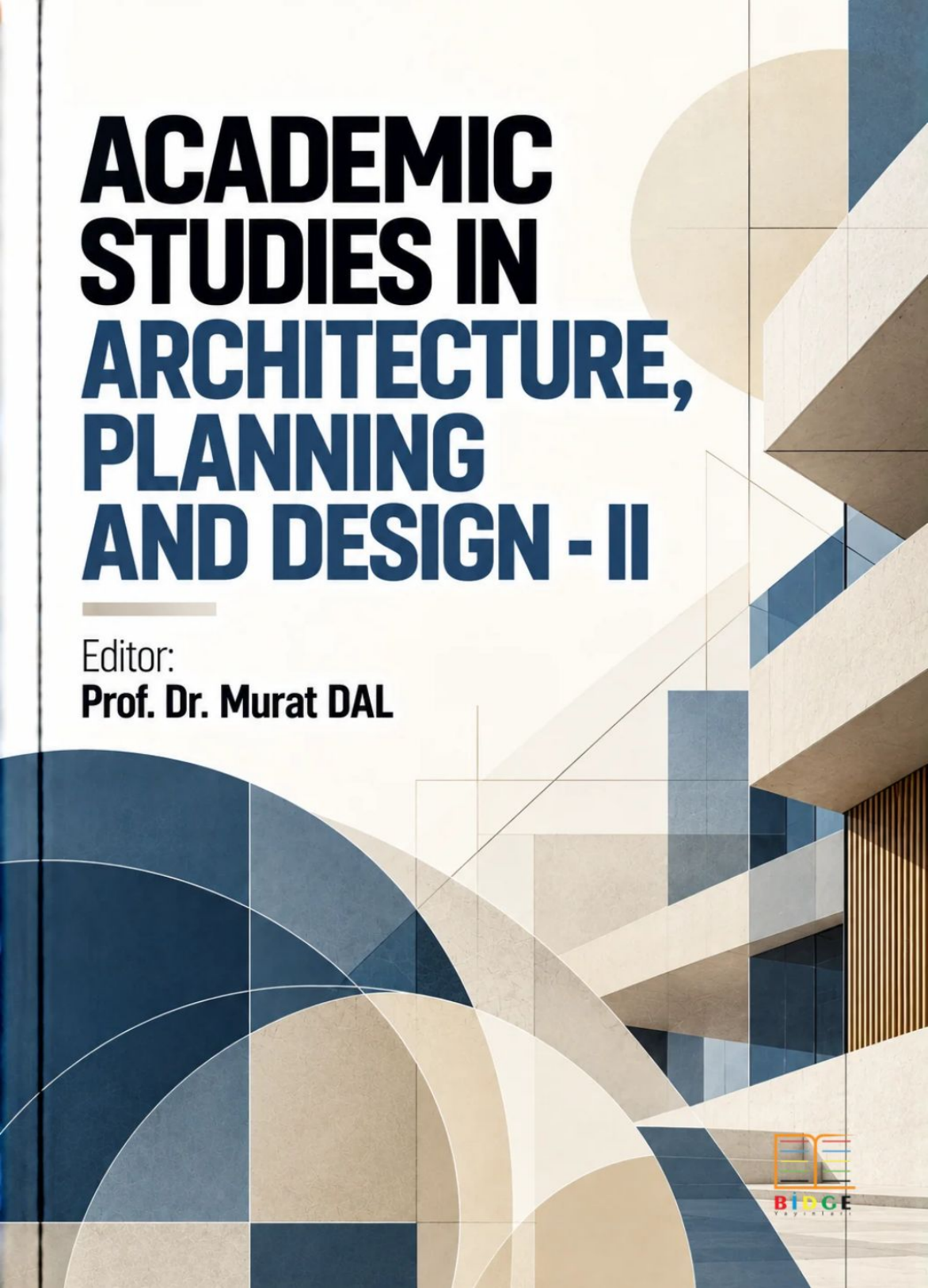
# ACADEMIC STUDIES IN ARCHITECTURE, PLANNING AND DESIGN - II

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**Prof. Dr. Murat DAL**



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# CHAPTER 1

# NATURE FROM DECORATION TO AGENCY: REPOSITIONING LİVİNG NATURE IN ARCHITECTURE

**NUR BEYDA KABAN**[1]

## Introduction

The climate crisis, the decline in biodiversity and environmental transformations occurring on a planetary scale make it imperative to reassess architecture's relationship with nature (Hamilton et al., 2015; Davis & Turpin, 2014). The modern understanding of architecture that developed following the Industrial Revolution treats nature largely as an external element that must be controlled by humans. In this approach, nature has largely been regarded as a landscape element situated around the building, an aesthetic decoration, or an auxiliary component supporting environmental performance (Morton, 2018; Rawes, 2023). Consequently, architectural production has taken shape as a human-centred design practice; natural entities, rather than being components participating in the formation of space, have been

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positioned as elements represented within the boundaries of the design.

However, in recent years, environmental philosophy, post-humanist theories and new materialist approaches have raised new debates regarding the place of nature in architecture by questioning the distinctions between human and non-human beings. For example, Morton's (2010) ecological thought, Haraway's (2016) 'becoming-with' approach, and Latour's (2025) actor-network theory, all argue that environmental formation processes cannot be explained by human agency alone. They contend that organisms, materials, climatic processes, and other non-human components also play an active role in these processes. These approaches propose moving beyond a conception that views nature as a passive object and instead accepting the existence of a relational world shaped by the mutual interactions between human and non-human actors.

