AI-Driven Data Integration in Real Estate Development Processes

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Abstract

The fragmentation of data on the existing built environment is a critical obstacle to the governance of urban spaces. Although a wide range of data sources is available, from satellite imagery and environmental sensors to socio-demographic and cadastral datasets, these resources often lack interoperability and integration.
This deficiency limits the ability of governments and stakeholders to conduct accurate monitoring, implement informed real estate development strategies, and promote sustainable urban regeneration practices.
The research aims to explore how the integration of advanced Artificial Intelligence (AI) models, particularly Generative Adversarial Networks (GAN) based technologies, can contribute to the development of innovative approaches for urban management and the enhancement of disused building stock. In particular, the analysis aims to investigate the role of AI in Due Diligence (DD) processes, through a literature review in the areas of Smart Cities (SC) and Urban Management (UM), to define a theoretical-methodological framework to support data-driven urban regeneration strategies.
These technologies enable the generation of predictive urban models by combining heterogeneous inputs, such as geospatial frameworks, land-use data, environmental performance, and socioeconomic indicators. The research adopts a multidimensional approach based on a systematic literature review, which identified more than 1,200 academic contributions. Through a multi-stage filtering process, the most relevant analyses were classified into two main areas: *"Artificial Intelligence and Smart Cities"* and *"Artificial Intelligence and Urban Management",* with a focus on *"Due Diligence"* and models for *"Architectural Heritage Enhancement."* Integrating AI capabilities into the development of urban regeneration strategies has the potential to create resilient and smart cities. This can optimise resources while minimising land consumption and enhance inclusive and collaborative governance. Despite growing scholarly interest, analysis has revealed significant gaps in the development of these technologies.
The proposed approach is in line with emerging urban agendas and promotes a transition to resilient, circular, and smart cities. This study advocates for digital innovation that is not only technologically advanced but also ethically grounded and socially inclusive.

Keywords: Artificial Intelligence, Urban Management, Architectural Heritage Reuse, GAN models, Due Diligence

Paper type: Academic Research Paper.

1 Introduction

Contemporary cities are complex and constantly evolving systems, where social changes and internal dynamics continuously redefine the urban fabric. In the next three decades, it is estimated that nearly two-thirds of the world's population will live in urban settings, highlighting the acceleration of global urbanisation (Acioly et al. 2020). This scenario poses significant challenges for urban planners and real estate developers, who must design innovative strategies to efficiently manage urban land and infrastructure.

A key element in supporting such strategies is reliable, updated, and meaningful data availability. The integration of advanced technologies and large-scale data management processes offers significant potential to enhance urban functionality, quality of life, and the development of Smart City (SC) ecosystems (Singh et al. 2024). Since urban development processes often lead to an unequal distribution of opportunities, the inclusion of social equity objectives in enhancement strategies is becoming essential (Barberis et al. 2020). In this regard, SC technologies can support efforts toward greater inclusion and sustainability (Al-Rimawi and Nadler 2023; (Ahmad Afaneh and Isam Shahrour 2017).

Sustainability can be pursued through the conscious management of the existing building stock. Buildings that have lost their original functions risk abandonment and underuse. Transforming this heritage into a resource requires adaptations in governance structures, institutional frameworks, and financial mechanisms (Baud et al. 2021).

To address these challenges, the future of cities depends on the integration of SC, Smart Real Estate (SRE) solutions, and other innovative technologies. Collaborative public-private partnerships will play a crucial role in promoting sustainable and innovative development (Deakin and Al Waer 2011). Within this integrated vision, cultural heritage becomes a strategic asset for the transition to more resilient and sustainable urban models.

The research aims to explore how the integration of advanced AI models, particularly GAN-based technologies, can contribute to the development of innovative approaches for urban management and the enhancement of disused building stock. The analysis aims to investigate the role of AI in Due Diligence (DD) processes, through a literature review in the areas of Smart Cities (SC) and Urban Management (UM, to outline a theoretical-methodological framework to support data-driven urban regeneration strategies.

The paper is structured into three main sections: the first introduces the theoretical framework and methodology; the second offers a critical review of the literature on AI, SC, and UM, focusing on DD; and the third discusses the results and proposes final reflections on possible operational developments.

2 Materials and methods

This literature review is based on a filtering methodological approach divided into 3 phases. The analysis is oriented toward the systematic and integrative analysis of the scientific literature with the objective of outlining the state of play about AI applications in urban contexts (Figure 1).

