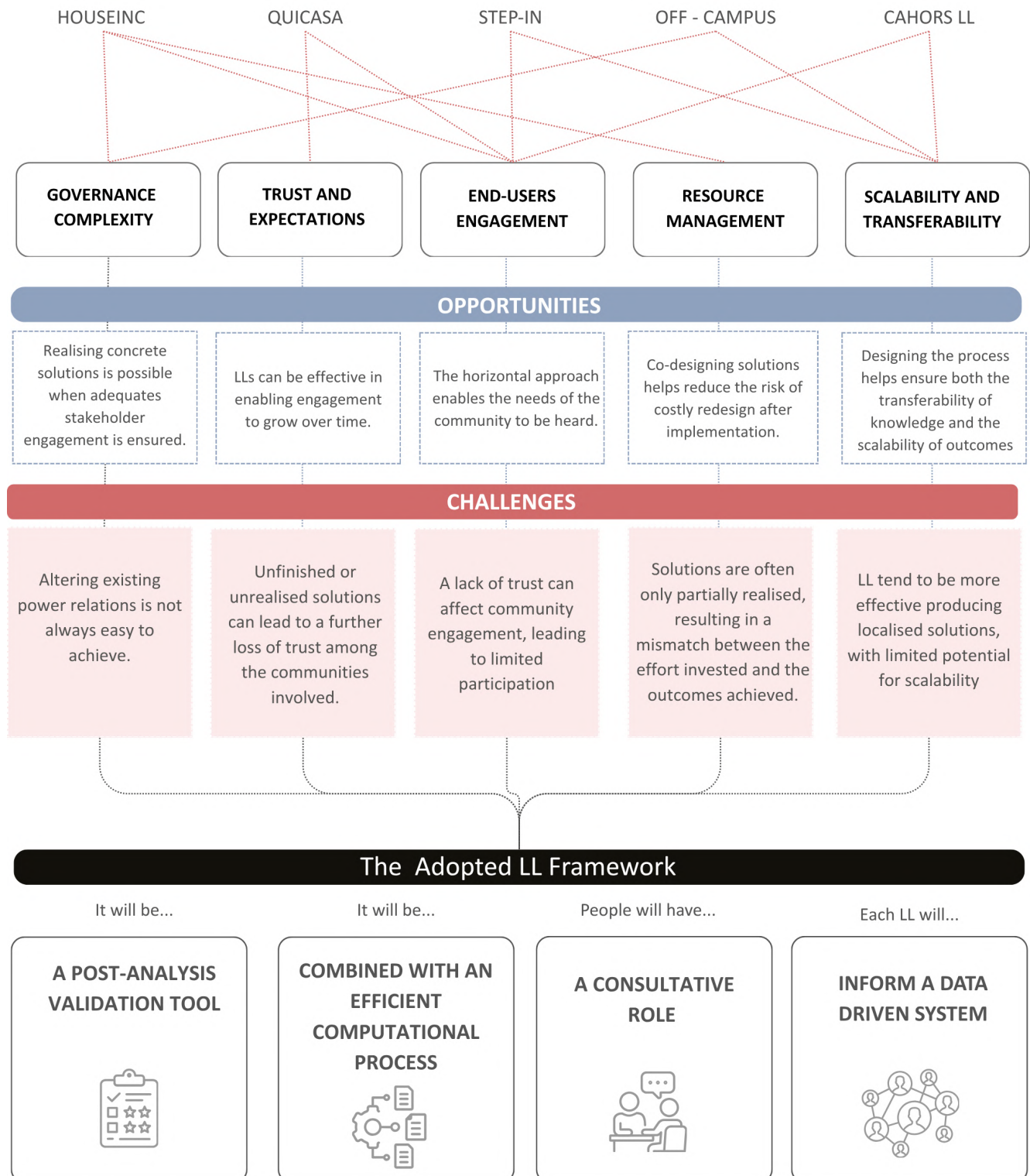
LOCATION: Cahors, France
FOCUS: Heritage, Energetic efficiency

ACTIVITY: The project address the complex challenge of retrofitting historic buildings (Claude et al., 2017), operating in a context where energy efficiency improvements and standard often conflict with heritage conservation policies. The LL framework brings together craftsmen, students, residents, local authorities, and material producers transforming users from passive recipients into active co-creators of the retrofit process.

MAIN FINDINGS: The variety of skills of the stakeholders and the micro-scale dimension of the LL enabled effectiveness, faster implementation and a stronger alignment between identified needs and proposed solutions.

The case studies have highlighted the limitations and opportunities of the LL methodology. However, due to its ability to position itself as an intermediary between different actors, it offers important insights for further reflection, development, and implementation. For this reason, the following chapters will explore this methodology by combining it with other approaches presented in the subsequent sections.

Figure 18: Opportunities, Challenges of the LL and the role of the LL in the project.



EVALUATING APPROACHES THROUGH THE LENS OF REPRESENTATION

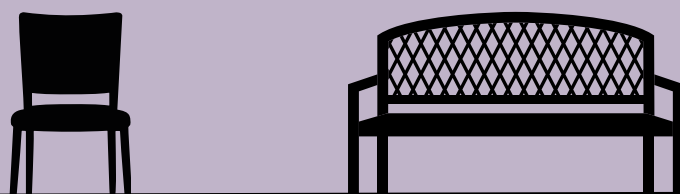
We can now evaluate the various approaches considered so far through the specific lens of how they represent vulnerability. On this basis, the Living Lab (LL) emerges as the methodology best suited to questions of representation. Community-led initiatives, by contrast, generate strong engagement, but only at a local scale — a strength that becomes a limitation when the goal is a structured, scalable system. A top-down approach, on the other hand, is effective in carrying out large-scale operations quickly, yet shows clear limits in its sensitivity to the range of problems that emerge from effects the original decision had failed to anticipate.

Representation, however, requires not only an approach but also a field of action. That field is identified here in spatial traces, presented in the next chapter. In this sense, every approach tends to produce traces in codified, formal, and structured shapes (the construction of housing itself, for instance) or in informal ones, such as the appropriation of space. In the case of the Living Lab, however, these forms cannot be as readily identified.

	TOP - DOWN MODEL	LIVING LAB	BOTTOM - UP MODEL
GOAL	To provide policies or actions to address large-scale needs	To act as an intermediary between actors	To respond directly to the needs of local communities
STATISTICAL DATA			
MATERIAL RESOURCES			
INSTITUTIONAL KNOWLEDGE			
EXPERIENTIAL KNOWLEDGE			
LIMITS	Failing to account for contextual specificities and lived realities	Limited resource efficiency and transferability.	Limited scalability and difficulties in addressing broader drivers
SPATIAL EVIDENCE	Large-scale interventions (e.g., housing construction, maintenance works)	Semi-formal adaptations of space	Informal adaptations and modification of the space

02.

WHAT SPACE TELL US



2.1 Space as Lived Production

Following the distinction made by Henry Lefebvre in “*The Production of Space*”, space can be understood through the triad of the *perceived*, the *conceived*, and the *lived*. Rather than functioning as an abstract theoretical framework, these three dimensions describe the concrete ways through which space is produced, organised, inhabited, and transformed through everyday life. Translating Lefebvre’s framework into the context of social housing, these dimensions can be associated with different layers of the built environment and its occupation. (LeFebvre, 1974)

- The first dimension- *espace perçu* (**perceived space**), refers to the material and practical dimension of space as shaped by everyday routines and spatial practices. Within the context of housing, this corresponds to how inhabitants physically occupy and navigate the built environment through recurring daily actions, movements, and uses.
- The second dimension- *espace conçu* (**conceived space**), refers to planned and represented space. This includes the spatial logic embedded within architectural and urban design processes, particularly the ideological and functional visions underlying the large modernist housing estates developed during the 1960s and 1970s. In this category belong the intentions of planners, architects, institutions, and housing authorities, together with the technical and political rationalities that shaped these projects.
- Finally, *espace vécu* (**lived space**) refers to space as directly experienced, appropriated and symbolically inhabited by residents. It is within this dimension that spaces are frequently used in ways that diverge from their originally intended functions. Domestic extensions, informal occupations, spatial appropriations, enclosed balconies, improvised meeting spaces, or altered uses of collective areas all reveal how inhabitants continuously reinterpret planned environments according to situated needs and lived realities.

It is precisely the misalignment between these dimensions, expressed by concrete spatial manifestations, that this research wants to register. The building therefore does not function as a neutral container but it records transformations and conflicts produced through inhabitation itself. These transformations do not necessarily emerge through extraordinary events but they rather belong to what Georges Perec defined as the *infra-ordinaire*: the repetitive and overlooked dimension of daily life. In housing, informal paths, domestic extensions, unauthorised modifications and spatial appropriations become ways through which residents negotiate their relationship with environments that frequently fail to accommodate their actual social, cultural, or economic needs.

The different uses of space may consequently be defined as forms of spatial ‘errors’. However, following the framework proposed in *Intelligence of Errors*¹, deviations and dysfunctions should not be approached merely as failures requiring correction but rather as traces capable of revealing deeper systemic contradictions.

¹ Intelligence of Errors is the Croatian Pavilion presented at the 19th International Architecture Exhibition of the Venice Architecture Biennale 2025. Developed by the interdisciplinary collective Institute of Errors at the University of Rijeka, the project investigates how errors in spatial design and urban policy can be understood not merely as failures to be corrected, but as valuable sources of knowledge for future design processes. Rather than seeking to eliminate mistakes, the project proposes an alternative design methodology that learns from them, treating errors as opportunities to better understand the complexity, uncertainty, and non-ideal conditions that characterise contemporary urban environments.

WHAT IS A SPATIAL 'ERROR' ?

ERROR = NEED

When Lefebvre's *conçu* and *vécu* collide, spatial modifications emerge as insurgent tactics to reconnect these fractured dimensions. This corrective agency spans a wide spectrum of interventions, ranging from the simple displacement of furniture to heavy, unauthorized structural extensions. Shifting the focus away from the moral and legal implications of these actions allows us to uncover their generative origin: the unauthorized modification of space exposes an unmet demand, forcing the architecture to bend to the realities of its users.

A definitive historical paradigm of this friction is the Quartiers Modernes Frugès in Pessac, designed by Le Corbusier in 1924. Conceived as a rigid, purist manifesto of the "machine for living," the complex imposed a highly standardized, geometric way of life upon its working-class residents. However, the inhabitants immediately initiated a systemic campaign of structural disobedience (Boudon, 1972). They bricked up Le Corbusier's iconic ribbon windows to reclaim domestic privacy, filled the open spaces beneath the pilotis to create extra rooms, and added pitched roofs over the modernist terraces. Rather than an aesthetic failure, the modifications apported by the residents of Pessac demonstrate that the user's everyday necessity will inevitably rewrite the space to his needs.

In this sense, spatial "errors" can be read directly on building façades, within the streets we traverse every day or even inside our own homes. Examples include bicycle poles repurposed as informal parking structures, desire paths emerging across green areas as shortcuts carved through repeated pedestrian movement, balconies permanently enclosed and transformed into extensions of living space, or parking lots temporarily appropriated as playgrounds. Even objects themselves, as Bruno Munari sought to demonstrate, are shaped by the way they are used. His adaptable armchair, for instance, can function as a reading space or as a bed, depending on the needs of the user. The same logic extends to every space we inhabit and traverse in everyday life: from the domestic balcony to the public bench in the park. **It is reasonable to argue that a higher intensity of use corresponds to a greater degree of spatial modification, directly related to the extent to which a space is inhabited, appropriated and reinterpreted over time.**

In many cases, these informal adaptations are more visible in peripheral or vulnerable urban areas, where the city often fails to fully respond to everyday needs. For example, the occupation of spaces—and in particular of housing units, a phenomenon that frequently occurs within social housing contexts—can be reinterpreted as a claim to the right to housing itself, beyond its legal framing. A shift in the interpretative framework of the phenomenon inevitably leads to different responses, focusing attention on the underlying structural causes that generate such practices, rather than solely on their legal status or symptoms.

If these transformations are interpreted not as deviations from design intent but as expressions of underlying needs, they become a powerful analytical tool for understanding how space is actually lived. These modifications often remain unnoticed precisely because they are embedded in ordinary, everyday practices that cut across cultural, generational, and social differences.

Spatial "errors" emerge as a transversal condition of human habitation. By observing the actual use of space and the objects that populate it, it becomes possible to interpret these deviations not as anomalies, but as indicators of underlying and often unspoken human needs.

Figure 19: Bruno Munari, "Seeking comfort in an uncomfortable chair", 1944



ERROR = SPATIAL EVIDENCE

Throughout history, buildings have never remained static objects. Their façades continuously accumulate traces of transformation, adaptation, and material reuse, becoming physical archives of collective actions. The Colosseum provides a powerful example: although today perceived as an immutable symbol of Roman identity, its current appearance is the result of centuries of modifications, collapses, material extraction, and reuse. The removal of its travertine facing during the Middle Ages and Renaissance transformed the monument itself, leaving visible scars that now constitute part of its historical identity. However, these ‘imperfections’ are traditionally excluded from formal representation of a building, like humidity, weeds, debris, dust, overcrowding, or atmospheric decay. These elements can reveal hidden urban processes and environmental dynamics that static models fail to capture (Gissen, 2009). For example, an element, such as dust or the accumulation of atmospheric sediment can transform the building into a physical diagram of wind flows, local pollution and the city's biological rhythms.

The architectural object is also a witness capable of narrating historical events, social dynamics and conflicts. This is the foundation of the work of Eyal Weizman and his Forensic Architecture, (Sousa A. N., 2014) examining the effects on the built environment of the Israeli occupation in Palestine. Weizman conceptualizes the built environment as an apparatus of “*slow violence*” a protracted, structural aggression embedded within the geography itself. The occupation is an environment that was conceived to strangle Palestinian communities, villages and towns, to create an environment that would be unliveable for the people there. Through the adoption of innovative spatial modelling, animation and visual technologies, Weizman turns architectural destruction into material evidence in the investigation of war crimes.

Architecture acts as a material archive in every building, not only in condition of destruction, occurred in the Palestinian genocide. To expose it, we must train our analytical vision to ask the right question to the built environment, revealing the truth behind it.

ERROR = SPATIAL DISOBEDIENCE

Spatial anomalies can operate simultaneously as indicators of systemic vulnerability and as catalysts for collective resilience. The concept of error could be interpreted at the territorial scale, in what Ignasi de Solà-Morales (1995) defined as the *terrain vague*, urban voids where the absence of formal control allows informal appropriations to co-produce an alternative, insurgent landscape.

In this sense, these ‘errors’ can be conceptualized as forms of *guerrilla urbanism*, spatial disobedience through which marginalized communities actively reinterpret and subvert oppressive environments. Peripheral urban zones—particularly low-income social housing estates—are historically the primary targets of spatial violence (Herscher & Iyer Siddiqi, 2014): a structural, geometric aggression where the built environment is weaponized to enforce segregation and social control. If these marginalized geographies exhibit the highest frequency of spatial anomalies and disruptive practices, it is because we must interlock the concept of the architectural “error” not only with the political reaction derived from the frustration produced by the spatial violence.

A definitive paradigm of this friction is found in the urban landscape of Nanterre, specifically within the Cité Pablo Picasso designed by Émile Aillaud in the 1970s. The organic, seemingly poetic geometry of these social housing towers acts as an ideological camouflage for a deeply flawed urban reality. Over time, the estate became increasingly isolated through the strategic deployment of heavy transport infrastructures—such as highways and railway lines—that functionally and physically severed it from the center of Paris, effectively creating a spatial trap optimized for police militarization and panoptic surveillance. As analysed by Léopold Lambert (2023), this specific form of spatial violence targets the predominantly Arab and post-colonial population residing in the area, functioning as a direct manifestation of a structural racism embedded within the French colonial continuum.

It is within this deliberately carceral geography that the tragic police killing of seventeen-year-old Nahel M. occurred, triggering an immediate wave of urban uprisings. In this context, the “errors” committed by the youth and residents of Nanterre—ranging from outright revolts and asymmetric confrontations with police forces to the rapid construction of defensive barricades—represent a profound and insurgent rewriting of the city. Far from being mere symptoms of urban decay or random acts of vandalism, these spatial disruptions constitute the physical externalization of a decolonial reaction.

Nanterre exemplifies a diffuse systemic phenomenon across the Parisian banlieues and countless other marginalized peripheries, where the geometric violence of top-down planning is systematically challenged by the defensive agency of its inhabitants.

Figure 20 - 22: These photos illustrate some of the visible “errors” found across the buildings. Signs of wear, vegetation emerging from the built fabric, and the coexistence of different façade patterns reveal a series of transformations over time. Each of these traces contributes to a broader narrative, providing insights into the relationship between residents, buildings, and everyday practices.







ERROR = HUMAN INTELLIGENCE

Within this framework, the conceptual alignment between the architectural "error" and human intelligence becomes deeply tangible through the everyday operational realities of social housing. The spatial anomaly represents the activation of a situated, human intelligence hacking a rigid system, translating the landscape architecture concept of "desire paths" into the vertical and internal dimensions of the building. This idea is not limited to domestic adaptation but emerges from the earliest ways in which humans experience and transform space. The film *Spatial Disobedience* by Ila Bêka and Louise Lemoine (2025) offers a powerful representation of this phenomenon, showing how children use their bodies, movements, and senses as instruments for interpreting and reshaping the urban environment. Through exploration, play, and spontaneous appropriation, children transform streets, corners, and overlooked spaces into territories of discovery and interaction.

We see this intelligence clearly when residents actively subvert the static geometries of building, install glass verandas, shading systems along the facade to correct thermal deficits, appropriate the sterile voids under open pilotis to serve as spontaneous community hubs, or demolish interior partition walls to dissolve the rigid divisions of the original blueprints. This systematic flexibility is what allows the building to survive through time, absorbs the contingencies of changing conditions and needs and shielding the rigid structure from functional obsolescence (Brand, 1995). For example, we can readily change the furniture inside a space, alter the function of a room or replace the facade cladding, allowing us to render a building constructed in the 1970s liveable today.

Historically the adaptive reuse was a natural and instinctive process. The Roman Forum, originally conceived as the political, commercial, and civic centre of ancient Rome, gradually evolved over time through successive layers of reuse and redefinition. Despite narratives of decline, what is particularly significant is its capacity to maintain a central urban role by continuously adapting to the changing needs of different historical periods (Davies, 2023). Similarly, many early Christian basilicas in Rome were progressively converted from civic buildings into religious spaces, demonstrating how spatial structures can be reinterpreted without being erased.

In more recent contexts, a comparable dynamic can be observed in the transformation of the High Line in New York, where an obsolete infrastructure has been reactivated as a public space, becoming an emblematic case of adaptive reuse in contemporary urban planning. Today, similar strategies are increasingly integrated by planners as tools for the regeneration of disused buildings and infrastructures.

Ultimately, this capacity to deviate and to 'fail' is precisely the cognitive prerogative that distinguishes human intelligence from machine computation. In an era increasingly dominated by data-driven optimization, algorithmic tools are fundamentally programmed to eliminate friction, minimize mistakes and prioritize predictive control. Applied to the city, smart infrastructures risk flattening the city into an administrative cyber-geometry (Picon, 2018). If the machine can only optimize within the parameters of a pre-established code, human intelligence thrives on the unexpected. The human capacity to adapt is inherently tied to the capacity to misbehave, miscalculate, and resist. This mechanical worldview exposes a profound epistemological divide, encapsulated in the definition of artificial intelligence as an extraordinary capacity for 'agency without intelligence' - calculating perfectly without understanding the information (Floridi, 2023).

Moreover, for a machine, the error is an absolute negative: a systemic failure or a loss of efficiency that must be erased. For the human being, however, the error is intentional and it is grounded in a creative improvisation of his human being. The capacity to learn from those deviations is structurally bound to the capacity to misbehave, to choose the inefficient path, to fulfill a psychological or emotional need.

The space - and the built environment - express of an open-ended, improvisational reason that no generative algorithm can simulate or replace. This resistance aligns Moreover, wrapping the domestic and social landscape in rigid predictive modelling deprives users of their cognitive capabilities (Sennet, 2018).

Figure 24: Martin Parr, photograph, Dublin, 1981. A woman using an umbrella as a protective shield against the rain.



2.2 Changing Perspectives

RECOGNISING THE 'ERROR'

According to the literature, the definition of the problem already implies a particular direction toward its solution (Rittel & Webber, 1973). Within this perspective, informal adaptations, spatial appropriations, or unauthorised modifications are signs of breakdown and but possible source of knowledge.

Unfortunately, defining what is an error and how to respond to it, depends on the interpretative frameworks through which urban phenomena are observed. This interpretative freedom reveals to be as powerful as it is dangerous when considering its possible implications. Normally, error is conceived as something that must be corrected and this definition itself can become highly problematic. If an error is something to be corrected, the focus immediately shifts toward identifying how to correct it, who produced the error and how to eliminate it in order to restore a condition of normality. For instance, if a degraded residential area or housing estate such as those previously discussed were interpreted as an “error” in comparison to more affluent, functional, and economically productive urban environments, the correction of that error could ultimately imply the elimination of the condition itself and therefore the demolition of the buildings or the displacement of the communities inhabiting them.

LEARNING FROM ERRORS

The approach, normally grounded in a broader culture of planning and design, is based on the assumption that progress necessarily requires the replacement, correction, or removal of existing conditions considered inadequate. Within this logic, transformation becomes associated with the restoration of order, efficiency, and functionality, in deep contrast with forms of informal occupation of the space which deviate from an ideal urban norm.

However, our perspective changes completely when “*erosion, breakdown, and decay*” (Zubčić, 2025) are taken as the starting point for understanding the lived environment. Within this approach, imagining forms of intervention implies learning from the conditions through which ‘failure’ becomes visible. This perspective allows these manifestations to be understood as interconnected expressions of broader systemic conditions, rather than producing interventions limited to the immediate correction of visible problems. Recognising patterns of ‘errors’ as part of a wider structural framework can help inform strategies that are more coherent with the actual scale and complexity of the issues involved. For example, in the case of Pruitt-Igoe, adopting such a perspective would have meant listening to the lived dynamics of the residents in order to reconstruct possible forms of intervention. Rather than interpreting the complex solely as a failed architectural object, the focus could have shifted toward understanding the infrastructural isolation, social fragmentation, economic exclusion affecting the community.

At the same time, it is important to clarify that understanding and accepting the nature of the error itself - defined as the concept of “*staying with the error*” (Zubčić, 2025) - does not imply the absence of constructive action or political intervention. On the contrary, the “*metic intelligence*”, is proposed as the capacity to transform breakdowns into **productive forms of knowledge and action**. In this sense, it becomes necessary to develop an interpretative and operational system capable of understanding what these spatial traces reveal about the deeper structural conditions that produced them. In fact, it is only when the social and economic infrastructure begins to reveal its fractures and inadequacies that its underlying mechanisms become visible (Star, 1999).

Moreover, this approach suggests that planners, designers and policymakers should go beyond the restoring of irregularities and instead develop the ability to learn from these deviations and use them to inform more situated and socially aware forms of intervention. This perspective becomes particularly relevant when considering what Valeria Graziano defines as “*popular illegalisms*” (Graziano, 2025) as everyday practices that exploit institutional gaps in order to secure forms of care, survival, and collective support. These ‘*violations of planned order*’ are situated responses to conditions of exclusion, overcrowding, infrastructural neglect. The causes are not an external anomaly, but an intrinsic product generated by the built environment’s own structural logic (Bratton, 2015). Consequently, the appropriate response needs to address the structural conditions that made such adaptations necessary in the first place.

The work of Santiago Cirugeda and his studio Recetas Urbanas, exemplifies this concept. Operating under the banner of “*Guerrilla Architecture*,” Cirugeda subverts the rigid bureaucracies of contemporary urban planning to reclaim abandoned spaces for public use. Within the context of post-austerity Spain, where state disinvestment has left approximately 500,000 buildings vacant, Cirugeda used his expert knowledge of urban legislation to exploit legal loopholes, effectively hacking the planning system. By intentionally occupying legal gray zones and navigating the boundaries of civil and criminal liability, his methodology challenges the concept of institutional “error” or illegality. As Cirugeda asserts, working outside formal legal frameworks becomes a deliberate strategy to restore architecture’s primal social function, prioritizing collective urgency over institutional over-regulation.

These highly flexible architecture - reversible structures composed of upcycled materials - absorb systemic failures and supply vital public spaces that the state fails to provide. For example, this initiative led to the construction of La Carpa in Seville, a self-built community classroom, facing institutional paralysis and severe educational deficits. Cirugeda collaborated with local collectives to build public infrastructures using discarded scaffolding, shipping containers, and industrial waste. Guerrilla urbanism ceases to be an anarchic transgression, but it becomes a mechanism to transform institutional voids into productive spaces.

Figure 25: Cirugeda’s first project in 1997 . He designed a a traveling playground installation that could be placed anywhere.



EXPANDING THE NOTION OF ERROR

However, the concept of spatial “error” alone does not fully account for the social and cultural context from which it emerges. Different cultural backgrounds, household structures, economic conditions, and everyday practices generate different ways of inhabiting space and, consequently, different material manifestations within the built environment. Referring to all these manifestations simply as “errors” risks reducing complex socio-spatial processes to deviations from a predefined norm. For this reason, this research distinguishes between:

- **Human trace** as the physical evidence left by everyday practices through which inhabitants appropriate, adapt, and negotiate space.
- **Spatial errors** are interpreted as a specific category of human traces, namely those that reveal a measurable discrepancy between the intended function of a space and its actual use.

This perspective is particularly relevant in contemporary social housing, where increasing cultural diversity challenges the assumption that a single spatial model can adequately respond to different forms of inhabitation. As Vertovec (2007) argues through the concept of *super-diversity*, contemporary societies are characterized not only by ethnic diversity but also by increasingly complex differences in class, age, education, migration trajectories and family structures. Consequently, housing can no longer be conceived as a culturally neutral container but domestic space is continuously negotiated and reshaped according to culturally embedded practices, values and social relations. This argument has long been supported by Amos Rapoport (1969), who demonstrated that the organization and everyday use of domestic space are fundamentally cultural rather than purely functional. The home is not simply a technical artefact optimized for efficiency, but a spatial representation of social norms, family structures, rituals, and patterns of interaction. As Edward T. Hall (1966) demonstrated through his theory of proxemics, cultures vary significantly in the way they structure interpersonal distance and territorial boundaries; consequently, the same architectural layout may enable certain cultural practices while constraining others. When planning adopts standardized, top-down models—often rooted in Eurocentric and modernist assumptions—it inevitably generates a mismatch between the intended use of space and the lived practices of its inhabitants. Farhan Karim (2020) argues that this standardization can even be interpreted as a form of architectural colonialism, imposing spatial logics derived from Western ideals of the nuclear family, privacy, and domestic order onto populations whose cultural practices are fundamentally different. Rather than being passive recipients of these spatial prescriptions, inhabitants actively reinterpret and transform their environment. As Blunt and Dowling (2006) observe, particularly in migrant households, domestic interiors are frequently reconfigured in order to preserve cultural identity and accommodate forms of everyday life that standardized layouts fail to support.

Historical housing projects clearly illustrate this phenomenon. The Bijlmermeer housing estate in Amsterdam, designed as the “*city of the future*” in the late 1960s, as part of Amsterdam’s post-war expansion, became a key example of mismatch between planned spatial logics and lived urban practices after being inhabited by large Surinamese and other migrant communities. The project was strongly influenced by: modernist urbanism (CIAM legacy), the separation of functions (housing / traffic / work / leisure), high-rise residential blocks surrounded by green space and elevated pedestrian circulation systems proved to be not comfortable for the migrant communities that mainly habited it.

As documented by Wassenberg (2013), the original design proved poorly aligned with everyday social practices and perceptions of safety. Over time, residents developed informal and adaptive uses of available spaces, while the estate itself underwent significant decline and subsequent regeneration processes. Moreover, a turning point occurred after a tragic plane crash in 1992, which triggered a broader political and urban recognition of the district’s problems. This event led to a large-scale regeneration process in the 1990s and 2000s, involving the demolition of many high-rise blocks, the introduction of mixed-use planning and the reconfiguration of circulation systems.

Similar processes have been documented in the peripheral housing estates of Paris, where residents have modified apartment layouts by removing internal partitions or redefining domestic functions in order to accommodate extended family structures and collective forms of living (Dikeç, 2007). What planning institutions frequently classify as unauthorized alterations can therefore be understood as adaptive responses to culturally specific needs. At the same time, however, informal adaptations can be problematic, as they may fail to comply with safety regulations, compromise the quality and long-term performance of the building (including for future residents), and risk remaining invisible to institutional actors. In doing so, they often do not translate into formal claims or actionable demands addressed to social housing providers or managing authorities, thereby limiting the possibility of transforming everyday needs into structured and collective interventions.

Figure 26: A 24-member family, Amsterdam, 1976



"We had no nightlife venues here, so at some point we started squatting in larger spaces. That way, we also held our own activities: discos, Surinamese parties... We have created our own entire infrastructure here"

"I cried for the first three weeks here; I wanted to go back, but that's not surprising; you come from a lovely warm country with nature, and then suddenly you're sitting here on the ninth floor."

Humphrey Krind, former resident of Bijlmermeer

Figure 27: Woman in the Netherlands wearing Surinamese flag



To conclude, starting from the notion of spatial ‘error,’ this research therefore arrives at the definition of the broader category of ‘human traces’, which will be adopted in the following developments as a more comprehensive interpretative framework. These traces are distinguished from spatial errors because they include not only spatial mismatches or deviations from an intended design logic, but also social, cultural, and behavioural dimensions that would be reductive to classify under the notion of “error”.

In this sense, investigating how space is experienced through sociological, demographic and cultural perspectives represents a relevant analytical dimension for the design and management of the built environment. In fact it can contribute to reframe the understanding of errors and deviant phenomena (ex. urban degradation) by moving beyond their mere spatial manifestation and addressing the underlying socio-economic causes that contribute to their emergence.

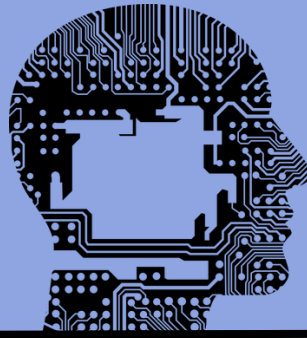
The following chapter will explore how these spatial traces can be represented and interpreted.

Figures 28-33: *ELEMENTAL*, Adaptations of the residential units of Quinta Monroy



03.

COMPUTATIONAL APPROACHES TO SPATIAL REPRESENTATION



3.1 From smart city to enabling technologies

In a context of profound housing and urban crises, a parallel technological revolution is reshaping not only patterns of interaction and social relations, but also the ways in which reality is observed, represented and acted upon. Recent advances in Artificial Intelligence (AI), computer vision, Geographic Information Systems (GIS), remote sensing, digital twins and the widespread diffusion of Internet of Things (IoT) devices have dramatically expanded the capacity to collect, process, and analyse urban data at multiple spatial and temporal scales. Rather than relying exclusively on surveys or expert observations, cities can now be understood through continuous streams of spatial and environmental information generated by sensors, satellite imagery, street-level photography, mobile devices, and digital platforms. At the same time, citizens become both the subjects and the producers of urban data, continuously generating digital and spatial information. These technologies are increasingly converging within the broader paradigm of the smart city. Even if it is not easy to identify a single definition of what a smart city is, it can be understood as a concrete urban environment or a process (BSI, 2014), in which citizen engagement, urban infrastructure and technology interact to shape a more resilient future.

As highlighted by Kitchin (2016), contemporary smart urbanism is grounded in 3 pillars:

- the city as a computable system, where urban phenomena are translated into quantifiable data and processed through models and algorithms aimed at prediction and optimisation. A key element of smart governance is evidence-based decision-making, which refers to the use of data, analytics, and digital technologies to support more informed, adaptive, and efficient public decision processes (Mills et al., 2021).
- smart cities operates through increasingly pervasive processes of datafication and algorithmic governance, in which everyday activities are continuously transformed into digital traces raising concerns regarding surveillance and transparency of data.
- the need for a renewed ethical and political reflection on how urban knowledge is produced and used, recognising that cities are not closed systems but complex, relational, and socially constructed environments.

Despite these technological advances, the implementation of smart cities has produced mixed results. Much of the first generation of smart city initiatives focused primarily on technological efficiency—optimising mobility, energy consumption, traffic management, and public services—while paying comparatively less attention to broader social dimensions and democratic governance. Recent literature has therefore criticised technology-driven approaches for assuming that complex urban challenges can be solved primarily through data collection and technological optimisation, (Akgün, Paolo Gerli, & Clare McTigue, 2024), privileging measurable phenomena over less tangible social and cultural dimensions of urban life (Kitchin, 2014). However, recent research is beginning to address this challenge by exploring more human-centred computational approaches but the field is still in its early stages. For instance, the City of Bologna is experimenting with a Civic Digital Twin approach that combines sensor data with citizen-generated information in order to support more participatory and data-informed decision-making processes (Luca et al., 2024). At an international scale, cities such as Amsterdam and Singapore have implemented digital twin systems with AI-driven simulations in urban governance (Reuters, 2024).

In this sense, citizens are increasingly positioned as active producers of urban data, generating continuous streams of information through their everyday interactions with digital infrastructures (Cardullo & Kitchin, 2019).

THE IMPLEMENTATION OF SMART CITY INFRASTRUCTURE: HOW IS IT GOING SO FAR?

As previously mentioned, several European cities have become leading examples of how these strategies can be translated into practice, building upon European initiatives such as the European Data Space for Smart and Sustainable Cities and Communities and the growing emphasis on Local Digital Twins (LDTs) through the newly established LDT CitiVERSE. These initiatives aim to promote interoperable digital infrastructures, facilitate data sharing across municipalities, and support evidence-based urban governance through common standards and shared technological frameworks. In Italy, since the launch of the National Smart Communities Plan and the Italian Digital Agenda in 2012, followed by significant investments through the PNRR, the implementation of smart city strategies has remained highly uneven across the country. Higher levels of digital maturity are generally observed in Northern Italy, while medium-sized and smaller municipalities often face administrative, financial, and technical constraints. Consequently, the ambitions of smart city risk reinforcing existing territorial inequalities if their implementation depends primarily on the resources and institutional capacity of individual municipalities. This highlights the need for scalable, replicable approaches that can be adopted across different local contexts, ensuring that digital innovation does not become a privilege of the largest or wealthiest cities but a shared opportunity for more equitable urban development.

IS THE SMART CITY ACTUALLY SMART?

However, despite these technological advancements, significant limitations remain. First of all we assist to a representational gap, in the capacity of digital systems to fully capture the complexity of urban reality. In particular, relying on partial or incomplete digital representations risks legitimising planning processes and policy decisions that do not adequately reflect the actual conditions, practices and needs of the places in which they are implemented.

At the same time, there is a risk of reframing citizenship within a data-driven logic, where participation is often instrumentalised to produce urban data rather than oriented toward meaningful political engagement or collective decision-making (Cardullo & Kitchin, 2019).

Furthermore, this issue is reinforced by persistent inequalities in access to digital technologies, commonly described as the global digital divide. According to the ITU (2023), approximately 2.6 billion people worldwide remain offline, while internet penetration in low-income countries is still significantly limited, with access rates close to 27% (ITU, 2023; World Bank, 2023). As a result, individuals who lack the necessary economic, cultural, or social resources may remain partially or entirely invisible within systems of urban data production. In addition, forms of social vulnerability—such as informal housing, precarious labour, or undocumented status—are difficult to quantify and are therefore absent in standard datasets and administrative indicators (OECD, 2020; UN-Habitat, 2022). This reinforces existing inequalities by privileging what can be captured, measured, and operationalised through data over what remains qualitative, informal, or context-dependent, as widely discussed in critical data studies and algorithmic governance literature (boyd & Crawford, 2012; Kitchin, 2014). Following a socio-technical perspective, digital technologies cannot be understood as neutral tools but they embed specific assumptions and power relations that shape how urban realities are governed (Sartori, 2015; Sartori & Bocca, 2022).

However, we also observe a representational gap, as previously discussed, as well as a perceptual gap. Despite the widespread promotion of smart city strategies, empirical research suggests that citizens often do not fully recognise or identify with the “smart city” as these initiatives frequently remain embedded within institutional, technical, or policy domains. Moreover, smart city narratives tend to operate as top-down policy and branding frameworks, contributing to a persistent gap between institutional imaginaries of “smartness” and citizens’ lived urban realities (Shelton, Zook, & Wiig, 2015). More broadly, this misalignment reflects a structural tension between technologically mediated urban governance and the inherently relational, informal, and context-dependent nature of urban life, which is not fully captured by data-centric models of the city (Kitchin, 2016).

