

# Integrated and Multilevel Knowledge

## Digital Approaches for Sustainable Planning and Heritage Conservation

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**Abstract** - *The city of Tirana is facing significant challenges related to urban expansion and traffic congestion, which undermine the quality of life for both residents and visitors of the Albanian capital. Rapid urbanisation has exerted increasing pressure on urban infrastructure and the historic centre, highlighting the need for innovative solutions for sustainable mobility and decentralized planning. The International PhD Workshop-Project (December 10–20, 2024), conducted within the framework of the joint international doctoral program IDAUP (POLIS University and Ferrara University), provided an opportunity to develop reflections and propose potential solutions to these challenges. The outcomes, stemming from an interdisciplinary and multi-scalar approach, emphasized the importance of data and contextual information as an essential foundation for accurate and informed planning. Both tangible and intangible data play a crucial role in understanding and managing complex urban territories. Beyond demo-sociological information, the combination of morphometric, cultural, and historical data allows for the construction of a detailed framework of territorial dynamics. Technologies such as GIS (Geographic Information Systems), laser scanning, photogrammetry, and HBIM (Heritage Building Information Modeling) enable the development of semantically enriched three-dimensional digital models, integrating the physical characteristics of the territory with its intangible values. These tools provide a knowledge base that supports sustainable planning, heritage conservation, and improved accessibility. This contribution aims to explore how data, represented and organized through advanced models, can support urban development strategies for Tirana, transforming the built environment into a strategic resource for inclusive and sustainable development. Cultural heritage, understood as a generative element of identity and cohesion, is analysed not only as an asset to preserve but as a dynamic factor capable of stimulating urban regeneration processes. The proposed methodological approach aspires to offer a replicable framework for other cities facing similar challenges.*

**Keywords** - Digital Data Management, HBIM and GIS, Multiscale Modelling, Integrated Survey, Heritage Conservation.

### Introduction

Contemporary cities are facing a multitude of crises, environmental, social, economic, and infrastructural. Alongside this complexity, traditional models of urban planning, often based on rationalist, top-down, and sectoral approaches, are increasingly struggling to provide effective and sustainable responses. In recent decades, the field of urban planning has undergone a gradual shift towards more open and participatory paradigms that emphasize relational dimensions and the interaction between different forms of knowledge [Amimi et al. 2024].

Tirana, the capital of Albania, represents a paradigmatic case of the tensions affecting cities

in transition. Its uncontrolled urban expansion, increased traffic, concentration of functions in the historic centre, and mounting pressure on cultural and landscape heritage have resulted in a fragmented, uneven, and hard-to-manage urban context. Tirana's challenge is not merely quantitative (too many cars, too much density) but qualitative: it is necessary to rethink the logic of centralization, redistribute flows and functions, and reconfigure urban forms as devices capable of orienting new spatial and social equilibria.

Within this framework, the International PhD Workshop-Project, held in Tirana in December 2024 as part of the joint IDAUP (Polis/Ferrara) program,

represented a moment of significant experimental and interdisciplinary value. Through the analysis of strategic urban sites, the critical reinterpretation of existing urban forms, and the use of advanced representational tools, the workshop highlighted how urban form can be understood not only as an outcome but also as an operational lever for directing flows, activating new centralities, and relieving the historic centre from unsustainable pressures.

At the heart of this process lies the importance of contextual and multilevel knowledge, made possible through the collection, organisation, and interpretation of data from different sources and scales. In this sense, data are not merely descriptive tools but transformative agents in urban planning. The integration of quantitative data (morphometric, demo-sociological, environmental) and qualitative data (symbolic values, historical stratifications, uses, and perceptions) enables the construction of a holistic vision of the territory.

Digital technologies, from GIS systems to laser scanning surveys, photogrammetry to HBIM, now allow the generation of semantically enriched digital models, capable of operationally capturing the complexity of urban heritage. Their interoperability also makes it possible to overcome the historic dichotomy between the architectural and territorial scales, paving the way for new forms of systemic and conscious design [Imperiale, 2024].