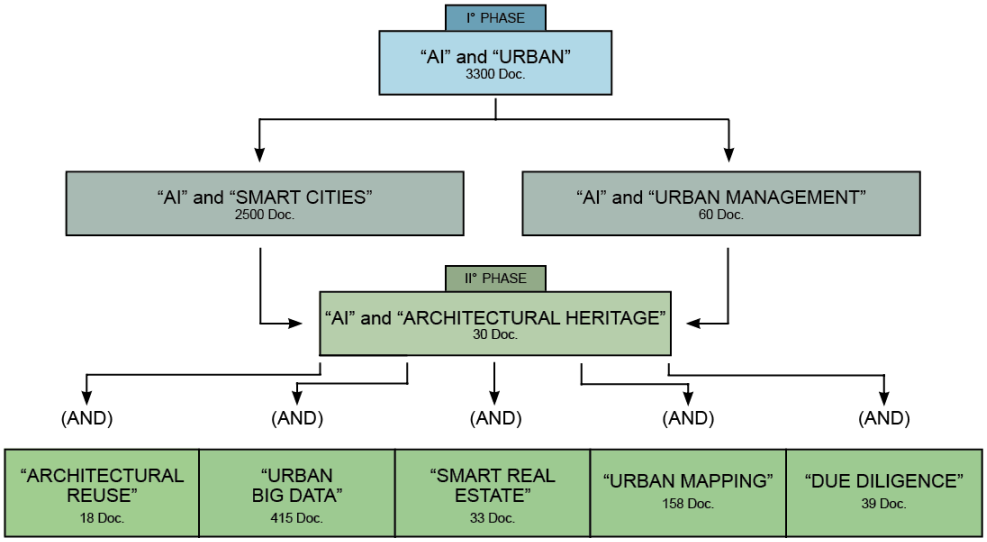

Figure 1: Methodological outline of research (Authors' elaboration)

The papers collection started in Phase 1 with the research of literature related to artificial intelligence and urban environment to define a general framework of reference for the application of AI in urban monitoring, development or transformation processes. In this research, the first extensive collection is composed of 3,300 scientific contributions. Papers were selected mainly through a targeted query on SCOPUS, focusing on its implications in urban ecosystems' governance, planning, and management, to trace emerging theoretical trajectories and identify the main areas of application of AI in the contemporary urban domain. The link between Generative AI and a more efficient and responsive management of cities is underlined in literature, as affirmed by Beroche, who stated that it can contribute significantly to urban management thanks to its ability to dramatically reduce the processing time and costs associated with analysing unstructured data. AI enables real-time scenario development and improves the decision-making capacity of public administrations (Beroche, 2023).

In the second phase of the data collection process, divide the research into two branches, and focus on the relationship between AI and smart cities or AI and urban management. In this research, the second step of the process collected 2,500 scholarly contributions regarding the relation between AI and smart cities and 60 papers relating to the link between AI and urban management. Both of these are sub-samples of the previous step.

Next, the bibliographic analysis focused on the exploration of AI applications in architectural heritage enhancement processes. This phase (Phase 2), by filtering papers collected in the steps 1 and 1b, led to the identification of 30 scholarly contributions deemed particularly significant for understanding the role of AI in the regeneration of the built environment and in defining strategies geared toward adaptive reuse. This phase investigated how AI-based theoretical models and technological tools support strategies for recovery, adaptive reuse, and regeneration of the built environment.

Finally, the last refined queries for the research are related to five subtopics (Phase 2b): architectural reuse, urban big data, smart real estate, urban mapping and due diligence. The selection of contributions favoured

those studies that present a data-driven and interdisciplinary perspective, integrating the knowledge of architecture, urban planning and data science. The thematic articulation that emerged from this phase confirms the centrality of an integrated and multidimensional approach, in which AI is configured not only as a technical support tool, but as a real catalyst for transformative processes oriented toward urban resilience, operational efficiency and long-term sustainability.

By filtering the final five subsamples on the basis of criteria such as consistency, completeness, innovation and the use of data, the final sample of analysis is composed by 23 papers, belonging to 1.200 different nationalities and 23 different authors (Table 1).