This theoretical shift has paved the way for the emergence of new design and production practices aimed at rethinking vitality in architecture. Approaches in which the capacities of living organisms for growth, adaptation and transformation are incorporated into design processes demonstrate that nature can be regarded not merely as a represented element, but as an active component participating in spatial production. Applications in which living organisms participate directly in structural production are among the examples of this transformation. In these applications, the components of nature cease to be a layer added to the structure at a later stage and become a constitutive element influencing the formation and transformation of space.

Despite the growing prevalence of discourses on ecological architecture, many 'green' and 'sustainable' designs still treat nature not as an active component of spatial production, but as a representational layer that creates the impression of environmental sensitivity (Latour, 2025). In green facades, vertical gardens and

similar applications, living organisms are treated as elements whose boundaries are defined and controlled by the design. Consequently, the fundamental problem is that many architectural approaches claiming to be ecologically oriented still treat the components of nature as objects of design and fail to recognise nature as an active participant in spatial production.

This situation highlights the need to reconsider the role of life in architecture. The study focuses on the potential consequences of the phenomenon of life, whereby nature ceases to be merely a design object in architecture and instead becomes a constitutive element of spatial production. This is shaped by the question, 'How does the role of nature's components as actors in spatial production transform architecture's established understanding of design? In this regard, the aim of the research is to discuss the evolving role of nature and its components in various architectural productions, as opposed to their being predominantly treated as represented, controlled and decorative elements in architecture. Within this framework, the forms of agency that natural elements can assume in architectural production, where living organisms participate directly in structural and spatial production processes, such as ‘Living Root Bridges’ and ‘*Baubotanik*’, where living organisms participate directly in structural and spatial production processes, the forms of agency that natural elements can assume in architectural production have been examined. The research's key argument is that these practices take nature out of the realm of architectural production, thus creating the spatial counterpart of the complex network of relationships between human and non-human actors.

The study's theoretical scope is confined to the philosophy of the environment, ecological thought and post-humanist theories that have emerged in the Anthropocene (Morton, 2010; Haraway, 2016; Latour, 2025). Within this scope, the concepts of ‘agency’, ‘non-human actor’, ‘becoming-with’ and ‘natureless ecology’ form the

theoretical foundation of the research. Furthermore, the study is limited to examples of 'Living Architecture' in which living organisms participate directly in structural formation. Thus, the evolving role of life in architecture is assessed through practices in which nature does not merely represent itself but actively participates in spatial production.

The research methodology is based on theoretical analysis and a comparative interpretation of selected architectural examples. Within this framework, the study adopts a critical interpretative approach aimed at understanding how nature moves beyond being merely an element represented in architectural production to become an active agent. In the research, Morton's ecological thought (Morton, 2010), Haraway's 'becoming-with' approach (Haraway, 2016) and Latour's actor-network theory (Latour, 2025) form the key points of reference. This theoretical framework enables the relationships between human and non-human entities to be considered as a non-hierarchical, network-based and process-oriented structure. Thus, in architecture, animacy has been evaluated not as a fixed category of object, but as a constantly evolving set of relationships.

The research involved examining architectural objects to understand how living matter is expressed in architectural production at various scales and levels. In this context, the assessment has included examples such as Living Root Bridges and Baubotanik, which use living material as a constitutive component of the structural system. It has also included a broader spectrum of living matter that interacts with architectural production, such as bio-reactive materials, microbial growth processes, and uncontrollable biological formations. These examples, which differ in scale, technique and context, share a common thread: they treat living material not as a static, completed object within the structure, but as

a system that grows, transforms and is partly unpredictable over time.

In this context, the emergence of life in architectural production has been examined. This has been done not merely as a designed and controlled ecological element. It has also been examined as an actor that transcends the designer's intent. This actor develops spontaneously. In some cases, it even redefines the integrity of the structure. The impact of biological agents on building performance, material lifespan and spatial continuity is made visible. This demonstrates that life is not merely a 'designed' process but also an 'encountered' one (Andino, 2026). In the selection of examples, consideration has been given not only to systems where living organisms are consciously integrated into the structure. Consideration has also been given to biological processes that transcend or conflict with architecture. Thus, living natural elements have been positioned as constitutive and transformative actors in architecture, and the relationship between structure and living organisms has been redefined as a dynamic, multi-layered field of ecological interrelationships rather than a static design problem.

During the analysis process, qualitative content analysis was used in conjunction with the comparative reading method. In this context, each example was evaluated across three key categories: (1) the position and function of living material within the architectural system, (2) the forms of interaction between human and non-human actors, and (3) the structure’s capacity for transformation and adaptation over time. These categories were structured with the aim of making visible the counterparts in architectural practice of the concepts of agency, becoming-with and network-based production relations discussed within the theoretical framework. In this way, the study systematically analysed how living matter operates in architectural production not merely as a representational element, but as a relational and processual actor. However, rather than

providing a technical performance analysis or an engineering-based assessment, the study conducts a conceptual analysis within the context of architectural theory and critical ecology. The findings in this regard aim to establish a theoretical framework for discussing the potential for life to act as an agent in architecture rather than producing generalisable, quantitative results. This approach assesses the position of the phenomenon of life within architectural production through a relational and process-based interpretation, rather than through measurable performance criteria.

**Nature As 'Decor'**

Modern architectural thought and construction practices are largely rooted in an epistemological distinction that separates nature from human culture (Latour, 2025). Architecture is positioned as a controlled practice of producing interior spaces that protects humans from the effects of nature, which are coded as variable, unpredictable and threatening, and which regulates and limits these effects. In this context, nature is not considered an active component in the design of architecture. Instead, it is viewed as an external reality that exists beyond the boundaries of the building and must be controlled. More often, it is seen as a source of aesthetic inspiration. In ecological criticism literature, this situation is explained by the instrumentalization of non-human entities and anthropocentric thinking. In the context of architecture, this has resulted in nature being reduced to a passive backdrop.