In this perspective, multilevel digital knowledge emerges as a crucial resource for imagining forms of urban planning that are more sensitive, sustainable, and rooted in the cultural value of territories, outlining conscious regeneration scenarios for complex and transforming cities such as Tirana.

This contribution aims to promote sustainability, understood as a measurable improvement in accessibility, resilience, and resource efficiency, and to frame heritage conservation as an operational and decision-making level that actively guides urban transformation.

Furthermore, it aims to explore, through a conceptual and methodological lens, how digital knowledge can support integrated and sustainable urban planning by addressing the following questions:

-How can multilevel and interoperable digital

systems contribute to constructing shared knowledge frameworks for planning and heritage conservation?

-In what ways can digital representation and semantic modelling foster a cultural shift from conservation as preservation to conservation as a proactive component of urban transformation?

-How can the Tirana context, understood as a city in transition, serve as a testing ground for reflecting on the scalability and transferability of such digital knowledge approaches?

### Multilevel Knowledge and Integrated Data for Sustainable Planning

In the contemporary urban context, marked by increasing complexity, fragmentation, and rapid change, the need to move beyond unidimensional analytical approaches is becoming ever more evident. What emerges is the importance of multilevel knowledge, a form of understanding articulated across different spatial and temporal scales, capable of integrating diverse disciplinary perspectives and valuing both physical and intangible data.

This approach builds on the idea that the city cannot be understood, nor governed, through a single interpretative lens. "La città è un organismo complesso, [...] un insieme di relazioni spaziali e costruttive vivificate dalla Storia" ("The city is a complex organism, [...] a set of spatial and constructive relationships animated by History") [Docci & Maestri, 2020]. Urban forms, social processes, collective memories, and morphological transformations constitute different but interrelated levels of a complex territorial system.

Within this framework, data play a central role as tools for reading, understanding, and representing the territory. They are not neutral, but active constructors of visions and decision-making tools. This calls for a critical reflection on the methods of data collection, selection, and aggregation, as well as on the forms of representation that make data "visible" and "operational" in planning processes [Mancantonio & Maietti, 2024].

In this perspective, multilevel knowledge is not merely distributed understanding, but a dynamic

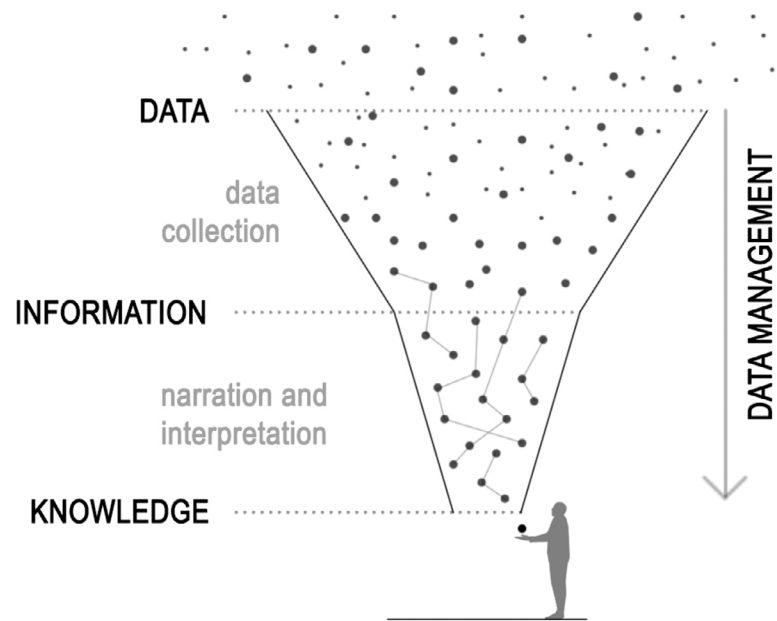


Fig. 1. Knowing to Decide. Source/ Graphic elaboration by the author.