Understanding smart cities not only as technical infrastructures, but also as cultural and narrative constructions can help shaping urban environment (Jasanoff & Kim, 2015). Socio-technical imaginaries can play a fundamental role in shaping both the development and the perception of digital technologies such as artificial intelligence and smart urban systems (Sartori & Bocca, 2022). These imaginaries—understood as collectively shared visions of desirable technological futures—can help structuring policy agendas, institutional strategies and public expectations, often influencing technological design long before any material implementation occurs. Consequently, digital technologies can:

- 1- BE UNDERSTOOD AS CONTESTED INFRASTRUCTURES that require collective deliberation and critical engagement.
- 2 - SUPPORT, RATHER THAN SUBSTITUTE, participatory and qualitative approaches to urban knowledge production.
- 3 - ENABLE THE REPRESENTATION of multiple urban perspectives and lived narratives.

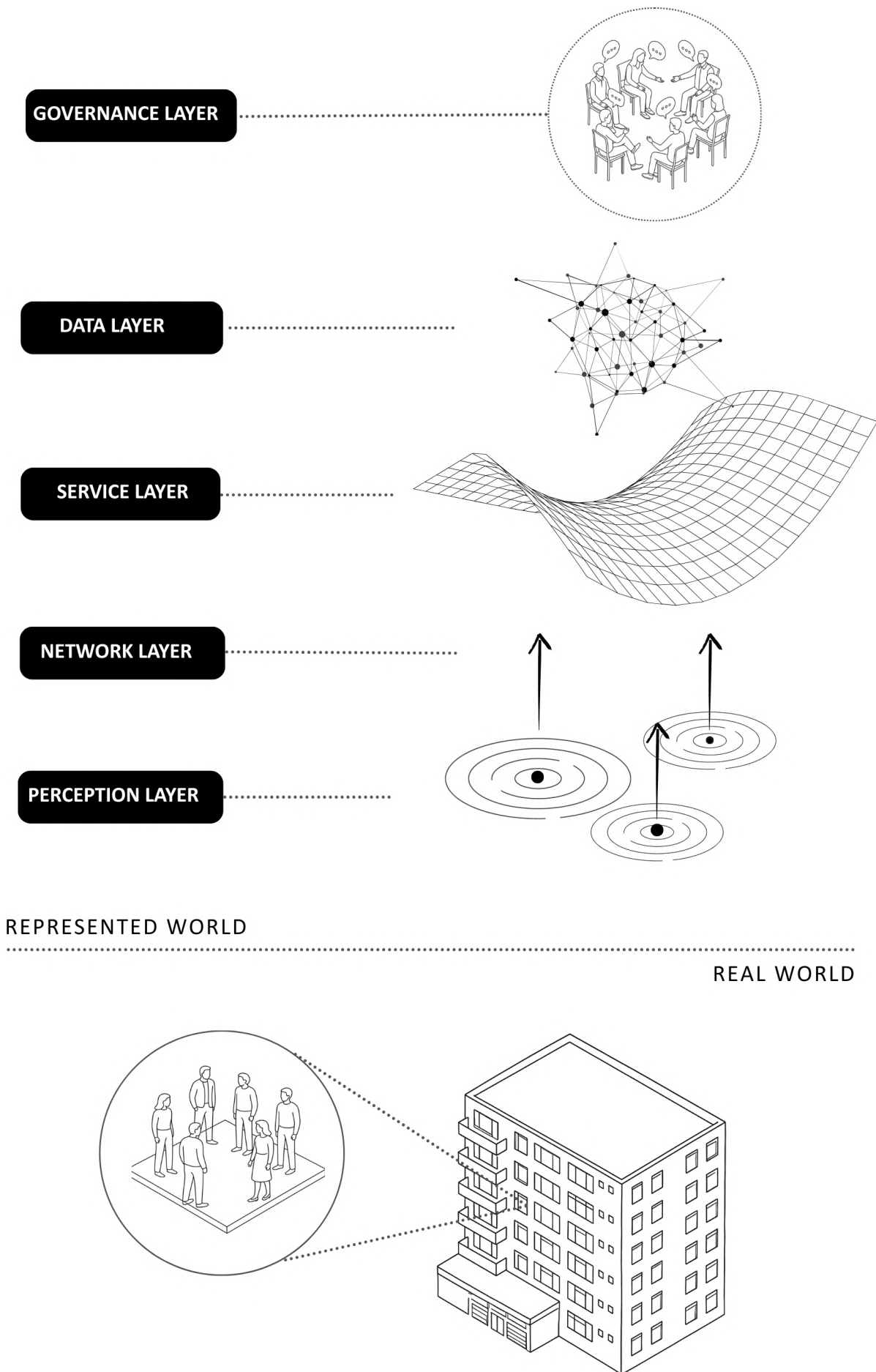


Figure 34: Schematic representation of the smart city and its interconnected layers.

3.2 Technologies as mediators

Technology can therefore play a fundamental role in collecting, processing, and delivering information. To better define its role within this research, it is first necessary to examine the different types of technologies involved and their potential to represent new forms of vulnerability and capture unmapped aspects of the lived space.

EMERGING TECHNOLOGIES

Even if, a gap between theoretical research and practical policy implementation remains, technological advancements in urban applications have been rapidly increasing. In particular, the exponential growth of heterogeneous data in contemporary urban systems has exceeded the capacity of traditional data management approaches, thereby requiring more advanced technologies for efficient processing and organisation (Mills , Steven, Pevcin, & Dvorak, 2021). For example, Big Data Analytics can manage a large amount of data, enabling predictive analysis, maintenance strategies and real-time decision-making, while IoT infrastructures collect data (Feng , et al., 2018). The integration of IoT and BDA ensures effective data processing, storage, and insight generation across smart city services (Ahmed , et al., 2017) , leveraging diverse data sources to improve planning, management, and sustainability. In this scenario, the adoption of 5G networks is central to digital transformation in smart cities, offering massive connectivity that enables large-scale IoT integration and enhanced public services (Skouby & Lynggaard, 2014)

The availability of these technologies of course has a direct impact not only on the urban application (transport, energy, etc) but also on building sector and showing potential the way the housing stock, especially when public, having one manager, could offer. Some of these technologies could be considered part of the Key Enabling Technologies (KETs), 6 groups of technologies introduced in 2009 by the European Commission seeking cross-sectoral innovation and long-term economic impact. These 6 domains include advanced manufacturing and materials technologies, life sciences, micro- and nanoelectronics, photonics, artificial intelligence, as well as security and connectivity technologies (European Parliamentary Research Service, 2021). The division proposed by Dipali et al. (2025) (Figure 34) for the application of KETs in urban contexts is adopted as a reference framework to understand how these technologies could interact and their application in the housing sector.

However, considering recent developments this framework has been updated with the complementary introduction of Key Digital Technologies (KDTs), highlight a shift of focus: from industry toward an integrated framework. Some of the factors contributing to this phenomenon include the rapid evolution of digital technologies, the intensification of global technological competition and the growing importance of the digital and sustainable transformation (European Commission, 2021).

The 2025 report by McKinsey & Company, highlights these trends, which show how technological progress is changing governance models, and socio-economic dynamics:

- **The rise of autonomous systems** introduces new forms of spatial organization and urban management. Autonomous robots and digital agents are no longer limited to executing predefined tasks; rather, they are increasingly capable of learning, adapting, and collaborating. For this reason, they are increasingly embedded in logistical infrastructures, service provision and even decision-making processes.
- **Emerging models of human–machine collaboration** are redefining how individuals interact with both technology and the urban environment. The shift toward immersive interfaces, adaptive systems, and context-aware technologies suggests a transition from passive use to active co-production, However, this also implies a growing dependency on technologically mediated experiences of space.
- **Technological innovation reveals a critical tension with sustainability.** The increasing demand for computational power places significant pressure on energy systems, land use, and infrastructure. In fact, data centers have a tangible spatial footprint, often externalized away from the urban centers that benefit from them. This spatial displacement can generate social and territorial inequalities, as the environmental and infrastructural burdens are unevenly distributed. Moreover, the presence of regulatory and logistical barriers highlights how technological deployment is deeply embedded in political and institutional frameworks.

3.3 AI for humans or humans for AI?

According to the 2025 report by McKinsey & Company identifying 13 major technology, particular attention must be given Agentic AI, artificial intelligence more broadly, immersive reality technologies, as well as energy and sustainability technologies, can have a direct impact on the urban and architectural domain, reshaping the way cities are designed, managed, and experienced. This technology has followed a rapid growth and expansion, also thanks to its broad application and to the large amount of investments: only between 2022 and 2024, +919%, signaling its potentially revolutionary capabilities (McKinsey, 2025).

However, EU continues to lag behind China and the United States in key technological domains¹. This gap is primarily attributed to insufficient levels of research and development funding, especially from the private sector, a shortage of highly qualified technological skills, and the lack of globally competitive industrial leaders within key KET sectors. Moreover, much of the data generated within Europe is currently stored and processed outside its borders, with a substantial share of its economic value also being extracted elsewhere (European Commission, 2021).

Moreover, its application is highly pushed by EU Union Address, as highlighted in 2030 Digital Compass, that foresees the development of an European ethical artificial intelligence, contributing to more efficient resource management and helping the digitalisation process². In particular, it is necessary to make this distinction:

ARTIFICIAL INTELLIGENCE (AI): The broad discipline of creating systems capable of performing tasks that normally require human intelligence, including reasoning, planning, learning, perception and decision-making. AI includes both rule-based systems and learning-based approaches.

MACHINE LEARNING (ML) : A subset of AI in which algorithms automatically learn patterns from data instead of being explicitly programmed. ML typically relies on structured datasets and statistical learning to make predictions or classifications.

DEEP LEARNING (DL) : A subset of Machine Learning based on deep artificial neural networks. Unlike traditional ML, it automatically learns hierarchical features directly from large amounts of raw data (images, audio, text) without requiring manual feature engineering.

VISION-LANGUAGE MODELS (VLMS) : A specialised class of deep learning models that jointly process visual and textual information. They combine computer vision and natural language understanding to interpret images, reason about visual content and generate language-based outputs.

Recent developments in computer vision and Vision-Language Models (VLMs) have significantly expanded the analytical capacity of urban studies by enabling the automated interpretation of large-scale visual datasets. These technologies are designed to extract structured information from images—such as street-level photography, satellite imagery, and drone data—and translate visual inputs into measurable urban features. In particular, deep learning architectures allow systems to identify and classify elements of the built environment, including building façades, street furniture, vegetation, infrastructure conditions, and visible signs of maintenance or decay but also urban activity patterns (Ibrahim, Haworth, & Cheng, 2020).

More recent developments in Vision-Language Models extend this capacity by integrating visual perception with natural language reasoning, enabling systems to not only detect objects within urban scenes but also generate semantic descriptions and contextual interpretations of spatial environments.

However, despite their analytical power, these systems remain fundamentally dependent on the quality, distribution, and representativeness of visual data, which introduces inherent biases in the way cities are interpreted and modeled.

1 From Mario Draghi speech at Politecnico di Milano: *“Last year the United States produced forty major foundation models, China fifteen, and the European Union only three.”*

2 Digitalisation is framed as a key enabler of rights and freedoms, allowing individuals and organisations to operate beyond territorial, social, and institutional constraints. It opens new opportunities for learning, working, social interaction, and economic participation, thereby expanding access to resources and capabilities (European Commission, 2021).

Nevertheless, their potential lies in their ability to scale urban analysis across large territories, enabling automatic monitoring of spatial change and providing new forms of computational urban knowledge that were previously inaccessible and resource-intensive through traditional qualitative methods.

Despite their growing use in urban studies, computer vision and Vision-Language Models introduce significant limitations. A central critique concerns the fact that such systems tend to produce partial and selective representations of the city, as they rely on datasets that are unevenly distributed across space and social groups. As a result, certain areas and populations are overrepresented—typically those that are digitally visible and well-documented—while others remain underrepresented or entirely absent from computational analysis (Shelton, Zook, & Wiig, 2015). Another important limitation concerns the interpretative capacity of these models. Although recent advances in computer vision and Vision-Language Models have significantly improved automated image analysis, their understanding of urban environments remains more limited than that of human observers and is strongly influenced by factors such as image quality, viewpoint, lighting conditions, and the characteristics of the training data (Vanky & Le, 2023). However, the challenges associated with these technologies extend beyond their technical limitations in interpreting data. Their deployment also raises broader ethical, social, and political risks that must be carefully considered.

RISK AND LIMITATIONS

ETHICAL LIMITS

The deployment of these technologies has raised considerable doubts, including from within the industry itself (Shepardson, 2020), particularly regarding the lack of transparency surrounding their use, their questionable accuracy (Hill, 2020; Lee, 2020), and the broader ethical implications associated with their application. For example, camera technologies can be used for policing and security purposes through the same underlying algorithms, raising ethical concerns among civil rights groups. In Singapore, around 80,000 cameras are installed across public spaces, many of which can perform real-time video analysis to detect potential threats (Lin & Purnell, 2019). Similarly, major technology companies such as Amazon, IBM, Microsoft, and Verizon provide surveillance tools that enable law enforcement agencies to analyse and combine multiple video sources for real-time monitoring of public spaces. In New York, for instance, police collaborations with Microsoft have introduced camera systems designed to detect “suspicious behaviour” (Stanley, 2019).

Across Europe, the deployment of facial recognition and AI-enabled surveillance systems remains primarily used for border control and experimental policing applications. Countries such as France, Germany, Spain and Italy tend to limit the use of AI surveillance to behavioural analytics and mobility monitoring rather than direct identification (CNIL, 2023; European Commission JRC, 2022). However, as demonstrated by the adoption of the EU AI Act, regulatory frameworks must keep pace with technological development in order to protect citizens’ privacy and fundamental rights.

ENVIRONMENTAL:

The rapid expansion of artificial intelligence, computer vision, and Vision-Language Models has also raised increasing concerns regarding their environmental sustainability. Training large deep learning models relies on high-performance computing infrastructures that consume considerable amounts of electricity and generate significant greenhouse gas emissions, particularly when powered by carbon-intensive energy systems (Strubell, Ganesh, & McCallum, 2019). The adoption of technological strategies within urban contexts therefore requires consideration of the intensive resource consumption generated by data centres, and the development of approaches capable of mitigating their environmental impact.

According to the International Energy Agency (2024), conventional data centres typically consume electricity comparable to that of 10,000–25,000 households, whereas hyperscale AI-oriented facilities may require electricity equivalent to more than 100,000 households (Gorey, 2025). The IEA further projects that global electricity demand from data centres will continue to increase rapidly over the coming years as AI applications become more widespread.

Beyond energy demand, AI systems consume water, raw materials, land and produce electronic waste.

For example, recent research estimates that AI-related infrastructures could consume around 5 billion cubic metres of freshwater annually by 2027, largely due to cooling requirements and electricity generation, while data centres may account for 3–4% of global electricity consumption by 2030 if current growth trends continue (European Commission, 2026; Li et al., 2023).

Moreover, data centers are responsible for the “data heat island effect” showing persistent temperature anomalies around major AI facilities (Marinoni et al., 2026). At the same time, the European Commission highlights that this

waste heat could potentially become a valuable resource if integrated into district heating systems, water purification processes or carbon capture technologies, illustrating how circular approaches may partially mitigate the environmental footprint of AI infrastructures (European Commission, 2026).

Consequently, adopting technological strategies for urban applications also requires anticipating and managing the intensive demand for energy, water, and computational resources generated by the data centres that underpin these systems.

SOLUTIONISM:

Any engagement with AI and smart city technologies in the context of social housing must reckon seriously with a risk that is structural rather than incidental: the risk of what Evgeny Morozov defined as solutionism. The term, which Morozov borrowed from architecture and urban planning, describes the tendency to recast complex social situations as neatly defined problems with definite, computable solutions — “recasting all complex social situations either as neatly defined problems with definite, computable solutions or as transparent and self-evident processes that can be easily optimized — if only the right algorithms are in place” (Morozov, 2013). More precisely, solutionism presumes rather than investigates the problems it claims to solve, reaching “for the answer before the questions have been fully asked.” (Dobbins, 2009).

What was stated in 2013 remains highly relevant when examining the evolution of technology up to the present day. Contemporary developments in artificial intelligence, particularly LLM models, have significantly narrowed the perceived boundary between human and machine intelligence, evoking futures that were once confined to speculative or science-fiction imaginaries by Asimov or

Lisberger, in which human cognitive capacities are progressively simulated or, in some cases, substituted by computational systems.

The main risk lies in becoming seduced by the apparent effectiveness and immediacy of these tools, without critically questioning whether fast, measurable, and optimised solutions can genuinely address problems that have persisted for decades¹. In fact, while computational systems excel in processing, prediction and optimisation, they remain structurally limited in their capacity to interrogate the social, political, and historical conditions. In the housing sector, it translates into a focus on efficiency and performance metrics, rather than on the structural causes of inequality, exclusion, and spatial vulnerability.

Morozov explicitly situates solutionism within a longer intellectual tradition, identifying it as the same logic that Jane Jacobs had attacked in the orthodox urban planning of her time. As argued in the first chapter of this research, the modernist planning failures of the post-war decades were produced by exactly the same epistemological move: the assumption that a sufficiently rational technical apparatus could define the problem of urban life, compute its solution, and implement it from above, without the participation of those whose lives would be shaped by the result. Solutionism, in this reading, is not a new phenomenon but it is the application of an error that architecture and urban planning have already made.

Solutionism, as Morozov observes, does not undervalue solutions in themselves and for this reason this research doesn’t start and end with revolving around the potential application of AI central in the housing governance, but the evidence reviewed in this chapter demonstrates that it can, and already has been, in technically impressive ways. For this reason, this research does not aim to propose direct solutions for improving the quality of social housing or responding operationally to the needs of residents. Nor does it focus on the development of new AI applications for housing governance, since, as the reviewed case studies demonstrate, a wide range of such applications already exists and will likely continue to expand in the future.

Instead, the research investigates the reading of space and the use of AI as a tool capable of supporting alternative forms of spatial interpretation. In this sense, AI is not understood as a definitive solution, but best option to explore different layers of urban reality. However, this technology is inherently necessary or irreplaceable but the possibility that other tools may prove more appropriate in addressing the representational challenges identified within the research, remains open.

1 “We must not fixate on what this new arsenal of digital technologies allows us to do without first inquiring what is worth doing.” (Morozov, 2013).

3.4 Case Studies :

A selected set of case studies will help to better understand how AI technologies have been applied to the urban domain to date. The analysis will focus on three technologies directly related to AI-based models, alongside one digital twin example used as a benchmark for large-scale urban solutions. This latter case is included to provide a broader reference framework, illustrating how AI-related approaches can be integrated into more complex, system-wide urban infrastructures. **The case studies were selected to explore a heterogeneous range of approaches to the application of technology in the representation of the lived environment.**

Particular attention is paid to both the risks associated with these tools and the objectives they pursue, as well as the aspects of the lived environment they seek to represent. In this way, the analysis aims to understand how these technologies contribute to the construction of more complex and articulated narratives of reality, also through their potential integration with participatory processes. Finally, an assessment of the associated risks is presented, in order to qualitatively evaluate the extent to which the potential drawbacks of these approaches may be considered invasive in relation to the benefits they provide.

01 - AI-BIM INTEGRATION

The integration of Artificial Intelligence (AI) with Building Information Modelling (BIM) allows to move from static digital modelling toward dynamic, data-driven decision-support systems. According to Attia (2025), AI-BIM integration enhances multiple dimensions of construction processes, including design automation, structural and energy performance analysis, cost estimation, scheduling, and facility management. AI enables the extraction and analysis of large datasets within BIM environments, supporting predictive modelling and improving coordination between architectural, structural, improving overall resource efficiency.

The article develops these claims through a comparative case study approach, contrasting a technologically integrated project—the Cleveland Clinic Abu Dhabi—with a traditionally managed hospital project in Dammam. In the integrated case, BIM and AI were used to support real-time decision-making, optimize energy and patient-flow systems, and improve facility management through predictive maintenance and data analytics. The results show significant performance improvements, including a reduction in design revisions, shorter approval cycles, lower costs, and improved construction quality compared to conventional methods (Attia, 2025).

However, the study also highlights critical challenges associated with AI–BIM integration, such as the need for advanced digital infrastructure and the upskilling of professionals. Moreover, these systems are primarily designed to enhance project efficiency and often focus on the optimisation of environmental and performance-based parameters. These models can represent and control quantifiable environmental parameters but they're not able to represent the complexity of social, economic and cultural factors that influence the life of the users. Moreover, this raises broader concerns about the loss of a holistic approach to design that determines the architectural quality.

02 - URBIA

One of the emerging applications of AI in the urban field is the UrbIA project developed by the University of Bologna (Mirko Degli Esposti, et al., 2025), exploring the multimodal AI systems for large-scale urban observation and analysis, extending the role of urban AI beyond simple representation towards forms of interpretation and decision-support. The project, conducted across six major Italian metropolitan areas — Rome, Bologna, Florence, Milan, Naples and Palermo — is currently be expanded and tested in many other European cities.

The data have been collected by the “Humarels”, 500 Human-scale Relational Agents per city sampling multiple panoramic viewpoints through the Google Street View Static API, using controlled camera parameters to capture targeted urban metrics observations of the urban environment through. The analysis of the images focused on Pavement Condition (PCI): , Façade Condition (FDS), Green Presence and Graffiti Index (presence of graffiti) and Urban Canyon Index (measuring the perceived enclosure of the street space,), aspects that were processed through GPT-4 Vision-based assessment, transforming visual observations into georeferenced urban metrics.

The resulting dataset allows the construction of comparative analyses focused on spatial heterogeneity, urban gradients and correlations between different urban conditions. In particular, the research investigates how visual and infrastructural qualities vary across metropolitan territories and how these variables interact within complex urban systems.

Beyond its technical implementation, UrbIA is particularly relevant because it exemplifies a broader shift within contemporary urban AI: the attempt to translate visual and spatial characteristics of the city into measurable and computationally interpretable data. The project demonstrates the growing capacity of AI systems to perform large-scale readings of the built environment, while simultaneously raising questions regarding what aspects of urban reality

become visible through these methods, and which dimensions remain excluded from computational representation. Although UrbIA successfully captures physical and perceptual characteristics of urban space, the system remains primarily focused on observable spatial conditions and measurable environmental indicators. Intangible social dimensions have not been detected yet and a lot of potential of this tool could still be implemented.

03. DIGITAL TWINS

Digital twins have become a central component of contemporary evidence-based urban governance and (European Commission, 2024). However, the most mature applications of digital twins have primarily focused on environmental and climate-related challenges. Alongside these technically oriented applications, increasing attention is being devoted to the development of participatory digital twins, although these initiatives remain at an early stage of implementation.

The Rotterdam case clearly illustrates this shift in direction. Initially developed as a 3D urban model integrating geospatial data, IoT sensors, and real-time urban information, the digital twin was designed to support urban planning, climate adaptation, and infrastructure management. Rather than functioning as a standalone tool, it has progressively become part of the Open Urban Platform (OUP), a city-wide data ecosystem that connects municipal services, research institutions, private actors, and civic applications into a shared digital infrastructure (Gemeente Rotterdam, 2025).

However, empirical research on earlier participatory pilots reveals significant limitations. The study by De Jaeger and Swerts (2026) on the Rotterdam Urban Digital Twin pilot demonstrates that citizen participation was constrained by multiple structural barriers, including digital exclusion, limited digital literacy, language barriers, and weak trust in municipal institutions. Participation was also largely mediated through traditional recruitment channels such as postal invitations and existing neighbourhood associations, which systematically excluded harder-to-reach populations, including younger residents. Even when participatory tools were available, citizens often lacked the ability or resources to engage effectively, for example due to difficulties using QR-code-based interfaces or understanding the digital tools provided. Moreover, the study highlights a fundamental issue of institutional non-integration, as citizen input was not always clearly embedded in formal decision-making processes, limiting its actual influence on planning outcomes (De Jaeger & Swerts, 2026).

In summary, digital twins are increasingly emerging as promising tools for supporting citizen participation and more transparent urban governance. However, not only we assist to challenges related to inclusiveness, accessibility, but also participatory processes are still predominantly consultative rather than co-creative. Citizens are generally invited to review, comment on, or validate predefined scenarios, rather than actively contributing to the construction of narratives, and visions that shape urban futures. As a result, many participatory digital twins focus primarily on gathering feedback and legitimising planning proposals instead of fostering the collective production of knowledge and shared urban imaginaries. This raises broader questions about whether these technologies truly democratise urban governance or simply digitalise existing participatory practices without fundamentally redistributing decision-making power.

04 - AI- CITY

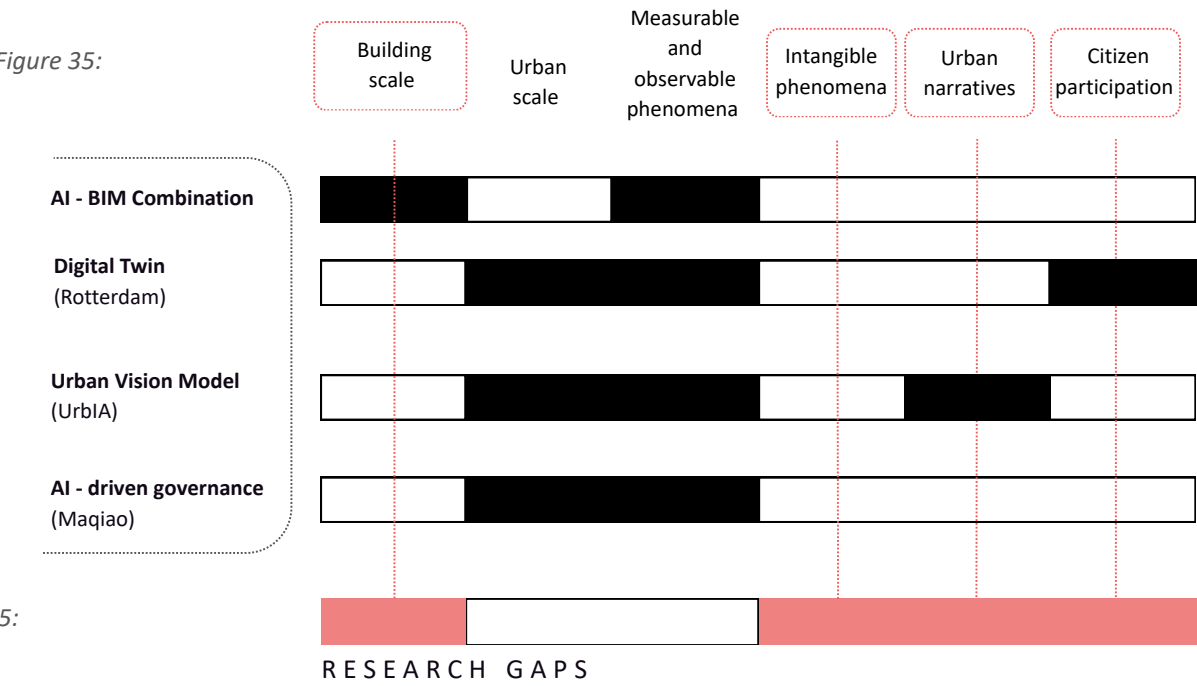
The Shanghai Maqiao AI Innovation Experimental Area represents China's first large-scale attempt to design a fully AI-integrated urban district, conceived as a prototype for future "AI cities." Located in Minhang District in Shanghai, the project aims to integrate artificial intelligence across the entire urban lifecycle, including planning, construction, governance, and daily operation (Zhiqiang, 2025)

A central feature of Maqiao is the establishment of an "urban brain" system, which integrates sensing, decision-making, response, and learning functions into a unified governance infrastructure. This system enables real-time data collection and analysis across multiple urban domains, supporting what the project defines as intelligent governance. The pilot zone is also designed as an experimental ecosystem for AI-driven urban life, where technologies are applied in scenarios such as mobility, healthcare, education, tourism, and public space management. Public environments like squares and parks are transformed into interactive spaces capable of sensing crowds, generating personalised experiences, and responding dynamically to user needs. This reflects a broader shift toward what the project describes as a transition from "everything connected" to "everything conversing."

The AI-driven system influence directly the environmental governance. For example, the system monitors air quality, carbon footprints, and ecological indicators in real time, linking environmental data to citizen-facing applications that can also influence household-level responses (e.g., smart home adjustments).

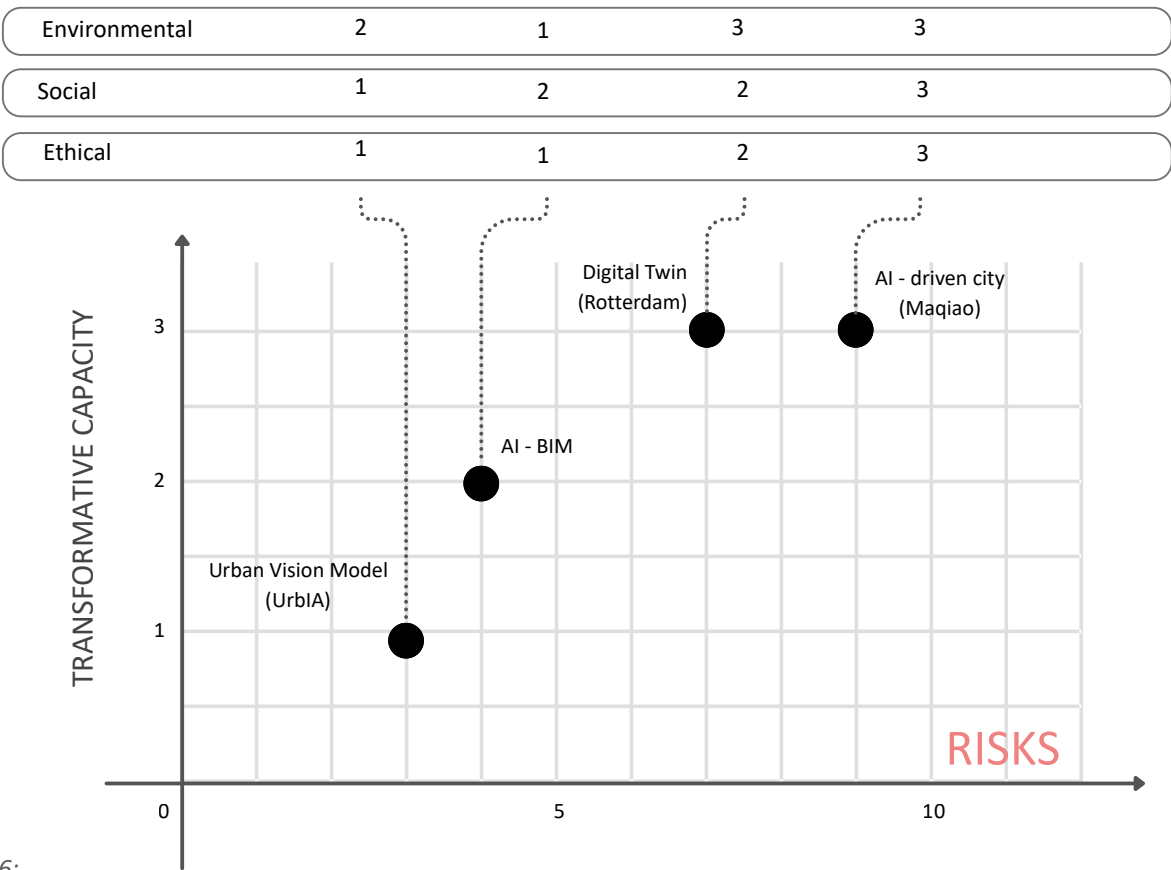
AREAS FOR FURTHER DEVELOPMENT

This matrix identifies research gaps and the areas covered by the case studies. The fields addressed by each individual case study are highlighted in black.



RISKS EVALUATION

This analysis compares environmental and social risks, as well as the risk of falling into solutionism, with the transformative capacity of each example. It suggests that these two dimensions tend to be proportional.



However, this case study presents several problematic aspects. Maqiao reframes urban governance as a continuous computational process in the hand of AI systems, raising concerns about the opacity of decision-making processes, as urban choices become increasingly embedded in algorithmic infrastructures that are not easily contestable or interpretable by citizens.

Moreover, Maqiao explicitly defines itself as an experimental zone, where technologies are tested in real urban conditions where citizens simultaneously are users, data producers, and experimental subjects. This raises questions related to transparency and the status of citizens.

Finally, the Maqiao model assumes that AI can objectively improve urban governance, but in practice it embeds specific assumptions about:

Finally, the Maqiao model assumes that AI can objectively improve urban governance, but in practice it embeds specific assumptions about:

- efficiency as the primary urban value
- predictability over uncertainty
- optimisation over negotiation

EVALUATION AND RESEARCH POSITIONING:

Furthermore, the analysis of the case studies reveals a strong predominance of approaches based on quantitative data and directly observable phenomena, highlighting a structural difficulty in capturing qualitative and intangible dimensions such as cultural, social and relational aspects of urban space. Within this framework, only the UrbIA model explicitly attempts to include and interpret elements that are typically excluded from conventional datasets, contributing to a more complex and layered representation of urban reality. Nevertheless, even in this case, such approaches remain partial, as they do not yet fully integrate the human component within interpretative and decision-making processes.

A further critical issue concerns participation. Apart from the Rotterdam case, most of the analysed technological don't consider the involvement of citizen in their computational model, resulting in a top-down approach.

Overall, three main categories of risk can be identified across the case studies. Each category is assessed using a qualitative three-point scale (1–3).

- Environmental risks, associated with the increasing scale of digital infrastructures and the consequent rise in energy consumption and material resource demand;
- Social risks, related to technological solutionism and the progressive reduction of urban complexity into automated systems with limited human mediation;
- Ethical risks, concerning the collection, management, and pervasive use of personal and sensitive data.

The comparative analysis further suggests that risk levels tend to increase in relation to the transformative capacity of each technology (assessed using a qualitative three-point scale 1–3). In particular, highly AI-driven systems applied to urban governance, such as the Maqiao case, demonstrate strong operational effectiveness but also significant critical issues in terms of control, transparency, and socio-political implications. Conversely, more limited Urban Vision models tend to have a lower transformative impact, but also present reduced risks in terms of privacy, data use, and systemic control potential.

The research is therefore structured around the following objectives:

- It focuses on the building scale within social housing contexts, due to its strong social and everyday life dimensions and its connection to broader urban dynamics. In fact, considering a large building stocks, publicly managed social housing, significant opportunities for application emerge.
- It aims to develop processes and systems capable of generating narratives of everyday urban reality, adopting original perspectives that are closely grounded in lived conditions and real-world urban issues.
- It seeks to explore new forms of participation and representation that are transversal, inclusive and capable of capturing diverse urban experiences.
- It builds upon the analytical capabilities of an Urban Vision model, selected as the most suitable technological approach due to its ability to interpret photographic data and, consequently, the lived spatial environment.
- It emphasizes the continuous integration of collected and analysed data with validation processes grounded in real human experience and interpretation.

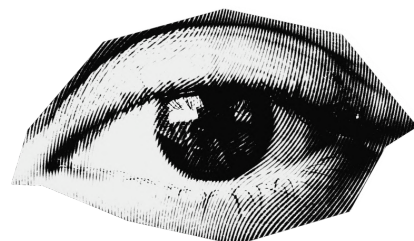
Figure 37: Representation of the core components of the proposed Building Data Management Framework

Single-building (housing) scale.



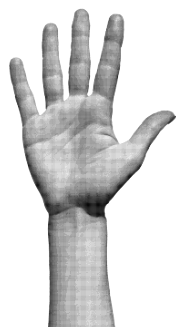
01

02



An alternative narration of the urban experience incorporating original point of views.

03



Development of cross-cutting methods for participation and representation.

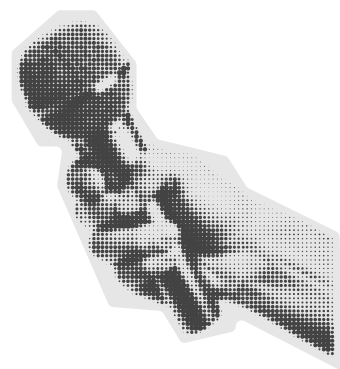
04

Leveraging an Urban Vision model due to its capacity to interpret and analyse images, combined with relatively low associated risk.