This reductionist approach continues to exist, having taken on new forms within contemporary discourses on sustainability and green design. 'Ecology without nature' highlights that the concept of nature as an entity separate from humanity, and as a holistic and idealised entity, recreates and strengthens the human–environment duality (Morton, 2010; 2018). According to this approach, positioning nature as a pure external reality that must be protected

severs the relationships nature establishes with other actors. Consequently, nature is reduced to a representational object abstracted from its relational and process-based structure. This situation indicates that, despite claims of ecological architecture, the human-centred distinction is indirectly reproduced. Thus, plant and biological elements are transformed into objects that are controlled within the boundaries of the architectural composition. Their own dynamics of growth, transformation, and autonomous development are suppressed (Morton, 2018).

When the 'decorification' of nature is assessed within the framework of debates on the new climate regime, it is demonstrated that a multi-actor ecological system is reframed within a human-centred regime of control by architecture. Latour (2025), within this line of debate, criticises modernity's ontological assumption that positions nature as a 'passive backdrop', arguing that the planet must now be understood as a complex of actors that responds to human actions, is reciprocal and unpredictable. This approach highlights the fundamental dualities -nature/culture, human/non-human, subject/object- on which modern architecture is based. These dualities conceal the constitutive role of non-human actors in spatial production processes and reduce them to either 'affected' or 'controlled' variables. However, climatic events, material behaviours and biological processes are active agents that guide design processes and often transcend human intervention.

In contrast, in architectural practice, factors such as climatic variability, material performance or biological interactions are mostly treated as external parameters that need to be controlled. This situation creates a blindness that delays the 'Facing Gaia', in the sense indicated by Latour (2025). Consequently, the use of nature as a decorative element signals not merely the production of an aesthetic surface, but also a theoretical tension indicating that

architecture has failed to sufficiently internalise the multi-actor and reciprocal world model represented by Gaia.

When considered alongside Haraway's (2016) 'becoming-with' approach, this theoretical framework renders the epistemological boundaries of architecture more visible. Haraway (2016) defines life not through singular subjectivities, but through interspecies relational networks and processes of mutual becoming. This approach emphasises that existence is constituted through relationships rather than fixed identities. In contrast, architecture largely conceives of design as a subject-centred process and treats the building as a finished, static product. Therefore, it is essential to reassess architecture's relationship with nature. Positioning living organisms on architectural surfaces as decorative elements or tools fails to bring about ecological transformation. This approach indirectly perpetuates the anthropocentric paradigm of modern thought.

Consequently, this decorative position of nature and its components within architectural production persist as a zone of tension in contemporary ecological practices. Within this framework, the forms of agency that natural elements can assume are illustrated by construction practices in which living organisms directly participate in structural and spatial production processes. These practices remove nature from its status as an object in architectural production. They represent the spatial equivalent of the multi-layered network of relationships formed between human and non-human agents.

## Living Components in Architectural Practice

As discussed within the theoretical framework, nature's role in architecture is too significant to be considered merely as a decorative element or representation. In recent years, approaches such as bio-design, living architecture and ecological production

have made it possible for living organisms to participate in spatial production processes at different scales and levels. This necessitates redefining the role of living organisms within architectural systems. In some cases, living organisms form the load-bearing structure, while in others, they are part of the building envelope, the material, or the systems that regulate the structure's environmental functioning. Therefore, when it comes to architectural production, life should not be viewed as a single, uniform category. Instead, it should be considered through various forms of agency and at different levels of relationality. In this regard, the roles of living systems in architectural production have been categorised into four fundamental groups based on their position within the architectural system: structure, covering, material and system (Table 1).

*Table 1. Forms of Positioning Living Natural Elements in Architecture*

| Category | Role of Living Matter in the Architectural System | Primary Function | Examples |
|---|---|---|---|
| **Nature as Structure** | The living organism is part of the load-bearing system. | Supporting structural loads and establishing spatial integrity | Living Root Bridges, Baubotanik |
| **Nature as Covering** | The living organism is integrated into the building skin or spatial boundaries. | Shading, microclimate regulation, and environmental performance | Green facades, living pavilions, vegetative shell systems |
| **Nature as Material** | Living matter participates in the production process of the building material. | Biological production, material transformation, and low-energy manufacturing | Mycelium composites, bio-composite structural elements |
| **Nature as System** | Living organisms participate in the | Energy generation, waste conversion, water | Algae bioreactor facades, Living Architecture |

| | | | |
|---|---|---|---|
| | building's operation and metabolic cycles. | treatment, and environmental regulation | projects, biological treatment systems |

*Source: Created by the author*

This classification has been developed to define the different roles that living matter assumes in architectural production. However, the categories in question are not clearly defined. In applications where living organisms contribute directly to spatial production through growth, adaptation and transformation processes, life can function as a structure, a material and a system simultaneously. For this reason, classification is treated as an analytical framework that aims to explain the different forms of life in architectural production.

1. Nature as A Structure

This approach refers to applications in which living organisms' function not merely as a supporting or decorative element in architectural production, but as a direct part of the structure's load-bearing system. In this approach, living matter ceases to be a layer added to the structure at a later stage and becomes a constitutive component of the structural formation. The form and load-bearing capacity of the structure are shaped by the growth, fusion, adaptation and response to environmental conditions exhibited by living organisms (Figure 1). This means that the structure is not seen as a finished and unchanging object, but as the result of a joint biological and technical process that changes over time (Ludwig et al., 2016).

