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Innovation, green infrastructures and urban form

Towards regenerative city models

In the contemporary global context—characterized by increasing environmental pressures, demographic asymmetries, and socio-economic fragmentation and structural inequalities—the relationship between urban form, ecosystem services, and territorial innovation acquires unprecedented strategic value. This Special Issue intends to critically explore and foster a new interdisciplinary debate aimed at rethinking the urban project within a framework of regenerative and systemic transformation.

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EDITORIAL PREFACE

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1 Introduction

In the contemporary global context, characterized by increasing environmental pressures, demographic asymmetries, and socio-economic fragmentation and structural inequalities, the relationship between urban form, ecosystem services, and territorial innovation acquires unprecedented strategic value. This Special Issue intends to critically explore and foster a new interdisciplinary debate aimed at rethinking the urban project within a framework of regenerative and systemic transformation.

Historically, cities have developed through a complex co-evolution of built forms and ecological systems. The integration between public spaces, green infrastructures, and urban morphology has not only structured the spatial configurations of the urban fabric but also supported green and blue infrastructures and multiple ecosystem services (Tzoulas et al., 2007; Valente et al., 2020; Salmond, 2016). In fact, the study of the relationship between the natural and artificial components of human settlements and how this relationship can give rise to interesting processes of urban morphogenesis is of relevance today. Yet, in many contexts, such integration has occurred incidentally, without being embedded in organic and strategic planning and design visions. Thus, it should not be forgotten that a part of the international urban planning community began reflecting on this topic many years ago, following research in urban and environmental ecology (Commoner, 1971). The ecosystem approach to the analysis and planning of the modern city finds its roots in the debate that emerged, particularly in Europe, between the late 1980s and early 1990s. The importance of the systemic approach in studying urban phenomena, combined with the intuition of the enormous potential of new technologies in shaping new configurations of human settlement, was explored alongside the growing awareness of the need to shape urban evolution through the development of a green system that is deeply integrated with other urban subsystems. "If optical fibers can make data, information, knowledge, and services travel through space in real time, transforming the movement of goods and people, which has traditionally defined urban areas based on vehicular logic, and if the new model of the wired city enables humans to overcome the constraints of spatial proximity, then the creation of an organic green sub-system within urban centers seems suited to overcoming the limitations of a development model rooted in a profound dichotomy with nature" (Gargiulo & Papa, 2021; Papa et al., 2021). The importance of the natural-green component within cities, which were expanding significantly in their material and spatial dimensions, was acknowledged

and emphasised in many studies and reports, including the well-known Green Paper on the Urban Environment published in July 1990 by the European Commission (1990). There was, without doubt, a growing awareness and a sufficient level of maturity in the belief that urban greenery should not be regarded as a marginal function of the city system, but rather as one of the key dimensions of urban transformation. In fact, the design and development of green space should be far from being a mechanical operation of planting arrangement or the adaptation of predefined schemes to different sites; rather it should follow a precise methodological process leading to a design hypothesis informed by multiple factors of different nature (Trupiano & Fistola, 1989). Today, it is important to revisit and update those reflections, reconsidering their systemic dimension. The eco-environmental component should be recognised as one of the most relevant urban subsystems. As a subsystem of the urban system, it must appropriately interact with the material space of the physical-spatial subsystem. In this sense, within a renewed foundational approach to territorial transformation governance, the urban natural dimension must be appropriately envisioned within a specific process. Three successive stages can be identified in this process:

- The first involves assessing and quantifying the existing green areas within each urban zone and subsequently calculating the amount of CO_2 they capture. As an initial, rapid evaluation of urban livability, this data can be compared with pollution levels in the same area;
- The second stage considers the relationship between ecosystem services and the land uses planned in the urban planning tool, to preliminarily evaluate their compatibility based on the activities to be implemented (Fistola, 2023);
- The third stage requires direct public engagement in evaluating and considering green transformations, envisioning their location and form in the urban context where they will take place. This perceptual prefiguration can be made possible by developing extended reality applications that citizens can install on their smartphones and use to "see" the proposed green spaces.

Although during the history of modern urban planning (Hall, 2014; Lemes De Oliveira, 2020) solutions of integration between urban form and the shape of urban green space (green belts, ecological corridors, green wedges) have often been experimented, the theme of an effective unitary conception of urban space has gradually disappeared from the horizon of urban studies. The design of urban green spaces (and sometimes even extra-urban ones) has become over time an increasingly sectoral topic, treated by specialists. Urban forestry, the design of urban parks, integrated arrangements between buildings and green infrastructure (such as green roofs or urban agriculture) have become topics theoretically treated by specialists and addressed separately from the design of urban space.