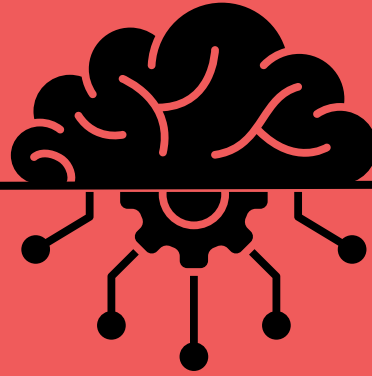
05

Ensuring data validation through human interpretation and participatory practices.



04.

A BUILDING DATA MANAGEMENT FRAMEWORK



As previously discussed, dealing with a built housing heritage that requires proper management not only in terms of quantity and provision, but also in terms of quality, which is often lacking. However, top-down approaches tend to fail and often generate additional problems. Bottom-up approaches are limited in scale and remain highly localized, while intermediate models such as Living Labs demonstrate significant potential but also important limitations, mainly related to participation processes and resource allocation. In this context, a growing diffusion of technologies can support faster and more cost-efficient processes, even if a lot of ethical, environmental and social concerns are raising.

To address this initial problem, the research aims to develop a process capable of integrating computational analysis with participatory components. The core of the analysis lies in extracting, through Urban Vision-based observation models, information about spatial use related to residential buildings and their surrounding context.

From patterns of spatial use, and drawing on the theoretical framework of spatial “errors” and more broadly “human traces,” it is possible to derive cultural and social data as well as insights into real human needs. This approach seeks to adopt a democratic and horizontal perspective, aiming to capture people’s voices primarily through their natural occupation of space. In fact, in housing management, and more broadly in urban planning methodologies, not only are such data largely absent, but also comprehensive information regarding the physical characteristics and conditions of the building stock is also often lacking. As a result, decision-making processes frequently rely on incomplete information, and any intervention should therefore allocate a significant amount of resources to the collection and analysis of missing data.

4.1 Structuring the Process

This research aims to establish a methodological and analytical framework capable of systematizing and integrating different forms of spatial-use data into a coherent decision-support system for public authorities. This BDMF is conceived as both a theoretical and operational model for the management of publicly owned and managed housing assets. Its purpose is to support public institutions in understanding how residential spaces are used, perceived, appropriated and maintained over time.

The space is conceived as a book upon which human traces are inscribed. Those constitute the spatial and direct expression of the needs, behaviors and cultural practices of its inhabitants. In this scenario, the BDMF functions as an analytical lens for interpreting spatial, social, and behavioral traces that are otherwise difficult to quantify.

The direct objective of this research is to design a methodology capable of gathering relevant information in a rapid, scalable, and continuously updated manner could generate broader benefits for housing management.

Moreover, even if the framework is developed in relation to public housing, the versatility of the collected data and the flexibility of the proposed methodology allow its application to a broader range of building typologies and urban contexts - like schools, public facilities, community centers.

A HYBRID NATURE:

1) COMPUTATIONAL SYSTEM: The proposed system integrates computational methods by leveraging their analytical capabilities in terms of speed, scalability, and traceability of evidence. The objective is to automate processes as much as possible in order to reduce both time and resource consumption.

Within this framework, the use of computational models includes Vision-Language Models (VLMs), such as those employed in the Urb-IA system, as well as alternative machine learning approaches. In the proposed workflow, two different models will be evaluated with different functions:

Image interpretation & data extraction : the VLM (GPT-4 Vision model) based on the UrbIA model, can interpret images semantically and describe urban conditions producing qualitative or semi-structured outputs.

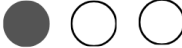
Data cross-analysis & spatial relations : MML Multimodal can performs statistical analysis, clustering and spatial correlation to detect structured interdependencies between variables and locations.

However, it is important to clarify that the intention is not to promote or depend on any specific technological solution. This choice is grounded, first, in the nature of the research, which focuses on procedural and methodological development rather than on technological implementation or laboratory-based experimentation. Such implementations may be developed in subsequent phases of research.

Second, this position aims to avoid falling into a solutionist logic, where emphasis is placed on technology itself rather than on the underlying needs and conditions it is meant to address. If the proposed process can be implemented through non-computational or alternative methods, its validity remains unchanged.

The case study presented in the following chapter, tested through empirical and analogical methods, demonstrates precisely this principle: the robustness of the process is independent of the specific technological framework employed.

Table 1. Comparison between VLMs and MML systems.

	VLM (eg. GPT-4V)	Multimodal ML (MML)
		
Semantic understanding	It understands and describes images in semantic terms	It converts images into numerical representations
Interpretation of Images	Language descriptions and structured qualitative labels.	Numerical vectors or predefined classification labels.
Output type		
Scalability	Less efficient for large-scale batch processing.	Optimized for large datasets and automated processing
Reproducibility	Lower (outputs may vary between runs)	Higher (consistent and stable outputs).
Use in analysis	Useful for qualitative interpretation.	Useful for analysis, clustering and statistical modelling.

2) PARTICIPATORY SYSTEM: recognising both the strengths and the limitations of data-driven systems, a participatory component is implemented through the Living Lab methodology, complementing computational analysis with contextual knowledge and lived experience. While computational models can efficiently identify patterns and generate evidence-based insights, they cannot fully capture the social, cultural, and experiential dimensions that shape the everyday use of space. The Living Lab therefore provides a structured environment in which these dimensions can be validated and enriched by residents and other stakeholders.

If this knowledge is systematically documented and reintegrated into the computational workflow, it can continuously train the AI system, improving its interpretative capabilities while supporting the development of more context-specific and socially grounded solutions.

The Living Lab is adopted because of its structured and research-oriented methodology, its ability to foster horizontal collaboration among different stakeholders, and its capacity to generate reliable and actionable knowledge through participatory processes. This makes it particularly suitable for bridging computational intelligence with human experience, creating a continuous feedback loop between data, interpretation, and decision-making.

DESIGN PRINCIPLES

The BDMF framework is guided by the following principles:



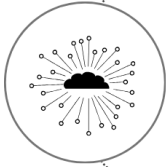
FLEXIBILITY AND SCALABILITY:

enabling the rapid collection and processing of data across large housing stocks across different contexts while maintaining sensitivity to local and site-specific conditions.



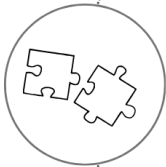
TRACEABILITY

an evidence-based decision making minimizes subjective interpretations and reduces human biases through transparent analytical processes.



DATA INTEROPERABILITY:

ensuring that collected datasets can be linked, compared, and continuously updated over time.



REPRESENTING TANGIBLE AND INTANGIBLE DIMENSIONS

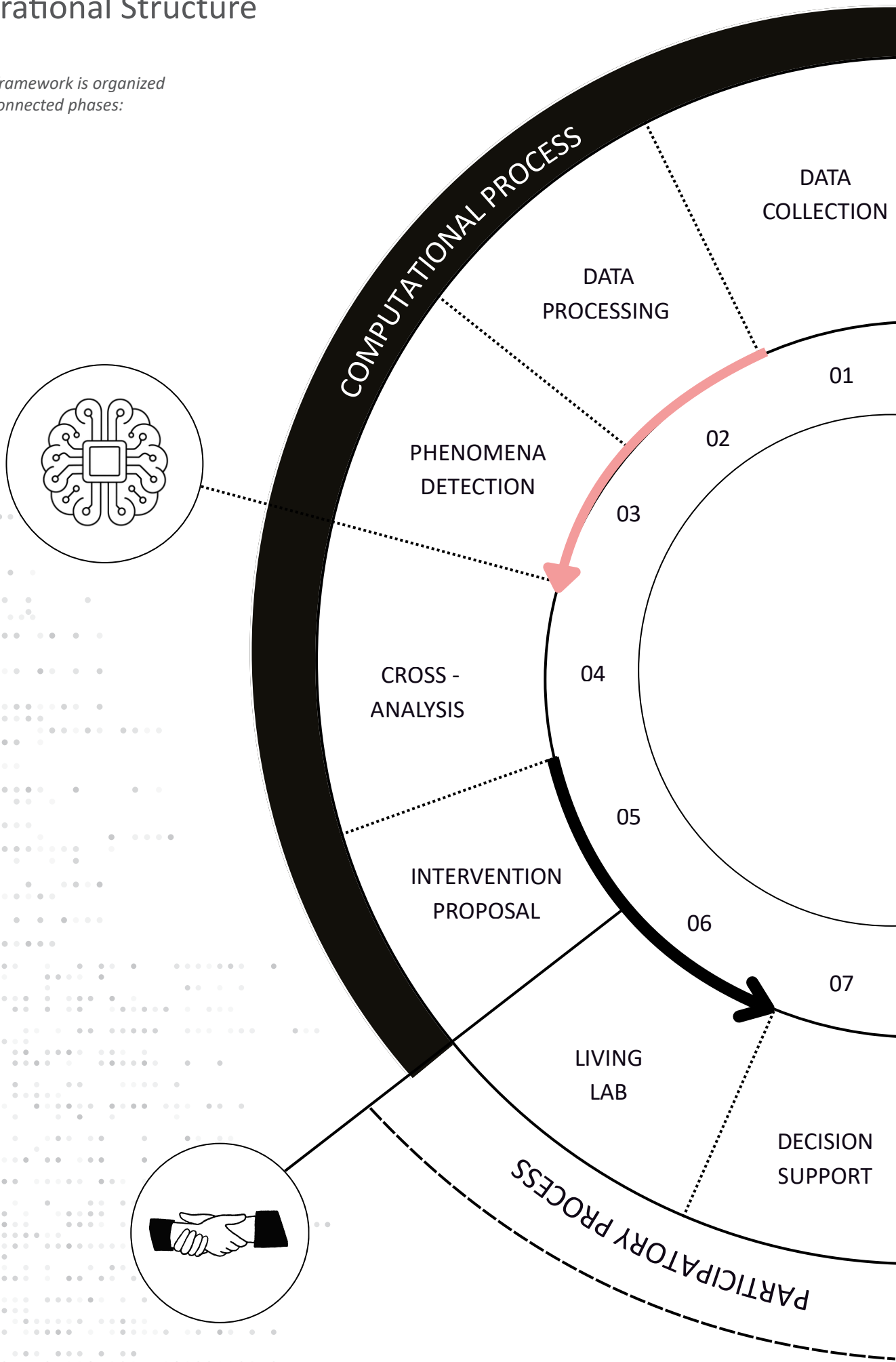
enriching existing spatial and physical data with social, behavioral and perceptual information.

USERS AND STAKEHOLDERS INVOLVED

The primary user of the system is the public authority responsible for housing management, planning, and maintenance. Public institutions act as both the main beneficiary and the principal decision-maker informed by the framework. However, the process also relies on the active participation of residents and local communities. Citizens are not considered merely subjects of observation but contributors to the production and validation of knowledge. Through participatory processes, surveys, feedback mechanisms, and collaborative forms of data verification, residents become essential actors in the construction of a more accurate understanding of everyday spatial practices.

4.2 Operational Structure

Figure 38: The framework is organized around 7 interconnected phases:



01. DATA COLLECTION



Figure 39: Phase 1

GOAL: Collecting data through multiple sources to create a comprehensive understanding of both the physical and social dimensions of housing environments.

OUTPUT: Dataset of images, information on flows and occupancy.

PROCESS: The framework collects and analyzes data across two interconnected spatial dimensions:

Analysis at the Housing Estate Level – AOB (Area of the Building) : This scale focuses on the residential building or housing estate itself, examining its physical characteristics, spatial configuration, patterns of use, maintenance conditions, and the interactions between residents and the built environment.

Analysis of the Surrounding Area – AOI (Area of Interest): This area of approximately 1 km², centered on the residential building under consideration, includes in the analysis the local network of services in the immediate surrounding of the housing estate. The choice of this spatial extent is informed by the concept of the 15-minute city, which promotes access to everyday services and opportunities within a short walking distance from one's residence.

The decision to adopt this dual-scale approach stems from the recognition that housing cannot be understood as an isolated entity. Examining both the building and its immediate surroundings allows for a more comprehensive understanding of how the conditions of everyday life inside the home are affected by external factors operating at the neighborhood scale. This relationship enables a more holistic assessment of residential environments and their capacity to support residents' well-being.

pretation. Rather than prescribing specific platforms or proprietary systems, it defines categories of tools that can be adapted or substituted over time without altering the overall structure of the methodology. This ensures long-term scalability and resilience of the framework, in line with its broader objective of supporting public housing governance through evidence-based decision-making.

OCCUPANCY SENSORS:

GOAL Representing *temporal* patterns of human occupation.

They register whether a space is being used and to capture patterns of human presence over time. The adoption of different types of occupancy sensing systems depends on the specific analytical objectives, spatial conditions and available resources. Low-cost sensors such as Passive Infrared (PIR) devices can be used to de-

test presence and measure occupancy duration in a binary form (occupied / unoccupied). These solutions are particularly suitable for large-scale deployment across extensive housing stocks where budget constraints are a key consideration. Radar-based technologies (such as mmWave sensors) may be introduced to provide a more granular estimation of occupancy intensity and temporal patterns, while maintaining relatively low costs and preserving user privacy compared to camera-based systems.

TIME-LAPSE CAMERA SYSTEM:

GOAL Representing *spatial* patterns of human occupation.

A network of fixed visual sensing units is deployed to collect photographic records at predefined intervals throughout the day (e.g., morning, afternoon, evening) and across different seasons. These images document the evolution of spatial conditions over time, enabling the observation of patterns such as occupancy dynamics, use of shared spaces, environmental variations, façade degradation, maintenance conditions, and informal spatial appropriations.

STREET VISUAL INVENTORY:

GOAL Reading images and extracting data

It combines multiple data acquisition strategies. On one hand, visual data are mainly collected through systematic street-level imaging using mobile mapping systems, existing street-view datasets, or autonomous agents capable of capturing 360-degree imagery at regular spatial intervals (e.g., every 50 meters).

On the other hand, this automated process could be complemented by urban walks and participatory field observations, where human agents record qualitative spatial information that may not be captured by machine-based systems.

While the primary aim is to study the use, appropriation of space, the BDMF avoids any form of surveillance or behavioural control over residents. For this reason, to protect the privacy the residents, the systems doesn't collect any type of information about the internal use of the housing unit but it primarily reads the building from the 'outside'. Focusing on visible spatial traces, the adopted point of view can be described as the form of monitoring, encompassed in the definition of "eyes upon the street" described by Jane Jacobs. Although this notion is inherently fluid and may risk sliding into forms of surveillance or control, it is fundamentally distinguished from them by its refusal to focus on the individual. Instead, it concentrates on collective dynamics and spatial patterns. Moreover, this form of observation is not an end in itself but it is oriented toward understanding how spatial conditions may reveal latent difficulties or unexpressed forms of fragility. In particular, the analysis is centered on:

THE FACADE is treated as a critical interface between private and public life. It is not only an architectural surface, recording the trace of time and environmental factors, but also a narrative layer through which patterns of habitation, social practices, and cultural behaviours become legible.

The visual material collected reflects the point of view of a pedestrian observer moving through the area, capturing what can be perceived through direct visual experience during everyday walks at different moments.

SHARED AND PUBLIC SPACES like courtyards, corridors, stairwells, and parking areas, particularly in housing typologies derived from modernist collective housing models. Where especially occupancy sensors are deployed to understand the rhythms and the spaces of communal life.

These spaces are considered ethically more appropriate for sensing, as they are already characterized by collective use rather than individual privacy. Moreover, in these shared spaces, the monitoring of human flows through occupancy sensors, avoids any form of direct tracking or identification of individuals.

02. DATA PROCESSING

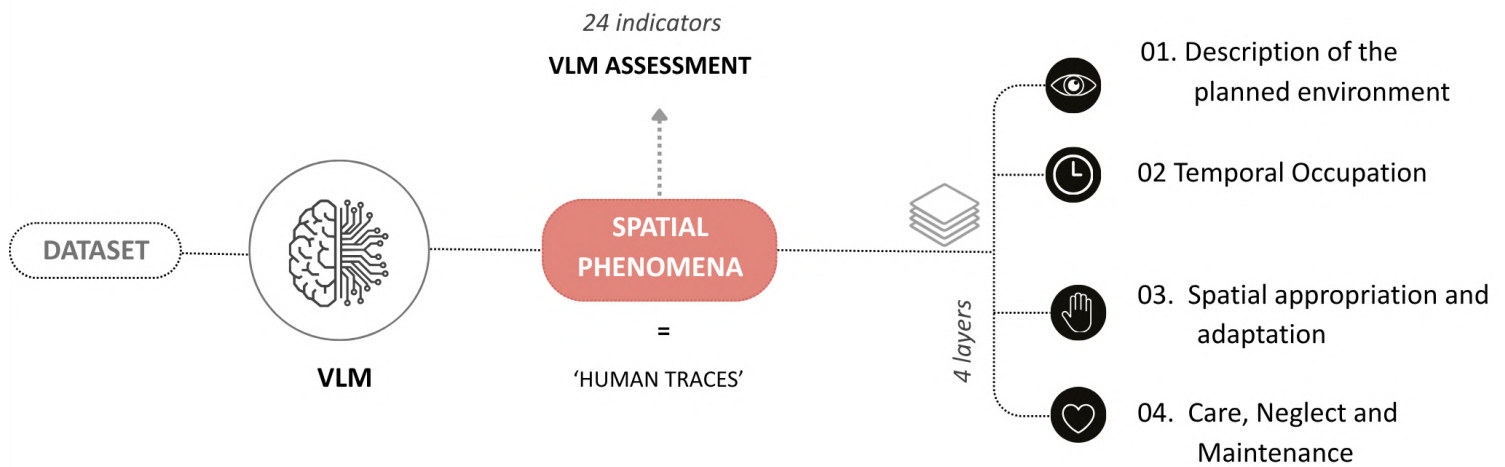


Figure 40: Phase 2

GOAL: To translate spatial phenomena (human traces) into numerical representations that can be processed and interpreted by computational AI systems.

OUTPUT: Quantitative data (indicators) extracted from observational datasets, structured according to clearly defined spatial categories and organised into four analytical layers.

PROCESS: Images are processed through a VLM, which performs semantic interpretation of visual content and assigns structured assessments based on predefined parameters. Each parameter is translated into a score, calibrated according to the complexity of the observed phenomenon, typically ranging from 1 to 3 or from 1 to 5. These scores constitute a structured dataset derived from visual analysis, enabling subsequent computational processing.

All collected data or 'human traces', referring to the previous theoretical background, are then organized into a 4-stage analytical sequence that describes the life cycle of spatial conditions: *describing, occupying, modifying, caring / degrading*.

01. DESCRIPTION OF THE PLANNED ENVIRONMENT

In this layer, the objective is to describe and deconstruct the morphological and infrastructural configuration of the study area. It incorporates information that typically remains unmapped or is not captured by conventional GIS datasets or satellite imagery, contributing to a more comprehensive representation of the existing urban environment.

Some indicators, such as the Canyon Index and vegetation coverage, are derived from the UrbIA framework and retain its primarily descriptive approach. These are complemented by additional indicators—including the availability of public transport and the quality of street lighting—which are identified as key factors influencing the accessibility, safety, and overall quality of urban space.

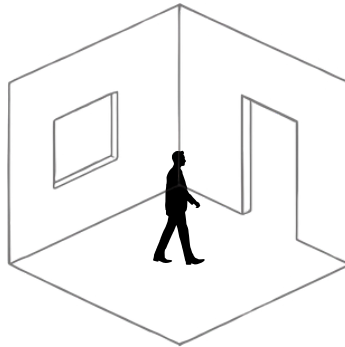
02. TEMPORAL OCCUPATION

This layer represents an epistemological shift from describing the static characteristics of the urban environment to understanding how space is experienced and inhabited. Rather than focusing solely on physical attributes, it investigates patterns of spatial occupation and the duration of human permanence, revealing the daily rhythms and metabolism of residential life.

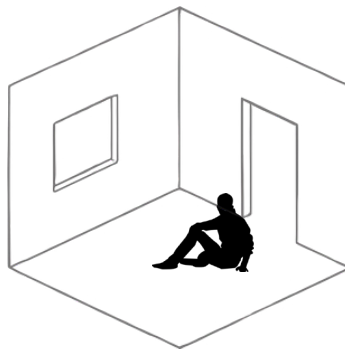
Drawing on the framework developed by the Gehl Institute, this layer assumes that the way people occupy and remain in public and semi-public spaces provides meaningful insights into the quality of those environments. The underlying hypothesis is that longer periods of permanence may indicate positive experiences, a stronger sense of place, or a greater willingness to engage in social interaction. Conversely, spaces that are only briefly occupied may reveal discomfort, limited opportunities for socialization, or poor environmental

Layers of Analysis

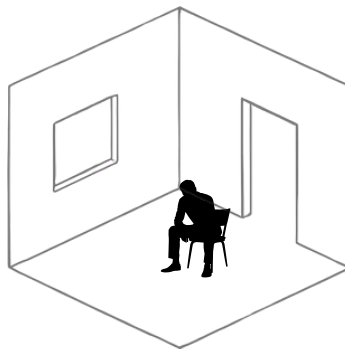
DESCRIPTION OF
THE PLANNED
ENVIRONMENT



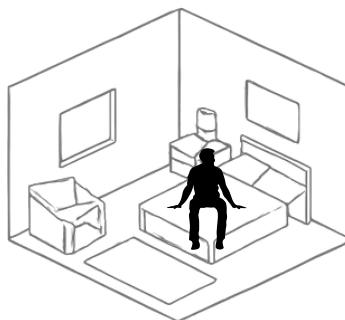
TEMPORAL
OCCUPATION



SPATIAL
APPROPRIATION
AND ADAPTATION



CARE, NEGLECT
AND
MAINTENANCE



Action

01. Describing

The man walks in and observes the room.

02. Occupying

The man sits in the empty room.

03. Modifying

The man brings a chair into the empty space.

04. Caring / Degrading

The man furnishes the room.

The temporal dimension of occupation also contributes to understanding the everyday rhythms of residents and the ways in which buildings are inhabited throughout the day. These observations are initially derived from empirical visual analysis—for example, by recording indicators such as the proportion of open and closed windows, the presence of people on balconies, or the use of shared outdoor spaces. Such observations do not aim to provide definitive evidence but rather to generate hypotheses about occupancy patterns. These hypotheses can subsequently be validated or challenged through complementary datasets, such as demographic or socio-economic information. For instance, a higher proportion of closed windows during daytime hours may suggest that many residents are away at work, whereas a greater number of open windows may reflect the presence of retired residents or people who spend more time at home. However, these interpretations should not be considered conclusive. Participatory activities and direct engagement with residents remain essential to contextualise these observations, verify the inferred relationships, and understand the social meanings that cannot be captured through visual analysis alone.



Figures 41–43: The same location observed at different moments, revealing changing patterns of occupation.

03. SPATIAL APPROPRIATION AND ADAPTATION

This layer investigates the tactile and material dimensions of how residents appropriate, adapt, and transform the built environment through their everyday practices. Physical alterations to the architectural fabric, interpreted as “spatial errors,” are understood as tangible manifestations of the discrepancy between the rigid design of the housing complex and the evolving needs and lived realities of its inhabitants. It should be noted that the graffiti index, derived from the UrbIA framework, has been included in this spatial category rather than in the subsequent layer, in recognition of its cultural and expressive value, refusing to reduce graffiti solely to a marker of neglect.



Figures 44–45: Different forms of spatial occupation and appropriation are reflected in the ways public and private spaces are used. Streets become not only corridors for movement but also places for staying, socialising, and every-

04. CARE, NEGLECT AND MAINTENANCE

This final layer analyses the observable conditions of urban decay through a systematic reading of multiple spatial indicators. The empirical observation focuses both on the building envelope and on the surrounding shared spaces and adjacent areas within the Area of Interest (AOI).

In peripheral urban contexts and social housing environments, decay is often stigmatised or reductively interpreted through narratives of criminality, vandalism, or individual responsibility. In contrast, this framework treats decay as a spatial condition, mapping these “errors” as indicators of broader structural processes, including institutional neglect and forms of socio-spatial vulnerability.

How Does a Vision–Language Model Interpret Images?

A DEEP DIVE INTO...

Figures 46: Man with a Movie Camera (1929)



In *Man with a Movie Camera* (1929), Dziga Vertov introduces the concept of the Kino-Eye, proposing the camera as an extension of human perception, capable of revealing aspects of reality that remain inaccessible to the human eye. Through mechanical vision, the city is not merely recorded but reinterpreted, generating a new form of knowledge based on observation, movement, and the discovery of hidden relationships. Applied to contemporary forms of computational vision, this idea suggests that digital technologies can become instruments capable of detecting and analysing patterns that exceed direct human perception. However, if the Kino-Eye expands human vision, artificial intelligence raises a further question: can the ability to recognise patterns also become a form of understanding?

Table 2 : Indicators analysed during Phase 2.

	Indicator	Goal	Area	Tool		
01 Description of the planned environment						
1.1	Green presence *	To describe the morphology of the built environment	AOI	Street Visual Inventory		
1.2	Canyon index *					
1.3	Lighting					
1.4	Public amenities	To evaluate the availability of public infrastructure				
1.5	Accessibility/public transport				To evaluate spatial accessibility to public transport	
02 Temporal Occupation						
2.1	Permanence in common areas	To analyse how common areas are used and occupied	AOB	Occupancy sensors		
2.2	Flows			To observe the daily rhythms	Time-lapse camera system	
2.3	Gathering points					
2.4	Night-time occupation					
2.5	Day- time occupation					
2.6	Parking occupation					
2.7	Public spaces occupation	To analyse the use and the permanence in selected public areas	AOI	Occupancy sensors		
03 Spatial appropriation and adaptation						
3.1	Informal seating	To describe the spatial appropriations of the living area	AOB	Time-lapse camera system		
3.2	Objects on balconies					
3.3	Graffiti index			To describe the spatial adaptations of the living area	Street Visual Inventory	
3.4	Grids/fences/barriers					
3.5	Enclosed balconies				Time-lapse camera system	
04 Care, Neglect and Maintenance						
4.1	Façade condition *	To evaluate the lack of maintenance and the level of urban decay	AOI	Street Visual Inventory		
4.2	Abandoned spaces					
4.3	Pavement condition *					
4.4	Waste	To evaluate the waste management				
4.5	Closed commercial activities	To evaluate the quality of public facilities				
4.6	Damaged bus stops					
4.7	Degraded public facilities					

	<i>Description</i>	<i>Source</i>
	Measures the quantity, distribution, and quality of green areas, including trees, vegetation, and publicly accessible green spaces.	(Degli Esposti et al, 2025)
	Evaluates street width, building height, and the degree of enclosure or openness of urban spaces.	(Degli Esposti et al, 2025)
	Evaluates the distribution and adequacy of artificial lighting in public spaces.	CIE Lighting Standards
	Assesses the availability, distribution, and condition of public facilities such as benches, playgrounds, fountains, and recreational infrastructure.	(OECD,2019)
	Evaluates the accessibility of the neighbourhood through public transport availability, connectivity, and proximity to mobility infrastructures.	(OECD,2019)
	Measures the presence and duration of human occupation in shared spaces, identifying areas that support everyday social activities and prolonged use.	(Gehl Institute, 2017); (Whyte ,1980)
	Analyses movement patterns within the area, identifying pedestrian circulation routes and distinguishing between spaces used for transit and spaces that encourage permanence.	(Gehl Institute, 2017); (Whyte ,1980)
	Identifies recurring locations where people gather, interact, and perform collective activities, revealing important social nodes within the neighbourhood.	(Gehl Institute, 2017); (Whyte ,1980)
	Evaluates evening and nighttime activity through indicators such as illuminated dwellings, active balconies, and visible residential presence.	(UN-Habitat, 2016)
	Analyses daytime activity patterns by observing the presence of residents, use of dwellings, and interaction between private and public spaces.	(Gehl Institute, 2017)
	Observes parking patterns and temporal variations in vehicle occupation to understand mobility behaviours and daily urban rhythms.	(Shoup, 1997)
	Evaluates the intensity and patterns of use of public spaces, identifying areas with frequent social activity and different forms of occupation.	(Gehl Institute, 2017)
	Detects resident-provided or spontaneous seating elements (e.g., chairs, benches, reused objects) that indicate informal appropriation and social use of space.	(Gehl, 2011)
	Analyses the presence of stored objects or personal items on balconies as indicators of domestic adaptation, space limitations, and everyday practices.	(Newman,1972)
	Evaluates the presence, distribution, and characteristics of graffiti, considering both potential signs of neglect and forms of cultural or artistic expression.	UrbIA project research
	Measures the presence of physical barriers affecting visual permeability, accessibility, and the relationship between buildings and public space.	(Newman,1972)
	Identifies balconies that have been enclosed or incorporated into interior spaces, indicating adaptations of domestic environments to changing spatial needs.	(Gehl, 2011)
	Assesses the visible condition of building façades, identifying deterioration, maintenance needs, and signs of structural neglect.	(Degli Esposti et al, 2025)
	Identifies vacant, unused, or abandoned buildings, vehicles, and areas that may indicate spatial underuse or social vulnerability.	(Ewing et al, 2013)
	Evaluates the quality and accessibility of pedestrian surfaces, identifying damaged, uneven, or poorly maintained pavements.	(Degli Esposti et al, 2025)
	Evaluates the presence and accumulation of abandoned waste, illegal dumping, and waste management issues in public areas.	(UN-Habitat, 2016)
	Measures the presence of vacant or inactive commercial spaces, highlighting potential gaps in local services and neighbourhood vitality.	(UN-Habitat, 2016)
	Assesses the physical condition and maintenance level of public transport facilities, including shelters, signs, and waiting areas.	(UN-Habitat, 2016)
	Evaluates the condition of shared infrastructures such as playgrounds, benches, recreational equipment, and public facilities.	(UN-Habitat, 2016)

Figures 47-48: Examples of how a Vision–Language Model perceives and interprets images and spatial data.



Figures 49-50: Examples of how a Vision–Language Model perceives and interprets images and spatial data.



03. PHENOMENA DETECTION

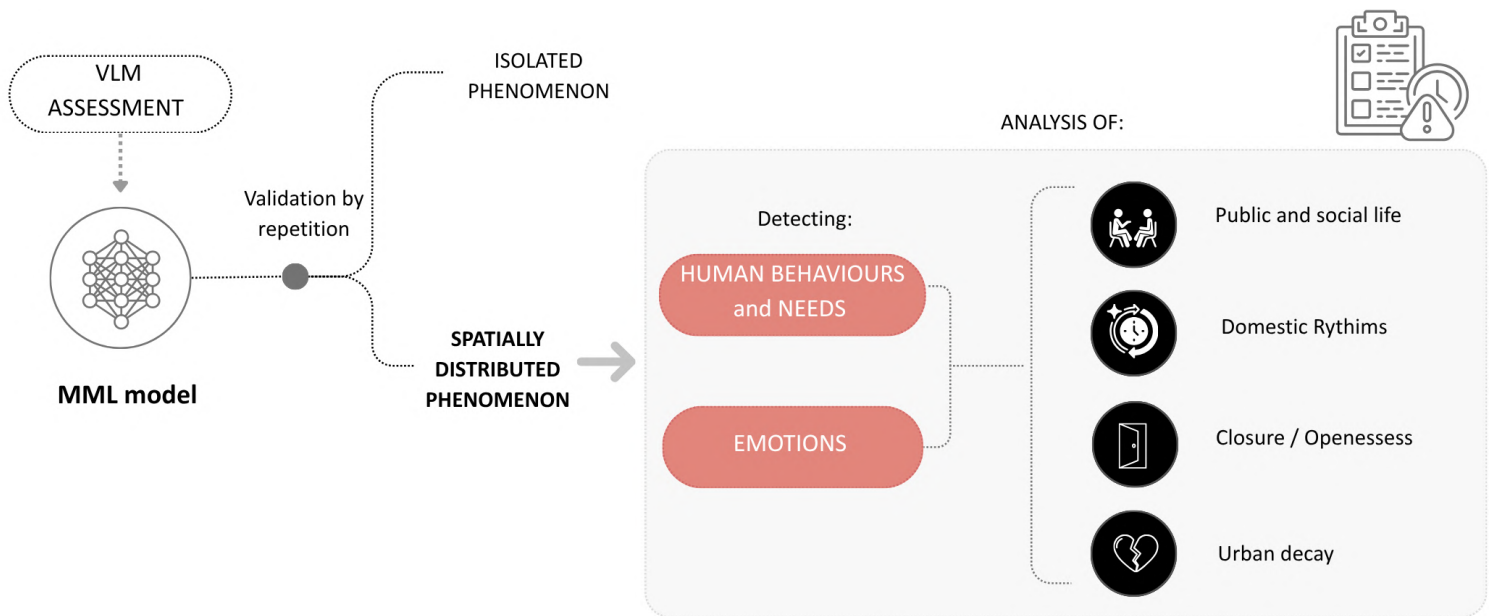


Figure 51: Phase 03

GOAL: To translate the numerical VLM-based assessment into human behaviours, needs or emotional conditions.

OUTPUT: Preliminary observations aimed at identifying and validating the presence of spatial phenomena that require further verification.

PROCESS: The first step consists in verifying whether observed signals represent isolated occurrences or recurring patterns. This distinction is essential to avoid over-interpreting singular events as meaningful spatial phenomena.

1ST VALIDATION STEP: If a phenomenon appears as an isolated case, the system can classify it as an anomaly and assign it lower analytical priority. Conversely, if the phenomenon is spatially distributed or recurrent across the study area, it can be considered consistent.

When a phenomenon X is identified as being typically associated with one or multiple factors. Consequently, when one or more of these factors occur, the likelihood of that phenomenon being present increases. The relationships between drivers and spatial phenomena are established through statistical associations. When recurring correlations are observed across previously analysed samples, these links can be further substantiated through complementary methods such as interviews, qualitative data, and field observations.

The repetition of these associations strengthens their validity and supports their integration into the reasoning framework of the AI system, which is fundamentally based on the identification and interpretation of statistical relationships between variables.

The correlation between these spatial indicators and human needs, behaviours, and emotional conditions is initially grounded in empirical observation, existing literature, previous studies and comparative research.

In this section, a MML approach is adopted to support the identification of:

- HUMAN BEHAVIOURS AND NEEDS
- EMOTIONAL AND SUBJECTIVE FACTORS

CAPTURING THE COMPLEXITY OF LIVED AND PERCEIVED REALITY:

01. PUBLIC AND SOCIAL LIFE

This combination of indicators supports the analysis of the use of public and collective spaces. Patterns of permanence and occupation can be examined in relation to residents' perceptions of belonging, safety, comfort, and social interaction. Literature suggests that the use of public space is strongly influenced by its physical qualities, accessibility, perceived safety, and opportunities for encounter and collective life.

Research on public space and social infrastructure has shown that well-designed and accessible environments tend to encourage longer periods of occupation and facilitate social interaction. For example, elements such as seating availability, accessibility, and environmental comfort significantly influence how people occupy and appropriate public spaces (Whyte, 1980). Moreover, Oldenburg's concept of Third Places (1989) highlights the importance of informal gathering spaces in fostering social relations, community formation, and a sense of belonging. In particular, parks, community facilities (ex. Benches and sitting areas) are physical sign of a social infrastructure.

Perceived safety also appears to influence patterns of occupation: safer-looking environments prove to be connected to higher levels of urban vitality (Nadai, Vieriu, Zen, & Dragicevic, 2016). Likewise, Newman's theory of Defensible Space (1972) suggests that spatial configurations capable of supporting natural surveillance and resident appropriation can contribute to safer and more actively used environments.

Within this framework, the mapping of places where residents tend to gather may provide valuable insights into the spatial conditions that support social interaction and everyday life. These conditions may be related to environmental qualities, accessibility, comfort, the presence of amenities, or other context-specific factors. At the same time, the absence of occupation should not automatically be interpreted as evidence of failure or social isolation. As discussed previously, collective spaces often serve different functions, and patterns of use may vary according to cultural practices, age groups, seasonal conditions, and everyday routines. For this reason, occupation data should be interpreted alongside physical, social, and perceptual indicators rather than as a standalone measure of social vitality.

Consequently, improving the quality and availability of public amenities, green areas, and collective facilities should not be understood merely as a way to increase occupation rates, but rather as a means of creating the conditions through which social interaction of space can emerge.