*Figure 1. Living root bridge*



*Source: URL 1*

The applications in this category feature living organisms that directly bear structural loads. The fundamental operating principle of the structural system is based on the guidance of tree roots and trunks, their joining via grafting (anastomosis), and their gradual thickening over time to acquire load-bearing capacity (Figure 2). This transforms load bearing from a static property into a process that evolves over time in accordance with the growth of the living organism. Living bridges and Baubotanik applications are prominent examples of this, where life functions as a constitutive component of the load-bearing system (Ludwig, 2012; 2016).

*Figure 2. Baubotanik tower*



*Source: URL 2*

In the ‘nature as a structure’ approach, the final form of the structure is not fully determined at the outset of the design process. In contrast, architectural form emerges from long-term interactions between human intervention, biological growth processes, and environmental conditions. Living organisms' ability to strengthen and regenerate over time, and to contribute to structural integrity, demonstrates that nature can be regarded as an active component in architectural production, rather than a passive object. In this respect, this approach presents an alternative understanding of architecture that views it not as the production of a finished object, but as a process of formation that develops and transforms over time (Ludwig et al., 2016; Shu et. al., 2021; Middleton et al., 2022).

2. Nature as A Covering

The ‘nature as a covering’ approach encompasses applications in which living organisms are used as an active component of the building envelope and spatial boundaries, without forming part of the structural system in architectural production. In this approach, living matter is not an element that establishes the structural integrity of the building. Living material is positioned as an interface that regulates the spatial atmosphere, environmental performance and the user–environment relationship. Plant life is not just a decorative addition to the building; it is a living organism that contributes to the environment. Instead, it produces a dynamic shell system that grows over time, varies in density, and responds to environmental conditions. For this reason, the architectural envelope should not be viewed as a static, finished surface (Figure 3). The envelope is regarded as a constantly evolving interface through seasonal cycles and biological processes (Well & Ludwig, 2020).

*Figure 3. Musée du Quai Branly*




*Source: URL 3*

Within this category, living organisms make a direct contribution to environmental performance processes, particularly microclimate regulation, shading, wind control and cooling through evaporation. Advanced green facade systems, vertical gardens and vegetated shading structures are among the common examples of this approach. In these systems, the vegetative mass benefits from the synergistic effect of water and plant elements (Well & Ludwig, 2020). Plants produce different permeability values during the summer and winter periods. This directly affects the building's energy performance and the urban microclimate. Thus, the architectural envelope does not merely form a physical boundary; it also functions as a climatic regulator (Perini et al., 2011; Rajak et al., 2022).

When considered alongside Haraway's (2016) understanding of relational ecology, the 'nature as a covering' approach is seen as a continuous process of co-becoming. However, current practices often control this relational structure through design. Systems are reduced to structures with pre-defined boundaries. This situation increases the participation of living organisms in spatial production. At the same time, it creates a binary structure that restricts them to specific performance criteria. In this context, nature can be regarded

as an intermediate zone in architecture where living organisms are both activated and kept under control.

3. Nature as A Material

This approach encompasses applications in which living organisms are directly involved in the formation of materials within the architectural production process. In this approach, life is treated as an active component that influences the production, growth and transformation processes of the material. Unlike industrial production, the material is shaped through biological processes. Consequently, architectural production is shifting from controlled factory processes to a network in which living systems self-organise (Vallas & Courard, 2017).

In these systems, living organisms directly determine the chemical and physical properties of the material (Carrete et al., 2023). Particularly in mycelium-based materials (Figure 4), fungal networks bind organic waste. This process results in the production of lightweight, low-energy and biologically degradable structural elements (Vallas & Courard, 2017). The growth dynamics of plant roots can also be guided in a similar manner through engineering processes. The integration of the natural fibre structure with biopolymer matrices homogenises the load distribution and increases the material's tensile strength (Carrete et al., 2023). All these processes demonstrate that the material is not merely a designed, static object. The material exhibits the characteristics of a system that grows over time and is self-organising.

*Figure 4. Bricks produced using mycelium*




*Source: URL 4,5*

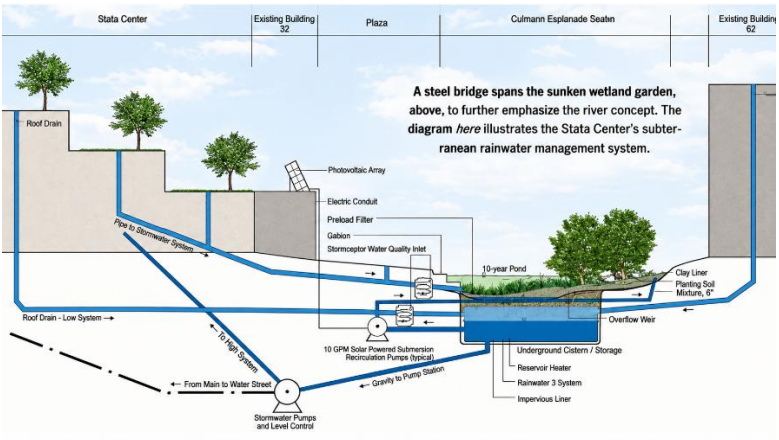
When the ‘nature as a material’ approach is considered alongside Haraway’s (2016) conceptualisation of ‘becoming-with’, it reveals that production relations take place on a non-hierarchical plane. Human and non-human actors play a shared role in this process. However, this form of production is often reduced to controlled biological processes within the boundaries defined by design. While this increases the participation of living matter in the production process, it simultaneously creates a binary structure that confines it to specific performance and form criteria. This tension also points to a liminal space (Latour, 2025). Although microorganisms are recognised as agents in material production, the boundaries of this agency are sharply defined by design decisions. Consequently, architecture transforms the dynamics of non-human actors into hybrid objects that can be controlled.