In the history of urban planning, however, there are experiments that have optimally combined the two themes of urban form and green space. It is enough to mention the first English and then European experiences of green belts and wedges (it is enough to mention the London plan by Abercrombie or the "five fingers" plan of Copenhagen) and the vast range of American experiences pertaining to the strand of environmental design.

Urban forms and green space are to some extent the positive and negative reading of an urban space that is actually unitary. And the form of the built environment conditions and in turn is conditioned by the form of the green space, external and internal to the city.

Today, the regenerative approach proposes a fundamental redefinition of this relationship. It calls for the embedding of ecological principles in urban planning and design, configuring green infrastructures as multi-scalar systems of ecological and social connectivity. This requires overcoming rigid and sectoral planning tools and adopting the concept of resilience that represents a new vision of sustainability, concerning a new approach based on multifunctionality, adaptation, redundancy, diversity (Ahern, 2011; Sharifi & Yamagata, 2018; Escolà-Gascón et al., 2024).

Concepts such as urban greening, green infrastructure, ecosystem-based adaptation, and more recently, nature-based solutions, are being widely adopted to emphasize the importance of urban ecosystems as

essential infrastructure for the sustainability of cities (Gutierrez-Velez, 2022). Examples such as the Superblocks of Barcelona (Rueda, 2019), or urban-rural sustainability integration (ESPON, 2014) demonstrate how urban morphology and green infrastructure can be strategically integrated to reduce socio-spatial inequalities and generate new forms of sustainability and urban resilience.

According to Rueda (2019), contemporary cities suffer from excessive car usage, which has serious consequences in terms of pollution, noise, insecurity, and unequal access to public spaces. The case of Barcelona's Superblocks is a prime example of contemporary urban regeneration. Starting in 2016, the Catalan city began a profound transformation of its public spaces with the aim of reducing the impact of vehicle traffic, improving air quality, and reclaiming space for people. The principle behind the project is simple yet effective: group nine urban blocks together to form a new unit — the Superblock — where motorised mobility is severely restricted and the space is converted for pedestrian, cycling and community use. This has resulted in streets becoming living spaces, with the introduction of urban greenery, flexible street furniture, vegetable gardens, play areas and places for socialising. This approach has brought significant benefits, including reduced pollution, increased social interaction and physical activity, and a revival of local commerce. However, the real value of Superblocks lies in their ability to transform existing urban areas without the need for demolition or significant investment, thanks to their modular, adaptable and replicable design (tactical urbanism). They are a true urban and territorial innovation tool that combines ecological, social and economic dimensions (Nakajima & Murayama, 2024). They are a concrete example of how cities can regenerate by integrating sustainable mobility, green infrastructure, and civic participation. Superblocks demonstrate how urban spaces can be used in healthier, fairer and more liveable ways, and represent one of the most promising trajectories for future cities. The superblock of Barcelona is also interesting because it intervenes on an urban fabric that had been designed in the modern era and constitutes an example of a very famous and imitated urban grid (at different scales) in many European cities and beyond. It is the demonstration that urban regeneration can start without large infrastructures, working within the scope of local urban design, as also demonstrated by the various experiences of Gehl (2010). The concept of proximity, understood as the effective densification of functions and opportunities in urban contexts, is central to overcoming spatial segregation and promoting social cohesion. Models such as the 15-minute city (Moreno, 2024exemplify urban regeneration approaches that prioritise proximity in planning, encouraging functional diversity, pedestrian accessibility, and soft mobility (Carra et al., 2021). On the other hand, the ET2050 scenario developed by the ESPON programme represents one of the most advanced visions for a sustainable and polycentric future for urban Europe. A central theme of the project is the integration of cities and rural areas, which is understood as overcoming the historical opposition between centre and periphery and urban vs rural. The proposed model aims to strengthen the functional relationships between urban and rural areas by promoting the development of integrated urban-rural regions that can share services, green infrastructure, natural resources, and innovation (Bianconi et al., 2018; Pellecchia et al., 2019). The ET2050 vision is based on the idea of complementarity: cities are no longer viewed as isolated entities, but as nodes in a network of smart, resilient and productive territories. This is accompanied by the concept of 'European eco-regions': territories combining energy autonomy, environmental sustainability and a high quality of life, which enhance local economies, agri-food chains and slow tourism. In this context, rural areas are not marginal domains but central players in the ecological transition process thanks to a planning approach that promotes multi-level governance, efficient land use, accessibility, and territorial equity. Ultimately, ET2050 offers us a model of integrated, polycentric development where innovation and cohesion are key tools for addressing 21(st)-century climate, social and economic challenges.