02. DOMESTIC RYTHIMS

This combination of temporal indicators, including parking occupancy, residential lighting patterns, window opening conditions, and the occupation of public and collective spaces, contributes to the analysis of the everyday rhythms of the neighbourhood. Rather than describing static spatial conditions, these indicators provide information on how the area is inhabited throughout the day and how residents interact with both domestic and public environments.

Changes in window opening patterns, for example, may indicate variations in the use of indoor environments and seasonal adaptation practices, while fluctuations in parking occupancy can reveal broader mobility patterns and levels of dependence on private vehicles. Together, these indicators contribute to the understanding of when residential areas are most active and how daily routines shape the occupation of space.

Comparing these information with demographic and socioeconomic datasets, may help reveal relationships between spatial practices and the demographic composition of the area. For example, neighbourhoods characterised by a significant presence of non-working populations, such as retirees, children, or individuals spending a substantial portion of their day at home, are likely to exhibit more continuous patterns of occupation throughout daytime hours.

The analysis of temporal rhythms is particularly relevant because urban vitality is not only determined by the presence of activities but also by their distribution throughout the day. Jane Jacobs famously argued that the continuous presence of people in public spaces contributes to natural surveillance and enhances perceived safety, contributing to increasing the social interactions.

Consequently, understanding when public spaces are occupied is as important as understanding how they are occupied. Areas characterised by prolonged periods of inactivity may experience lower levels of informal surveillance and fewer opportunities for social interaction, while environments supporting a more continuous presence of residents often display greater levels of vitality and collective use.

Monitoring nighttime activity, observing the lighting patterns of the facades of the buildings, represents a particularly significant dimension as the evening period often represents one of the few moments when households gather after daily commitments. Prolonged use of domestic spaces during these hours may therefore indicate a collective dimension of family life and of inhabiting the home. In this regard, it is important that such a cultural practice be reflected in the design and renovation of future housing units, through

deeper engagement with residents in order to better understand how social life is experienced within domestic spaces. Moreover, according to interviews¹, the absence of social opportunities during evening hours contributes to feelings of isolation, particularly among younger populations. In fact, if successful urban environments are characterised by activity patterns extending beyond standard working hours (Gehl, 2010), creating more cultural and recreational opportunities during the evening may therefore strengthen residents' attachment to place and reduce perceptions of marginality.

However, temporal occupation patterns can also support decisions regarding mobility and service provision, as different demographic structures generate different temporal demands. For example, areas characterised by a continuous daytime presence may require public transport services distributed throughout the day, while neighbourhoods with strong commuter populations may benefit from increased service frequency during peak commuting periods and extended evening schedules.

03. CLOSURE / OPENESSESS

This section investigates the degree of openness and closure of residential buildings, understood as the relationship between the internal domestic sphere and the external urban environment. The analysis focuses on observable spatial behaviours of the building envelope, aiming to interpret how residents mediate between visibility, exposure, and protection.

For example, the study of closed or visually obscured windows during daytime—based on façade images captured at different times of the day—can be interpreted as an indicator of the need to screen the dwelling from sunlight, heat, or external visual exposure. This condition may suggest potential design responses such as improved window systems and façade insulation strategies (e.g. external thermal insulation), the integration of shading and screening devices, or, in some cases, the future reconfiguration or functional upgrading of housing units to enhance comfort and adaptability.

Similarly, the presence of enclosed balconies may indicate a desire to extend the usable living space and increase the functional capacity of the domestic environment. Such modifications can be read as spatial traces of discomfort, spatial inadequacy, or everyday adaptation strategies, potentially linked to stress or frustration related to housing conditions.

Conversely, a high presence of balcony grids, fences, or physical barriers around the building may be associated with concerns related to safety and territorial control. These elements can be interpreted as strategies aimed at improving both actual and perceived security, regulating flows of people, and reinforcing privacy and spatial boundaries. However, their presence may also contribute to a reduced perception of openness and accessibility, potentially generating feelings of insecurity or social withdrawal.

From this perspective, excessive spatial closure can be associated with stress and reduced livability. Counteracting these effects requires interventions aimed at maintaining accessibility and urban attractiveness, such as improving local services, enhancing pedestrian permeability, and ensuring safe but open access to residential complexes. Adequate lighting and clearly structured circulation routes can further contribute to the creation of a continuously active and socially monitored neighbourhood, supporting both safety and urban vitality.

04. URBAN DECAY

A further aspect of analysis concerns the level of urban neglect, expressed through observable indicators such as litter accumulation, graffiti on building façades, insufficient lighting, and general signs of physical decay affecting both the built environment and public infrastructure. These include deteriorated façades, damaged pavements, and abandoned elements such as vacant buildings or unused children's facilities.

The theoretical framework most directly relevant to this reading is the broken windows theory², proposed by Wilson and Kelling in 1982 Atlantic article and grounded in earlier experimental work by psychologist Philip Zimbardo. The theory argues that a single unrepaired broken window is a signal that no one cares and so breaking more windows costs nothing: disorder increases levels of fear among citizens, which leads them to withdraw from the community and decrease participation in informal social control.

Both physical disorder and social disorder exert causal effects on crime directly and indirectly. Directly, by signalling to potential offenders that residents are indifferent; indirectly, by inducing fear that causes residents to restrict their movements and disengage from public life.

However, this theory must be applied with caution, not only because it is based on the assumption that disorder and crime are different constructs, but also because the levels of socioeconomic disadvantage and racial heterogeneity influence people's perceptions of disorder even more than actual observed 'broken windows' (Gau & Pratt, 2010).

¹ Interviews will be presented in the next chapter

Physical signs of decay are interpreted through the lens of existing vulnerability and institutional trust and community history. For example, a deteriorated facade in a neighbourhood with strong community bonds and responsive governance reads differently than the same facade in one characterised by institutional abandonment and social atomisation.

Physical neglect, like insufficient lighting, abandoned buildings, unrepaired common areas in public housing estates are not simply maintenance problems but also political problem of recognition of the space and the community within it.

Yet some signs of urban decay demands a more nuanced reading. For example, researches on graffiti subcultures has identified its multiple social functions, including the reconstruction and appropriation of urban space (Ferrell, 1993), a form of political resistance (Austin, 2001) and expression of cultural identity (Lachmann, 1988). More recent studies further highlight graffiti as a form of public communication and spatial negotiation within contested urban environments (Young, 2014).

Physical decay can be understood as the outcome of different and sometimes overlapping processes.

- It may be institutionally produced, reflecting a failure of care and maintenance that public governance is responsible for addressing.
- It may emerge as action/reaction of the citizens, signalling a weakened sense of attachment to place or functioning as an expression of broader social and cultural dynamics.

For a system designed to interpret spatial signals, capturing these nuances is challenging yet essential, as distinguishing between these two dimensions is crucial for a correct reading of the urban context. This differentiation can be further explored and validated through direct engagement with residents, as well as through the analysis of complementary socio-demographic datasets in the subsequent phase of the research.

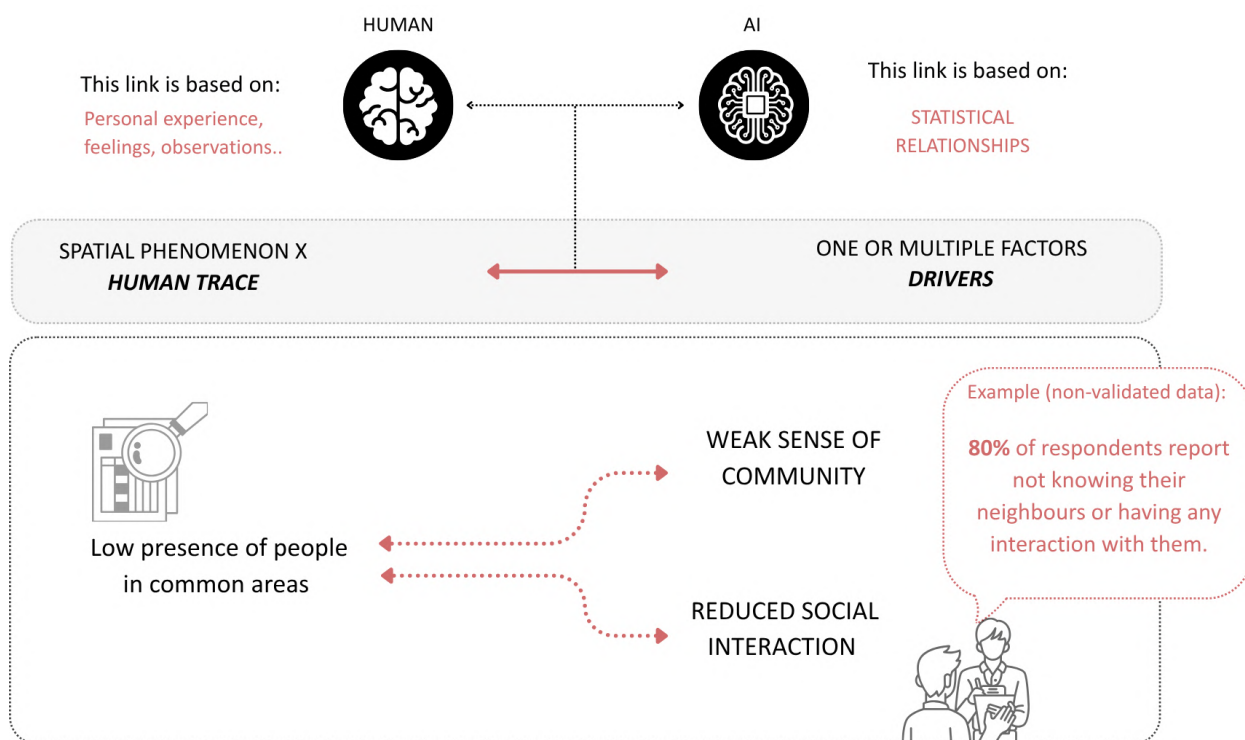


Figure 52: Comparing AI-Driven Spatial Interpretation and Human Understanding

Table 3 : Interpretation of spatial data

<i>Spatial phenomenon (Trace)</i>	<i>Need / Behaviour</i>
Spatial use of common areas	
High permanence, high concentration of people and the presence of informal seating arrangements	Strong social interaction, collective gathering, and spatial appropriation.
Low permanence or concentration of people registered	Potential social isolation, weak community engagement or limited attractiveness of the space.
Uneven distribution of people across the space	Variations in comfort, attractiveness, or usability caused by environmental conditions and spatial configuration.
Domestic Rythims	
Predominance of closed or visually obscured windows during daytime	Low daytime presence within dwellings, indicating a demographic structure characterized by working population Low indoor–outdoor interaction, potential lack of environmental comfort or social withdrawal.
Majority of open windows during daytime combined with insufficient public amenities	High daytime presence within dwellings, indicating a demographic structure characterized by non-working or partially home-based populations and continuous domestic use of space.
Parking areas intermittently occupied combined with insufficient transport services	High car dependency for residents to access workplaces, educational institutions, and other daily destinations
Majority of dwellings active during evening and nighttime hours	Potential need for nighttime or evening-oriented activities, Adequate living rooms or kitchens as shared and social spaces during end-of-day hours
Closure / Openness	
Predominance of closed or visually obscured windows during daytime	Need to screen the dwelling from sunlight, heat, or external visual exposure; It indicates a demand for greater privacy.
High presence of enclosed balconies	Desire to extend the usable living space and increase the functional domestic area.
High presence of grids on balconies or fences around the building	Improving actual and perceived safety, in order to create a more secure residential environment.
Frequent use of physical barriers	Regulating flows of people and reinforce privacy and territorial boundaries.
Urban decay	
High presence of graffiti on walls	Expression of social, political, or artistic identity, indicating a need for cultural recognition and spatial appropriation.
Frequent signs of physical decay (building façades, street pavement) and abandoned elements (buildings, children infrastructure)	Lack of adequate public maintenance and reduced investment in the built environment.
Dirty streets and widespread graffiti	Low level of collective care for public space and a perceived sense of neglect or abandonment.
Insufficient street lighting	Reduced perceived safety and lack of natural or formal surveillance in specific urban areas.

<i>Emotion</i>	<i>Proposed Intervention</i>
	Maintain and improve the quality of common spaces; introduce additional seating and amenities to support social activities.
	Create or enhance spaces that encourage social encounters and strengthen community bonds among residents.
	Identify preferred gathering locations to understand which areas already support social activity and where targeted improvements, services, or public amenities could be introduced.
	Verify and improve the efficiency of public transport services to support residents' mobility, especially during peak hours.
	Verify and improve the efficiency of public transport services to support residents' mobility, especially during peak hours.
	Adjust public transport schedules to ensure regular and reliable services, with specific attention to school entry and exit times.
	Improve connectivity and transport services in order to reduce car dependency and enhance sustainable mobility options.
	Improving services sport and cultural spaces, bars, cinema etc and improving evening and nighttime connections to the rest of the city.
	Improve the size and the comfort of living rooms and kitchens in future renovation interventions.
	Introduce more efficient windows and façade insulation systems (e.g. external thermal insulation) to improve energy performance and comfort.
	Integrate façade shading devices and screening systems.
	Consider the expansion of future housing units or the functional upgrading and reconfiguration of interior layouts.
	Enhance the continuous activity and overall liveliness of the district, improving its capacity to attract and retain users.
	Improve pedestrian permeability and spatial legibility, ensuring safe but not isolated access to residential complexes, with adequate lighting and clear circulation routes.
	Introduce cultural activities and dedicated spaces to channel and support forms of artistic and social expression.
	Improve maintenance strategies and overall care of public spaces to enhance environmental quality and usability.
	Organize citizen assemblies and participatory processes to rebuild trust between residents and institutions.
	Improve urban lighting, particularly in blind spots and low-visibility areas, to increase perceived safety and spatial legibility.

	Stress and Frustration
	Sense of Isolation
	Low perceived safety
	Comfort and Restorativeness
	Sense of Belonging
	Vitality

HUMAN TRACE 01: Social and public life in Pilastro

Phase 03 - PHENOMENA DETECTION

A second and contrasting spatial pattern emerges. The observational analysis reveals a shortage of public services and neighbourhood infrastructure, including limited public transport accessibility, an insufficient number of public facilities within parks, deteriorated street furniture, inadequate lighting, and numerous vacant commercial premises. Visible graffiti, deteriorated pavements, abandoned objects, and signs of limited maintenance further contribute to this condition.

EMOTIONS: This condition may contribute to feelings of isolation and abandonment, potentially reinforcing processes of social exclusion

- NEED/ HUMAN BEHAVIOURS: This highlights the need to integrate services, improve connectivity, and enhance the quality of urban spaces, particularly in terms of their attractiveness.

Phase 04 - CROSS ANALYSIS ¹

The preliminary observations can be further enriched by integrating complementary datasets.

01) A first aspect concerns the symbolic representation of Pilastro within the city. Beyond its physical characteristics, the neighbourhood appears to suffer from a limited presence within the urban communication system. Road signs and public wayfinding rarely identify Pilastro itself or highlight its community facilities and public spaces. Instead, directional signage predominantly refers to the A14 motorway, the Tangenziale, or nearby commercial centres. Pilastro is often represented as a place to pass through rather than a destination with its own identity, reinforcing the historical perception of separation from the rest of Bologna.

02) The second source of validation derives from the Open Citizen Relationship Management (CZRM) dataset, which records maintenance requests and reports submitted directly by citizens to the Municipality of Bologna. The dataset includes reports related to urban maintenance and everyday problems, such as public green spaces, urban furniture, waste management, environmental degradation, accessibility, public lighting, traffic, and public safety. As a form of bottom-up data collection, these reports offer an important opportunity to compare observed spatial traces with issues explicitly perceived and communicated by residents.

The comparison reveals a strong consistency between the field observations and the reported maintenance issues. The most frequently reported categories in Pilastro closely mirror the trends observed across Bologna as a whole, with particular concentrations in public green spaces, urban degradation, and environmental degradation. At a more detailed level, the reports consistently highlight problems related to waste accumulation, inadequate maintenance of green areas, deteriorated streets and public squares, and deficiencies in public lighting. These findings directly support several of the spatial observations identified during the empirical assessment, particularly those concerning waste accumulation (Indicator 4.4), degraded public facilities (Indicator 4.7), insufficient lighting (Indicator 1.3), and the condition of public spaces (Indicators 1.4 and 4.3). The convergence between observational data and citizen-generated reports therefore increases the reliability of the detected phenomena and reduces the likelihood that they represent isolated or subjective interpretations.

03) The analysis also confirms a transformation in the neighbourhood's commercial structure. While many of the small commercial premises originally integrated into the ground floors of residential buildings are now vacant or closed (Indicator 4.5), Pilastro remains well served by large-scale commercial facilities located along its edges, particularly near major shopping centres. This suggests that commercial activity has not disappeared but has progressively shifted from neighbourhood-scale services towards larger retail infrastructures, potentially reducing the everyday vitality of local public spaces.

04) Finally, the broader territorial context further contributes to understanding Pilastro's spatial condition. The neighbourhood is physically enclosed by two major transport infrastructures—the A14 motorway and the Tangenziale di Bologna—which continue to reinforce both its physical and symbolic separation from the surrounding urban fabric. Although these infrastructures ensure regional accessibility, they also create strong physical barriers that limit permeability and contribute to the long-standing perception of Pilastro as an isolated urban enclave.

¹ Based on Data ISTAT, Comune di Bologna and empirical observations

04. CROSS ANALYSIS

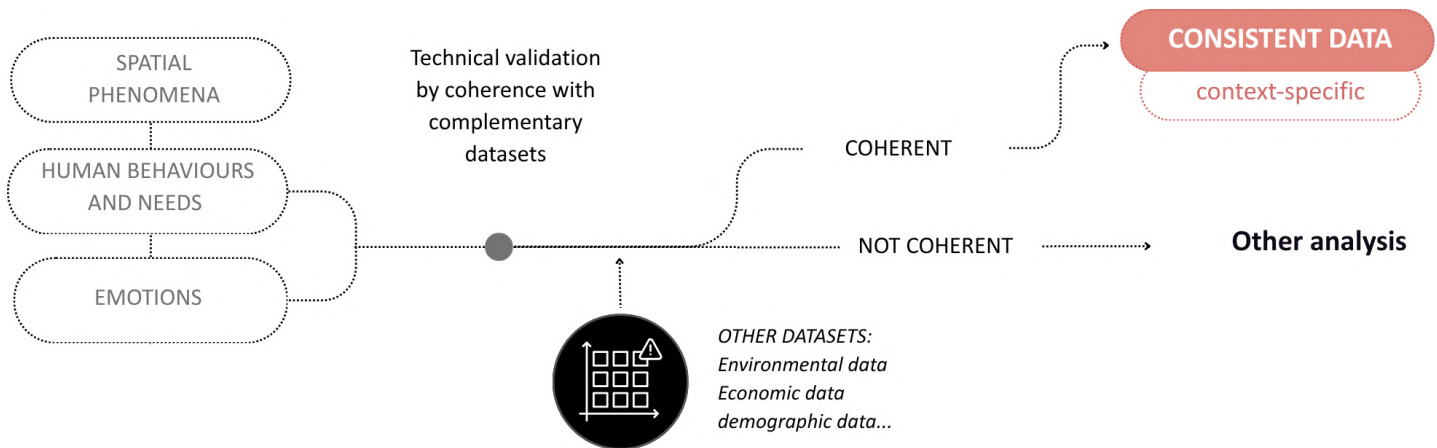


Figure 53: Phase 04

GOAL: Phenomena are preliminarily analysed in order to relate them to their spatial and contextual conditions.

OUTPUT: A refined set of validated phenomena derived from the initial screening of observed spatial indicators.

PROCESS: At this stage, the phenomenon is cross-checked against additional relevant datasets. These may include information on green space maintenance, socio-economic conditions, infrastructural quality, or other contextual variables. This step allows the system to assess whether the observed behaviours and need and the spatial evidences, are consistent with broader environmental and social conditions, thereby strengthening its interpretative validity.

2ND VALIDATION STEP: A cross-analysis allows the system to assess whether the observed behaviours and need and the spatial evidences, are consistent with broader environmental and social conditions, thereby strengthening its interpretative validity.

This constitutes a first level of technical validation, still independent from direct experiential input, to verify the coherence across datasets is confirmed. While a purely top-down system could operate at this stage alone, the integration of lived experience introduces an additional layer of interpretation. Empirical knowledge derived from residents not only enriches and connects elements that may not be evident through technical analysis alone, but also helps reveal new relationships between phenomena, thereby contributing to the refinement and training of the analytical system itself.

05. INTERVENTION PROPOSAL

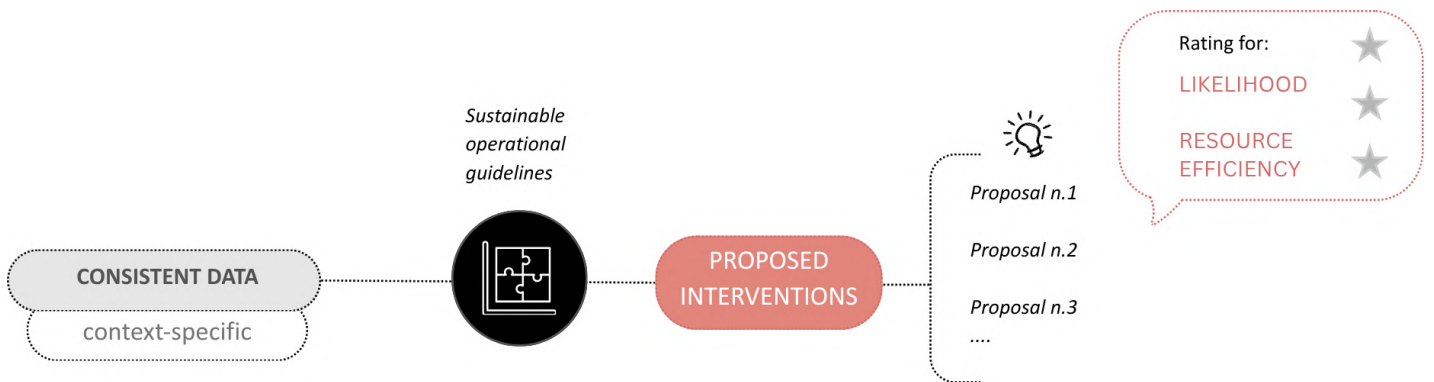


Figure 54: Phase 05

GOAL: To propose preliminary intervention strategies in the form of general guidelines, based on the observed spatial conditions and validated phenomena.

OUTPUT: A set of initial intervention proposals derived from coherence between validated phenomena and feasibility considerations.

PROCESS: Based on the identification of recurring spatial phenomena, specific intervention strategies can be associated with corresponding conditions detected and validated by the system. These interventions are not intended as definitive solutions but rather as preliminary guidelines to be further refined through subsequent development phases and participatory validation with residents. In addition, the system can be supported by a predefined backbone of intervention strategies, structured according to recurring urban conditions and aligned with broader sustainability principles promoted by the European Union in the context of the energy and ecological transition. Proposed interventions can be evaluated according to two main criteria:

- **Likelihood:** the degree to which a proposed solution is suitable for and consistent with the specific context.
- **Resource efficiency:** the extent to which a proposed solution is feasible in terms of available resources, capacities, and operational constraints.

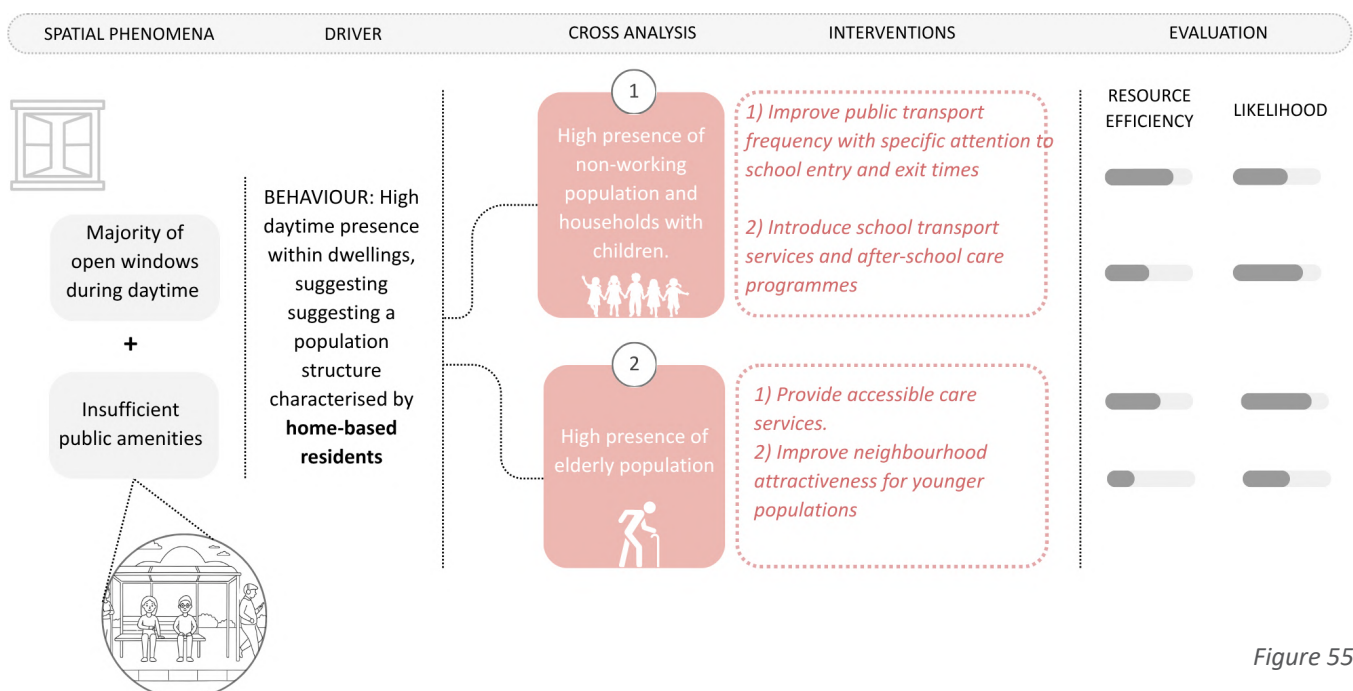


Figure 55:

06. LIVING LAB

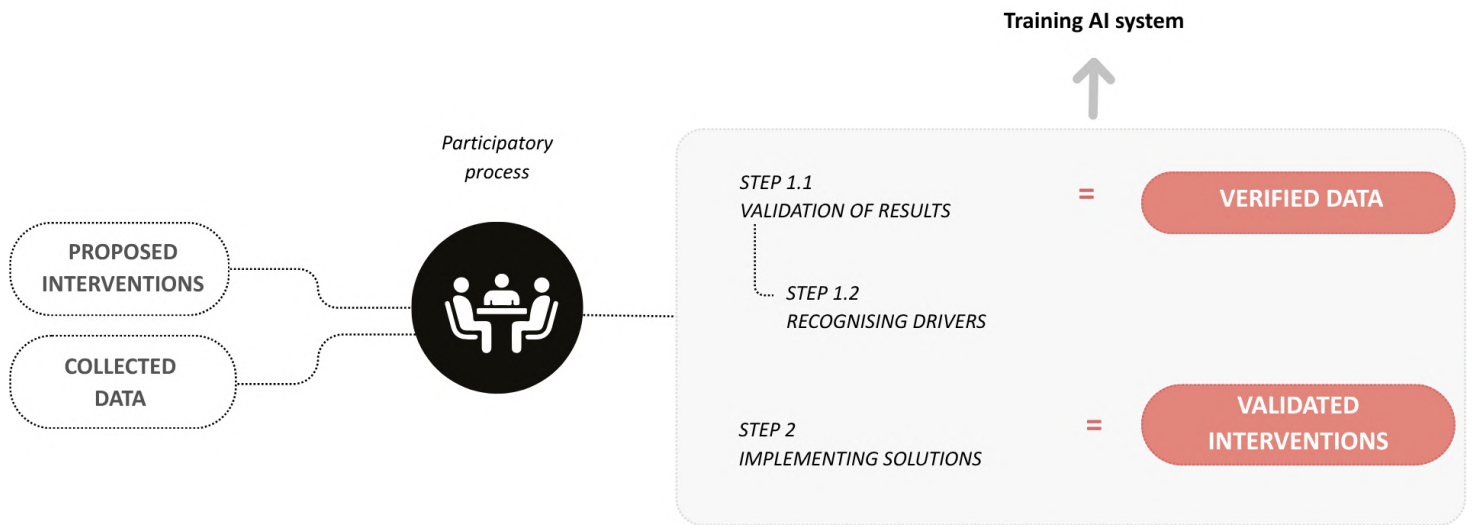


Figure 56: Phase 06

GOAL: The participatory phase of the framework aims to verify of the information produced by the computational mapping process and to implement or modify the proposed interventions.

OUTPUT: A refined set of validated phenomena derived from the initial screening of observed spatial indicators.

PROCESS: To test the outputs produced through the computational process, the Living Lab methodology proved to be the most suitable theoretical framework for addressing this research question. Its strength lies in its capacity to adopt a bottom-up approach, allowing for an open-ended process in which the final outcomes are not predetermined but co-produced through the interaction of multiple stakeholders.

The Living Lab methodology, introduced in Chapter 1, becomes operationally central, acting as a collective infrastructure open to innovation, experimentation. The horizontal, multi-stakeholder structure is precisely what the validation of an AI-generated vulnerability layer requires: not a technical review conducted by experts, but a situated, participatory process in which the results of the mapping are tested against the knowledge of the people who inhabit the mapped spaces.

The process can be divided into two main sequential phases: validation of results and identification of solutions. In addition, a third complementary phase is introduced, aimed at identifying underlying drivers and strengthening capacity-building processes, as previously developed and tested within the HouseInc framework. These phases have been experimentally validated within the HouseInc process, where they demonstrated positive outcomes in supporting both analytical robustness and participatory engagement.

SCALE: The scale of experimentation operates at the territorial level, specifically at the district or building scale, through direct engagement with residents. In this phase, since the primary objective is to validate the lived experience of space, it is essential to select a participant pool that reflects the social, demographic, and cultural complexity of the housing environment. A representative sample of approximately 20 participants is therefore proposed.

The sampling structure should ensure balance across key demographic dimensions (eg. Age distribution, ethnicities, gender..). This collective and diversified participation is essential to ensure a robust validation of the computational results.

SPACE OF EXPERIMENTATION: This collective process is recommended to take place in informal settings within the neighbourhood or local urban context, where participants may feel more comfortable.

STAKEHOLDERS INVOLVED: The stakeholders involved in this phase assume differentiated but complementary roles:

Users (residents): they play a central role in validating the detected issues and may contribute additional knowledge based on lived experience, potentially expanding or challenging the computational findings.

Facilitator (academia / public sector / private intermediary): acting as a mediator of the process, ensuring that information is properly collected, structured, and communicated among stakeholders. The facilitator may be appointed by public institutions, academic bodies, or private organisations. All activities and outcomes should be documented and made publicly accessible to ensure transparency.

Public sector (municipality, housing managers): it contributes to institutional knowledge and operational expertise, supporting the interpretation of relationships between drivers and identified issues, and contributing to the formulation of initial response strategies.

Private sector (NGOs, digital platforms): supporting the process by providing facilitation tools, technical expertise, or implementation opportunities for addressing identified challenges.

Academia: it contributes to methodological balance, critical reflection, and the development of innovative and evidence-based solutions.

VALIDATION OF RESULTS – Phase 1.1

Stakeholder involved: categories 1- 2

The primary objective of this phase is to validate the spatial phenomena identified through computational analysis and their interpretation in relation to the use of urban space. Citizens are actively involved in the validation of the main issues detected within the area, contributing with their perceptions and lived experiences, which may further enrich and refine the system's outputs.

This phase also enables the integration of additional contextual insights derived from everyday experience, which may not be captured through computational methods alone.

ACTIVITIES PROPOSED:



THE URBAN WALK: This activity consists of a guided collective walkthrough of the study area (building or neighbourhood), during which participants are asked to observe and react to specific spatial conditions previously identified by the computational analysis (e.g. levels of decay, spatial porosity, use of common areas, perceived safety).



COLLECTIVE DISCUSSION: This activity is based on a structured discussion using a curated set of images extracted from the computational and VLM-based analysis. The selected images represent key spatial conditions identified in the previous phases, such as levels of physical decay, spatial porosity, use of common areas, and indicators of social activity or inactivity. Participants are invited to collectively interpret the images in relation to their lived experience of the place.

RECOGNISING DRIVERS – Phase 1.2

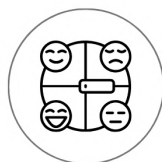
Stakeholder involved: categories 1- 2

This second LL session focuses on connecting the detected spatial issues with their underlying drivers. The aim is to move beyond a descriptive reading of phenomena and support participants in identifying possible causal relationships between different dimensions of the urban context.

ACTIVITIES PROPOSED:



CONNECTING THE DOTS In this phase, stakeholders are encouraged to actively “connect the dots” between heterogeneous datasets and lived experiences. Participants are divided into small groups. Each group is assigned one main issue identified in the previous analytical phase (e.g. urban decay, low spatial vitality, perceived insecurity).



EMOTION MAPPING Participants are provided with a map of the study area and invited to identify places associated with different emotions, such as safety, comfort, stress, isolation, happiness, or belonging. They are encouraged to explain the reasons behind their choices and, where possible, relate these emotions to specific spatial characteristics or everyday experiences. The resulting emotional maps are then compared with the spatial phenomena identified through the computational analysis, helping to validate, refine, or challenge the AI-generated interpretations while revealing subjective dimensions that cannot be inferred from visual data alone.

IMPLEMENTING SOLUTIONS – Phase 2

Stakeholder involved: categories 1- 5

In this third phase, the Living Lab shifts from validation and interpretation towards the co-design of solutions. Building upon the driver–issue framework developed during the previous phase, participants work together to identify intervention strategies capable of addressing the root causes of the observed phenomena rather than their symptoms alone. The proposed interventions are evaluated according to their feasibility, relevance to the local context, resource requirements, and potential social and spatial impact. The objective is not to produce definitive projects, but to define realistic implementation pathways that can subsequently be developed by public authorities and other stakeholders.

ACTIVITIES PROPOSED:



INTERVENTION STRATEGIES: Starting from the priority issues and their mapped drivers, participants work together to generate one or more intervention strategies for each issue. Each proposal is discussed in terms of its expected impact, feasibility, resource requirements, responsible actors, and implementation timeline. At the end of the session, all groups present their proposals, which are collectively compared and discussed to identify common priorities and potential synergies.



FUTURE SCENARIO WORKSHOP: Participants work in groups and are invited to imagine how the neighbourhood could look and function in 5–10 years if one of the priority issues were successfully addressed. Using maps, photographs, and simple visual materials (sticky notes, sketches, icons), each group develops a future scenario that responds to residents' needs while considering available resources and local constraints. .

The results are documented, and integrated into a dataset that contributes to the training of the AI system, effectively functioning as a computational memory of the entire process. In addition, the outcomes are communicated and presented to individual stakeholders as well as to public institutions responsible for the implementation of the proposed interventions. This ensures both transparency and the potential translation of co-produced knowledge into actionable urban policies and on-the-ground solutions.

The 3 Living Lab phases generate knowledge that directly feeds back into the computational framework, contributing to the continuous training and refinement of the AI system. In this sense, the Living Lab functions as a computational memory of the entire process, allowing experiential and participatory knowledge to become part of the system's evolving knowledge base. More specifically, the three phases contribute to:

- validating or challenging the relevance of spatial indicators and observed phenomena;
- establishing relationships between perceptual dimensions and patterns of spatial use;
- identifying new intervention strategies and contextual solutions that can be associated with similar conditions in future applications.