4. Nature as A System

The ‘nature as a system’ approach involves viewing living organisms not as individual objects, surfaces or materials in architectural production, but as holistic system components that influence a building's environmental and operational performance. In this approach, living organisms are directly integrated into the metabolic processes of the architectural system, such as energy production, the water cycle, waste conversion and air quality. Consequently, architectural production is not considered merely as spatial organisation. The building is regarded as a metabolic system

intertwined with ecological and biological processes (Well & Ludwig, 2020).

*Figure 5. The role of natural components as actors within a system*



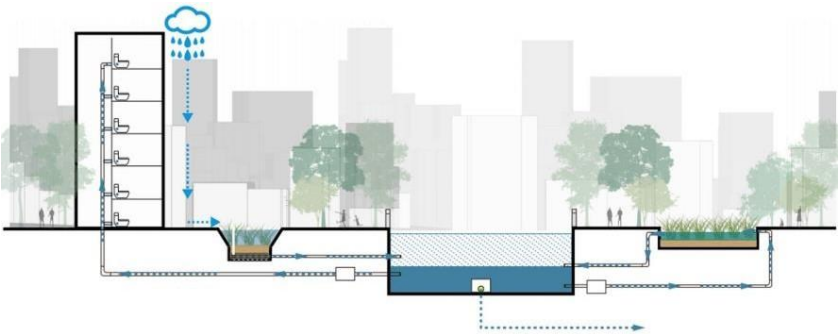

*Source: URL 6*

This category includes algae-based facade systems, bioreactors and algae walls, as well as plant-based treatment systems integrated into blue-green infrastructure. Algae bioreactor facades convert sunlight into biomass through photosynthesis. This mechanism generates energy and reduces carbon emissions. In such systems, the structure ceases to be a static shell and transforms into an entity engaged in continuous energy exchange. Similarly, plant-based and hydraulic systems integrated into greywater treatment in buildings mimic the natural water cycle (Figure 5). This integration turns architecture into an ecological filtration mechanism, utilising the combined effects of the plant and water components (Well & Ludwig, 2020).

When the ‘nature as a system’ approach is considered alongside discussions of the new climate regime, it reveals that architecture is not a closed, human-centred sphere of object production. The building becomes part of a multi-actor, open-ended ecological network. From this perspective, non-human actors

(micro-organisms, climatic processes, water and energy flows) are not merely regarded as environmental inputs. These components play a role as constitutive partners of the system (Latour, 2025).

*Figure 6. The role of natural components as actors within a system*



*Source: URL 7*

This comprehensive system framework (Figure 6) redefines the boundaries of the architectural object in the context of Morton's (2010) object-oriented ecology. The absolute distinction between structure and environment is dissolving. The architectural system, breaking free from the control of a singular human will, opens up to the unpredictable interrelationships of non-human entities. This process creates a broad spatial reflection of Haraway's (2016) concept of 'becoming-with'. The system integrates the metabolic activities of biological organisms with the building's operational cycles on a non-hierarchical plane. However, even at this scale, technical control is exercised through engineering parameters. While this makes the systemic role of living organisms visible, it also incorporates biological cycles into specific performance criteria. Consequently, the design process is situated between the autonomy of the system and the limits of technical control.

## Conclusion

This study has discussed how the relationship between architecture and nature has been shaped by an anthropocentric epistemological framework, and how this relationship should be reconsidered in light of contemporary ecological theories. In modern architectural practice, nature has long been considered an external element that must be controlled or represented as an aesthetic surface. This approach has reduced nature to a supporting element of design, rather than an integral part of spatial production. Even contemporary discourses on sustainability often perpetuate this anthropocentric regime of separation, treating nature as a passive object.

In contrast, this study has treated nature as a network of relational and process-based actors, rather than a passive backdrop, drawing on the theoretical approaches of Morton, Haraway and Latour. Within this framework, living matter is not assessed as a fixed category of object in architectural production, but as a relational field of existence that transforms, interacts and participates in production processes over time.

The classification developed in the analytical section has revealed the various ways in which life is incorporated into architectural design. The categories of nature -structure, covering, material and system- have revealed that the roles of living organisms within the architectural system are not singular but rather exhibit a multi-layered and transitional structure. This demonstrates that architecture is not a closed field of production defined solely by human design. It also shows that non-human factors play a fundamental role in the production process.

Examined samples demonstrate that applications such as living bridges and Baubotanik treat vitality as a load-bearing and constitutive component of the structure. In this regard, the study does

not view the quantitative limitations of Baubotanik approaches or their slowness at an industrial scale as a weakness. On the contrary, these practices should be interpreted as epistemological prototypes and points of resistance that stand in opposition to contemporary industrial architectural paradigms. Such micro-practices, developed through parks, public spaces or lightweight structures, offer alternatives to control-oriented design habits. Similarly, biomaterials and system-based applications demonstrate that architectural production can be understood not as the creation of a static form, but rather as an ecological process that evolves over time. Nature and its components are not merely a 'green layer' added to the architectural object from the outside; they are an active participant in the processes of technical performance, temporality and structural integrity.

However, the theoretical and practical approaches discussed in the study also have limitations and barriers to implementation in architecture. The fact that such approaches, which incorporate living organisms into the production process, are not widespread in contemporary architectural practice and are represented by a limited number of global examples imposes an empirical limitation on the study's analytical framework. This limitation stems from the fact that, unlike industrial construction processes, biological systems require time to develop, meaning their production processes are very long term. The use of living organisms as structural actors necessitates a multidisciplinary, precise and dynamic planning process that goes beyond conventional design practices. These design and implementation processes, which require a body of technical, normative and ecological knowledge, are creating a new field of expertise.