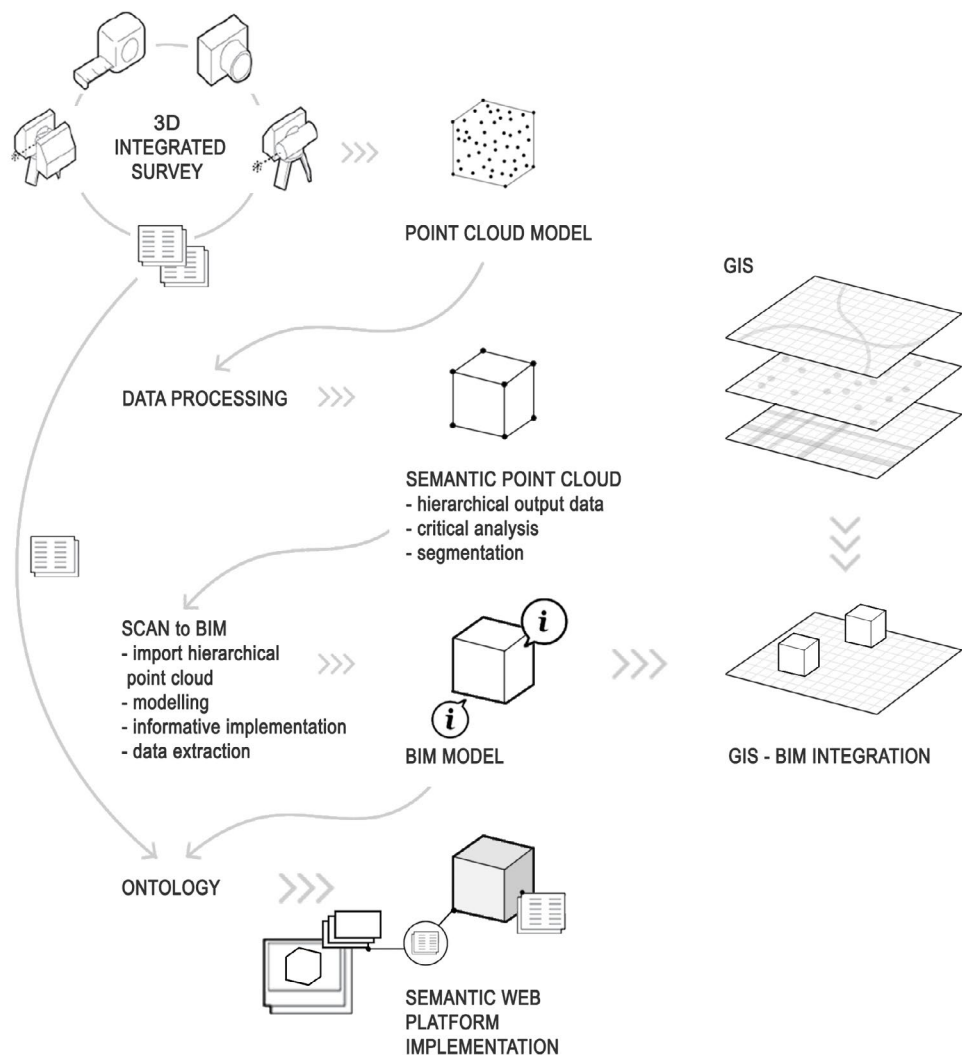


Fig. 2. Methodological diagram. Source/ Graphic elaboration by the author.



Fig. 3. From left to right: Sauk, Paskuqan, Skanderbeg Square, and Kombinat. Source/ Photos and graphic elaboration by the author

process of transforming information into shared comprehension, capable of guiding collective choices. As Enrico Giovannini, former president of the Italian National Institute of Statistics (ISTAT), emphasized, “la statistica serve ad aumentare la conoscenza, ma deve parlare alla persona nella sua completezza” (“statistics should serve to increase knowledge, but must speak to the person in their entirety”), not just to the rational mind. The growing availability of data, from big data to open data, does not automatically translate into greater decision-making capacity: it is essential to read and use data consciously, from both technical and design standpoints, so that information is not just undifferentiated noise, but becomes “operational knowledge” and a strategic orientation in urban planning (Figure 1).