At the end of the process, the computationally detected phenomena are validated through residents' lived experience and stakeholder knowledge, while additional observations that could not be captured by the computational analysis are incorporated into the dataset

07. INFORMING THE GOVERNANCE

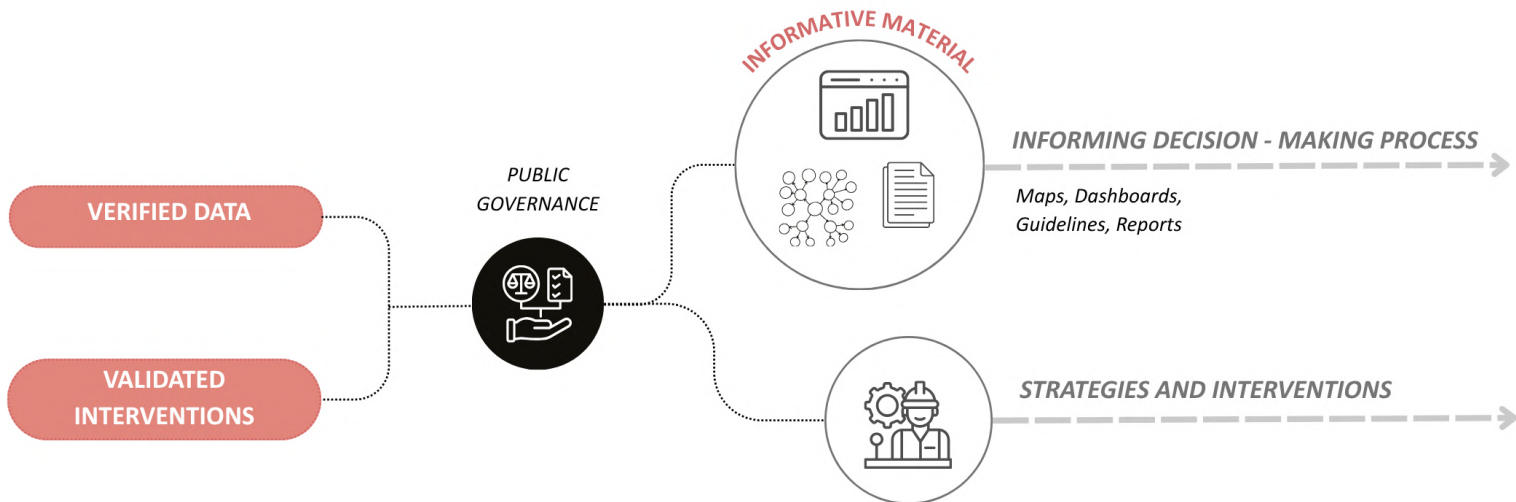


Figure 57: Phase 07

GOAL: This phase aims to communicate and translate the results of the entire process into actionable insights for the relevant public authority.

OUTPUT: These outputs provide a decision-support system for public governance, enabling more targeted, evidence-based, and context-sensitive interventions. The proposed framework generates three main outputs:

1. **Data Repository:** a structured storage system collecting and organising all generated and integrated datasets. This repository acts as a long-term knowledge base, preserving spatial, social, environmental, and participatory information for future monitoring and decision-making.
2. **Conversational AI Assistant:** an interactive AI-based interface supporting public governance by allowing users to navigate, query, and interpret the collected information. The conversational agent facilitates access to complex datasets and supports administrative decision-making processes.
3. **Interactive Online Dashboards:** a set of open-access interactive dashboards providing visualisation, interpretation, and decision-support functions through the following outputs:

Collected Data Visualization: Spatial maps visualising the distribution of detected phenomena and the previously analysed spatial layers. The maps are open-source, accessible to different users, and filterable according to selected criteria, allowing exploration of different dimensions of the urban environment.

Problematic Conditions Matrix: Cross-analytical matrices combining spatial indicators with socio-economic and demographic datasets. These matrices aim to identify structural correlations, recurring patterns, and relationships between physical conditions and social vulnerabilities.

Identified Priorities: matrix of the main issues emerging from computational analysis and participatory processes. This section presents validated priorities and concerns collected through direct engagement with residents and stakeholders.

Validation Gap Analysis: comparison between computationally detected phenomena and those validated through participatory processes. This analysis highlights potential gaps between data-driven interpretations and lived experiences, identifying areas where quantitative assessments may not fully capture local realities.

Intervention Framework: A structured set of possible interventions and design guidelines derived from computational analysis and participatory co-design processes. Each intervention can be evaluated according to feasibility, expected impact, opportunities, and potential risks.

Comparative Case Studies : AI-supported collection of relevant examples and comparable interventions. This section provides references and best practices from similar contexts to support implementation strategies and anticipate possible challenges.

Open Reports and Data Access: Downloadable reports and datasets enabling transparency, reproducibility, and further analysis by citizens, researchers, and public institutions.

PROCESS: At this stage, the computational system integrates the full spectrum of data generated throughout the process, including initial spatial observations, validated phenomena, and co-produced intervention proposals refined through stakeholder engagement. Based on this comprehensive dataset, it is possible to produce, with other data visualization systems and GIS, a set of outputs designed to directly inform public governance structures responsible for managing the housing stock or the relevant spatial scale of intervention.

These outputs provide a decision-support system for public governance, enabling more targeted, evidence-based, and context-sensitive interventions. In this way, the complexity of the housing environment can be translated into actionable strategies that support more efficient management and improve the overall quality of life within residential contexts.

POST- PROCESS PHASE

In an ideal scenario, following the communication of results to the relevant public authorities, one or more intervention strategies are implemented in order to address the identified issues. Once realised, these interventions are expected to modify the physical environment and, consequently, the quality of life of residents.

However, a crucial step within the overall methodological framework lies beyond implementation. As discussed throughout this research, a BDMF -based system enables the establishment of a continuous feedback loop. The new spatial conditions produced by interventions generate new patterns of use, as well as new forms of spatial “errors” and human traces. Continuous monitoring and system updates therefore ensure that these emergent conditions are reintegrated into the analytical framework, allowing them to function as feedback signals for the system itself. In this sense, the process does not end with the implementation of an intervention but remains open and iterative, constantly informed by the evolving reality of the urban environment.

Within this perspective, “human traces” are reinterpreted not merely as indicators of existing conditions, but as dynamic signals of a living system capable of producing responses, adaptations, and new forms of spatial behaviour among its inhabitants.

The following chapter presents a case study designed to test and illustrate the dynamics described above in a concrete context.

Information as a Tool for Democracy

Figures 58: Jacob Riis – How the Other Half Lives (1890)

A DEEP DIVE INTO...



At the end of the 19th century, Jacob Riis used photography as a tool to make the inadequate living conditions of working-class and immigrant communities in New York's tenement districts visible, transforming representation into a means of social awareness and political action.

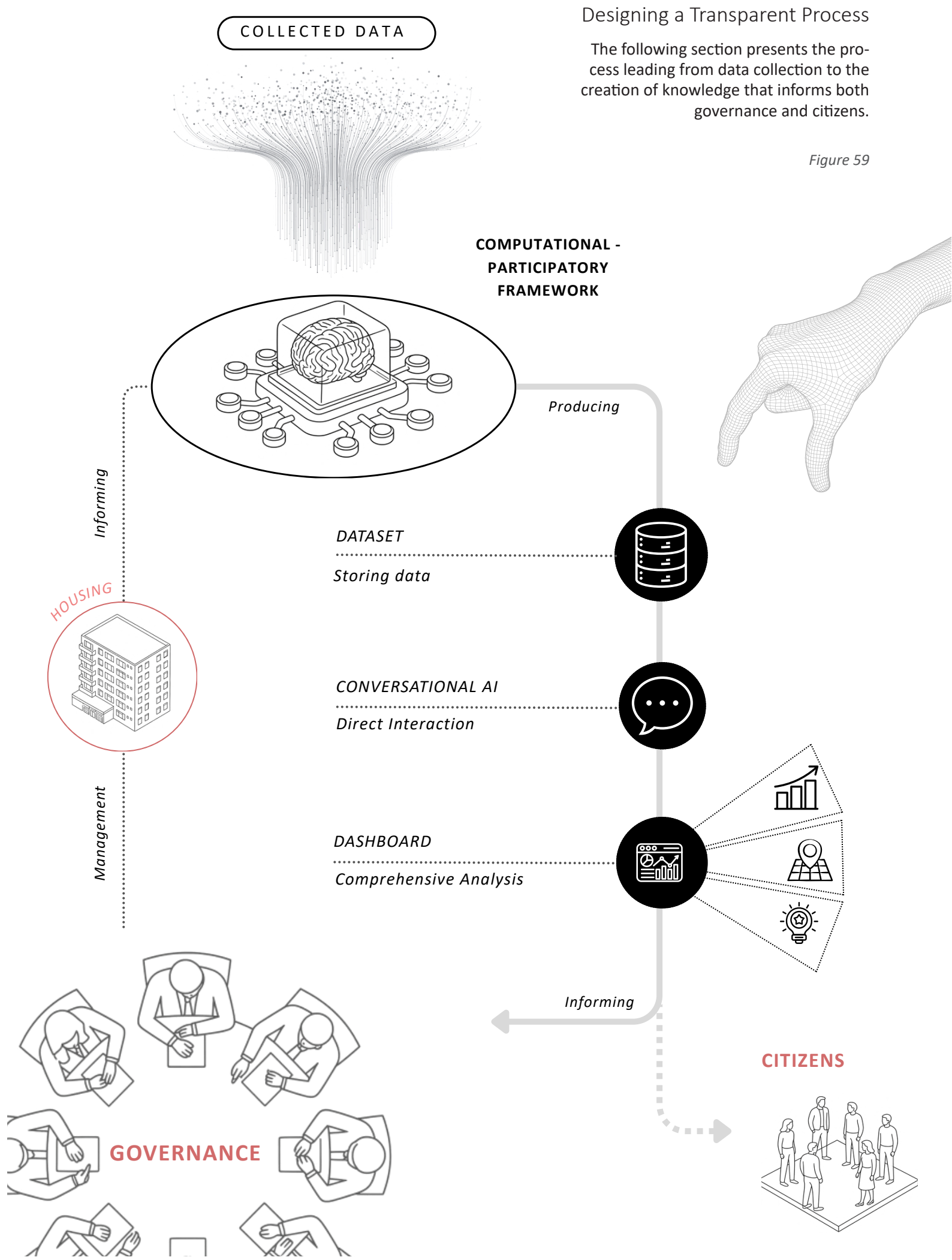
Similarly, in the contemporary digital era, communication and representation increasingly mediated by data, are political tools. In fact, they shape the way information is produced, accessed, interpreted, and ultimately used to form opinions. While the growing availability of information can facilitate access to knowledge, the quality of public understanding remains deeply influenced by which information is collected, selected, and communicated.

Therefore, ensuring transparent processes and accessible data has become a fundamental aspect of democratic participation. However, if one dimension of digital governance focuses on collecting, organising, and making information available, another crucial dimension concerns how this knowledge is translated, communicated, and transformed into meaningful opportunities for civic engagement.

Designing a Transparent Process

The following section presents the process leading from data collection to the creation of knowledge that informs both governance and citizens.

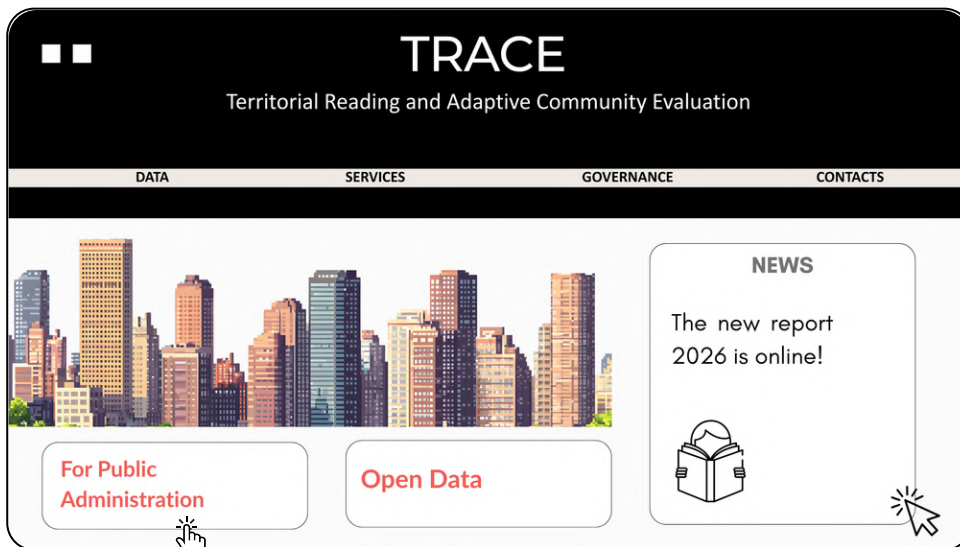
Figure 59



A civic dashboard:

This section presents examples of dashboard interfaces developed to communicate data, processes, and platform functionalities to users.

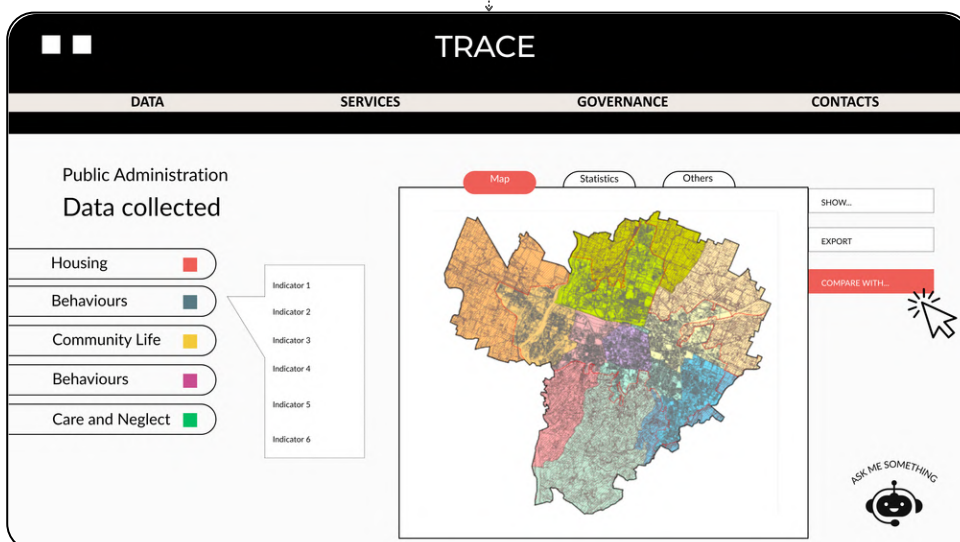
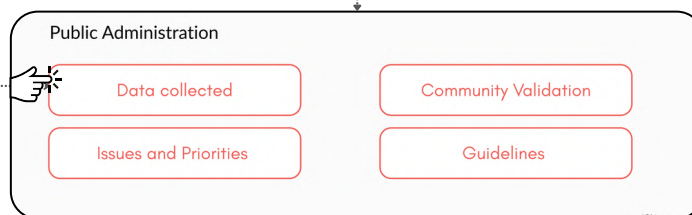
Figure 60



A chatbot can help users navigate data.



People can access the collected datasets, while periodic reports are published to keep the information updated.

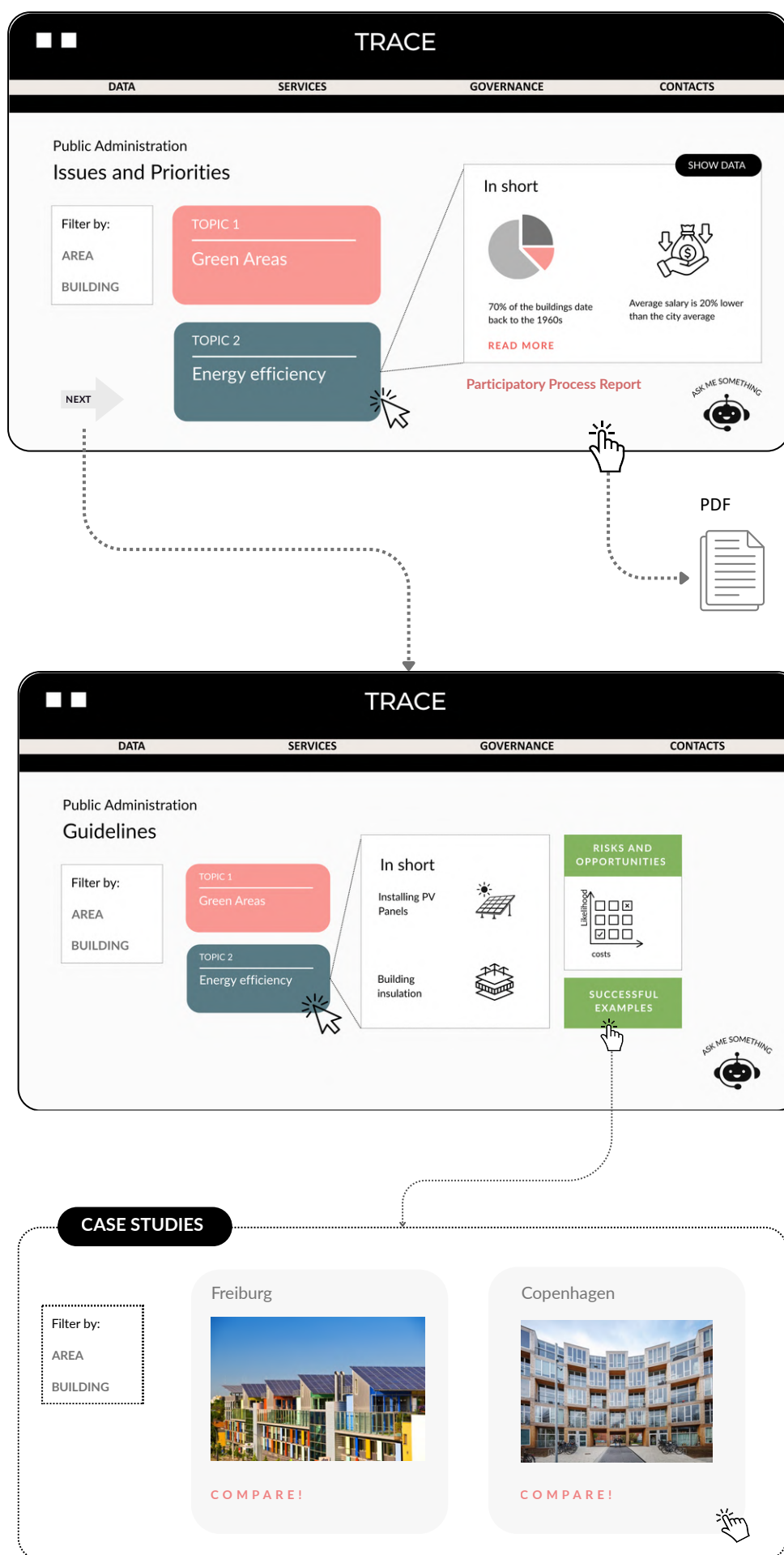


Maps can be downloaded in different formats (GIS, CSV, ...)



The data can be compared with other linked datasets considered relevant and informative.

Figure 61



Identified issues and the outcomes of participatory discussions are presented here.



Potential interventions and planning guidelines can be visualised, together with their associated risks and opportunities.

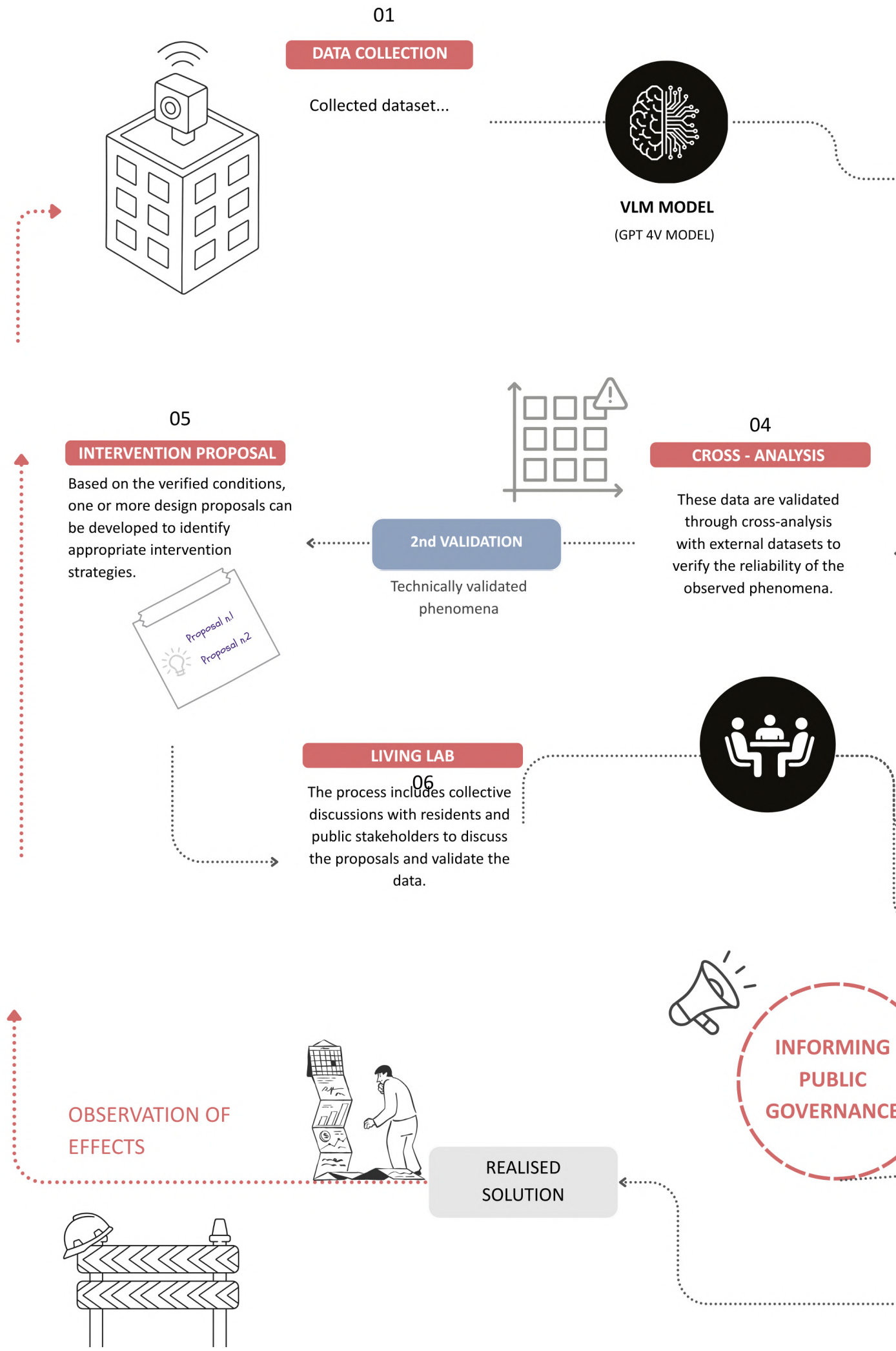


A collection of comparative case studies can support the future implementation of proposed interventions by identifying potential challenges, anticipating risks, and highlighting opportunities observed in similar contexts.

Figure 62

COMPUTATIONAL PROCESS

PARTICIPATORY PROCESS



02

DATA PROCESSING

We obtain an assessment of selected

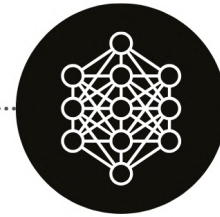
SPATIAL PHENOMENA

=

'Human Traces'



divided in:
4 LAYERS



MML MODEL

03

PHENOMENA DETECTION



HUMAN BEHAVIOURS
and NEEDS

EMOTIONS

1st VALIDATION

3rd VALIDATION

VERIFIED PHENOMENA

VALIDATED PROPOSAL

DATA TO TRAIN AI MODELS

07

COMMUNICATION OF RESULTS

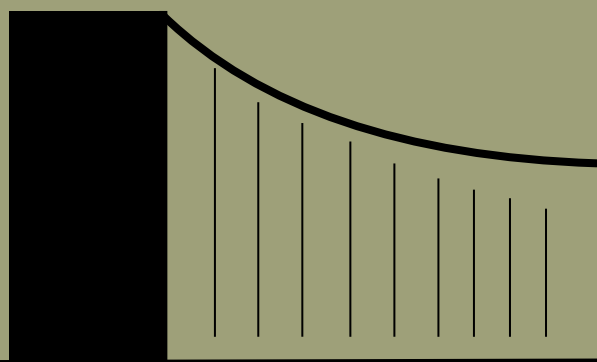
These data are validated through cross-analysis with external datasets to verify the reliability of the observed phenomenon.

Open - source data



05.

READING 'HUMAN TRACES' IN PILASTRO



The framework is intended to be validated and tested through the case study of Il Pilastro, a residential district on the outskirts of Bologna, empirically exploring the direct application of this framework in a real-world context. Within this framework, an empirical assessment is carried out in the Pilastro neighborhood, focusing specifically on the Virgolone building (AOB) and its immediate surroundings (AOI). The process is organized into distinct phases.

Pilastro is located approximately 4 km north-east of Bologna's historic city centre, within the San Donato–San Vitale District. Although physically connected to the city, its development has historically been influenced by major transport infrastructures—including the A14 motorway, the Bologna ring road (Tangenziale) and the railway corridor—which have contributed to a persistent perception of spatial separation from the rest of Bologna (Comune di Bologna, 2020; Casu, 2020).

Figure 63



The neighbourhood represents one of Bologna's largest concentrations of public housing. In fact, 31% of occupied dwellings are public housing units (ERP), where approximately 36% of the neighbourhood's residents lives (Comune di Bologna, 2020). Despite its relatively high residential density, the neighbourhood is distinguished by an extensive system of public green spaces. Large parks—including Parco Pier Paolo Pasolini—together with generous open spaces between residential blocks, make Pilastro one of the greenest urban areas in Bologna, reflecting the original modernist planning principles that privileged light, air, and open space over compact urban form (Comune di Bologna, 2020).

Pilastro originated during the early 1960s as part of Bologna's ambitious post-war public housing programme (PEEP). Rather than designing a conventional residential suburb, planners envisioned an autonomous urban settlement capable of functioning as a "second city" alongside Bologna. Inspired by rationalist planning ideals, the masterplan integrated housing, schools, commercial activities, sports facilities, public services and extensive green infrastructure into a single self-sufficient urban organism. The project reflected the optimism of post-war welfare policies, where architecture and planning were expected to improve social conditions through carefully designed urban form (Casu, 2020; Università Roma Tre, 2020).

The first residents mainly consisted of working-class families relocated from Bologna's historic centre, together with migrants arriving from southern Italy during the period of rapid industrialisation. However, many of the planned services were delivered only years after the construction of the housing estates. During its early decades, residents experienced limited public transport, insufficient commercial activities and weak connections with the city centre, reinforcing a perception of isolation that would profoundly influence both the neighbourhood's development and its public image (Comune di Bologna, 2020).

Over time, Pilastro developed a remarkably strong local identity. Through neighbourhood associations, cultural initiatives, sports organisations and grassroots mobilisation, residents gradually transformed what had initially been perceived as an isolated peripheral settlement into a socially active community. Nevertheless, several historical events—including the Uno Bianca massacre in 1991—contributed to consolidating a negative public narrative that continues to shape the collective imagination surrounding the neighbourhood (Casu, 2020; Antigone, 2023).

Today, Pilastro presents a far more complex reality than the stereotypes that have long characterised its public image. Nevertheless, socio-economic indicators continue to identify the neighbourhood as one of the most vulnerable areas of Bologna. According to the ISTAT Socio-economic Deprivation Index (IDISE), Pilastro experiences relatively high levels of social and economic deprivation, with vulnerabilities particularly affecting families, young people, and its large population of foreign citizens (ISTAT, 2026).

AOI

It analyzes a 1 km²
area around the
building

AOB

The selected
building

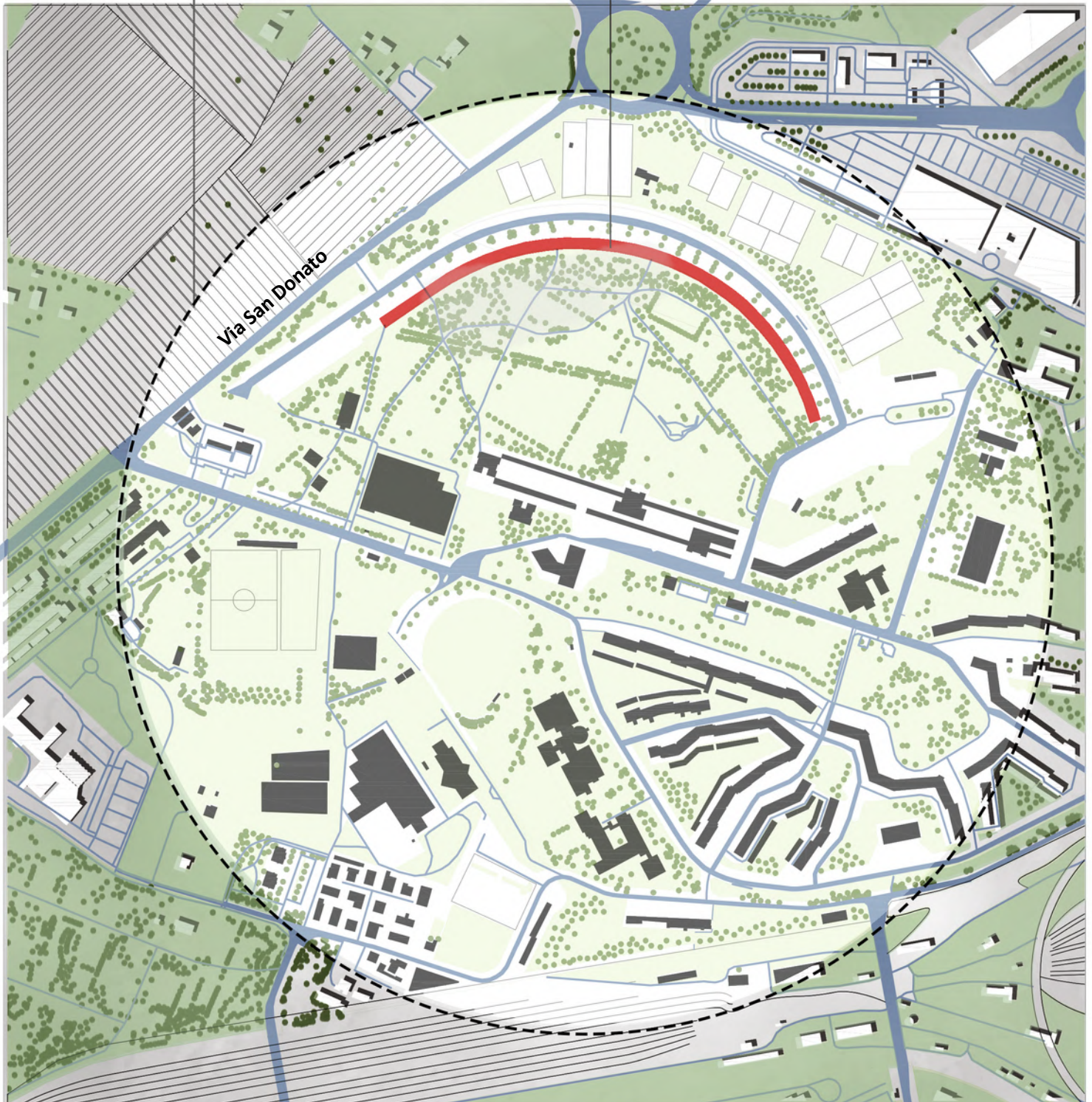
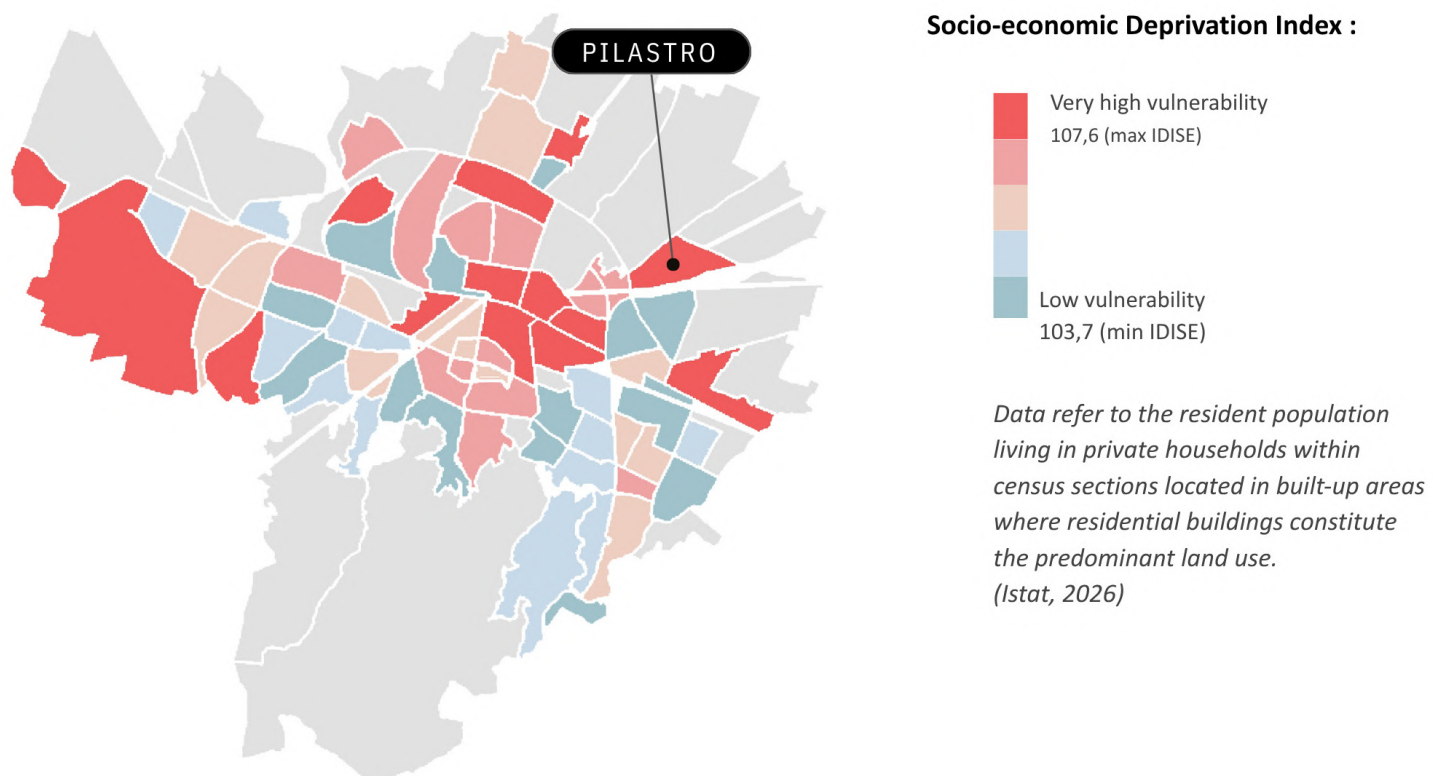


Figure 64: Plan of Pilastro
indicating the Area of Inter-
est (AOI) and the selected
building (AOB)

From the perspective of this research, Pilastro represents a particularly significant case study precisely because of this apparent contradiction. While statistical indicators effectively describe conditions of socio-economic disadvantage, they fail to capture the richness of the neighbourhood's social practices, spatial adaptations, informal uses, and collective identity. The history of Pilastro demonstrates that many of its defining characteristics emerge not from conventional datasets but from the continuous interaction between residents and the built environment. For this reason, Pilastro provides an ideal testing ground for the proposed framework. Starting from a neighbourhood widely recognised as socially complex, this testing phase simulates the design computational and participatory process of the BDMF to empirically investigate whether computational analysis of spatial indicators and human traces can reveal dimensions of urban life that remain invisible within traditional statistical representations.

Figure 65:



LOCAL INITIATIVES IN PILASTRO

Over the years, Pilastro has drawn considerable attention, both from the city administration and from the local community itself, which has responded to the neighbourhood's challenges through a series of initiatives that go beyond physical regeneration to address community networks, civic engagement, and the recognition of resources already present on the ground.

A turning point in this respect was the participatory process Pilastro 2016, launched in 2014 and built around the fiftieth anniversary of the neighbourhood's founding. It brought together residents, associations, and local institutions — including ACER Bologna, the CAAB agri-food centre, and the University of Bologna. This groundwork fed directly into Paesaggio Pilastro, a landscape-regeneration project structured across nine intervention areas, including the re-design of Piazza Lipparini as a collective space, financed through the 2016 national programme for the requalification of peripheral urban areas (roughly €18 million allocated to Bologna).