Consequently, this research proposes that the increasing prominence of life in the field of architecture should be interpreted not merely as a technical advancement or an alternative material, but

as a transformative epistemological shift. This approach opens up a discussion about rethinking architectural production and moving away from a one-sided mechanism of control. It presents a vision of production within a dynamic, open-ended, relational framework, where human and non-human actors interact. It can therefore be anticipated that future architectural production will focus on establishing an integrated spatial organisation through systemic agency rather than the control of nature.

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# CHAPTER 2

# THE GREEN HERITAGE OF THE REPUBLIC: HISTORICAL URBAN PARKS, PUBLIC LIFE, AND URBAN MEMORY IN ANKARA

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## Introduction

Cities are not merely settlements composed of physical structures; they are complex living spaces that are constantly being reproduced through the interaction of economic, social, cultural, and political processes. Within this dynamic structure, public open spaces serve as fundamental venues where individuals carry out their daily life practices, develop social relationships, and forge connections with the city (Jacobs, 1961; Carr et al., 1992; Gehl, 2011). In particular, urban parks are regarded not merely as green spaces that meet recreational needs but as landscape elements that bridge the natural environment and urban life; they are also considered important cultural landscape elements that strengthen social interaction, support urban identity, contribute to the formation

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of collective memory, and reflect the historical development of cities (Chiesura, 2004; Cranz & Boland, 2004; Thompson, 2002).

The relationship between the historical continuity of public spaces and social memory has become more apparent, particularly within the framework of Lefebvre's (1991) theory of "*The Production of Space*", Halbwachs's (1992) approach to collective memory, and Nora's (1989) concept of "places of memory." While Lefebvre (1991) emphasizes that space is not merely a physical reality but is constantly reproduced through social relations, Halbwachs (1992) argues that collective memory is transmitted from generation to generation through specific spaces. Similarly, Nora (1989) states that physical environments such as urban parks, squares, and public open spaces are concrete representations of social memory. Lynch's (1960) urban image approach and Relph's (1976) place identity theory also highlight the decisive role of public open spaces in the sense of belonging that individuals establish with the city. When these theoretical approaches are evaluated together, it becomes clear that historic urban parks are not merely landscape arrangements belonging to the past; they are important carriers of urban identity, daily life, and social memory.

An examination of the historical development of urban parks reveals that these spaces have served varying social and political purposes across different periods. Created in the nineteenth century to mitigate the negative effects of industrialization, urban parks have, over time, been associated not only with functions such as aesthetics, hygiene, recreation, and public health, but also with goals such as national identity, modernization, and the reorganization of public life (Cranz, 1982; Taylor, 1995). Particularly in newly established capitals, parks were regarded as public showcases that made the state's ideals of modernization visible; they played a significant role in conveying a contemporary way of life to society through the urban landscape (Mumford, 1961; Hall, 2002).

In Turkey, the replanning of Ankara as the capital following the proclamation of the Republic stands as one of the most striking examples of this transformation. The Republican administration conceived Ankara not only as the administrative center of the new state but also as a spatial representation of the ideology of modernization (Tekeli, 1998; Cengizkan, 2004; Batuman, 2013). In this context, the city was designed as a model capital where the culture of contemporary life, a new understanding of public life, and a modern civic identity would be cultivated. The Jansen Plan, prepared in line with this vision, addressed residential areas, public buildings, the transportation system, and green spaces within a holistic planning framework; parks, in particular, were planned as fundamental public spaces that would shape the social life of the new capital. For this reason, Ankara's historic urban parks are regarded not merely as recreational areas, but as one of the most important components of the Republic's modernization project as reflected in the public sphere.

The public open spaces created during the early Republican era were not merely examples of landscape design; they also served as spatial representations of a new understanding of public life. The concerts, open-air movie theaters, children's playgrounds, sporting events, national holiday celebrations, and everyday recreational activities held in these parks contributed to the development of public practices that supported modern urban life. Consequently, these parks are regarded not merely as green spaces but as public spaces that support a modern understanding of citizenship, contribute to the development of public life, and play a significant role in the formation of collective memory. However, over the course of nearly a century, Ankara's rapid population growth, transportation-focused planning decisions, intense pressure for development, and shifting urban development policies have transformed a significant portion of the city's historic parks both

physically and functionally. Some parks have disappeared entirely, while others have lost their original design character due to a reduction in their area. Nevertheless, these spaces continue to live on in Ankara's collective memory; they remain important elements of the cultural landscape that represent the social life and urban culture of the Republican era. This situation necessitates that historic urban parks be evaluated not only based on their physical characteristics but also through the historical and social meanings they embody.

Studies on Ankara provide important insights into the approach to urban planning during the Republican era, the Hermann Jansen Plan, the historical development of specific parks, and green space policies (Tekeli, 1998; Cengizkan, 2004; Batuman, 2013). However, it is evident that the existing literature largely focuses on the history of planning, the history of architecture, or individual park examples. In contrast, studies that holistically examine historic urban parks within the context of the Republic's modernization policies, the reorganization of public life, everyday life practices, collective memory, and cultural landscape heritage are quite limited.

The primary objective of this study is to examine Ankara's historic urban parks—established during the Early Republican period—in the context of modernization, public life, and urban memory, thereby revealing the parks' founding purposes, social functions, the transformations they have undergone, and their place within the city's contemporary identity. To this end, the examples of Millet Garden, Gençlik Park, Güvenpark, Kızılay Park, Zafer Square, Kurtuluş Park, and Hacettepe Park have been evaluated in light of historical documents, plans, archival photographs, newspaper articles from the period, and relevant literature. Analyses of spatial changes over time were conducted for Gençlik Park, Güvenpark, Hacettepe Park, and Kurtuluş Park, for which historical plans, aerial photographs, and satellite imagery were available with sufficient continuity. Millet Garden, on the other hand, was

evaluated based on plans from the early Republican era, historical maps, and current condition data; however, due to the limited availability of aerial photographs from that period, it could not be analyzed within the same time series as the other parks. Furthermore, the study aims to make a unique contribution to the literature by treating these parks not merely as elements of the Republic era's planning or landscape history, but as cultural landscapes where modern public life is produced, daily life practices are shaped, and collective memory is constructed. In this context, the study examines the planning and social objectives behind the creation of Ankara's historic urban parks during the Early Republican period, how they contributed to the development of public life, the physical and functional transformations they underwent over time, and how they can be assessed today in terms of Ankara's cultural landscape heritage and urban memory.