Table 1: Final paper sample (Authors' elaboration)

N	AUTHORS	Arch. He. reuse	Urban Data	Real estate	Urban mapping	Due Diligence	Topics
1	Ahmad Afaneh and Isam Shahrour, 2017				X		1
2	Allam and Dhunny, 2019		X		X		2
3	Al-Rimawi and Nadler, 2023			X		X	2
4	Al-Rimawi and Nadler, 2025		X	X			2
5	Barberis et al., 2020	X	X	X		X	4
6	Batty, 2016		X				1
7	Beroche et al., 2023				X		1
8	Bosone et al., 2019	X					1
9	Bosone et al., 2021	X				X	2
10	Cellucci, 2021	X		X			2
11	Cesario, 2023		X	X	X		3
12	Chioma et al., 2020			X			1
13	Cinquepalmi et al., 2023	X	X	X	X	X	5
14	Cugurullo et al., 2024		X		X		2
15	Djokić et al., 2025				X		1
16	Girard and Gravagnuolo, 2025	X	X	X			3
17	Gravagnuolo et al., 2021	X					1
18	Gravagnuolo et al., 2024	X		X		X	3
19	Kandt and Batty, 2021		X		X		2
20	Maha Shree J et al., 2024	X					1
21	Oral, 2024					X	1
22	Seagraves, 2024				X	X	2
23	United Nations, 2017		X		X		2

Just one of the 23 papers analysed covers all five topics underlined in the research, and just one analyses 4 to 5 topics, excluding urban mapping. Three contributions focus on different combinations of three topics, while most of the papers analysed face just one or two topics.

3 Results

The results outline the advancement of research in the respective fields analysed, but also highlight theoretical and operational gaps that need further exploration. Indeed, recent reflections on *"Urban Artificial Intelligence"* confirm the emergence of a hybrid field, in which AI is configured as an invisible but crucial infrastructure in the transformation of cities. Urban AI acts as a catalyst for complex processes, enhancing predictive analytics, data interoperability and future scenario building. As highlighted in the report *"The Future of Urban AI"* (Batty et al. 2023), the adoption of AI in cities still faces challenges related to data reliability and institutional fragmentation.

It has thus emerged how the adoption of AI tools allows for the expansion of the capacity for evaluative analysis of the built heritage, thanks to the possibility of cross-referencing heterogeneous data (morphological, structural, historical, energy, environmental, economic-social) and generating predictive outputs useful for the definition of sustainable regenerative scenarios. The most recent applications show the evolution of these tools from simple computer aids to intelligent analytical environments, which can integrate qualitative and quantitative assessments to identify the most promising use cases, minimising risks and maximising positive socio-economic impacts.

In general, the SC concept acquires an evolution from a purely technological paradigm toward an adaptive system capable of receiving and responding to citizens' needs in real time. This transition implies an increasing integration between innovative technologies, digital infrastructure, and civic participation, outlining scenarios

in which AI can become an enabling tool to improve operational efficiency and the equity and resilience of urban systems.

The emerging vision is to consider cities as *"smart ecosystems"* in which the digital infrastructure is intertwined with the physical and social components of the territory (Cugurullo and Acheampong, 2024). Addressing the scope of UM extends a second front of consideration, as the analysed papers tend to evaluate AI as a tool for supporting strategic planning, built asset management, and urban governance. From this perspective, AI is explored as a technology that can expand the analytical capacity of public and private actors, facilitating predictive asset valuation practices and environmental monitoring (Al-Rimawi and Nadler 2025). As highlighted in the report "*Generative AI for Urban Governance"*, generative AI technologies do not just support technical processes but also take on an inherently political nature.

Moreover, according to the Urban AI Guide, "Urban Artificial Intelligence" is a synthesis of co-production between cities and innovative technologies. AI transforms cities, but the cities themselves - with their data, infrastructure, and communities - shape the development of smart solutions (Popelka et al. 2023).

The first, related to AI and Architectural Reuse, comprised 18 scholarly contributions investigating the potential of AI in supporting adaptive reuse strategies of existing architecture. The analysed contributions highlight the growing role of smart technologies in assessing the conservation state of buildings, simulating sustainable transformation scenarios, and defining operational strategies aimed at rehabilitating the built environment. As a result of the last filtering process, some recurrent themes emerged that were used as keywords for the research. Five distinct sub-samples contributed to the final sample definition, each focusing on a different aspect. The first, related to AI and Architectural Reuse, was composed of 18 scholarly contributions investigating the potential of AI in supporting adaptive reuse strategies of existing architecture. The contributions analysed extol the growing role of smart technologies in assessing the conservative state of buildings, simulating sustainable transformation scenarios, and defining operational strategies aimed at rehabilitating the built environment. (Gravagnuolo et al. 2024) affirmed that effective decision-making processes in the context of cultural heritage require appropriate tools. In this sense, evaluation is central in constructing choices, recognising values, interests and needs, and exploring the different factors that may influence decisions.