In parallel, the Laboratori di Quartiere, launched in May 2017 as part of the Comune di Bologna's Piano per l'Innovazione Urbana, introduced a proximity-based planning method across the whole city, Pilastro included. Through public meetings, listening sessions, mapping exercises and participatory budgeting, this initiative focused on youth inclusion and public space design.

Among more recent experiences, the GRETA project (GReen Energy Transition Actions, Horizon 2020) offers a relevant example of participatory work applied to energy transition. Carried out in the Pilastro-Roveri district between 2021 and 2023, it investigated the conditions related to the emergence of "*energy citizenship*," combining resident engagement with the area's industrial partners, among them CAAB-FICO, home to one of the largest photovoltaic installations on industrial rooftops in the EU.

Moreover, the community relies on a network of spaces: the Casa di Quartiere Pilastro, a former elderly social centre converted into a community-managed hub; DOM la cupola del Pilastro, an arts and performance venue opened in 2009 in a former gymnasium; and Circolo La Fattoria, active since 1967 as a long-standing point of reference for neighbourhood aggregation and social cohesion, hosting cultural activities since 1992.

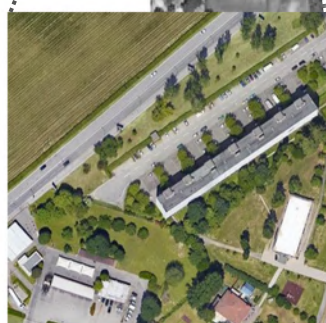
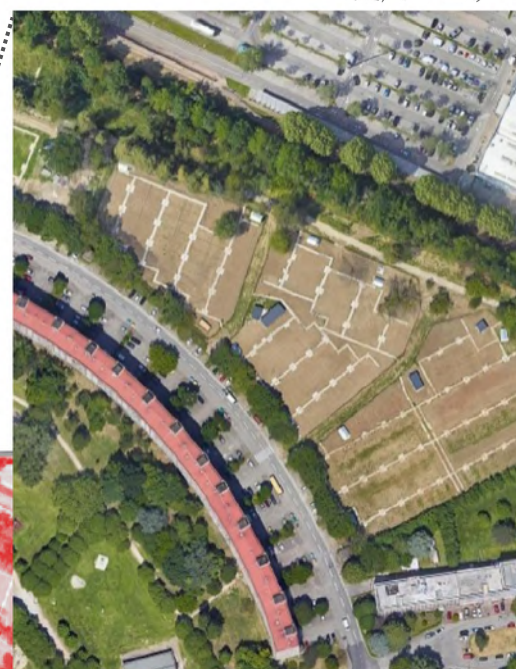
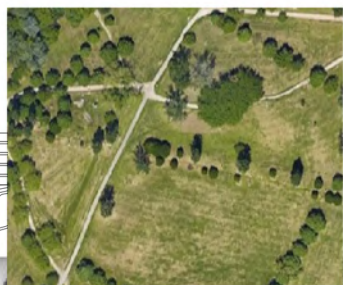
Figure 66:

The Virgolone is located adjacent to community gardens and in close proximity to one of the city's main commercial areas.



PARCO PASOLINI

It is one of the neighbourhood's largest and most significant green spaces. It serves as a major public space for everyday community life.



Pilastro is situated on the urban fringe of Bologna, marking the transition between the urban fabric and the surrounding peripheral landscape.



PARCO MITILINI

It represents one of the main aggregation spaces, particularly for young people, with several sports facilities and its proximity to the Luigi Spina Library contributing to its role as a local social hub.



VIRGOLONE

The Virgolone represents the architectural and symbolic landmark of Pilastro and constitutes one of the largest public housing complexes in Bologna. Built between 1974 and 1977 as part of the second phase of the neighbourhood's development, the seven-storey, curvilinear building extends for approximately 700 metres and comprises 552 dwellings, originally divided between the former Istituto Autonomo Case Popolari (IACP) and housing cooperatives. Designed by architects Giuseppe Morelli and Giuseppe Manacorda, the project formed part of a broader urban strategy intended to correct the social imbalance created during the first phase of Pilastro's construction. Rather than concentrating exclusively low-income households, the new development sought to attract a more socially diverse population and strengthen the neighbourhood's identity through a recognisable urban form (Biblioteca Salaborsa, 2020; Regione Emilia-Romagna, 2024).

The building's distinctive curved geometry embraces Parco Pier Paolo Pasolini, establishing a close relationship between architecture and landscape that reflects the modernist planning principles underlying the entire neighbourhood. Conceived by architects Paolo Bettini and Marco Ferrari, the approximately 16-hectare park was designed as the principal collective open space of Pilastro, combining extensive green areas with cultural and recreational functions. Between 1974 and 1984, sculptor Nicola Zamboni created the monumental installation *Percorso umano*, composed of around 200 life-sized sculptures distributed throughout the park, transforming it into one of Bologna's most significant examples of public art integrated with residential space.

Immediately behind the Virgolone are the neighbourhood's urban gardens (*orti urbani*), which, together with Parco Pasolini, form part of a broader system of green infrastructure extending across the district. These gardens provide opportunities for food production, informal encounters, and intergenerational interaction, and have become important places of everyday social life. Together with the park, they contribute to a network of open spaces that distinguishes Pilastro from many other post-war housing estates, where green areas often function merely as residual spaces rather than actively appropriated community infrastructure. Today, despite ongoing socio-economic challenges, the Virgolone, Parco Pasolini and the urban gardens continue to constitute the spatial and social core of the neighbourhood, supporting everyday practices of recreation, encounter, and collective identity while remaining central to recent regeneration initiatives.





5.1 Simulation of the BDMF

EXPERT VALIDATION:

As a preliminary validation step, the proposed framework was discussed with experts through a combination of literature review and semi-structured interviews involving scholars and practitioners from the fields of architecture, sociology, and digital technologies. This phase aimed to validate the theoretical assumptions underpinning the research and to identify the main knowledge gaps outlined in the previous sections.

At this stage, the discussion focuses on non-localised knowledge, addressing challenges that are common across different public housing contexts rather than those specific to a single case study.

The expert validation highlighted several recurring issues:

Communication gaps in public housing management. The relationship between housing authorities (e.g., ACER) and residents is often fragmented. There is frequently a disconnect between implemented interventions, how they are actually used by residents, and the information available to housing managers. In addition, limited financial and human resources make the management of public housing stock particularly challenging, while the lack of standardised and comprehensive datasets further constrains evidence-based decision-making.

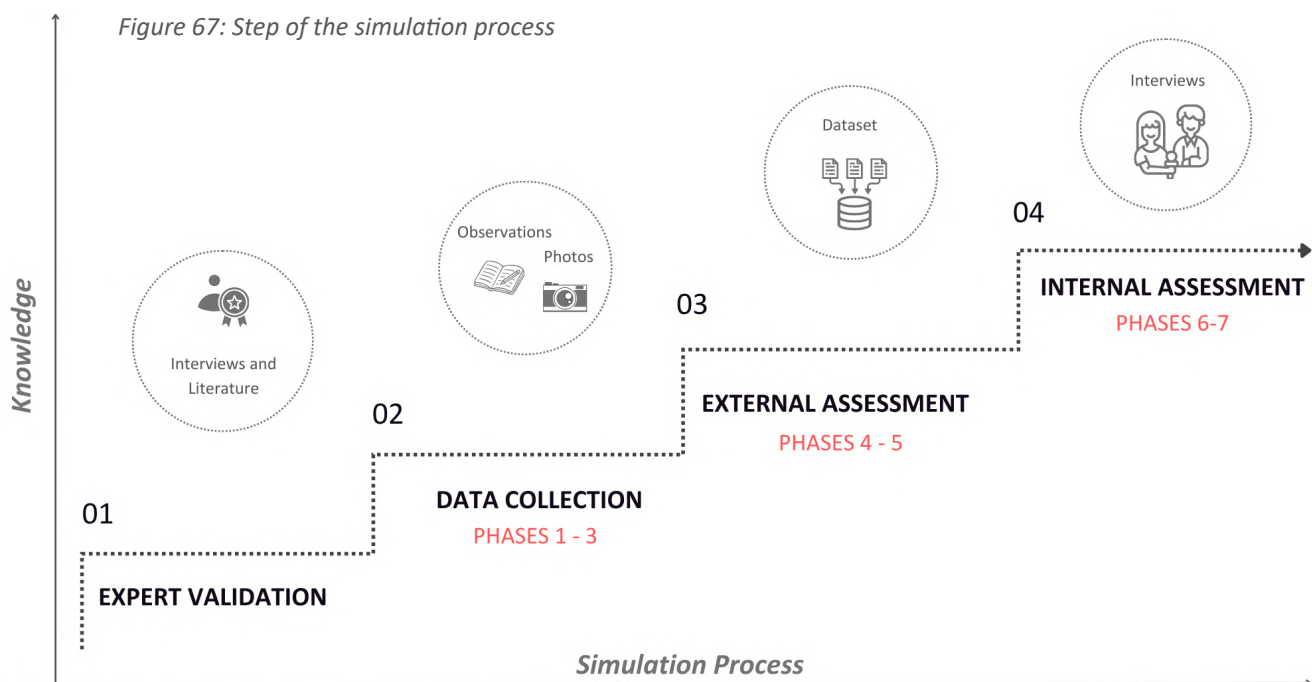
The potential of computational technologies. Experts recognised that technologies such as Urban Vision systems (e.g., UrbIA) can significantly support large-scale data collection and urban monitoring. However, current applications predominantly focus on describing the physical characteristics of the built environment, while the social meanings, behaviours, and lived experiences embedded within these spaces remain largely unexplored.

Limitations and risks of AI and Smart City technologies. Although AI and Smart City applications offer considerable opportunities for improving urban management, their adoption also raises important concerns regarding data privacy, ethical governance, transparency, accessibility, and the risk of reinforcing existing inequalities. These aspects highlight the need for participatory approaches capable of complementing computational analysis with contextual and human-centred knowledge.

COLLECTION OF MATERIAL AND OBSERVATIONS :

This second phase involves an on-site data collection of the spatial phenomena observed in the Pilastro area. During this stage, no direct interaction with residents is foreseen, nor is an in-depth investigation of the neighbourhood's historical background conducted. The aim is to maintain the most objective observational standpoint possible by minimising human interpretative bias.

The objective is to reduce subjectivity in both the detection and validation of spatial findings. In this sense, the approach seeks to preserve a neutral observational perspective, approximating the logic of an "Urban Vision" system based exclusively on the reading of spatial and physical conditions.



EXTERNAL ASSESSMENT - ANALYSIS OF DATA:

In this phase, the focus shifts to the analysis and documentation of the study area in order to validate the previously identified spatial phenomena. The aim is to cross-check the observed findings with external datasets and sources, including environmental, economic, social, and historical documentation. This step enables a broader contextualisation of the initial spatial observations, allowing them to be interpreted within a wider set of structural conditions and background dynamics. By integrating heterogeneous sources of information, the analysis supports a more robust and multi-dimensional understanding of the phenomena under investigation.

DATA PROCESSING (PHASE 02)

In this phase, the collected data are analysed through a qualitative empirical assessment, replicating the interpretative process that would normally be performed by the AI system. Rather than simply identifying isolated spatial conditions, the objective is to understand how different physical elements interact and what potential social meanings, behaviours, and needs they may reveal. The complete assessment sheet is provided below, while the following discussion critically interprets the main patterns emerging from the observed indicators.

The first relevant aspect concerns the relationship between the original planning principles of Pilastro and the current use of its urban structure. The neighbourhood clearly preserves many characteristics of its modernist conception: large distances between buildings (1.2), extensive green areas, particularly within Parco Pier Paolo Pasolini (1.1). However, the analysis also reveals a tension between the quantity of public space and its actual usability. Although green areas are abundant, the presence of adequate public infrastructures appears limited: benches are frequently present but often deteriorated, while children's play facilities and other collective amenities are insufficient (1.4 Public amenities). This suggests that the issue is not the absence of open space itself, but rather the limited capacity of these spaces to support diverse forms of everyday use and social interaction.

Public lighting is insufficient and concentrated mainly along primary roads, leaving parks and secondary pedestrian areas poorly illuminated (1.3 Lighting). Combined with scarce public transport availability and overcrowded stops (1.5 Accessibility/public transport), this condition may contribute to a perception of isolation, particularly during evening hours.

The analysis of temporal occupation reveals a complex and non-uniform use of space. Public spaces are not generally abandoned; on the contrary, parks are actively used throughout the day and certain areas of Parco Pasolini function as recurring gathering points for groups of residents (2.7 Public spaces occupation). This suggests the presence of strong informal social practices and a capacity of residents to appropriate collective spaces. However, this vitality is spatially selective. Transitional spaces such as porticos and stairwells are mainly used for circulation rather than social interaction (2.2 Flows), while some common areas appear avoided despite their potential role as social infrastructure (2.1 Permanence in common areas). This indicates that the physical availability of collective space does not automatically translate into social use; spatial configuration, environmental quality, and perceived safety strongly influence appropriation patterns.

Residential behaviours also reveal important adaptations between the designed environment and everyday needs. The widespread presence of informal seating elements provided by residents (3.1 Informal seating) demonstrates active appropriation and the creation of alternative social spaces where formal infrastructures are insufficient. These elements should not simply be interpreted as signs of lack of maintenance, but rather as evidence of residents actively modifying their environment to satisfy unmet social needs. Similarly, the extensive use of balconies as storage areas (3.2 Objects on balconies) and the frequent enclosure of balconies to enlarge domestic space (3.5 Enclosed balconies) suggest a mismatch between the original housing design and contemporary household requirements. These transformations indicate a desire to increase domestic comfort, privacy, and functional space, but they may also reveal forms of spatial inadequacy within the existing housing stock.

Although the original architectural structure maintains a high level of permeability and visual openness, the presence of window grilles, barriers, and protective elements in a significant proportion of dwellings (3.4 Grids/fences/barriers) indicates attempts by residents to regulate the relationship between private and public space. These modifications may respond to perceived security concerns, the need for privacy, or a desire to control exposure to the external environment. At the same time, the coexistence of open architectural principles and individual defensive adaptations highlights a central tension within modernist housing estates: collective openness does not always correspond to residents' contemporary perceptions of comfort and safety.

A particularly relevant observation concerns the interpretation of signs of degradation. Physical decay is not uniform across the neighbourhood. Building façades generally show limited deterioration (4.1), suggesting that the main structural components of the housing stock have been relatively maintained. Conversely, other elements of everyday urban experience show more evident problems: damaged pavements (4.3), abandoned vehicles and vacant spaces (4.2), illegal dumping and waste accumulation (4.4) and the closure of commercial activities located on the ground floors of residential buildings (4.5).

However, these signs of neglect must be interpreted carefully. Graffiti represents a more ambiguous spatial trace, simultaneously functioning as a potential sign of abandonment and as a cultural expression, particularly under the porticos, and as a form of identity construction and a claim of visibility within public space. Similarly, the presence of informal resident-led maintenance activities, such as the care of flowerbeds and shared green areas (4.7 Degraded public facilities), demonstrates that physical neglect does not necessarily correspond to a lack of attachment to place. On the contrary, these practices reveal forms of local stewardship that coexist with institutional shortcomings.

Overall, the empirical analysis reveals Pilastro as a neighbourhood characterised by multiple and sometimes contradictory conditions. The same spatial characteristics can generate different interpretations: large open spaces can represent both environmental quality and a lack of social control; graffiti can indicate both neglect and cultural expression; informal adaptations can represent both deficiency and active appropriation. Therefore, the observed phenomena cannot be understood through a single indicator but require a relational reading that connects physical traces, resident behaviours, and contextual factors. These preliminary interpretations will be further tested through the following cross-analysis phase, where spatial observations are compared with socio-economic, demographic, and qualitative data.

The following section focuses on two significant spatial traces emerging from the previous observational analysis. These traces illustrate how computational observations can be translated into preliminary hypotheses regarding social dynamics, emotional dimensions, and potential spatial needs. At this stage, these interpretations should be understood as hypotheses generated by the framework, awaiting validation through complementary datasets and participatory engagement.

Figure 69: Analysis of the selected indicators divided into the 4 layers

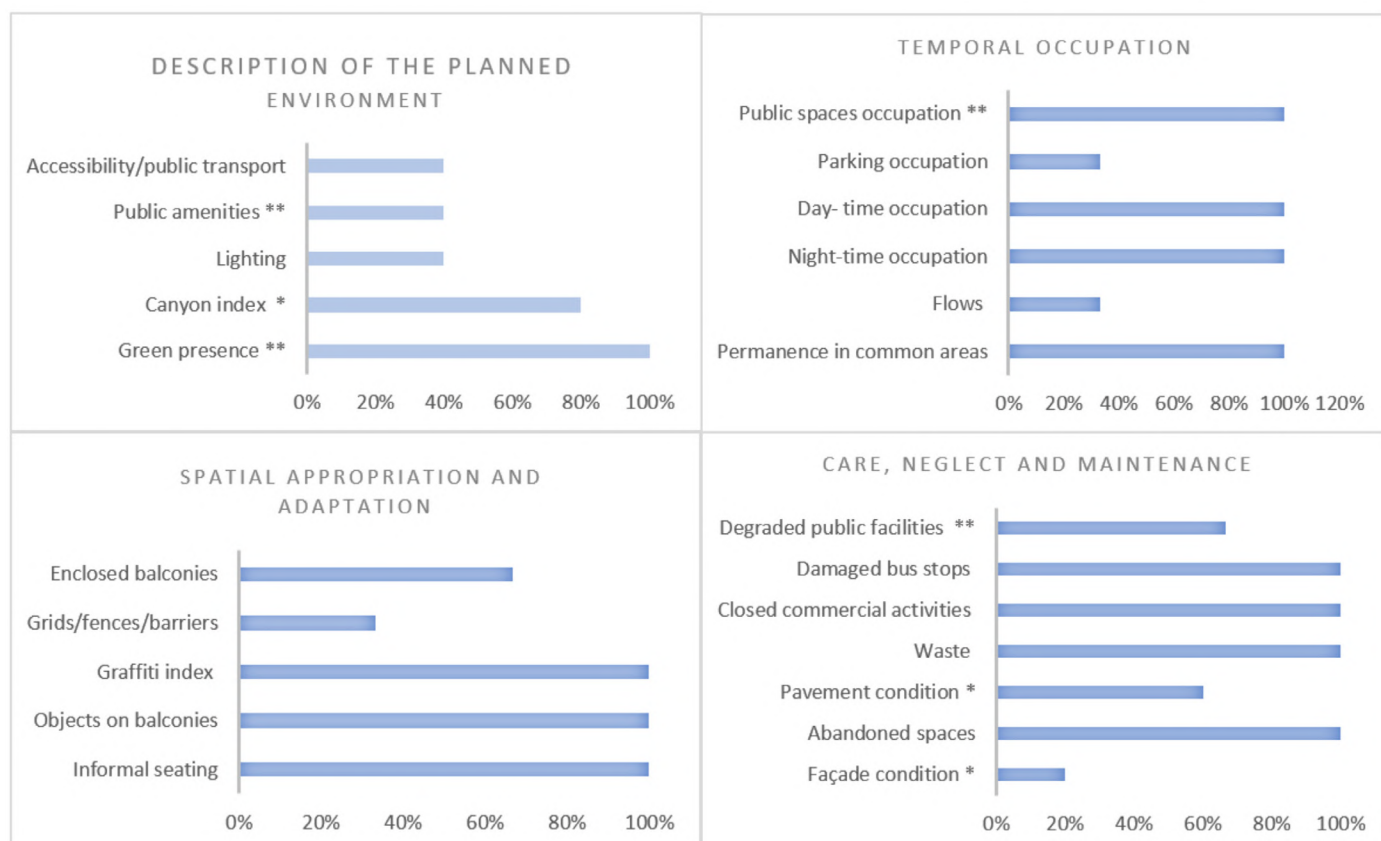
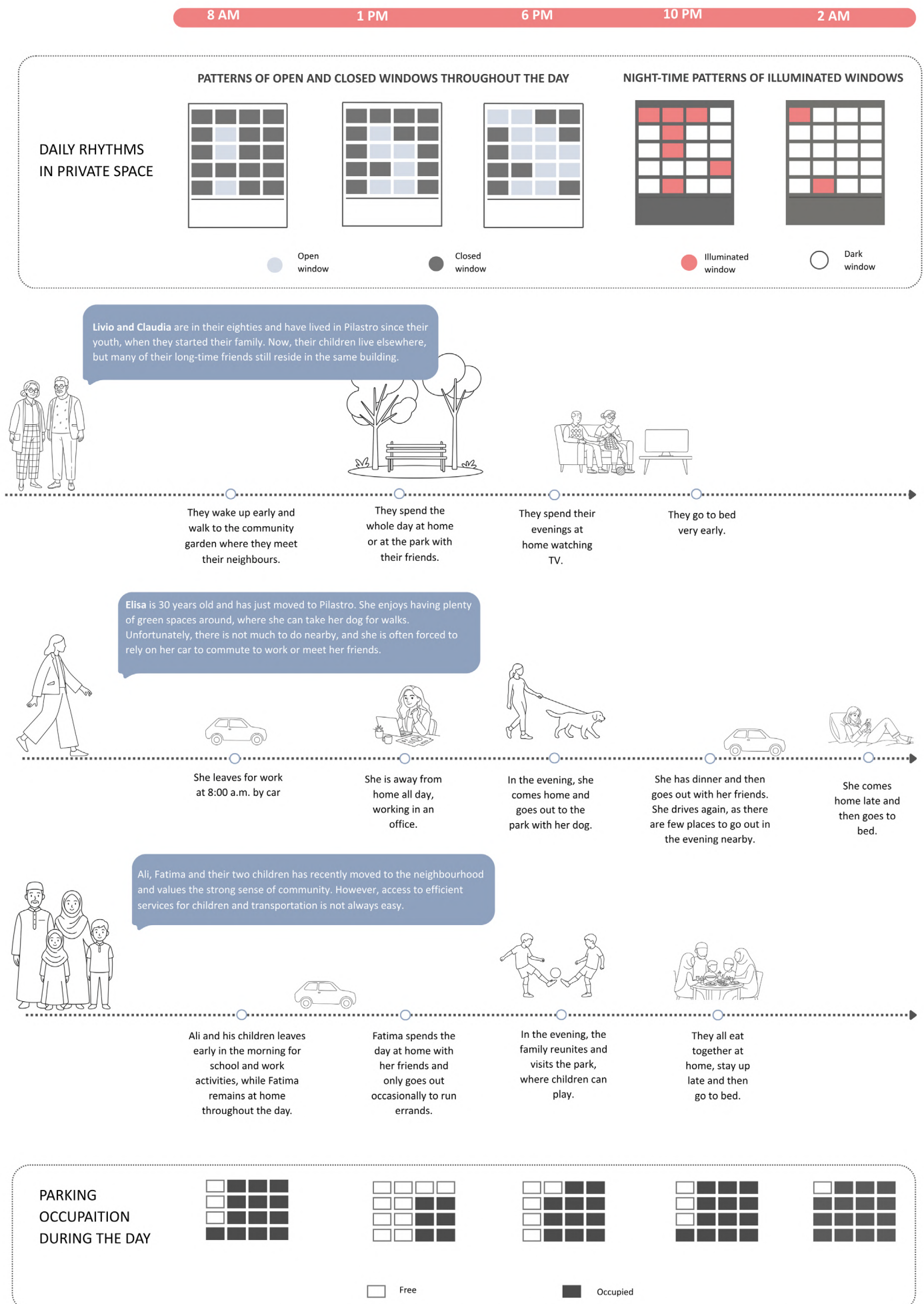


Table 3: Simulation of the assessment process

01 Description of the planned environment				
1.1	Green presence **	AOI	100%	Green spaces are abundant, with a high density of mature trees throughout the neighbourhood. In particular, Parco Pier Paolo Pasolini is characterised by extensive tree coverage, contributing to environmental quality and thermal comfort.
1.2	Canyon index *	AOI	80%	Streets are generally wide, with generous spatial dimensions and large distances between buildings.
1.3	Lighting	AOI	40%	Public lighting is insufficient and mainly concentrated along primary roads. Parks and secondary pedestrian areas remain poorly illuminated, potentially affecting perceived safety during evening hours.
1.4	Public amenities **	AOI	40%	Benches are frequently found, including at street intersections, although many are in poor condition. Conversely, there is a noticeable shortage of children's play facilities and related public infrastructure.
1.5	Accessibility/public transport	AOI	40%	Public transport stops are relatively scarce and often overcrowded, with users experiencing long waiting times.
02 Temporal Occupation				
2.1	Permanence in common areas	AOB	100%	Patterns of spatial occupation vary considerably across the neighbourhood. Certain areas, such as the portico, appear to be consistently avoided, while others show clear evidence of prolonged human presence and everyday activities (see Indicator 3.1).
2.2	Flows	AOB	33%	Transitional spaces, including porticos and stairwells, are used almost exclusively for circulation and rarely function as places of social interaction or permanence.
2.3	Gathering points	AOB	-	-
2.4	Night-time occupation	AOB	100%	Residential activity is high, as suggested by the large number of illuminated dwellings and active balconies during evening hours.
2.5	Day- time occupation	AOB	100%	More than 50% of the observed windows remain closed during daytime, often combined with curtains, shutters, or other visual barriers that significantly reduce visibility between the interior and the public realm.
2.6	Parking occupation	AOB	33%	A marked variation in occupancy is observed between daytime working hours and the evening, reflecting different rhythms of residential use.
2.7	Public spaces occupation **	AOI	100%	Public parks are generally well used throughout the day, with relatively consistent levels of activity. Certain spots, especially in Pasolini Park, also function as recurring gathering places, where the same groups of residents regularly meet and spend time together.
03 Spatial appropriation and adaptation				
3.1	Informal seating	AOB	100%	Informal seating elements provided by residents (plastic chairs) are present in common outdoor spaces.
3.2	Objects on balconies	AOB	100%	More than 50% of balconies are extensively used for storage rather than outdoor living.
3.3	Graffiti index	AOI	100%	Graffiti is widespread and highly visible across multiple surfaces, particularly beneath the portico. Rather than being interpreted solely as signs of degradation, these interventions reveal significant cultural and artistic value. Similar patterns can be observed throughout the Area of Interest (AOI).
3.4	Grids/fences/barriers	AOB	33%	Approximately 30–50% of dwellings are equipped with window grilles or other protective barriers. While these additions may reflect concerns related to security and privacy, the original architectural structure remains generally open and permeable, preserving the openness envisioned in the original design.
3.5	Enclosed balconies	AOB	67%	Approximately 30–50% of balconies have been enclosed and incorporated into the dwelling, either as additional storage space or as an extension of the domestic environment. These modifications suggest that the original apartments may not adequately satisfy residents' spatial needs.
04 Care, Neglect and Maintenance				
4.1	Façade condition *	AOI	20%	Building façades generally show limited visible deterioration, indicating relatively good structural maintenance.
4.2	Abandoned spaces	AOI	100%	Several abandoned vehicles and a small number of vacant or abandoned buildings are present within the study area.
4.3	Pavement condition *	AOI	60%	Pavement conditions are poor in several locations, with visible signs of deterioration.
4.4	Waste	AOI	100%	Illegal dumping and accumulated waste are common. Most waste collection points are surrounded by overflowing bins and discarded materials.
4.5	Closed commercial activities	AOI	100%	Numerous commercial premises, particularly those originally planned on the ground floors of residential buildings, are currently vacant or permanently closed.
4.6	Damaged bus stops	AOI	100%	Bus stop facilities are generally in acceptable condition.
4.7	Degraded public facilities **	AOI	67%	Signs of decay are visible in public amenities such as benches and playground equipment. Green areas are, in some cases, poorly maintained. At the same time, there is evidence of informal care by residents, who occasionally maintain flowerbeds, gardens, or shared outdoor spaces on their own initiative, demonstrating local stewardship despite limited institutional maintenance.

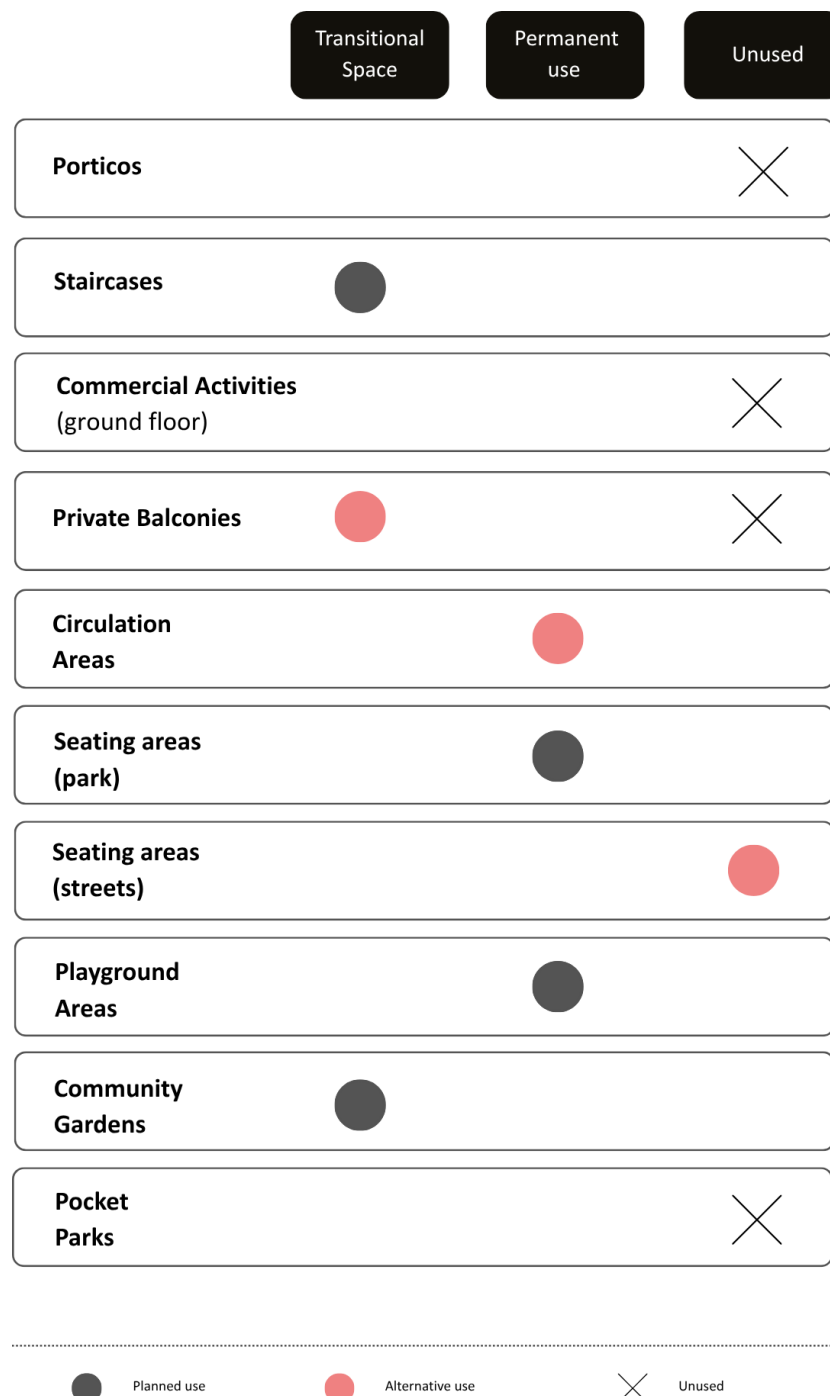
Figure70: Conceptual representation of everyday human rhythms and their relationship with the selected indicators through the development of three proto-personas.



USE OF SPACE

Through direct observation, it becomes possible to identify whether spaces are actively used, by whom, and whether everyday practices correspond to the original intentions of the design. Deviations between planned and real uses are not interpreted merely as failures, but as potential indicators of adaptation, emerging needs, or alternative forms of appropriation. These observations contribute to a deeper understanding of how inhabitants interact with the built environment and how spatial conditions can support or constrain everyday life.

Figure 71: Analysis of observed spaces and their use.



Figures 72-81:

01



The porticoed area at the ground floor of the building remains consistently unoccupied and is frequently avoided by users. People tend to choose alternative routes. This behaviour may be linked to a perceived sense of insecurity within the space.

02



Stairwell areas, together with the portico, are used only as transitional spaces with very limited occupation. Empty bicycle parking areas and general signs of neglect suggest a lack of care for these spaces and a low level of appropriation by users.

04



Private balconies are used for storage purposes and appear to be rarely actively used by residents. In many cases, they have been enclosed with permanent structures, suggesting that social life tends to take place in shared outdoor spaces

03



The ground-floor commercial spaces in many buildings, designed to extend the social life and activities of the neighbourhood, remain closed and underutilized.

06



Seating areas located within parks constitute genuine spaces of permanent social interaction for local residents, especially for elders.

05



These circulation spaces, designed to function as transitional areas, are instead used as spaces for resting and social interaction. These areas provide effective shelter from heat and benefit from natural ventilation.

08



Playground areas frequently experience high levels of crowding, indicating intense but concentrated use.

07



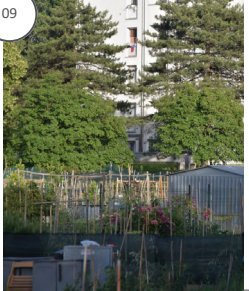
Unlike the benches located within parks, those positioned along the streets show fewer signs of use and are generally in poorer maintenance condition.

10



Small green areas and pocket parks, lacking of adequate infrastructure or in poor condition, remain largely unused and fail to fulfil their intended function.

09



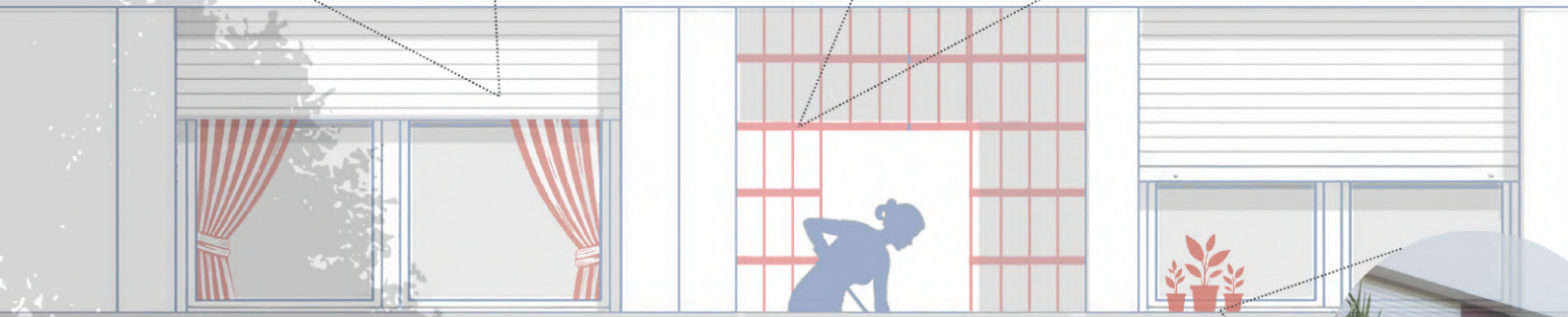
Community gardens are spaces where people gather showing an intense and varied use by different users.