2. Sustainable innovation as an enabling process

In contemporary debates on urban regeneration, territorial innovation is emerging as a strategic tool for addressing environmental, social, and economic urban challenges in an integrated way. It is not merely a

technological vector, but rather a transformative, systemic process rooted in local knowledge, relational proximity, and institutional embeddedness (Oh et al., 2024). The capacity to respond to current environmental challenges in relation to sustainable innovation is a multidimensional topic of growing interest to many scholars of technical disciplines, urban planning and territorial governance (Alberti, 2018; Boons & McMeekin, 2019).
Although territorial innovation is often associated with technological development, a broader, more systemic interpretation links it to a process that is grounded in local contexts and relational proximity, and that has the capacity to generate shared value (Cooke, 2011).
In this context, scientific research has increasingly addressed desirable innovation, i.e. components focused on sustainability (Barbieri et al., 2020), systemic transitions (Markard et al., 2012; Köhler et al., 2019; Branco et al., 2024), and the sectoralisation of impacts towards innovation aimed mainly at economic growth and territorial competitiveness (Edler & Boon, 2018).
As highlighted by Asheim & Coenen (2005), innovation is not an abstract or transferable input, but a socially and territorially embedded phenomenon, shaped by learning dynamics and the proximity between actors, institutions, and place-based knowledge. In this sense, the urban and regional space is not a passive geographical container, but a relational space in which interactions, shared values, and co-production processes generate new forms of value. More recently, scholars such as La Foresta (2021) have argued that the innovative potential of a territory is primarily determined by its human capital intensity, the presence of knowledge-intensive activities, and the capacity to foster institutional coordination and socio-economic integration. Innovation is therefore the result of a complex interplay between tangible and intangible resources, local capacities, and shared strategic visions. In urban contexts, sustainable innovation emerges from the interconnection of multiple systems: governance, education, culture, mobility, health, energy, and the environment. It implies a capacity for adaptive learning and inclusive transformation, enabling territories to respond dynamically to complex challenges such as climate change, demographic transitions, and economic polarization. Importantly, innovation today is seen as the engine of territorial regeneration, capable of triggering endogenous development and collective well-being. This shift is reflected in contemporary planning models which embrace participatory, place-based, and multilevel approaches. As underlined by De Falco (2017), a key condition for effective territorial innovation lies in the co-construction of meaning and value, involving citizens, institutions, and economic actors in shared visions of sustainable development. This objective can be pursued through technological innovation (including digital innovation) and retro-innovation (Bauman, 2020), following the example of natural co-evolutionary processes (Gould & Vrba, 2008). This involves developing strategies and plans to regenerate urban-rural functions, natural eco-structures and welfare service networks. Innovation is therefore a key factor in the ecological transition and the driving force behind a new territorial development paradigm that is increasingly recognised as critical to territorial competitiveness, social cohesion, and environmental sustainability. Innovation is a method and an objective of regenerative planning, restructuring territorial dynamics to create resilient, inclusive and liveable cities and regions (De Bonis et al., 2014). In this sense, innovation and regeneration are two interdependent dimensions of the same transformative paradigm. Urban regeneration is no longer simply a matter of redevelopment or environmental remediation; it must be based on an integrated, adaptive vision of change capable of articulating the material, social and symbolic dimensions. Urban regeneration centred on sustainable innovation cannot ignore the need for a paradigm shift from sectoral, growth-centred approaches to systemic, place-based, participatory, well-being-oriented strategies. Regenerated cities are not merely 'renewed cities', but places that enable proximity, nature and community to coexist in dynamic balance.

3. Toward new urban models of sustainability

Numerous case studies confirm the effectiveness of territorial innovation as a regenerative strategy that addresses urban challenges in a systemic and place-based manner (Moraci et al., 2024). In urban areas,

innovation is no longer a top-down or sector-specific process, but an integrated, participatory, place-based approach that activates latent territorial capital and promotes new models of sustainable urban development. Notably, the green dimension — understood not only as an environmental element, but also as true biophilic, relational and symbolic infrastructure — is emerging as a key driver in contemporary regeneration processes. The Hafen City project in Hamburg is one of the most emblematic urban regeneration projects in terms of environmental and infrastructural aspects. Here, urban design incorporates open public spaces, linear parks and green solutions along the waterfront to combine sustainability, environmental quality and urban attractiveness. Greenery links architecture and landscape, residential, cultural and productive functions, and contributes to redefining the identity of a strategic part of the post-industrial city (Scaffidi, 2024).