From this perspective, the adoption of AI emerges as an enabling tool to address the multidimensional complexity characterising adaptive reuse processes (Gravagnuolo et al. 2024). Indeed, the literature highlights how the proper use of AI can contribute significantly to economic growth, social welfare and environmental regeneration, promoting more sustainable and circular urban development.

In parallel, the extensive literature on urban Big Data, numbering 415 scientific papers, has offered a solid methodological framework, highlighting the potential of AI in data management. his component has reinforced the paradigm of data-driven urban governance, where predictive analytics and advanced modelling are essential tools for adaptive and informed planning. In particular, Big data provides a lens through which the complexities of urban form can be analysed, understood, modelled, and even imagined and tested in different scenarios (Djokić et al. 2025).

Further reflections emerged from the comparison with the area of Smart Real Estate, represented by 33 studies, in which how AI can contribute to real estate valuation and the definition of sustainability-oriented investment strategies are analysed. In this area, it emerges how the integration of digital technologies, such as Internet of Things (IoT), BD, AI and digital twin (DT), enables more efficient real estate asset management and data-driven decision support, improving quality of life and promoting sustainable urban development (Al-Rimawi and Nadler 2023). In addition, recent studies show that the deployment of smart buildings and interconnection with urban infrastructure contribute significantly to reducing energy consumption and emissions, enabling new real estate valuation and investment models based on sustainability and operational efficiency (Al-Rimawi and Nadler 2023).

Also of considerable relevance is the area of Urban Mapping, which is explored in depth through 158 contributions highlighting the use of AI to create high-resolution urban representations capable of dynamically rendering the city's morphology. Geospatial Deep Learning (DL) technologies, applied to the analysis of satellite and aerial imagery, enable the precise identification of urban morphology and the development of three-dimensional models of built fabric and street networks. In particular, the adoption of advanced convolutional models, integrated into a GIS environment, enables the extraction of complex features such as building footprints and street networks from orthorectified imagery, improving the accuracy of urban analyses and supporting the definition of more informed and responsive spatial policies. (Orusa et al., 2024).

Finally, the theme of Due Diligence, investigated through 39 papers, highlighted how AI can optimise the preliminary stages of decision-making through a more efficient and transparent analysis of technical, legal, economic, and environmental information related to real estate assets. However, critical literature analysis

highlights a significant gap: the lack of structured theoretical frameworks and shared metrics to systematically assess the “urban reusability” of disused buildings.

3.1 “Artificial Intelligence” AND “Smart Cities”

From the analysis of the co-occurrences related to the combination of the keywords *“Artificial Intelligence”* and *“Smart Cities”*, elaborated through VOSviewer, by applying a co-occurrence analysis of terms, authors, or publications, using a distance-based visualisation approach where the proximity between nodes reflects the strength of their relationship, based on techniques such as the VOS (Visualization of Similarities) mapping method.

The relationships between the main key terms in the examined literature are illustrated in Figure 2. The network graph shows five large clusters that emerge, distinguished by the colours red, green, blue, yellow, and purple, with a total of 422 occurrences.