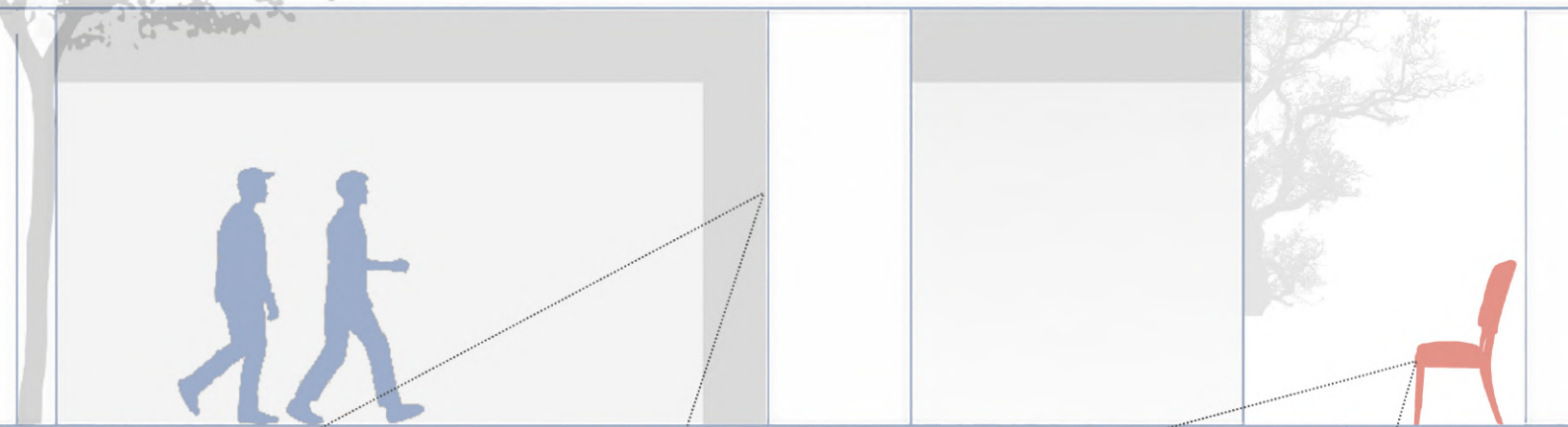
PERMANENTLY
ENCLOSED
BALCONIES



SECURITY
BARRIERS



OBJECTS ON
BALCONIES



GRAFFITI



INFORMAL
SEATING AREAS

HUMAN TRACE 01: Social and public life in Pilastrò

Phase 03 - PHENOMENA DETECTION

One of the most evident patterns emerging from the field observations is the extensive and recurring occupation of public spaces. Green areas, particularly Parco Pier Paolo Pasolini, are consistently used as gathering places by residents throughout the day. Repeated photographic surveys conducted on different days over several weeks revealed that many of these meeting places are occupied by the same groups of people, suggesting stable routines of social interaction rather than occasional use.

Additional evidence of informal appropriation can be observed beneath the porticoes, where residents have placed chairs and other seating elements, transforming circulation spaces into places for staying, socialising, and seeking shade during warmer periods. Similarly, the community gardens located behind the Virgolone building remain active throughout the day and are frequented by residents of different ages, genders, and cultural backgrounds. These spaces appear to function not only as productive landscapes but also as important social infrastructures capable of fostering encounters, everyday interactions, and a shared sense of belonging.

A further indicator is the informal maintenance of public green spaces. Although several areas suffer from limited institutional maintenance, numerous flower pots, cultivated plants, and small gardening interventions demonstrate residents' willingness to care for their surroundings, reinforcing the interpretation of these spaces as collectively valued environments. From this perspective, we can identify:

- **EMOTIONS:** Taken together, these spatial traces suggest the presence of a relatively strong sense of community and local attachment.
- **NEED/ HUMAN BEHAVIOURS:** It may indicate a continuing demand for spaces that support everyday social life and collective interaction. Potential intervention strategies could therefore include strengthening neighbourhood social infrastructure through additional seating, playgrounds, fountains, community gardens, and cultural or associative centres capable of reinforcing existing social networks.

It should be emphasised that these interpretations remain **preliminary** and require validation through the participatory phase of the research.

Phase 04 - CROSS ANALYSIS ¹

Beyond the computational assessment, additional insights can be derived from five systematic field surveys conducted between May and June, at different times of the day and on different days of the week. Although these observations are not statistically representative, they provide valuable qualitative evidence of how different social groups appropriate and experience public space.

01) Repeated observations suggest clear differences in the use of public space across cultural backgrounds. Individuals who appeared to have migrant backgrounds were consistently observed occupying parks, public spaces, and communal areas more frequently than residents who appeared to be of Italian origin.

This pattern is particularly relevant considering Pilastrò's demographic composition.

- Foreign citizens account for approximately **21% of the neighbourhood's population** (compared with 15% across the municipality of Bologna).
- Public housing accommodates approximately 30% of Italian residents and 59% of non-Italian residents, reflecting the important role of social housing in shaping the neighbourhood's multicultural character.

Pilastrò hosts communities from a wide range of national backgrounds, including Moroccan, Nigerian, Tunisian and Sri Lankan residents, while Albanian, Bangladeshi and Filipino communities represent some of the largest foreign groups.

Despite the predominance of Italian residents within the overall population, this proportion is not reflected in the observed use of public space. This discrepancy suggests that cultural background may influence the frequency and patterns of outdoor public space use, although further qualitative investigation would be required to understand the underlying social and cultural dynamics.

02) A second recurring pattern concerns the concentration of young people within Parco Pier Paolo Pasolini and the public spaces surrounding community and cultural facilities. These locations consistently function as neighbourhood social hubs, attracting groups of adolescents and young adults who use them for meeting, leisure, and informal activities. The proximity of community infrastructure appears to play a significant role in activating public space. Notably, many of the young people regularly occupying these spaces appeared to have migrant backgrounds.

¹ Based on Data ISTAT, Comune di Bologna and empirical observations

This observation is more relevant when associated with the fact that approximately 80% of foreign young people are living in public housing structure (ERP).

03) Moreover, a marked gender imbalance was observed among younger users. Across the five observation sessions, males aged were consistently much more visible than females, among young people, with an estimated ratio of only of two girls for every ten boys occupying the same public spaces. Young men and boys frequently gathered in groups and remained outdoors for prolonged periods, whereas young women appeared considerably less visible within the same environments. Although these observations cannot explain the underlying causes, they suggest that gender significantly influences access to and appropriation of public space.

This pattern is consistent with extensive research showing that women generally report higher levels of perceived insecurity in public spaces than men, which often results in different patterns of spatial behaviour and use. Interestingly, however, this gender imbalance appears to diminish among older generations. Unlike the younger age group, the presence of older men and women in public space appeared relatively balanced, suggesting that gender differences in spatial occupation become less pronounced with age.

04) Among working-age adults (30–50 years), a different pattern emerged. Women from diverse cultural backgrounds were more frequently observed using public spaces during daytime hours, often accompanied by children or moving in small groups. Their relatively high presence outside conventional working hours may reflect different employment conditions, caregiving responsibilities, or everyday routines, although these interpretations require validation through interviews and demographic analysis. This observation is partially supported by labour market statistics, which show a significant gender gap in employment within the Bologna metropolitan area (approximately 77% employment among men compared with 66% among women). Moreover, Pilastro is among the areas characterised by some of the **lowest median female incomes** within the city, suggesting structural differences in labour participation and economic conditions.

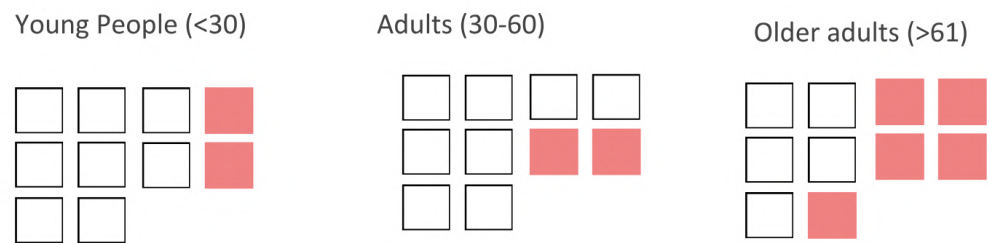
05) Older residents, by contrast, tended to occupy quieter and more secluded areas of the neighbourhood, favouring benches, shaded spaces, and peripheral green areas. In particular, elderly residents were frequently observed in the parks surrounding the Virgolone and the main public housing buildings. This tendency is coherent with the demographic composition of the neighbourhood, where a very high proportion of residents aged 70 years and over live in public housing.

Overall, these complementary analyses considerably expand the understanding of the spatial phenomena initially identified through the computational assessment. The preliminary observations are not only technically supported by demographic and socio-economic evidence but also reveal additional social dimensions that could not have been inferred through spatial observation alone. The following section applies the same analytical approach to a second spatial phenomenon identified during the fieldwork.

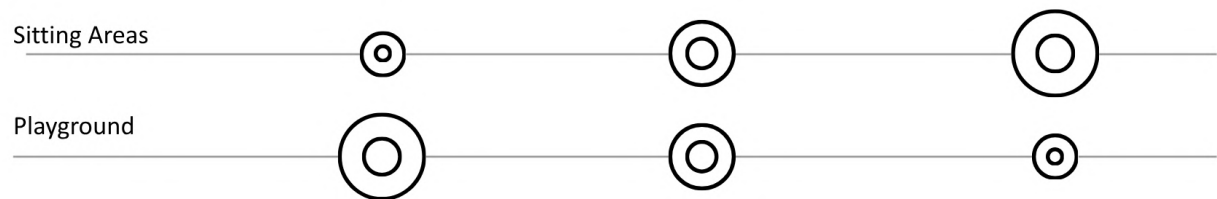


Figures 83:

01. Gender Distribution in Public Spaces



02. Age Distribution in Public Spaces in Proximity to

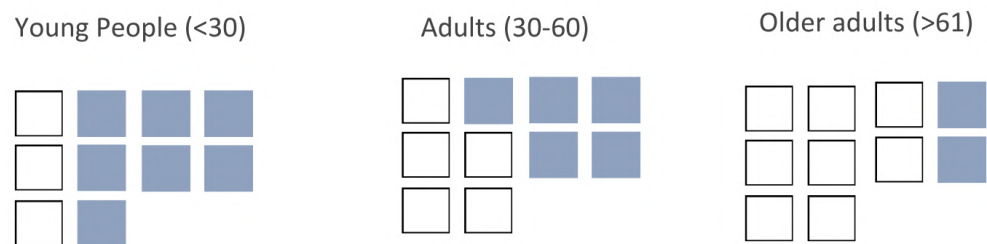


03. Perceived security in public spaces



Source: Istat, Bilancio di Genere, 2025

04. Distribution of Public Space Users by Presumed Ethnic Background



05. Daytime Occupation of Public Spaces



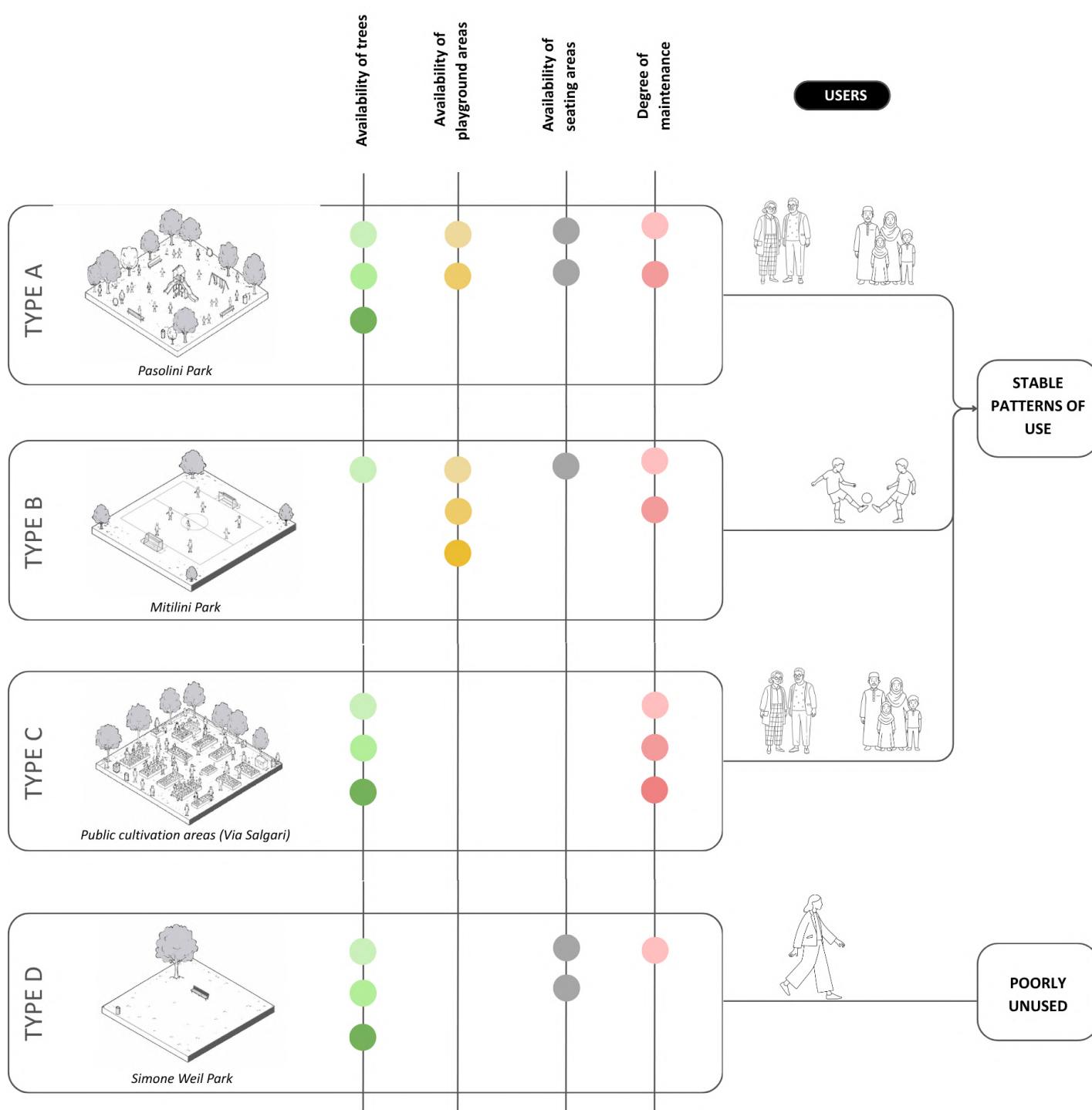
ITALIAN FOREIGN
FEMALE MALE

USE OF SPACE

The analysis of green areas reveals significant patterns in relation to how space occupation changes according to different environmental and spatial factors, such as the availability of trees (and therefore climatic comfort and aesthetic quality), the presence of public facilities, and maintenance conditions. By comparing four different types of green spaces, ranging from simple undeveloped areas to more structured parks such as Parco Pasolini, it is possible to observe how their characteristics influence the type and intensity of users associated with them.

The results suggest that green spaces left as simple open areas, without additional functions or infrastructures, tend to have a limited presence of users and reduced social activity. Conversely, spaces equipped with facilities, seating areas, playgrounds, or opportunities for interaction are more likely to become active places of permanence and social exchange. In the context of Pilastro, this highlights the importance of considering green areas not only as ecological resources but also as green and social infrastructures, where spatial qualities and public amenities play a crucial role in supporting everyday community life.

Figure 85: Diagrams of analysis of green spaces



Phase 03 - PHENOMENA DETECTION

A second, contrasting spatial pattern emerges from the observational analysis. While the first trace highlighted the strong capacity of residents to appropriate and activate public spaces, this second trace points to the limited provision of public services and neighbourhood infrastructure. The analysis reveals reduced accessibility to public transport, an insufficient number of facilities within green areas, deteriorated street furniture, inadequate lighting, and numerous vacant commercial premises. Additional indicators—including graffiti, deteriorated pavements, abandoned objects, and signs of limited maintenance—reinforce the presence of a broader condition of physical and institutional neglect.

However, this phenomenon extends beyond the physical environment. It is also reflected in the way the neighbourhood is represented within the city. Pilastro appears to have a relatively weak presence in urban signage and public communication. Compared with central areas of Bologna, where neighbourhoods and public destinations are frequently identified through wayfinding systems, Pilastro is rarely mentioned. Road signs predominantly direct movement towards the ring road, motorway connections, or large commercial centres, rather than towards the neighbourhood itself or its community facilities. Although this difference is partly explained by the higher concentration of services in central areas, it also reflects a limited symbolic visibility of Pilastro within the wider urban structure.

EMOTIONS

- A perceived sense of abandonment and isolation.
- Limited restorative qualities in both public and private spaces, potentially affecting everyday well-being and comfort.

NEEDS / HUMAN BEHAVIOURS

- A potential need for greater inclusion within the wider urban system, expressed through improved access to services, opportunities, and better-maintained public spaces.
- A demand for environments that foster belonging, care, and everyday social interaction.
- An increased tendency to rely on informal adaptations and community initiatives to compensate for limited institutional support.

Phase 04 - CROSS ANALYSIS ¹

To validate these observations, the spatial evidence was compared with external datasets, including the Open Citizen Relationship Management (CZRM) database. This platform collects annual reports submitted directly by citizens to the Municipality of Bologna regarding maintenance issues and situations of urban discomfort, including traffic, public space, green areas, environmental degradation, street lighting, urban furniture, and social decay.

The comparison confirms a strong correspondence between the observed spatial traces and citizens' reported concerns. The temporal trends recorded in Pilastro broadly follow those observed across Bologna, while highlighting a concentration of reports related to public green spaces, urban degradation, and environmental maintenance. More specifically, recurring issues include waste accumulation, insufficient maintenance of green areas, deteriorated streets and public squares, and inadequate street lighting. These findings validate the physical signs identified through field observation, demonstrating a high level of consistency between computational observation and citizens' lived experiences.

While everyday neighbourhood services remain relatively limited, the area is characterised by the presence of large-scale retail facilities and commercial centres. At the urban scale, Pilastro is further conditioned by major transport infrastructures, including the ring road and surrounding arterial roads, which physically and symbolically reinforce its peripheral position within the metropolitan system.

Taken together, Trace 01 and Trace 02 reveal two complementary dimensions of the neighbourhood. On one hand, Pilastro demonstrates remarkable social resilience, characterised by active community appropriation and everyday adaptation of space. On the other hand, these practices coexist with structural deficiencies in public services, maintenance, and institutional investment. Rather than representing contradictory conditions, the two traces complement one another, providing a more comprehensive understanding of the context in which the Virgolone and the surrounding neighbourhood are embedded.

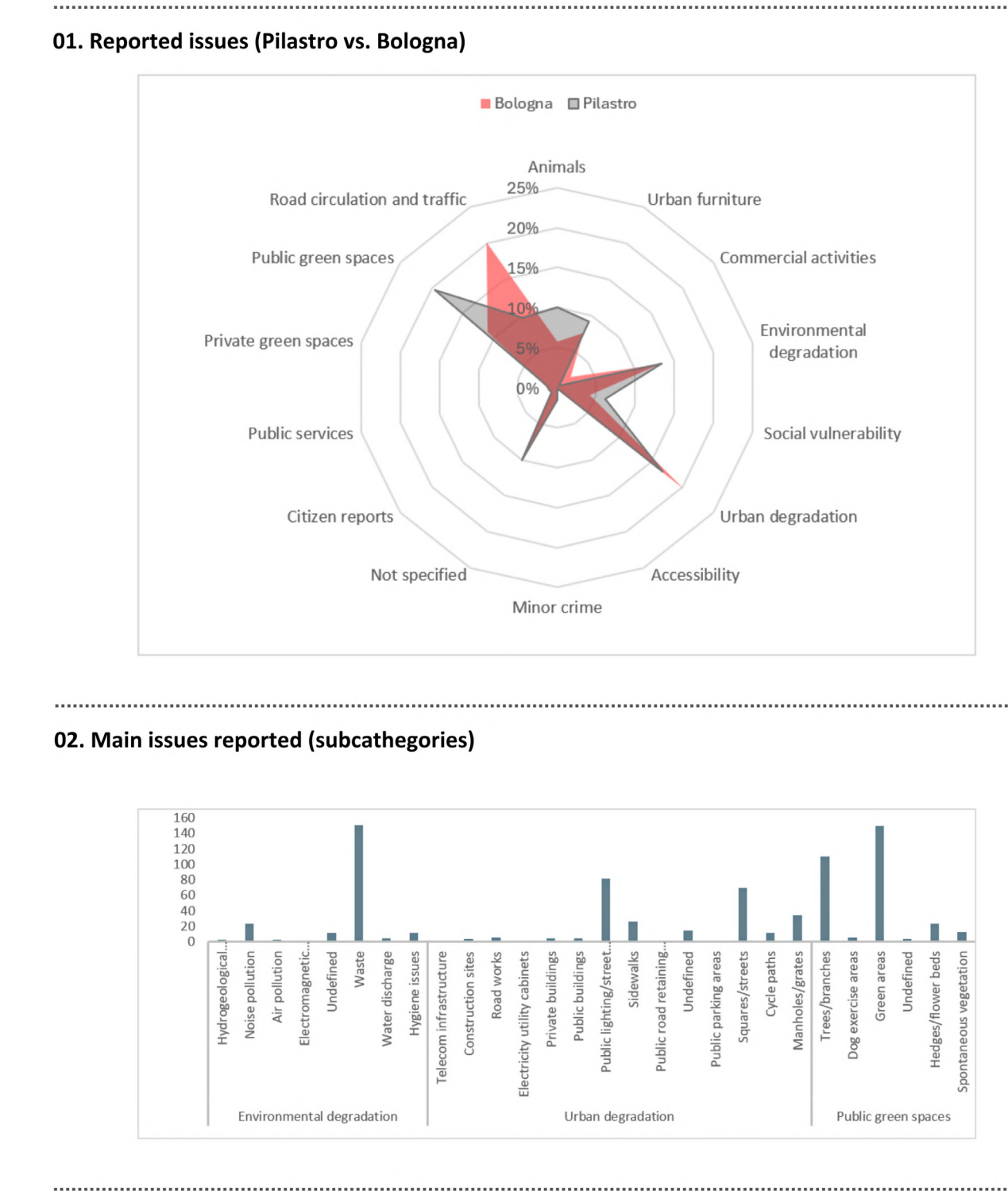
¹ Based on Data ISTAT, Comune di Bologna and empirical observations

Figure 86 - 91: Observations in Pilastro reveal a complex condition where signs of limited institutional maintenance coexist with different levels of residents' care and appropriation of space. While deteriorated infrastructures, neglected public areas, and damaged urban elements may indicate a lack of long-term institutional investment, other spaces reveal forms of active care,



Taken together, these complementary datasets validate and enrich the two spatial traces previously identified. On the one hand, they confirm the existence of a neighbourhood characterised by strong forms of everyday social appropriation, informal care, and community life. On the other, they reveal persistent deficiencies in public services, maintenance, symbolic representation, and connectivity. Rather than representing contradictory conditions, these two dimensions coexist and mutually reinforce one another, offering a more nuanced understanding of the context in which the Virgolone and the wider Pilastro neighbourhood are embedded.

Figure 92:



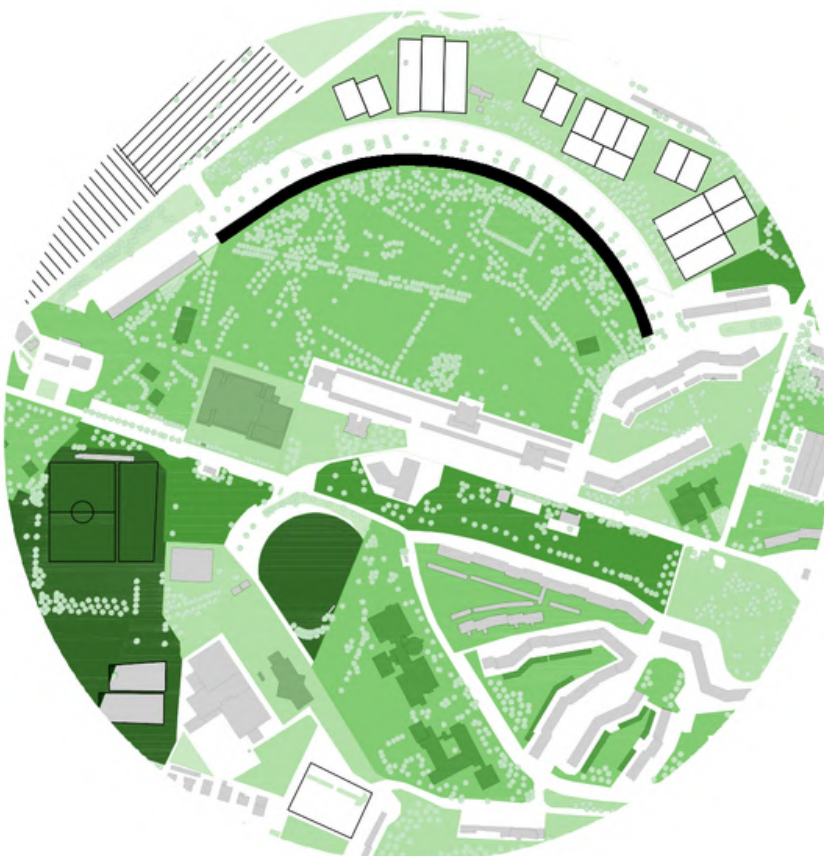
MAP OF KEY COMMUNITY SPACES



- Road and transitory spaces
- Green Areas
- Buildings

Figure 93

MAP OF PRIORITY GREEN AREAS FOR ENHANCEMENT



- Low Priority
- High Priority

Figure 94

PHASE 05 - PROPOSAL INTERVENTIONS

Based on the observed spatial phenomena, three preliminary intervention for each 'trace' can be identified. These proposals should be interpreted as preliminary intervention directions. Their appropriateness, feasibility and priority should subsequently be validated and refined through the participatory Living Lab process.

TRACE 01

Strengthening existing community life and public space appropriation



1.1

Designing new public spaces that encourage social encounters and cultural or recreational activities, with particular attention to young people and intergenerational interaction.



1.2

Improving the quality and comfort of existing public spaces by upgrading public furniture, introducing additional seating, drinking fountains, shaded areas and children's playgrounds



1.3

Strengthen existing community infrastructures by supporting neighbourhood associations, community gardens, and flexible spaces for informal and cultural activities.

TRACE 02

Improving availability and accessibility of services and reducing the perceived isolation.



1.1

Reactivating vacant ground-floor commercial units through temporary uses, community-led initiatives, cultural activities, or local services.



1.2

Strengthening neighbourhood-scale public services by improving maintenance, public lighting, accessibility, and everyday urban facilities.



1.3

Improving pedestrian and cycling connectivity both within the neighbourhood and between Pilastro and the surrounding districts.

Figure 95

INTERNAL ASSESSMENT - Lived Experiences

In this phase, the analysis moves into direct engagement with local residents. Semi-structured interviews and participation in public or community meetings are used as primary methods for collecting and validating data. The objective is to incorporate lived experiences and subjective perceptions of space, complementing the previously collected external datasets. This allows for a deeper understanding of how spatial conditions are experienced, interpreted, and negotiated by the people who inhabit the area on a daily basis.

PHASE 06 - SIMULATION OF PARTICIPATORY ACTIVITIES

Rather than organising an ad hoc focus group to simulate the proposed Living Lab, the validation process relied on existing forms of community participation and interviews. This approach was adopted for two main reasons: the practical difficulty of recruiting a representative sample of residents and the intention to minimise participation bias by observing discussions that emerged spontaneously from the community itself.

In particular, attending neighbourhood meetings organised by the recently re-established Pilastro Popular Committee (Comitato Popolare del Pilastro) was an opportunity to observe how residents collectively discuss everyday problems, negotiate priorities, and formulate shared concerns regarding the neighbourhood. The committee represents a renewed form of grassroots mobilisation within the neighbourhood and brings together a relatively diverse group of participants, ranging from teenagers (approximately 16 years old) to residents over the age of 70, with a heterogeneous cultural composition.

During the process, these forms were adopted to collect data:

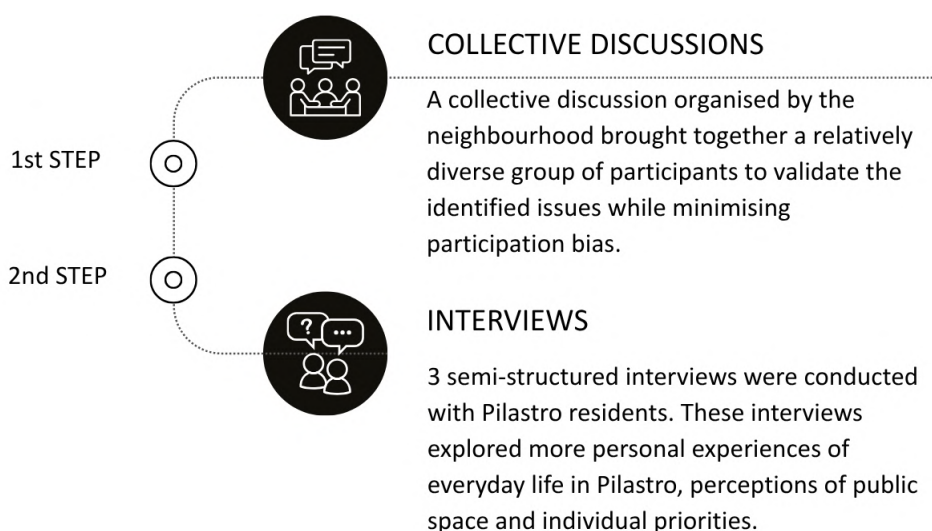


Figure 96

1st Validation phase

The first validation phase focused on understanding whether the spatial traces previously identified effectively reflected residents' everyday behaviours, needs, and emotional perceptions of the neighbourhood. The discussions and interviews confirmed many of the preliminary observations while revealing additional social dimensions that could not be inferred from spatial analysis alone.

Overall, the validation process confirmed the previously observed phenomena while adding new behavioural, emotional, and contextual information that could not be captured through spatial analysis alone. These complementary insights enrich the knowledge base and contribute to the continuous refinement of the computational framework.

HUMAN BEHAVIOURS



- Walking is perceived as one of Pilastro's main strengths, with residents describing it as one of the few neighbourhoods where daily activities can still be comfortably carried out on foot.
- Green spaces are actively used and informally cared for by residents, confirming the observed forms of stewardship.
- Many residents, particularly older generations, have lived in the neighbourhood for several decades, contributing to strong local knowledge and stable social networks.
- Young people's use of public space appears heterogeneous: while some actively participate in neighbourhood associations and outdoor activities, others rarely use public spaces or participate in community life.

EMOTIONS



- A strong sense of belonging and local pride emerged across many participants, who described Pilastro as a community with a distinctive identity.
- The attachment coexists with a persistent feeling of social stigma associated with living in Pilastro. In particular, younger residents reported experiencing prejudice and exclusion, especially within school environments, where their place of residence often carries negative stereotypes.
- Affection for the neighbourhood's green spaces also emerged repeatedly, with residents describing them as an important component of local identity and quality of life.

NEEDS



Housing (ERP)

- Inadequate maintenance of public housing, with recurring complaints regarding deteriorating building conditions.
- High energy costs and dwellings considered too small or unsuitable for larger families.
- Vacant public housing units despite persistent housing demand.
- Difficulties associated with ERP allocation criteria, where even small increases in household income may jeopardise eligibility, creating barriers to socio-economic mobility.

Public Services

- Insufficient healthcare services, particularly for children and economically vulnerable families.
- A shortage of after-school programmes and summer activities for young people.
- Limited opportunities and dedicated spaces for youth, with local associations also reporting difficulties due to the lack of available facilities and financial resources.

Accessibility and Connectivity

- Public transport and connections with the rest of Bologna continue to be perceived as inadequate, confirming a long-standing issue repeatedly mentioned by residents.

2nd Validation phase

Through neighbourhood discussions and direct interviews, residents were also invited to identify possible actions to improve living conditions in Pilastro. These proposals represent community-generated priorities emerging from lived experiences and everyday knowledge of the neighbourhood.

The main proposals identified include:

- Creation of spaces for children, recreation, and sports activities, including playgrounds, larger sports facilities, and dedicated areas for young people.
- Improvement and regular maintenance of public green areas, recognising the importance of existing green infrastructure as a key element of neighbourhood identity and social life.
- Strengthening mobility services and public transport connections, addressing the long-standing perception of isolation and improving accessibility to the rest of Bologna.
- Greater use and activation of the neighbourhood community centre (Casa di Quartiere) through more frequent activities, especially targeted at young people and intergenerational interaction.
- Reuse of vacant commercial premises as community-oriented spaces, including possible food distribution points, social services, or local support activities.

These proposals largely overlap with the intervention directions previously identified through the spatial analysis, confirming the relevance of the detected phenomena while introducing additional priorities emerging directly from residents' experiences. The following illustrations explore how these community-generated visions could be integrated into the neighbourhood.

Figures 97-98: Photos of the residents of Pilastro and the Comitato Popolare



"I would never leave Pilastro. I have spent 30 years of my life here, and I feel good living here where everyone knows each other here."



Future Scenarios for Pilastro

Figures 99: Virgolone, Pilastro

A DEEP DIVE INTO...



The final section presents a series of hypothetical scenarios showing how the ideas and solutions generated through the participatory process can be transformed into practical interventions. It concludes by exploring how these actions could be managed, monitored, and prioritised by public stakeholders through the proposed Building Data Management Framework, bridging citizen contributions with institutional decision-making.

01. Activating Community Spaces



Transforming the portico passageways into comfortable places for staying by introducing seating and small-scale public amenities. These spaces could function as genuine climate refuges, encouraging everyday social interaction while strengthening the pedestrian connection between the northern side of the Virgolone and Parco Pier Paolo Pasolini.

02. Local Community Hubs



Reactivating vacant commercial premises by converting them into spaces for community associations, cultural centres, storage and distribution facilities, or other neighbourhood-oriented services. Encouraging the establishment of small local businesses to increase street vitality, strengthen the local economy, and support everyday social interaction.

Figure 101

03. Green as Public Infrastructure



Enhancing Parco Pier Paolo Pasolini as a multifunctional green infrastructure by improving the maintenance of its green areas, introducing additional public amenities such as seating, playgrounds, and drinking fountains, while simultaneously promoting biodiversity, climate resilience, and everyday social interaction.

Figure 101

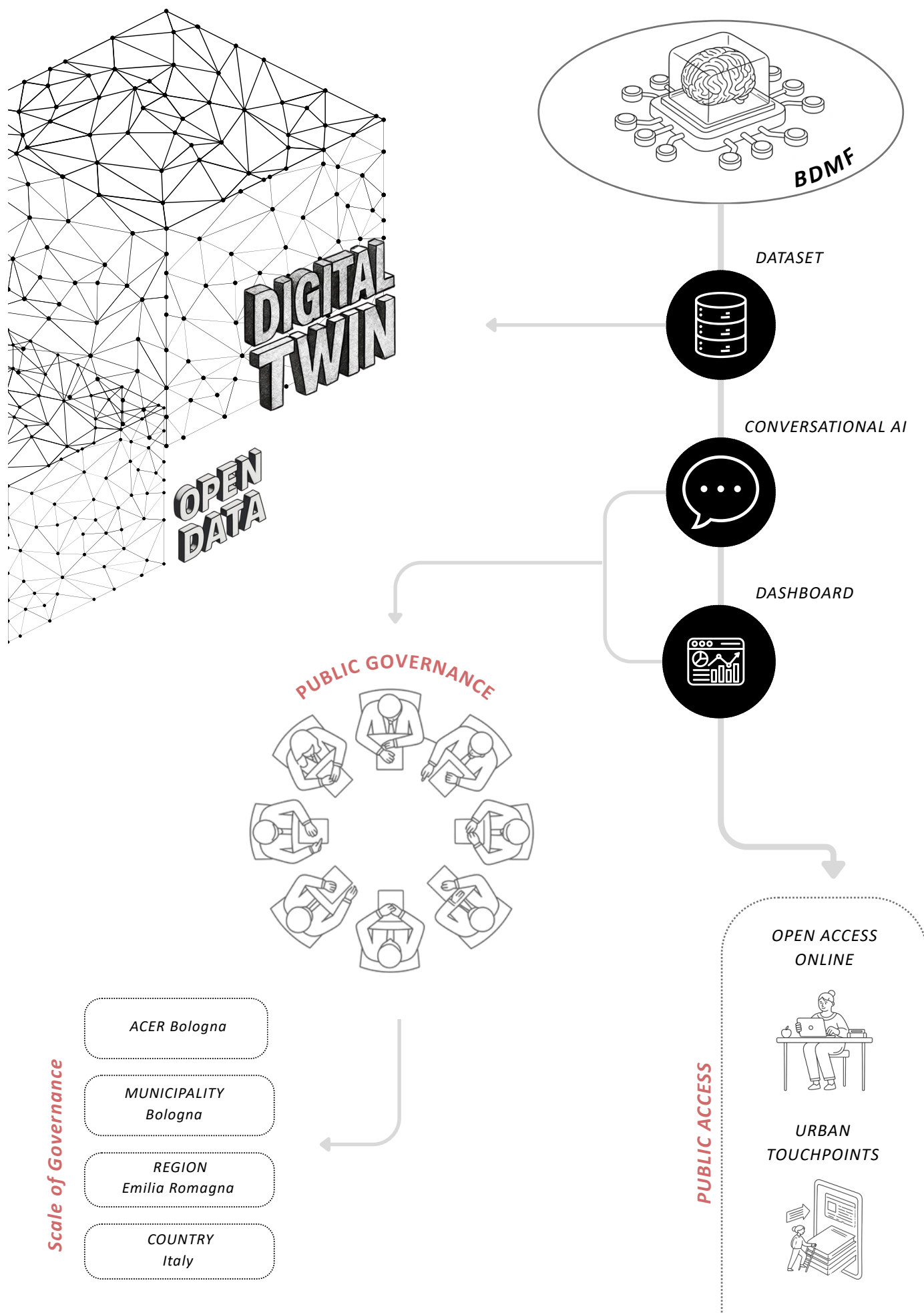
INFORMING THE GOVERNANCE

To conclude this simulation phase, the proposed workflow demonstrates how the generated data and co-designed solutions can be integrated into existing governance infrastructures. On one hand, the collected information could directly contribute to the Municipality of Bologna's Civic Digital Twin, enriching it with qualitative and spatially grounded knowledge derived from residents' experiences. On the other hand, the outputs produced by the framework can generate structured datasets that are directly usable by public institutions for monitoring, evaluation, and decision-making processes.