Overcoming the traditional idea of statistics as a tool reserved for institutions, and instead seeing it as a form of knowledge useful to society as a whole, as Giovannini suggests, implies a profound redefinition of the ways in which data are produced, interpreted, and communicated. Data must not only be “correct,” but also “meaningful,” capable of conveying the complexity of urban realities in a legible and accessible way. In this light, territorial representation plays a central role: effective visualization, the narrative of phenomena, and the use of indicators that speak to people’s lived experiences become decisive tools for transforming data into awareness, and awareness into action [Giovannini, 2013].

Multilevel knowledge can be operationalized in the form of an integrated digital infrastructure, capable of aggregating, processing, and delivering heterogeneous information (geometric, geospatial, historical, social, and symbolic) within a unified and queryable system. This infrastructure becomes an essential tool for conscious and contextual urban planning, one that makes complexity intelligible while supporting informed design and policy decisions.

Within this approach, territorial information is no longer a simple support, but a true design resource, capable of guiding decisions sensitive to multiple layers of meaning: morphological, functional, environmental, as well as historical, symbolic, and identity-related.

From a methodological perspective, this framework builds on open and interoperable data standards, aligning with international recommendations and current research trends [Salah et al., 2025; Cepa et al., 2024]. The structure relies on three main components: (1) data frameworks, including IFC 4.3 and CityGML 3.0, to enable cross-domain interoperability (ISO 16739-1:2018; OGC 2022 - Optoelectronics Global Conference 2022); (2) semantic structuring, through CIDOC-CRM and Linked Data logic, to ensure metadata coherence and long-term accessibility; and (3) process principles such as transparency, reusability, and multi-scale coordination. As underlined by Salah et al. (2025), the definition of consistent Levels of Detail (LOD), Levels of Information (LOI), and Levels of Accuracy (LOA) is crucial for ensuring the reliability and scalability of HBIM-based workflows.

### Digital Tools for Knowledge Representation and Integration

In the context of urban planning that is both conscious and culturally rooted, digital tools are not merely technical supports, but true cognitive and decision-making agents. Technologies such as GIS, HBIM, photogrammetry, and laser scanning, when integrated within a coherent semantic infrastructure, enable multilevel representation

and the aggregation of heterogeneous forms of knowledge, contributing to the construction of an interoperable, updatable, and multi-actor urban knowledge ecosystem.

The development of open-standard collaborative platforms, such as those explored in the European INCEPTION project [Maietti et al. 2020], has made it possible to associate three-dimensional geometries not only with technical and material data, but also with symbolic, narrative, and functional content, integrating semantic ontologies to reveal the historical stratifications and identity relationships of places. These infrastructures allow for an augmented representation of urban space, where digital objects become true nodes of knowledge connected to a structured and queryable information network [Marcantonio & Maietti, 2024; Parinello et al. 2024; Borucka et al. 2023].

The digitization process today unfolds through integrated methodological workflows, from high-information-density surveying techniques (e.g., TLS -Terrestrial Laser Scanning- and photogrammetry) to parametric and semantic modelling of the built heritage. This enables the development of HBIM models capable of hosting structured metadata related to morphologies, materials, decay, usage values, historical transformations, and potential functions. These models are not simple 3D representations, but dynamic archives, tools for both design and governance [Maietti & Tasselli, 2020; Lombardi & Rizzi, 2024].