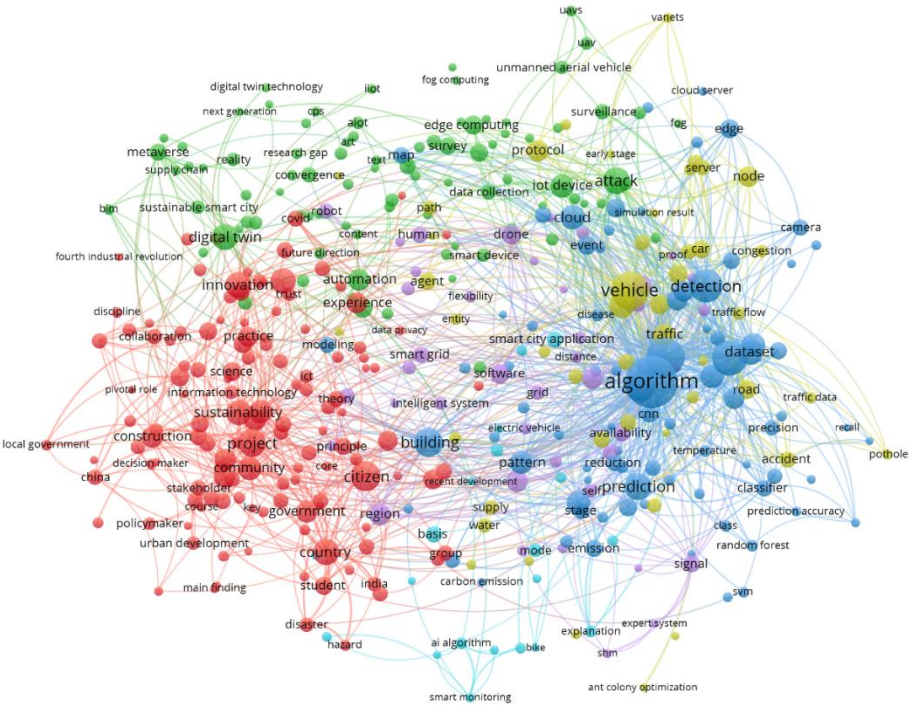

Figure 2: Map of co-occurrences emerging from the research. "Artificial Intelligence" AND "Smart cities"
Authors’ elaboration

The red cluster includes public policies, urban planning, and sustainability concepts. Keywords such as *“CO2 emissions”*, *“project”* and *“community”*, closely related to terms such as *“country”*, *“citizen”*, *“urban development”*, and *“government”*, highlight the centrality of regulatory and social aspects.

In the blue cluster, a focus on the relevance of IT, algorithmic and predictive is observed. The concentration of keywords such as *“prediction”*, *“probability”,* and *“machine learning”* underlines the importance of the data-driven approach. It is interesting to note how *“building”* and *“map”* occupy an intermediate position between the clusters belonging to the urban sphere and those belonging to the IT/technological sphere.

In the green cluster, on the other hand, concepts that recall the use of advanced technologies such as *“sensors”, “digital twin”*, and *“automation”* prevail. The presence of terms related to automation and robotics, combined with references to smart tracking, suggests potential solutions to transform the analysis and intervention processes.

The purple cluster can be interpreted as representing the “smart network” theme, encompassing both the physical and digital infrastructures, with particular emphasis on flexibility and the interaction between human and cyber interfaces.

The yellow cluster highlights the widespread application of AI in the mobility sector, which is traditionally one of the earliest fields to integrate artificial intelligence technologies. In this representation, network governance and innovation are in a form of dialogue and the relationships between the concepts analysed highlight an evolving panorama in which interdisciplinarity and the ability to integrate different skills appear crucial to promoting new urban policies (Figure 3).

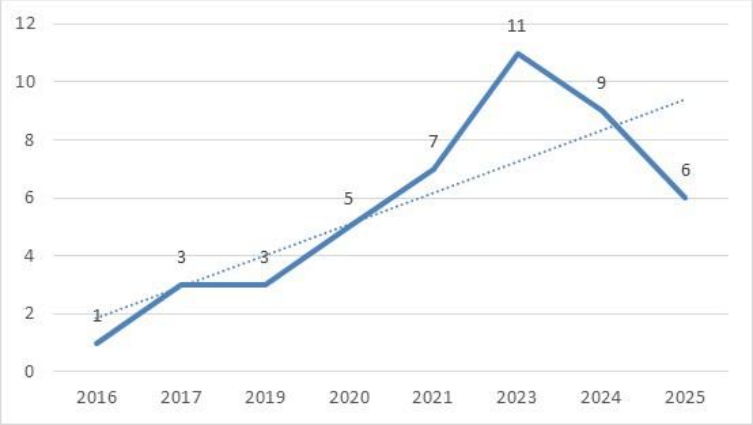

Figure 3. Trend of analyzed publications over the years (Authors' elaboration on Genuary 2025)

The emergence of a data-driven urban paradigm, currently in a phase of progressive consolidation, is characterised by an increasing integration of analytical methodologies, decision-making frameworks, and sustainability imperatives. However, this integration remains fragmented and inconsistent, underscoring the imperative for further theoretical elaboration and operational innovation to ensure that intelligent urban solutions enhance system optimisation and foster the development of more equitable, inclusive, and resilient urban environments.