## Historic Urban Parks: Modernization, Public Life, and Urban Memory

### Public Spaces and Urban Parks

Public spaces are fundamental physical environments that are open to all segments of society, where social interaction takes place and urban life is shaped. Urban parks, located within public open spaces, are not merely green areas used for recreational purposes; they are regarded as multifunctional landscape components that support social integration, provide ecological services, and contribute to the formation of urban identity (Carr et al., 1992; Gehl, 2011; Chiesura, 2004).

The concept of public space has gained a new dimension through Lefebvre's (1991) "*Production of Space*" approach. According to Lefebvre, space is not merely a physical environment; it is a dynamic process in which social relations are produced, reinterpreted, and constantly transformed. In line with this approach,

urban parks are not merely planned green spaces but are spaces of social production that gain meaning through individuals' everyday practices. Similarly, Jacobs (1961) notes that one of the fundamental conditions for a vibrant and safe urban life is people's active use of public spaces. Gehl (2011), on the other hand, links the success of public open spaces not so much to their physical size as to the daily activities people carry out in these spaces and the level of social interaction that takes place there. For this reason, urban parks are viewed as public platforms where social life takes place, beyond their functions as places for walking, resting, and recreation.

Studies conducted in recent years have also demonstrated the positive effects of urban parks on physical health, mental health, social cohesion, and quality of life. In particular, the World Health Organization (2016) emphasizes that accessible and high-quality green spaces in cities are of critical importance not only for adaptation to climate change but also for public health. Similarly, UN-Habitat (2022) notes that public open spaces are one of the fundamental spatial components that enhance social inclusion in the creation of sustainable cities. In this context, urban parks have evolved into strategic public spaces that are no longer viewed merely as an element of landscape design but are addressed in line with multidimensional goals such as social sustainability, ecological resilience, the preservation of cultural heritage, and the improvement of quality of life (Ahern, 2013; European Environment Agency, 2022).

**Urban Parks, Collective Memory, and Urban Identity**

Urban parks are not merely part of the natural and physical environment; they are important public spaces that reflect the historical development, social memory, and cultural identity of cities. Historic urban parks, in particular, are regarded as cultural landscape areas that contribute to the formation of collective memory by bringing together the shared experiences of different

generations (Halbwachs, 1992; Nora, 1989). According to Halbwachs (1992), individual memory is not independent of the social environment and maintains its vitality through specific spatial references. For this reason, parks, squares, and other public open spaces are not merely physical spaces; they are social environments where past experiences are recalled and a shared identity is produced. Nora (1989), meanwhile, notes that in modern societies, social memory is increasingly concentrated in specific places and defines these areas as "places of memory" (lieux de mémoire). Historic urban parks also feature among these "places of memory" as spatial representations of past events, celebrations, and experiences of daily life. Lynch's (1960) theory of the urban image and Relph's (1976) approach to place identity also highlight the importance of public open spaces in the sense of belonging that individuals develop toward the city. According to Lynch, people's mental image of the city is shaped through specific focal points and public spaces; Relph, on the other hand, notes that place identity is formed through the emotional bonds people develop with specific places.

Recent studies also show that historic urban parks are not merely physical entities to be preserved, but also bearers of intangible cultural heritage. ICOMOS (2025) emphasize that, in the preservation of cultural landscapes, social memory, place identity, and historical continuity must be taken into account alongside physical integrity. For this reason, in the evaluation of historic urban parks, not only their design features but also the social and cultural relationships they establish with city residents are accepted as important criteria. In line with this approach, Ankara's historic urban parks, established during the Early Republican era, are evaluated not merely as planned green spaces but as cultural landscape areas that carry the Republic's ideals of modernization, its understanding of public life, and its social transformation into the present day. In this

regard, these parks serve as important public open spaces that ensure the continuity of urban memory and reflect the spatial heritage of the Republican era.

## Modernization and Public Open Space Policies During the Republican Era

With the proclamation of the Republic, not only did Turkey's political system undergo a fundamental transformation, but so did the approach to urban planning. The new Republic did not view modernization as limited solely to institutional and legal reforms; it also regarded the urban space as one of the fundamental tools for shaping a new way of life and a contemporary understanding of society (Tekeli, 1998; Cengizkan, 2004; Batuman, 2013). During this process, planning activities were approached in conjunction with the goals of constructing national identity, disseminating a contemporary lifestyle, and reorganizing public life.