The integration of BIM and GIS opens new perspectives for building a comprehensive urban vision that spans different scales of design and knowledge. The interoperability of these systems

allows for the connection of territorial data with architectural models, making visible the interactions between morphologies, infrastructures, and heritage, across both central and peripheral urban contexts [Imperiale, 2024] (Figure 2). The growing convergence between these digital environments has stimulated extensive research on data interoperability and semantic consistency across different spatial scales. Recent studies highlight the potential of open standards, such as IFC, CityGML, and GeoPackage, to ensure integration between distinct domains while preserving data structure and integrity [Guyo et al., 2021; Cepa et al., 2024]. Within this framework, interoperability emerges not merely as a technical challenge but as a methodological condition for building a shared, multilayered, and sustainable knowledge ecosystem.

Linked Data solutions, in particular, represent a promising paradigm for connecting heterogeneous datasets without altering their native structures, fostering the creation of distributed and queryable information architectures over the long term [Guyo et al., 2021]. This approach, oriented toward semantic connection rather than simple format conversion, extends interoperability beyond the limitations of individual software systems, supporting open and collaborative workflows.

In Tirana, this approach lends itself to being tested in heterogeneous urban areas, where different critical issues call for targeted yet coordinated solutions. In the southern quadrant of the city, for example, the Sauk neighborhood, with its linear development along an infrastructural axis, provides an ideal context to explore scenarios

of controlled densification and the creation of new centralities, through the use of GIS models integrated with morphometric and socio-economic data. Further north, the Paskuqan area, near the city's administrative border, raises questions related to informal expansion and lack of services. Here, photogrammetry and geospatial mapping can serve as initial tools to understand ongoing transformations and propose urban integration guidelines, supporting processes of regularization and participatory planning.

More central contexts, on the other hand, pose challenges related to functional pressure on heritage and management of urban flows. The Skanderbeg Square area, significantly transformed in recent years, constitutes a laboratory for testing semantic digital models capable of integrating historical data, current uses, and tourism scenarios. In this case, the adoption of HBIM and 4D models could restore the temporal and symbolic depth of urban space, turning it into an operational tool for dynamic and shared conservation [Münster et al. 2024]. Finally, neighborhoods like Kombinat, a former industrial and residential hub from the socialist era, offer a valuable opportunity to explore the potential of informative modelling of modern heritage. Through digital surveys and integration with historical and perceptual data, it becomes possible to imagine paths of adaptive regeneration, where the site's working-class and architectural memory becomes a driver for new uses and forms of belonging (Figure 3).

Across all these (hypothetical) scenarios, it becomes clear that multilevel knowledge and digital integration can provide tangible support for urban planning, by enabling the connection between infrastructures, memories, morphologies, and design intentions.

### Empirical Outlook – The Kombinat Case

The Kombinat district provides an exemplary context for exploring the operational potential of an integrated digital framework for heritage conservation and urban regeneration.

Located about six kilometres southwest of Tirana's historic core, it occupies a strategic position along the

Rruga e Kavajës corridor, the main axis connecting the capital with the Adriatic port of Durrës. This location gave the area a central industrial and infrastructural role throughout the socialist period, when it hosted the Kombinati i Tekstileve "Stalin", Albania's largest textile complex and a flagship of socialist modernization [Bushati, 2023].

Conceived in the early 1950s as a self-contained workers' city, Kombinat embodied the ideological synthesis of production, residence, and collective life: housing, schools, theatres, and green spaces surrounded the factory core, expressing the ideal of a socially cohesive, gender-progressive, and self-sufficient community.