Similarly, Barcelona's new urban plan, with its Superillas Verdes (Green Superblocks) project, proposes radically restructuring the existing urban fabric through widespread pedestrianisation, de-impermeabilisation and the addition of micro-parks, urban gardens and ecological corridors. This approach places greenery at the heart of strategies for public health, climate resilience and social innovation. In Paris, the new metropolitan plan (Métropole du Grand Paris) promotes a systemic vision in which greenery forms a network of connective infrastructure capable of generating ecological continuity between the city centre and the suburbs. Projects such as the Parc des Hauteurs in Bagnolet and the Bois Habité in Montreuil demonstrate how green strategies can stimulate regeneration in vulnerable neighbourhoods by introducing nature-based solutions and urban ecosystem services.

Amsterdam is also notable for integrating greenery into regeneration processes with a particular focus on the multifunctionality of public spaces. The Rainproof plan and new neighbourhoods such as Buiksloterham combine environmental sustainability, water resilience, and architectural innovation. This demonstrates how green and water management can be integrated into urban morphology through circular and adaptive approaches.

Finland is also an interesting case of regenerative urban planning and circular transition. The city of Lahti, located in southern Finland, was awarded the title of European Green Capital in 2021 thanks to an integrated urban and territorial sustainability strategy that combines digitalisation, the circular economy and active citizen participation. Lahti is now an advanced model of urban co-creation, where the interface between city and countryside is interpreted as a dynamic space for environmental and social innovation. The city's strategic plan is based on a number of key transformative levers: (1) Digital tools & smart monitoring: through the use of digital applications such as CitiCAP (citizen's cap and trade platform), citizens monitor their carbon footprint from daily travel and receive incentives for virtuous behaviour. Technology thus becomes a tool for environmental awareness and individual action; (2) Circular economy & zero-waste policies: Lahti actively promotes circular economy models in various sectors, from waste treatment to industrial production. The Kujala Waste Centre ecological district is one of Europe's most advanced hubs for material recovery, recycling and reuse; (3) Citizen participation & urban-rural nexus: local planning is based on co-design practices that actively involve local communities in setting environmental goals and designing shared solutions. In particular, neighbourhood workshops and educational programmes are set up to strengthen the link between green spaces, urban agriculture and sustainable practices. Taken together, these cases demonstrate that localized innovation is not peripheral to mainstream urban agendas, but rather central to the ecological transition (Sgambati, 2022). They highlight how spatial planning, when combined with participatory governance and territorial intelligence, can guide transformative processes that are adaptive, just, and regenerative.

4. City and green spaces: the biophilic perspective

Moving beyond the framework of biophilic design (Beatley, 2016), regenerative urbanism must embrace territorial intelligence, defined as the capacity of a territory to mobilize and integrate resources, networks, and knowledge towards shared goals of sustainability and well-being (De Falco, 2017). Territorial intelligence

fosters the emergence of resilient ecosystems where ecosystem services, social equity and economic innovation converge.

A more radical approach to the relationship between greenery and cities is expressed through the themes of 'nature in the city' and 'the city in the garden'. This movement of thought and set of practices can be defined as 'biophilic cities' (Lefosse et al., 2023). The biophilic approach is essentially philosophical, presupposing respect for all life forms and care for the connections and co-evolutionary relationships between multiple ecosystems. The aim is to move beyond an anthropocentric view of our relationship with nature. Supported by the theory of biophilia (Kellert and Wilson, 1993), biophilic design aims to strengthen the connection between humans and nature to improve human health, well-being, and quality of life. Logically, at the territorial scale, biophilic urban planning proposes the reconciliation of human beings with nature on physical, mental, and social levels (Bathri & Kasliwal, 2019). The biophilic approach to designing built spaces begins at the level of individual buildings and is initially characterised as a specialised branch of architectural design (Zari, 2018). It is accompanied by the biomimetic approach, which involves using technologies inspired by the solutions adopted by plants and animals in nature. This incorporates the natural evolutionary process into the conception of the form and functionality of objects, methods, and tools.