In this context, interactive dashboards and conversational AI systems become mediating interfaces between complex datasets, institutional actors, and citizens, translating information into accessible knowledge and supporting more informed governance decisions. The application of the framework can operate across multiple governance scales depending on the identified issue and the type of intervention required. At the building scale, the data can support the management and regeneration of public housing assets, directly informing actors such as ACER. At the neighbourhood and urban scale, the outputs can support the planning and management of public spaces, services, and infrastructures, while at a broader level they can contribute to the development of regional and national policies.

Citizens can access and interact with these datasets through open online dashboards, increasing transparency and enabling a more informed relationship with public institutions. Furthermore, the implementation of physical urban touchpoints could extend access beyond digital platforms, making the tool more inclusive and visible within the neighbourhood. Ultimately, the proposed system should not be understood as a fixed technological solution, but as an adaptable infrastructure capable of supporting different actors, scales, and future applications.

Figure 102



Conclusion and Future Developments

This research has explored the potential of computational tools, spatial analysis, and participatory processes to support the regeneration of complex urban contexts by proposing the Building Data Management Framework (BDMF) as an intermediary system between spatial knowledge, citizens' experiences, and public governance. The research originated from the assumption that contemporary urban challenges cannot be adequately addressed exclusively through traditional top-down planning approaches or through purely quantitative, data-driven models. While institutional datasets are increasingly capable of describing measurable aspects of the urban environment, they often fail to capture the social, cultural, and emotional dimensions that continuously shape the everyday production of space. As a consequence, important forms of knowledge remain invisible within planning processes, limiting the capacity of public institutions to understand how urban spaces are actually experienced and appropriated by their inhabitants.

CONTRIBUTIONS AND LIMITATIONS OF THE RESEARCH:

A first contribution of this research is therefore theoretical. Although concepts such as spatial appropriation, everyday practices, environmental psychology, informal urbanism, and place attachment have been extensively investigated across architecture, sociology, anthropology, and urban studies, no coherent framework currently exists that interprets these phenomena through the concept of spatial errors. Rather than considering spatial errors as anomalies or failures to be corrected, this research proposes to understand them as observable human traces that reveal the discrepancy between the intended function of urban space and its everyday use. These traces are not interpreted as problems in themselves, but as physical manifestations of needs, behaviours, cultural practices, emotions, and adaptive strategies that conventional planning tools rarely recognise. By bringing together fragmented contributions from different disciplinary fields, the research proposes a first conceptualisation of spatial errors as a source of knowledge capable of informing urban regeneration.

Building upon this theoretical foundation, the research developed the Building Data Management Framework as a methodological process designed to support public-sector decision-making. Rather than proposing a technological solution to urban complexity, the framework demonstrates how computational analysis and participatory methodologies can be combined within a single workflow capable of translating spatial observations into actionable knowledge. The proposed process identifies and maps spatial evidence through computational analysis, organises these observations into structured indicators, validates their interpretation through participatory activities, and finally translates the resulting knowledge into support for public governance. In this sense, the framework should not be interpreted as an automated decision-making system, but as a mediating infrastructure capable of facilitating dialogue between different forms of knowledge, scales of observation, and institutional actors.

One of the strengths of the proposed methodology lies precisely in the integration of computational and participatory approaches. Vision-Language Models and Multimodal Machine Learning enable the systematic observation of large quantities of spatial information, identifying recurring patterns that would be difficult to detect manually. At the same time, participatory processes remain fundamental to contextualise, validate, and expand the interpretations generated through computational analysis. Rather than competing with one another, artificial intelligence and human knowledge become complementary components of the same interpretative process. Computational tools increase the capacity to observe complexity, while participation ensures that the interpretation of spatial evidence remains grounded in the lived experiences of residents.

Nevertheless, the proposed framework should not be interpreted as an objective or neutral representation of urban reality. The process itself is built upon a series of methodological choices that inevitably introduce forms of selection and interpretation. The indicators adopted in the framework represent only one possible way of observing urban space and are the result of a deliberate process of abstraction. Although the methodology attempts to minimise bias through transparency and participatory validation, every analytical framework inevitably reflects assumptions regard

ing what should be observed, measured, and interpreted. Consequently, the framework does not eliminate subjectivity but rather attempts to make it explicit and negotiable throughout the decision-making process.

Several limitations therefore emerge from the research. First, the proposed framework has been developed at a methodological level, while the detailed implementation of its computational architecture and participatory protocols falls outside the scope of this study. Future applications may reveal technical, organisational, or operational challenges that cannot be fully anticipated at this stage. Similarly, the computational models adopted within the framework remain dependent on the quality, availability, and representativeness of the data used. Vision-Language Models and Multimodal Machine Learning can identify spatial patterns and correlations, but they cannot independently interpret social meanings, intentions, or cultural values. Their outputs should therefore always be understood as preliminary interpretations requiring human validation rather than definitive representations of reality.

The framework also raises significant ethical and social questions. The collection and interpretation of spatial evidence inevitably involve issues related to privacy, transparency, and the governance of urban data. Furthermore, although participatory methodologies seek to broaden representation, participation itself is never equally distributed. Certain social groups may remain excluded due to cultural, economic, linguistic, or technological barriers, potentially reproducing existing inequalities within the knowledge production process. Increasing transparency through digital platforms does not automatically imply greater democracy. Even when information becomes more accessible, meaningful participation still depends on citizens' willingness and ability to engage, as well as on institutional openness to incorporate their contributions into actual decision-making processes.

Another important limitation concerns the relationship between observable spatial evidence and the interpretations derived from it. Throughout this research, correlations between spatial traces and underlying needs, behaviours, or emotions have primarily been established through qualitative interpretation supported by existing literature and participatory validation. While this approach provides a valuable interpretative framework, stronger empirical validation would require larger and more diverse datasets capable of comparing observations across different socio-cultural contexts. The robustness of the proposed methodology will therefore increase as the framework is applied to larger populations, multiple neighbourhoods, and different urban conditions.

An additional aspect emerging from the research concerns the dynamic nature of urban environments themselves. Cities continuously evolve through new forms of appropriation, adaptation, maintenance, deterioration, and everyday negotiation. Consequently, the implementation of regeneration strategies based on the framework would inevitably generate new spatial evidence that could subsequently be observed, interpreted, and incorporated into future decision-making cycles. Rather than representing a linear sequence of actions, the BDMF should therefore be understood as an iterative feedback loop in which urban transformations continuously produce new knowledge capable of informing subsequent interventions.

The application of the framework to the Pilastro neighbourhood in Bologna provided an initial opportunity to test the feasibility of the proposed methodology. Although the case study does not constitute a complete empirical validation of the framework, it demonstrates the potential relationship between observable spatial evidence and broader interpretations concerning everyday urban life. The analysis revealed the coexistence of two complementary realities.

On one hand, the neighbourhood exhibits strong forms of social resilience, spatial appropriation, and community attachment, expressed through the continuous adaptation and collective use of shared spaces. On the other hand, structural weaknesses remain evident in relation to accessibility, maintenance, public services, and the neighbourhood's peripheral position within the wider urban system.

Rather than interpreting these conditions as contradictory, the research suggests that they constitute interconnected dimensions of the same urban reality. The strong sense of community observed in Pilastro often compensates for institutional shortcomings, while the persistence of structural vulnerabilities contributes to reinforcing external narratives that continue to portray the neighbourhood primarily through its deficiencies. One of the outcomes of the research has therefore been to propose an alternative reading of Pilastro, recognising both its vulnerabilities and its existing social capacities. By following a transparent, step-by-step methodology in which computational observation precedes participatory validation, the framework attempts to construct a more balanced representation of the neighbourhood that neither romanticises nor stigmatises peripheral urban contexts.

Future developments should focus on testing the framework within real governance environments and across multiple case studies. Its integration with Digital Twins, Open Data platforms, municipal GIS infrastructures, and existing planning procedures would provide valuable opportunities to assess its operational feasibility. Long-term monitoring could further transform the framework from a static analytical methodology into a continuously evolving system capable of following the transformation of neighbourhoods over time.

At the same time, expanding participatory validation through larger and more heterogeneous groups of residents would strengthen the reliability of the identified patterns and improve the framework's capacity to represent the diversity of urban experiences. Future research could also investigate the applicability of spatial evidence beyond public housing, exploring its potential use in other planning contexts such as public spaces, educational facilities, mobility systems, healthcare environments, or climate adaptation strategies.

The ambition of this research is not to automate urban decision-making but to use digital tools to contribute to a more human-centred understanding of the city, without replacing the collective production of urban knowledge. Ultimately, this research argues for the need to build new forms of collaboration between technology and human knowledge, considering them as complementary rather than opposing forces.

BIBLIOGRAPHY

Figure	Source
1	Author's elaboration (2026).
2	Charles Marville, Haut de la rue Champlain (vue prise à droite), 1877-1878. Musée Carnavalet,
3	RomaToday. (n.d.). Case popolari Roma: dati e manutenzione. https://www.romatoday.it/politica/case-popolari-dati-manutenzione.html
4	Author's elaboration (2026).
5	GreyScape. (n.d.). Modernism was framed: The truth about Pruitt-Igoe. https://www.greyscape.com/modernism-was-framed-the-truth-about-pruitt-igoe/
6	A+T. (n.d.). Le Corbusier & Pierre Jeanneret: Unité d'Habitation. https://aplust.net/blog/le_corbusier_p_jeanneret_unit_dhabitation_hy_id_or_social_condenser0/
7	Modernisme Pompidolien. (n.d.). La Grande Borne, Grigny – Designed by Émile Aillaud. Tumblr. https://www.tumblr.com/modernismepompidolien/71885619186/la-grande-borne-grigny-designed-by-%C3%A9mile
8	Sublimista. (n.d.). Corviale – Mario Fiorentino: Il chilometro verde. https://sublimista.it/corviale-mario-fiorentino-chilometro-verde/
9	Architectuul. (n.d.). Robin Hood Gardens. https://architectuul.com/architecture/robin-hood-gardens
11	Zero. (n.d.). Un film sul Pilastro. https://zero.eu/it/news/un-film-sul-pilastro/
12	Zero. (n.d.). Un film sul Pilastro. https://zero.eu/it/news/un-film-sul-pilastro/
13	Zero. (n.d.). Un film sul Pilastro. https://zero.eu/it/news/un-film-sul-pilastro/
14	HouseInc Project (2026), University of Bologna.
15	Taylor & Francis Online. (2024). [Article retrieved from Taylor & Francis Online]. https://www.tandfonline.com/doi/full/10.1080/15710882.2024.2339496
16	Taylor & Francis Online. (2024). [Article retrieved from Taylor & Francis Online]. https://www.tandfonline.com/doi/full/10.1080/15710882.2024.2339496
17	ScienceDirect. (2017). [Article retrieved from ScienceDirect]. https://www.sciencedirect.com/science/article/pii/S221462961730018X
18	Author's elaboration (2026).
19	Domus. (2012). Ricerca della comodità in una poltrona scomoda. https://www.domusweb.it/it/dall-archivio/2012/03/31/ricerca-della-comodita-in-una-poltrona-scomoda.html
20	Mauritius Images. (n.d.). <i>External facade of an old building in a state of abandonment</i> .
21	Author's elaboration (2026).
22	Author's elaboration (2026).
23	Triennale Milano. (2025). Spatial Disobedience. https://triennale.org/eventi/spatial-disobedience
24	Lomography. (n.d.). Martin Parr Short & Sweet sbarca al Museo Civico Archeologico di Bologna. https://www.lomography.it/magazine/354440-martin-parr-short-sweet-sbarca-al-museo-civico-archeologico-di-bologna
25	Designboom. (2015). Santiago Cirugeda: Urban recipes. https://www.designboom.com/architecture/santiago-cirugeda-urban-recipes-2-25-2015/
26	99% Invisible. (n.d.). Blood, sweat & tears: City of the future (Part 2). https://99percentinvisible.org/episode/blood-sweat-tears-city-future-part-2/
27	99% Invisible. (n.d.). Blood, sweat & tears: City of the future (Part 2). https://99percentinvisible.org/episode/blood-sweat-tears-city-future-part-2/
28 - 33	Domus. (2005). Elemental: Aravena. https://www.domusweb.it/it/architettura/2005/11/15/elemental-aravena-.html
34–40	Author's elaboration (2026).
41–43	Author's photograph, Paris (2024).
44–45	Author's photograph, Valencia (2026).
46	Vertov, <i>Man with a Movie Camera</i> (1929)
47–48	Author's photograph, Paris (2024).
49	Author's photograph, Bologna (2026).
50	Author's photograph, Paris and London (2026).
51–57	Author's elaboration (2026).
58	Riis, <i>"How the Other Half Lives: Studies Among the Tenements of New York"</i> , (1890)
59–64	Author's elaboration (2026).
65	ISTAT, Indice di Disagio Socio-Economico IDISE (2021)
66–67	Author's elaboration (2026).
68	Beani, <i>Il Pilastro</i> , (2025).
69–71	Author's elaboration (2026).

- 72–81 Author's photograph, Bologna (2026).
- 82–85 Author's elaboration (2026).
- 86–91 Author's photograph, Bologna (2026).
- 92–97 Author's elaboration (2026).
- 98 Pilastro Bologna. (2022). Un documentario sul rione Pilastro. <https://www.pilastrobologna.it/2022/11/27/un-documentario-sul-rione-pilastro/>
- 99 Zero. (n.d.). Un film sul Pilastro. <https://zero.eu/it/news/un-film-sul-pilastro/>
- 100–102 Author's elaboration (2026).

CHAPTER 1

- 1 Aalbers, M. B. (2008). The financialization of home and the mortgage market crisis. *Competition & Change*, 12(2), 148–166.
- 2 Anguelovski, I. (2013). From environmental trauma to safe haven: Place attachment and place remaking in three marginal
- 3 Arnstein, S. R. (1969). A ladder of citizen participation. *Journal of the American Institute of Planners*, 35(4), 216–224. <http://doi.org/10.1080/03616959.1969.10471446>
- 4 Barreca, A., Curto, R., & Rolando, D. (2023). Real estate market latent variables and multiculturalism in Turin. In *Cities and*
- 5 Batty, M. (2018). Digital twins. *Environment and Planning B: Urban Analytics and City Science*, 45(5), 817–820. <https://doi.org/10.1080/23749669.2018.1511111>
- 6 Beani, R. (Director). (2025). *Il Pilastro* [Motion picture].
- 7 Betavatz, E., & Toussaint, E. (2021). How private and public debt crises exacerbate housing problems in the EU. *Κοινωνική*
- 8 Bollier, D., & Helfrich, S. (2019). *Free, fair, and alive: The insurgent power of the commons*. New Society Publishers.
- 9 Pagella Politica. (2019, November 21). Case popolari: Immigrati avvantaggiati, italiani emarginati? Pagella Politica.
- 10 Cassa Depositi e Prestiti. (2017). *Housing sociale: Stato attuale in Italia e nei principali Paesi europei*. Cassa Depositi e Prestiti.
- 11 Caudo, G. (2022). *Regenerate Corviale*. (Pubblicazione da verificare: manca editore/editore istituzionale).
- 12 CENSIS. (2025). *Case dormienti: Una ricchezza sommersa*. CENSIS.
- 13 United Nations Committee on Economic, Social and Cultural Rights. (1997). The right to adequate housing (Art. 11.1): Forcibly
- 14 Chiodelli, F., Coppola, A., Belotti, E., & Berruti, G. (2021). The production of informal space: A critical atlas of housing informality
- 15 Conte, P. (2013). *Cose (quasi) umane: Per una filosofia della sedia*. Cose.
- 16 Pieri, F. D. (2017). *Il Pilastro: Storia di una periferia nella Bologna del dopoguerra*. FrancoAngeli.
- 17 Davidoff, P. (1965). Advocacy and pluralism in planning. *Journal of the American Institute of Planners*, 31(4), 331–338. <http://doi.org/10.1080/03616959.1965.10471446>
- 18 Davis, M. (1990). *City of quartz: Excavating the future in Los Angeles*. Verso.
- 19 Della Spina, L., Galati Casmiro, R., & Giorno, C. (2026). *Regenerating public residential assets: Ex-ante evaluation tools to support*
- 20 Desmond, M. (2016). *Evicted: Poverty and profit in the American city*. Crown Publishers.
- 21 Municipal Dreams. (2024). *Robin Hood Gardens, Poplar: "Presence, dignity and a bit grim"*. <https://municipaldreams.substack.com/p/robin-hood-gardens-poplar>
- 22 Durning, A. (2021). Yes, other places do housing better, case 3: Paris. Sightline Institute. <https://www.sightline.org/2021/11/09/yes-other-places-do-housing-better-case-3-paris/>
- 23 Elkington, J. (1997). *Cannibals with forks: The triple bottom line of 21st century business*. Capstone.
- 24 European Commission. (2020, February). *Developments and forecasts on continuing urbanisation*. European Commission.
- 25 Fainstein, S. S. (2010). *The just city*. Cornell University Press.
- 26 Federcasa. (2024). *Osservatorio nazionale ERP: Anno 2023*. Federcasa.
- 27 Federcasa. (2026). *Osservatorio nazionale ERP: Anno 2024/2025*. Federcasa.
- 28 Federcasa. (2026). *Report dell'Osservatorio nazionale ERP 2024/2025*. Federcasa.
- 29 fio.PSD ETS. (2022). *Abitare il cambiamento nella grave emarginazione adulta in Italia*. fio.PSD ETS.
- 30 Franzosi, M. (2025). *Millennial in cerca di un tetto disperatamente*. La Repubblica.
- 31 Friedrich, C. (Director). (2011). *The Pruitt-Igoe myth* [Film]. ZED.
- 32 Fullilove, M. T. (2010). Housing is health care. *American Journal of Preventive Medicine*, 39(6), 569–572. <https://doi.org/10.1016/j.amepre.2010.05.008>
- 33 Gauvin, L., Vignes, A., & Nadal, J.-P. (2018). *Modeling urban housing market dynamics: Can socio-spatial segregation pressure*
- 34 GRINS Foundation. (2024). *Analysis of measures to enhance the energy efficiency of Italian buildings*. Ministero dell'Università e della Ricerca.
- 35 Hamdi, N. (2004). *Small change: About the art of practice and the limits of planning in cities*. Earthscan.
- 36 Harvey, D. (1982). *The limits to capital*. University of Chicago Press.
- 37 Harvey, D. (2012). *Rebel cities: From the right to the city to the urban revolution*. Verso.
- 38 Hayek, F. A. (1945). The use of knowledge in society. *The American Economic Review*, 35(4), 519–530.
- 39 Lefebvre, H. (1991). *The production of space*. Blackwell Publishing.
- 40 Housing Europe. (n.d.). *Recovery and resilience plan Italy*. Housing Europe.

Howe, F. C. (1912). The city as a socializing agency: The physical basis of the city: The city plan. In *The city: The hope of de*

Jacobs, J. (1961). *The death and life of great American cities*. Random House.

Marcuse, P. (1998). Sustainability is not enough. *Environment and Urbanization*, 10(2), 103–111. <https://doi.org/10.1177/>

Marcuse, P. (2009). From critical urban theory to the right to the city. In A. Brenner, P. Marcuse, & M. Mayer (Eds.), *Cities*

Merry, S. E. (2016). The seductions of quantification: Measuring human rights, gender violence, and sex trafficking. *Univer*

Ministero del Lavoro e delle Politiche Sociali. (2021). Piano nazionale degli interventi e dei servizi sociali di contrasto alla p

Nguyen, H., & Marques, P. (2021). The promise of living labs to the Quadruple Helix stakeholders: Exploring the sources of

Organisation for Economic Co-operation and Development. (2023). *L'edilizia abitativa in Italia attraverso il telescopio e il n*

Pacchi, C. (2018). Epistemological critiques to the technocratic planning model: The role of Jane Jacobs, Paul Davidoff, Rey

Pauling, D. (2010). I'm sick of concrete jungle creeping up on Robin Hood Gardens. *East London Advertiser*. <https://www.>

Pieri, F. D. (2019). Il Pilastro: Storia di una periferia nella Bologna del dopoguerra. *Planning Perspectives*.

Poggio, T., & Boreiko, D. (2017). Social housing in Italy: Old problems, older vices, and some new virtues? *Critical Housing*

The Guardian. (2015). Pruitt-Igoe: The troubled high-rise that came to define urban America – A history of cities in 50 buil

Putnam, R. D. (2000). *Bowling alone: The collapse and revival of American community*. Simon & Schuster.

Robinson, D. (2010). The neighbourhood effects of new immigration. *Environment and Planning A: Economy and Space*, 4.

Sandercock, L. (1998). *Towards cosmopolis: Planning for multicultural cities*. John Wiley & Sons.

Sestil, M. (Director). (2017). *Sotto un cielo di piombo* [Film].

Söderberg, S. (2020). *Urban displacements: Governing surplus and survival in global capitalism*. Routledge.

SoHoLab. (2020). *Towards a definition of socially oriented urban living labs*. SoHoLab.

United Nations Department of Economic and Social Affairs. (2025). *World urbanization prospects 2025*. United Nations.

UN-Habitat. (2009). *The right to adequate housing*. United Nations Human Settlements Programme.

United Nations Committee on Economic, Social and Cultural Rights. (1991). CESCR General Comment No. 4: The right to ac

World Bank Group. (2020). *Urban development*. World Bank Group.

Wachter, S. (2022). *Governing with urban living labs*. Springer.

Wehrmann, A., Pentzold, C., Rothe, D., & Bischof, A. (2022). Introduction: Living labs under construction. *Journal of Comm*

CHAPTER 2

Anne, R., & Crenn, C. (2021). Nouvelles questions ethniques. *Revue européenne des migrations internationales*, 37(2–3).

Awan, N., Schneider, T., & Till, J. (2011). *Spatial agency: Other ways of doing architecture*. Routledge.

Blunt, A., & Dowling, R. (2006). *Home*. Routledge.

Boudon, P. (1972). *Lived-in architecture: Le Corbusier's Pessac revisited*. MIT Press.

Brand, S. (1995). *How buildings learn: What happens after they're built*. Penguin Books.

Bratton, B. H. (2015). *The stack: On software and sovereignty*. MIT Press.

Clossick, J. (2023). Urban depth and social integration. In *Everyday streets: Inclusive approaches to understanding and des*

Florida, L. (2023). AI as agency without intelligence: On ChatGPT, large language models, and other generative models. *Phi*

Gissen, D. (2009). *Subnature: Architecture's other environments*. Princeton Architectural Press.

Graziano, V. (2025). The rabble's lifecraft: Institutional tinkering and popular illegalisms. In *Intelligence of Errors*. Croatian

Herscher, A., & Iyer Siddiqi, A. (2014). Spatial violence. *Architectural Theory Review*, 19(3), 269–280.

Hertweck, F. (2020). *Architecture on common ground*. Lars Müller Publishers.

Jackson, S. J. (2014). Rethinking repair. In T. Gillespie, P. Boczkowski, & K. Foot (Eds.), *Media technologies: Essays on comn*

Lambert, L. (2023). Colonial continuums: Introduction. *The Funambulist*.

Lambert, L. (2023). Nahel M., Nanterre, and the French colonial continuum. *The Funambulist*.

de Solà-Morales Rubió, I. (1995). Terrain vague. In C. C. Davidson (Ed.), *Anyplace* (pp. 118–123). MIT Press.

Dikeç, M. (2007). *Badlands of the republic: Space, politics and urban policy*. Blackwell Publishing.

Perec, G. (1997). *Species of spaces and other pieces*. Penguin Books. (Original work published 1974).

Picon, A. (2018). Urban infrastructure, imagination and politics: From the networked metropolis to the smart city. *Internat*

Rapoport, A. (1969). *House form and culture*. Prentice-Hall.

Rittel, H. W. J., & Webber, M. M. (1973). Dilemmas in a general theory of planning. *Policy Sciences*, 4(2), 155–169.

Sennett, R. (2018). *Building and dwelling: Ethics for the city*. Farrar, Straus and Giroux.

Sennett, R. (1970). *The uses of disorder: Personal identity and city life*. Knopf.

de Sousa, A. N. (Director). (2014). *The architecture of violence* [Television episode]. In *Rebel Architecture*. Al Jazeera Engli

- 90 Star, S. L. (1999). The ethnography of infrastructure. *American Behavioral Scientist*, 43(3), 377–391.
- 91 Taleb, N. N. (2012). *Antifragile: Things that gain from disorder*. Random House.
- 92 Tinker, I. (1997). Family, household, and housing: A gendered perspective. In *Infrastructure for living*.
- 93 Wassenberg, F. (2013). Large housing estates: Ideas, rise, fall and recovery: The Bijlmermeer and beyond. Delft University
- 94 Weizman, E., & Herscher, A. (2011). Architecture, violence, evidence. *Journal of Architecture*, 16(4), 455–469.
- 95 Zubčić, M.-L. (2025). On the animal that errs and its cunning in a broken world. In *Intelligence of Errors*. Croatian Architect

CHAPTER 3

- 96 Ahmed, E., Yaqoob, I., Hashem, I. A. T., Ahmed, A. I. A., Imran, M., & Vasilakos, A. V. (2017). The role of big data analytics in
- 97 Akgün, E. Z., Gerli, P., & McTigue, C. (2024). Breaking barriers for breaking ground: A categorisation of public sector challenges
- 98 ARUP. (2025). *AI for future cities: Urban planning and design*. ARUP.
- 99 Attia, A. R. (2025). The impact of integrating artificial intelligence and Building Information Modeling (BIM) systems on the
- 100 Baba, V. V., & Hakemzadeh, F. (2012). Toward a theory of evidence based decision making. *Management Decision*, 50(5), 1000–1015.
- 101 British Standards Institution. (2014). *Smart city framework – Guide to establishing strategies for smart cities and communities*.
- 102 Casiddu, N., Porfirione, C., & Vacanti, A. (2023). Tecnologie capacitanti per ambienti adattivi: il caso studio Living Hub. *TEC*
- 103 Dipali, D., Zade, N., Manjula, H., & Pallavi, M. (2025). Key enabling technologies for smart city development: A comprehensive
- 104 Dobbins, M. (2009). *Urban design and people*. Wiley.
- 105 Decode39. (2026). Europe risks falling behind in the global tech race. Decode39.
- 106 European Commission. (2021). *2030 Digital Compass: The European way for the Digital Decade*. Publications Office of the
- 107 European Parliamentary Research Service. (2021). Key enabling technologies for Europe's technological sovereignty. *European*
- 108 European Union. (n.d.). *Smart cities and communities*. European Commission. <https://digital-strategy.ec.europa.eu/en/policies/smart-cities>
- 109 Feng, F., Zhang, L., Meng, S., Shah, K., Wang, Z., & Ren, K. (2018). A blockchain-based privacy-preserving payment mechanism
- 110 Ferrante, T., & Romagnoli, F. (2023). Supporto o automazione nelle decisioni: Il ruolo dell'intelligenza artificiale per il progresso
- 111 Floridi, L. (2011). *The philosophy of information*. Oxford University Press.
- 112 Friedman, G. (2017). The irony of high tech. *Geopolitical Futures*.
- 113 Garcia, J., & Zhang, J. (2016). Conceptualizing smartness in government: An integrative and multi-dimensional view. *Governance*
- 114 Gaspari, J., Antonini, E., & Marchi, L. (2023). Tecnologie abilitanti per supportare la transizione energetica nell'ambito dell'energia
- 115 IBM. (2011). *IBM Intelligent Operations Center for Smarter Cities*. IBM.
- 116 Jaeger, A. D. (2026). Right to the digital Twin City? Citizen participation and limits-by-design in Rotterdam's urban digital transition
- 117 Kitchen, R. (2014). *The data revolution: Big data, open data, data infrastructures and their consequences*. SAGE Publications.
- 118 McKinsey & Company. (2025). *McKinsey Technology Trends Outlook 2025*. McKinsey Global Institute.
- 119 Mills, D., Pevcin, P., Dvorak, J., & Steven, P. (2021). Evidence-based public policy decision-making in smart cities: Does extant
- 120 Degli Esposti, M., Bazzani, A., Dellacasa, C., Pietropoli, M., Falcioni, M., & Massimo, M. (2025). Urban complexity through various
- 121 Mora, L., Deakin, M., Zhang, X., Batty, M., De Jong, M., & Santi, P. (2021). Assembling sustainable smart city transitions: A review
- 122 Morozov, E. (2013). To save everything, click here: The folly of technological solutionism. *PublicAffairs*.
- 123 Sharif, R. A., & Pokharel, S. (2022). Smart city dimensions and associated risks: Review of literature. *Sustainable Cities and*
- 124 Skouby, K. E., & Lynggaard, P. (2014). Smart home and smart city solutions enabled by 5G, IoT, AAI and CoT services. *IEEE Communications Magazine*
- 125 The Federal Ministry of Education and Research. (2024). *Key technologies for the future of Europe*. Federal Ministry of Education and Research
- 126 University of Genoa. (n.d.). *Living Hub*. https://simav.unige.it/living_hub
- 127 Wessendorf, C., Kopka, A., & Fornahl, D. (2025). Key enabling technologies (KETs) in the technological space: Embeddedness and
- 128 Zhiqiang, W. S. (2025). *Shanghai Maqiao: AI innovation experimental area*. Springer Nature.
- 129 Riferimento APA 7th corretto
- 130 Organisation for Economic Co-operation and Development. (2020). *How's life? 2020: Measuring well-being*. OECD Publishing.
- 131 Sartori, L., & Bocca, G. (2022). Minding the gap(s): Public perceptions of AI and socio-technical imaginaries. *AI & Society*, 37(1), 1–15.
- 132 Sartori, L. (2015). *Alla ricerca della smart city / smart citizenship*. Regione Emilia-Romagna.
- 133 UN-Habitat. (2022). *World cities report 2022: Envisaging the future of cities*. United Nations Human Settlements Programme.
- 134 World Bank. (2023). *Digital development overview*. World Bank.
- 135 Shelton, T., Zook, M., & Wiig, A. (2015). The “actually existing smart city”. *Cambridge Journal of Regions, Economy and Society*
- 136 Kitchen, R. (2016). The ethics of smart cities and urban science. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*
- 137 Da completare con autore/i. Il link da solo non permette di costruire una citazione APA completa. Servono autore, anno e

- 138 Lincoln Institute of Land Policy. (n.d.). Land, water, and the impacts of data centers. <https://www.lincolnst.edu/publicati>
- 139 International Energy Agency. (2025). Energy and AI. International Energy Agency. <https://www.iea.org/reports/energy-an>
- 140 European Commission. (2026). AI data centre waste heat could be used for water purification and carbon capture. Europe
- 141 European Commission. (n.d.). Local Digital Twin Toolbox. Interoperable Europe. <https://interoperable-europe.ec.europa.e>
- 142 Rotterdam Municipality. (2025). Rotterdam Citiverse. City of Rotterdam. <https://rotterdamcitiverse.com/en/>

CHAPTER 4

- 143 Gau, J. M., & Pratt, T. C. (2010). Revisiting broken windows theory: Examining the sources of the discriminant. *Journal of C*
- 144 Gehl, J. (2010). *Cities for people*. Island Press.
- 145 Mehta, V., & Bosson, J. K. (2010). Third places and the social life of streets. *Environment and Behavior*, 42(6), 779–805. [ht](http://)
- 146 Nadai, M., Vieriu, M., Zen, G., & Dragicevic, S. (2016). Are safer looking neighborhoods more lively? A multimodal investig
- 147 Whyte, W. H. (1980). *The social life of small urban spaces*. Project for Public Spaces.
- 148 Wilson, J. Q., & Kelling, G. L. (1982). Broken windows. *The Atlantic Monthly*, 249(3), 29–38.
- 149 OECD. (2019). *Benchmarking accessibility in cities: Measuring access to public transport and infrastructure*. OECD Publishi
- 150 OxyTech. (2015). EN 13201:2015 – The new standard for road lighting. OxyTech. <https://www.oxytech.it/PDF/EN13201-2>
- 151 Gehl Institute. (2017). *Public life data protocol*. Gehl Institute.
- 152 Seattle Department of Transportation. (2017). *Public life data protocol: Beta publication*. City of Seattle. <https://www.sea>
- 153 UN-Habitat. (2016). *Global public space toolkit: From global principles to local policies and practice*. United Nations Huma
- 154 Shoup, D. C. (2005). *The high cost of free parking*. Planners Press.
- 155 Gehl, J. (2011). *Life between buildings: Using public space*. Island Press.
- 156 Newman, O. (1972). *Defensible space: Crime prevention through urban design*. Macmillan.
- 157 ASTM International. (2020). *Standard practice for roads and parking lots pavement condition index surveys (ASTM D6433-*
- 158 Ewing, R., & Handy, S. (2012). *Measuring urban design: Metrics for livable places*. Island Press. <https://doi.org/10.5822/97>
- 159 Degli Esposti, M., Bazzani, A., Dellacasa, C., Pietropoli, M., Falcioni, M., & Massimo, M. (2025). Urban complexity through v
- 160 Liu, H., Li, C., Wu, Q., & Lee, Y. J. (2023). Visual instruction tuning. *Advances in Neural Information Processing Systems*, 36.
- 161 Li, J., Li, D., Xiong, C., & Hoi, S. (2022). BLIP: Bootstrapping language-image pre-training for unified vision-language unders
- 162 Radford, A., Kim, J. W., Hallacy, C., Ramesh, A., Goh, G., Agarwal, S., Sastry, G., Askell, A., Mishkin, P., Clark, J., Krueger, G.,
- 163 OpenAI. (2023). *GPT-4 technical report*. OpenAI. <https://cdn.openai.com/papers/gpt-4.pdf>
- 164 Goodfellow, I., Bengio, Y., & Courville, A. (2016). *Deep learning*. MIT Press.
- 165 Bishop, C. M. (2006). *Pattern recognition and machine learning*. Springer.
- 166 Phillips, S. A. (1999). *Wallbanging: Graffiti and gangs in L.A.* University of Chicago Press.
- 167 Young, A. (2014). *Street art, public city: Law, crime and the urban imagination*. Routledge.
- 168 Lachmann, R. (1988). Graffiti as career and ideology. *American Journal of Sociology*, 94(2), 229–250.
- 169 Castleman, C. (1982). *Getting up: Subway graffiti in New York*. MIT Press.
- 170 Macdonald, N. (2001). *The graffiti subculture: Youth, masculinity and identity in London and New York*. Palgrave Macmilla
- 171 Austin, J. (2001). *Taking the train: How graffiti art became an urban crisis in New York City*. Columbia University Press.
- 172 Wacquant, L. (2008). *Urban outcasts: A comparative sociology of advanced marginality*. Polity Press.

CHAPTER 5

- 173 Riferimento APA 7th
- 174 Città Metropolitana di Bologna & Comune di Bologna. (2026). *Indice di disagio socio-economico IDISE (2021)*. Servizio Stuc
- 175 Istituto Nazionale di Statistica. (2026). *Il disagio socio-economico degli individui e delle famiglie a livello sub-comunale: L'i*
- 176 Comune di Bologna. (2021). *Piano Urbanistico Generale (PUG) di Bologna*. Comune di Bologna.
- 177 Cristina, G. (2017). *Il Pilastro: Storia di una periferia nella Bologna del dopoguerra*. FrancoAngeli. (FrancoAngeli)