At the heart of this complex lies Sheshi i Kombinatit, the district's main square and historic civic centre. Originally designed as a representational space surrounded by cultural and administrative buildings, it served as the symbolic and social core of workers' life. Today, although its physical boundaries have been blurred by informal urban growth, the square retains a strong collective memory and notable spatial potential. Its strategic position at the intersection of Rruga e Kavajës and Rruga e Kombinatit could once again act as a catalyst for civic and cultural reactivation, anchoring future regeneration initiatives and re-establishing a public focal point within Tirana's expanding urban system. Today, Kombinat stands as a layered urban palimpsest. The decline of industrial activity after the 1990s and the subsequent informal expansion transformed its socialist spatial order into a fragmented yet dynamic urban fabric [Dino & Griffiths, 2024]. The mix of decaying industrial halls, dense residential patterns, and emerging creative spaces reveals both the district's vulnerability and potential, a territory at the intersection between historical memory and future urban transformation. From a strategic perspective, Kombinat is not a peripheral enclave but a latent node within Tirana's metropolitan structure. Its proximity to the main east-west corridor and the availability of underused industrial land position it as a potential secondary centre capable of rebalancing urban flows currently concentrated around Skanderbeg Square. Reinforcing Kombinat's role as Tirana's western gateway could therefore contribute to a polycentric

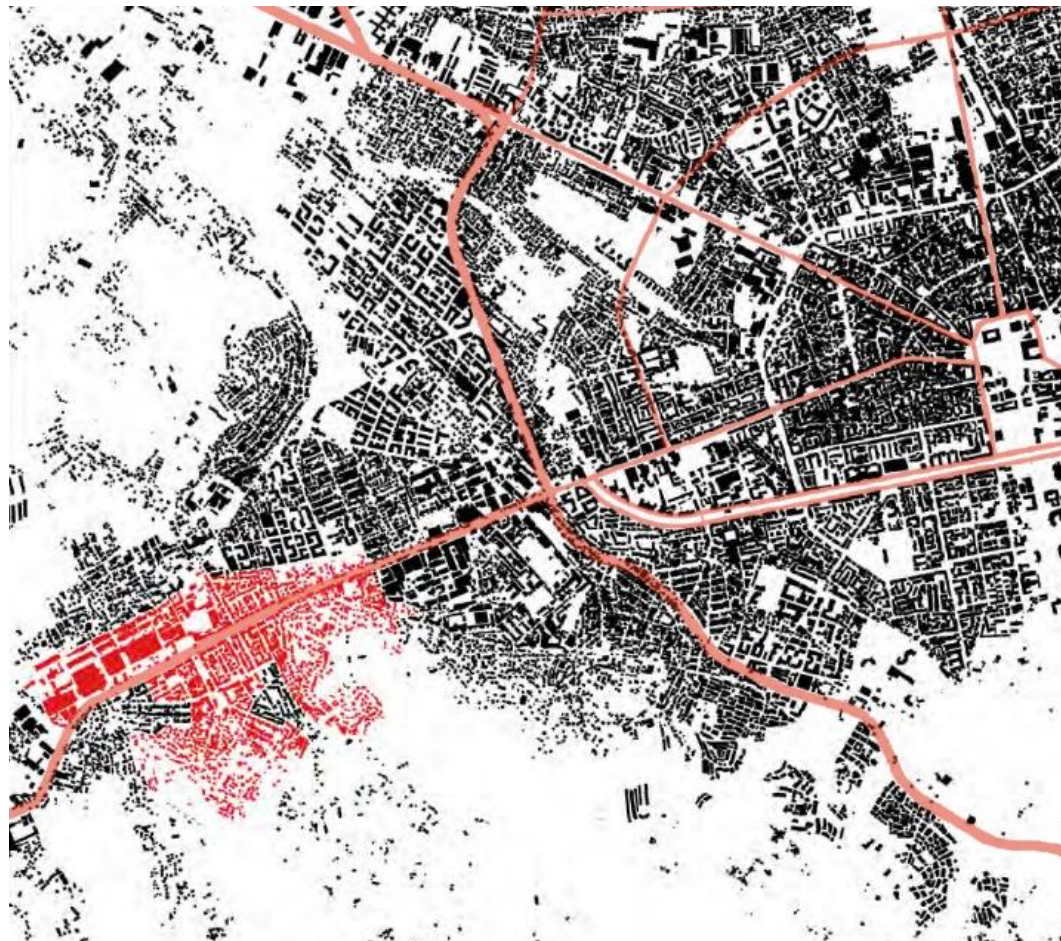


Fig. 4. Kombinat district. On the left a view of the main square of the residential center of "Stalin" Textile Kombinat 1979. Source/ Graphic elaboration by the author.