Biophilic design, initially a component of urban design at the neighbourhood or city level (Thomson and Newman, 2021), has recently evolved into a global conception of urban space and the principles that should underpin its development. The biophilic approach revisits the theme of place as a key factor in sustainability, albeit in a different way, even in the absence of explicit configurational or morphological choices regarding settlement forms. This highlights a recurring theme in the rhetoric of the biophilic city and its limitations in our discourse: an initial indifference to urban forms and the belief that widespread biophilic greening initiatives can give every urban space a biophilic character. However, 'biophilic' elements are employed at various geographical scales, including urban parks, green corridors, urban farms and green streets. This forms a set of solutions that reintroduces the relationship between urban morphology and green space.

Biophilic urban planning (Beatley, 2011) is considered an advantageous solution for addressing the challenges of both climate change and economic development. It provides a set of techniques and devices that are useful for tackling specific issues, such as urban heat islands and particulate reduction. Furthermore, it acts as a model for a new, more productive way of designing cities. However, this aspiration can lead to the creation of environments whose construction and management are expensive, which is potentially in conflict with the objective of ensuring access to 'natural' spaces — one of the fundamental principles of this line of research and application. The sophisticated use of green materials in urban construction also risks becoming a form of urban and real estate development that supports eco-gentrification processes.

In his 2016 handbook, Beatley set out the basis for the evolution of Green Urbanism into Biophilic Urbanism, using Singapore as a prime example of the shift from a conventional 'garden or green city' to a biophilic 'city in a garden' (Beatley and Newman, 2013) then made the latest advance in biophilic urban planning by extending it to a bioregional scale to emphasise its contribution to making cities more resilient while improving social and natural capital (Newman et al., 2017).

In terms of urban form, it seems that biophilic urban planning is moving towards polycentric structures rather than reproducing the highly compact settlement models that are typical of eco-cities or certain other New Urbanism experiments. The case of Singapore is illuminating here again: the city's territorial master plan openly and explicitly chooses the polycentric model, integrating various infrastructure levels and basing the urban design's underlying structure on the urban ecological network. This recovers the original ideas of environmental planning to some extent; as mentioned at the beginning of this article, these ideas were based on the concept of a green network of parks as a structuring element of the urban landscape.

This Special Issue invited scholars to investigate this integrated paradigm through diverse disciplinary lenses—urban planning, geography, design, environmental science, and regional studies—exploring how morphological

analysis, green infrastructure planning, and innovation ecosystems can jointly contribute to the transition towards new urban and territorial models.

5. Overview of collected contributions

The contributions presented in this Special Issue reveal an emerging paradigm of human settlement where eco-environmental systems function as integrated protective frameworks for vulnerable urban populations while forming networks that enhance safety and livability through strategic integration with existing urban infrastructures. This collection demonstrates how contemporary urban challenges demand innovative approaches that simultaneously address social equity, environmental resilience, and spatial transformation through the lens of regenerative urbanism.

The assembled papers explore diverse yet interconnected themes that collectively illustrate this paradigm shift. Social inequalities rooted in settlement patterns are examined through the lens of the revitalizing potential of university campuses in European contexts, including Sarzano and Ferrol (Prado-Acebo & Río Vázquez, 2025). The co-design of spatial and social infrastructures emerges as a critical methodology for creating more inclusive urban environments (Contato & Ronsivalle, 2025).

Several contributions focus on regenerative urban models, particularly examining how Positive Energy Districts represent a fundamental paradigm shift in sustainable development (Pidalà, 2025), and how the restoration of Mediterranean urban rivers, exemplified by the Guadalmedina in Malaga, can create vital ecological corridors within dense urban contexts (Mora-Esteban et al., 2025). The research also addresses the unique challenges facing historic urban forms, as demonstrated through studies of ancient cities like Viterbo (Errigo & Iva, 2025), while presenting innovative assessment tools for urban greenery health specifically adapted to Mediterranean climatic conditions (Sanfilippo et al., 2025).

The case studies span diverse geographical and typological contexts: from the adaptive reuse of former military sites in Cagliari (Colavitti et al., 2025) to Seoul's ambitious vision for infrastructural renaturalization (Canessa et al., 2025), from the transformative potential of bicycle infrastructure networks in urban redesign (Centanaro & Sommariva, 2025) to new methodological frameworks for understanding both the intrinsic qualities and network properties of urban green spaces (Cutini & Mara, 2025). Together, these contributions provide a comprehensive foundation for reimagining urban settlements as integrated socio-ecological systems.

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