3.2 "Artificial Intelligence" AND "Urban management"

The co-occurrences from the scientific literature relating to the binomial "Artificial Intelligence" and "Urban Management" are represented by the semantic map in Figure 4. The map is divided into two main sets, which reflect a polarisation between a conceptual and a technical-functional approach.

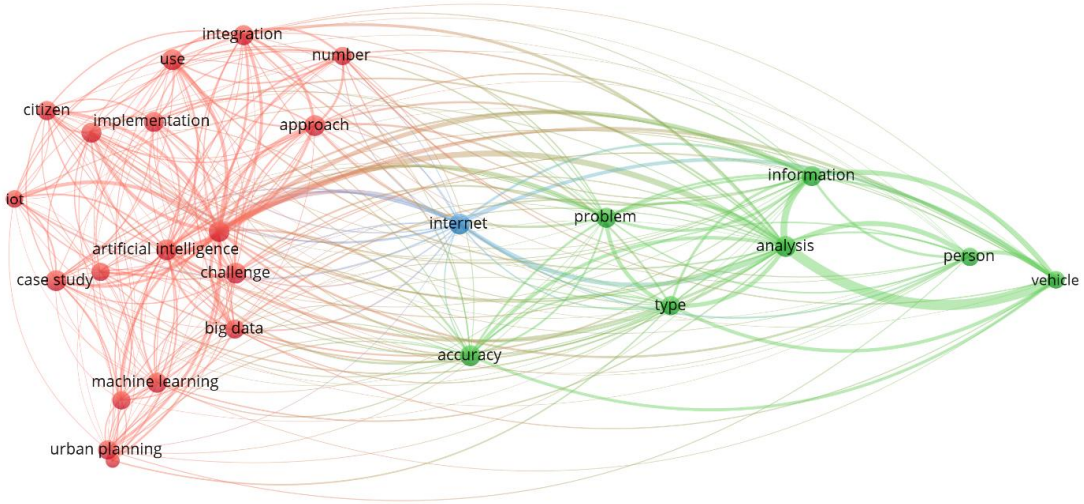

Figure 4: Map of co-occurrences emerging from the research. "Artificial Intelligence" AND "Urban Management"

The red cluster focuses on concepts such as "Artificial intelligence", "Urban planning", "Implementation", "Integration", "IoT" and "Big Data". This area signals a theoretical and methodological interest in the strategic role of AI in urban planning and management processes. The recurrence of terms such as "Use", "Challenge" and "Citizen" suggests a reflection on the potential, but also the critical issues, connected to the social, cultural and organisational dimensions of the introduction of AI in cities. The green cluster, on the other hand, focuses on more operational concepts such as "Analysis", "Information" and "Accuracy". This section outlines a literature focused on AI as a tool for optimisation and automation, particularly in traffic management, big data analysis, and the construction of predictive models. The focus is on analytical precision, data classification and the efficiency of intelligent systems in urban contexts.

Interestingly, the intermediate position occupied by the term internet seems to act as a conceptual node between the two clusters, reflecting the role of digital infrastructures in the connection between decision-

making processes and emerging technologies. A still fragile connection between the different conceptual structures emerges as an element of final critical reflection. The map confirms how AI is now recognised as an incentive for the evolution of urban management, but at the same time highlights how the scientific approach to the topic is still fragmented, with an evident separation between theoretical visions and practical applications.

3.3 "Artificial Intelligence" AND "Due Diligence"

The scarce presence of scientific contributions dedicated to AI and Due Diligence or the valorisation of unused Architectural Heritage underlines a gap in the current literature. These areas represent a promising research field, in which AI could evolve as a technical tool and cognitive decision-making infrastructure, capable of supporting more sustainable, inclusive and built-regeneration-oriented urban policies.

Although still marginal in the scientific debate, the topic of DD represents a strategic area for the application of AI, operating on two distinct levels: urban and architectural.

AI can enhance DD practices at the urban scale by supporting predictive assessments on brownfield sites, territorial risks and regenerative potential. The studies by (Al-Rimawi and Nadler 2023 - 2025) show how the integration of innovative technologies and data-driven tools strengthens the preliminary phases of decision-making processes in the real estate and urban planning fields, transforming DD into a strategic lever for sustainable planning.