Fig. 5. A memory of Tirana's Bazaar in a 1940 painting and a photo of today's Pazari i Ri. Source: <https://www.albanianews.al/rubrica/chiche/tirana-bazar>

urban model, consistent with the objectives of the city's green belt and decentralization strategies.

From an operational standpoint, the proposed digital framework for Kombinat could begin with the digital surveying and modelling of a limited number of representative structures, such as the surviving textile halls, the power plant, the main square, and the adjacent residential blocks, using the IFC 4.3 schema (ISO 16739-1:2018). Their integration into a CityGML Level of Detail 2 (LoD2) environment, through open formats such as GeoPackage or OGC Web Feature Services, would allow for the evaluation of data exchange consistency and attribute preservation. Comparable European studies report attribute-retention rates above 90% and geometric accuracy within a few centimetres, providing a realistic benchmark for future applications in Tirana [Cepa et al., 2024; Guyo et al., 2021].

Once established, HBIM-GIS interoperability could support a range of participatory and governance-oriented applications:

- Spatial analysis using GIS-based network models to estimate the accessibility impacts of new public or cultural functions, identifying how improved pedestrian or public transport connectivity could expand the urban catchment area.

- Semantic mapping following the CIDOC Conceptual Reference Model (ISO 21127:2014), linking physical attributes (materials, conservation state, use) with intangible values (historical, symbolic, or social), thus generating a semantic layer for monitoring and prioritizing conservation actions.

- Integration with the European INSPIRE framework, ensuring interoperability with environmental and planning datasets and enhancing transparency in urban decision-making.

- Participatory visualization tools, allowing citizens and stakeholders to explore adaptive-reuse or spatial transformation scenarios directly within the federated digital model.

Ultimately, the Kombinat case demonstrates how the integration of HBIM, GIS, and semantic ontologies can transform industrial heritage into a data-rich laboratory for inclusive and sustainable urban regeneration. The digital framework thus becomes not only a technical infrastructure, but also a cultural and political instrument, one that promotes transparency, co-design, and a renewed connection between citizens and the material and immaterial layers of their urban identity.

## Cultural Heritage as Intangible Infrastructure

In the context of global urbanisation, many cities are undergoing a process of aesthetic and functional homogenization, in which local specificities are progressively erased in favour of globalized models. This phenomenon, often described as generic urbanism, generates increasingly similar urban environments, where space is standardized, materials are replicable, and architectural forms are interchangeable.

As cities become strategic nodes within global flows, they tend to lose connection with their local dimension, developing transnational identities aligned with the logic of competition [Atzori, 2009]. As early as the 1970s, Henri Lefebvre sharply identified this tension between urban expansion and the loss of the city as a social and political space. In *La Révolution Urbaine*, he called for a return to a city capable of producing meaning, a place of collective expression and not merely a technical infrastructure of capital. Where urban space becomes a commodity, reclaiming the symbolic and

historical value of place becomes a political act of resistance.

An example of this is the “Quartiere dell'Arte” (Art District) project in Naples, where urban regeneration was based on the enhancement of cultural and relational assets, combining creativity, memory, and social cohesion. Its value lies not in the scale of the physical intervention, but in its ability to activate networks of meaning and participation through cultural identity [Castronuovo, 2022]. Similarly, in Qatar, the creation of iconic cultural architecture, such as the Museum of Islamic Art and the Qatar National Library, has helped to build a new national identity, giving heritage a central role in the collective narrative [Guerriero, 2024]. Cases such as Naples and Qatar demonstrate that cultural heritage can act as an alternative generative force. From this perspective, urban identity is not an obstacle to modernization, but a living and dynamic resource capable of driving regeneration, innovation, and participation.