At the architectural scale, several contributions explore the application of AI in the technical and performance assessment of the built environment, with a particular focus on adaptive reuse processes (Cinquepalmi et al. 2023; Gravagnuolo et al. 2021; Barberis et al. 2020). In these studies, AI enables the automated analysis of morphological, energy, and structural data, integrating multi-criteria approaches to support more informed and sustainable decision-making. Despite its potential, the literature points to a fragmented landscape, characterised by the absence of consolidated models and scalable applications. This highlights the pressing need to develop robust methodological frameworks that can establish AI as a reliable decision-making tool within urban and real estate regeneration processes.

4 Conclusions

The literature review reveals significant gaps, particularly the absence of tools specifically designed to support urban regeneration through the rehabilitation of disused spaces and buildings using AI technologies. While advanced technologies offer promising solutions, the risk of disproportionate and top-down applications remains, potentially neglecting social and cultural dynamics. Hence, it is crucial to integrate community engagement tools and participatory governance strategies to balance technological innovation with urban resilience (Allam and Dhunny 2019). The effectiveness of AI tools lies in their ability to process large volumes of data, refining analyses and automating resource optimisation. Various subcategories of AI — including GAN models, Generative Pre-Trained Transformers (GPT), Machine Learning (ML), Information and Communication Technology (ICT), Internet of Things (IoT), Cloud Computing, and Software as a Service (SaaS) — form the technological infrastructure for data-driven urban development (Talari et al. 2017). Successful SC and SRE solutions implementation requires high-tech information systems and sharing platforms to analyse collected data (Al-Rimawi and Nadler 2025). Moreover, the literature identifies the fragmentation of local policies and the difficulty in implementing data-driven strategies as significant barriers to efficient and sustainable urban development (Acioly et al. 2020). Although Urban Big Data (BD) represents a highly innovative sector, critical issues such as data source fragmentation and lack of interoperability persist. One notable weakness is the limited connection between real estate (RE) research and urban regeneration and sustainability efforts. While many studies apply AI to asset valuation and market trend prediction, few address the relationship between real estate markets and adaptive reuse strategies. This suggests that the real estate sector remains largely anchored to traditional development models focused on new constructions, rather than enhancing existing assets. The convergence of AI, BD, and property management models may offer a pathway to overcome these challenges, fostering more rational and effective urban resource management and promoting smart but also sustainable, inclusive, and adaptable cities to future challenges. The level of integration of AI into urban governance is still limited by theoretical and operational limits, even if the European Union tends to propose new operational applications oriented towards sustainability, circularity and territorial equity.

The research has highlighted how AI today represents a stimulus to rethink the contemporary city, especially in urban regeneration and valorisation of abandoned buildings. The adoption of generative models and predictive tools based on data opens up concrete operational scenarios to overcome the critical issues related to information fragmentation, lack of interoperability and the absence of systemic approaches.

SC technologies have reached sufficient maturity to be integrated into operational processes, but highlight also the lack of a structured model to guarantee interoperability between data and digital platforms (Al-Rimawi and Nadler 2025). A structural barrier that limits the real potential of AI in urban contexts, making it urgent to build open, integrated and scalable information ecosystems.

In this scenario, the issue of the reuse of abandoned buildings remains marginal in the scientific debate. The introduction of the Reusability Index (RI) by the European Commission represents a first step towards the definition of shared metrics (Barberis et al. 2020).

Future research developments will have to focus on the creation of interoperable frameworks capable of connecting predictive models and urban decision-making processes. Only a convergence between technological intelligence and social vision will transform cities into intelligent organisms capable of learning, evolving and generating social value. The challenge for the cities of the future is not only technological but profoundly cultural; integrating AI is not an end but a means to build safer, more resilient, and inclusive urban environments.

5 Ethics declaration

The authors declare that they have respected all ethical standards during the research process. All sources and references have been properly cited, and any potential conflicts of interest have been disclosed. The research was conducted independently and without external influences.

6 AI declaration

The authors confirm that Artificial Intelligence tools were used to assist only in language refinement and summarization. No AI system was employed for the generation of original scientific content, analysis, or critical evaluations included in this paper. The authors retain full responsibility for the originality, accuracy, and integrity of the research findings.

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