In contemporary debate, cultural heritage can no longer be understood as a static object to be protected, but as an active resource capable of shaping urban transformation. This approach moves beyond purely conservationist views, recognising heritage as an infrastructural element, both material and immaterial a network of meanings, memories, and identities that structures collective life and guides the use and form of space [Castronuovo, 2022].

Tirana today finds itself at a crucial stage of urban and identity redefinition. The post-socialist transition has left behind a fragmented urban landscape, where Ottoman architecture, the legacy of socialist modernism, and new interventions often inspired by globalized models coexist. In this context, the enhancement of cultural heritage emerges as a strategic lever to counteract the loss of urban identity and promote sustainable, inclusive, and locally rooted regeneration.

Projects such as the restoration of Tirana Castle, the revitalization of the Pazari i Ri (Figure 5), or the transformation of Skanderbeg Square demonstrate that it is possible to combine innovation and memory, transformation and historical continuity, guiding urban development toward greater cultural and social coherence.

In this perspective, cultural heritage, including architectural elements, building techniques, local narratives, social practices, and symbolic rituals, becomes an active repository of knowledge and culture, capable of fostering belonging and social cohesion [Guerriero, 2024]. Conservation is therefore not an end in itself, but a condition for generating new meanings and uses, valuing historical layering as a resource rather than a constraint.

It is thus necessary to overcome the long-standing dichotomy between conservation and development in urban policy and embrace a model of strategic integration in which the valorization of cultural heritage becomes both driver and guide of urban processes. This implies recognising the centrality of intangible resources, memory, identity, culture, as fundamental components of the urban infrastructure.

Such a vision also calls for a redefinition of the epistemological foundations of planning, including not only technical and metric data, but also the narrative and relational contents that form the soul of places. The city is not only a space to be designed, but a complex cultural environment to be read, interpreted, and consciously transformed.

In this context, tools such as GIS and semantically enriched HBIM take on a strategic role, offering

a design platform capable of restoring depth, memory, and meaning to places. Through these technologies, urban transformation can be guided by knowledge that is richer, layered, and culturally grounded.

## Conclusions

In the face of growing urban, environmental, and social challenges affecting complex cities like Tirana, the development of sustainable transformation strategies cannot take place without a deep understanding of the territory and its multiple layers. In this context, multilevel knowledge, built through the integration of quantitative and qualitative, material and immaterial data, becomes a necessary condition for guiding conscious decisions, ones that hold together memory, design, and innovation.

The adoption of interoperable digital technologies, such as GIS, HBIM, and parametric modelling tools, is not merely a technical evolution, but a cultural shift. These tools make it possible to overcome the fragmentation between forms of knowledge and scales of intervention, promoting systemic and contextual planning that is attentive to local identities and emerging dynamics.

The case studies explored during the IDAUP workshop, although hypothetical in nature, demonstrate the potential of these approaches to read, valorize, and regenerate urban contexts in transition. With its complex layering and unresolved tensions between centre and periphery, Tirana represents fertile ground for experimenting with knowledge-driven methodologies based on collaborative digital models. The city can become not only an object of analysis but also a laboratory of replicable practices, capable of fostering a new phase of urban planning centered on listening to the territory and valuing its plurality. Ultimately, rethinking the city through the lens of integrated and digital knowledge means placing at the centre the places, stories, and relationships that inhabit it, and building design tools that are both analytical and imaginative. Above all, it means recognising that a sustainable urban future is built today, through the capacity to restore meaning and depth to the territories we inhabit. The fate of large cities in the near future cannot, and must not, be that of indistinguishability. On the contrary, the uniqueness of place, made up of memory, culture, language, and landscape, is the true strategic resource for addressing the challenges of globalization. To recognise, enhance, and project urban identity into the future means building a city that is not only functional, but also meaningful, capable of evoking emotion, reconnecting communities, and truly representing its inhabitants.

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