In the modern urban planning paradigm, public open spaces and urban parks were not viewed merely as recreational areas; they were designed as public spaces that promote public health, support social interaction, and make the culture of modern life visible. This approach is closely related to the Garden City movement, modernist planning principles, and the functional city model, all of which have influenced European urban planning (Howard, 1902; Mumford, 1961; Hall, 2002). Green space systems have been recognized as one of the key components not only for enhancing the aesthetic quality of cities but also for creating healthy living conditions and supporting social integration. In this context, the re-planning of Ankara as the capital became one of the most significant spatial implementations of the Republic's modernization policies. The plan, prepared by Hermann Jansen, addressed residential areas, the transportation system, public buildings, and green spaces within a holistic planning framework; urban parks, meanwhile, were conceived as key focal points shaping public life in the new capital

(Tankut, 1993; Tekeli, 1998; Cengizkan, 2004). In particular, the parks were planned as shared spaces where different social groups could come together, modern lifestyles could be experienced, and a new public culture could develop. Public open spaces such as Millet Garden, Gençlik Park, Güvenpark, Kızılay Park, Zafer Square, Kurtuluş Park, and Hacettepe Park—established during the early Republican era—were designed not merely as landscape interventions to organize the physical environment, but as public spaces that supported the Republic's concept of modern citizenship and contemporary urban life. Cultural events, national holiday celebrations, concerts, open-air cinemas, and recreational activities held in these spaces contributed to the public's adoption of a new lifestyle (Batuman, 2013; Cengizkan, 2004).

Today, urban parks hold strategic importance not only as green spaces with historical value but also in terms of preserving cultural landscape heritage, adapting to climate change, promoting social inclusion, and achieving sustainable urbanization. UN-Habitat (2022) emphasizes that the preservation of historic public open spaces is one of the fundamental policies in the creation of sustainable cities. For this reason, the assessment of Ankara's historic urban parks, established during the Early Republican era, is significant not only for examining the spatial heritage of the past but also for identifying cultural landscape values that will contribute to future sustainable urban policies.

## The Development of Urban Parks in Ankara During the Early Republican Era

### The Planning of Ankara as the Capital and Green Space Policy

With the proclamation of the Republic and the selection of Ankara as the capital, a comprehensive urbanization process was initiated that aimed not only to establish a new administrative center in Turkey but also to reflect the ideals of modernization in the built

environment. Ankara, which during the Ottoman period was a medium-sized Anatolian city with a population of approximately 30,000–40,000, was redesigned by the Republican administration as a contemporary, healthy, and planned capital (Tekeli, 1998; Tankut, 1993). In this process, the city was conceived not only as an administrative center representing the political identity of the new state but also as a model capital where the culture of modern life would be cultivated.

The planning efforts carried out during the early years of the Republic focused not only on the construction of public buildings but also on the organization of residential areas, transportation systems, public squares, and green spaces within a holistic planning framework. This approach drew inspiration from the European urban planning principles of the time and, in particular, from the Garden City movement (Howard, 1902; Hall, 2002). The creation of healthy living environments, the limitation of dense development, and the development of green space systems were among the fundamental principles of the early Republican planning philosophy. In line with this, the Ankara Master Plan, prepared by German urban planner Hermann Jansen—who won the international planning competition held in 1928—became one of the most important planning documents of the Republican era (Cengizkan, 2004). The Jansen Plan introduced a modern planning approach that took the city's natural topography into account and integrated green spaces with the transportation system and residential areas. Parks, boulevards, recreational areas, and green corridors were planned as integral parts of the city's physical development; the aim was to create a continuous system of open and green spaces in Ankara. In Jansen's planning approach, green spaces were not viewed merely as aesthetic elements; they were regarded as strategic components for improving the urban climate, promoting public health, developing recreational opportunities, and creating public spaces where diverse social

groups could come together (Tankut, 1993; Tekeli, 1998). In this regard, parks have been among the fundamental public spaces that brought the Republic's modern urban vision into everyday life. The green space system established during Ankara's planning process did not merely aim to organize the physical environment; it also functioned as a spatial tool supporting the new Republic's policies of social transformation. Parks and squares were designed as spaces where modern lifestyle was experienced, social interaction was strengthened, and public life became visible. For this reason, Ankara's urban parks from the early Republican era are regarded not only as products of landscape design but also as spatial reflections of the ideology of modernization (Batuman, 2013).

## The Development of Ankara's Historic Urban Parks During the Early Republican Period

The urban parks created during the process of Ankara's redevelopment in the Early Republican period were designed not merely as landscape arrangements intended to meet the city's need for green spaces, but as significant components of the modernization process reflected in the public sphere. The Republican administration viewed the public open spaces to be created in the new capital as places where a contemporary culture of living would flourish, social interaction would be strengthened, and a modern understanding of citizenship would be experienced in everyday life (Tekeli, 1998; Cengizkan, 2004; Batuman, 2013). In this vein, the park system established in Ankara was influenced by the networks of green spaces and recreational systems widely adopted in European urban planning. In the master plan prepared by Hermann Jansen, parks, squares, boulevards, and tree-lined axes were treated as part of a comprehensive system of open green spaces that complemented one another. The aim was to increase access to green spaces for residents of different parts of the city, ensure ecological continuity within the urban fabric, and support public life (Tankut,

1993; Hall, 2002). Public open spaces created during this period—such as Millet Garden, Gençlik Park, Güvenpark, Kızılay Park, Zafer Square, Kurtuluş Park, and Hacettepe Park—were developed in accordance with common planning principles, despite their varying scales and functions. These parks were designed not only to create recreational areas in different parts of the city but also to serve as focal points supporting public life between administrative centers, residential areas, and transportation corridors. As a result, the parks have evolved from being merely green spaces for leisure into important components of the city's social and cultural life. During the early Republican era, national holiday celebrations, open-air concerts, theater performances, children's activities, sports events, and everyday recreational activities held in these parks contributed to the spread of the new Republic's vision of social life. In particular, the more active participation of women, children, and families in public life was encouraged through these spaces; parks functioned as inclusive public spaces where different social groups could come together (Batuman, 2013; Cengizkan, 2004).

Urban parks have also been among the symbolic spaces of the Republic. Through monuments, sculptures, ceremonial areas, fountains, wide pedestrian promenades, and monumental landscaping, the new state's ideals of modernization were made visible in public spaces. In this regard, parks are regarded not merely as products of landscape design, but as cultural landscape areas representing the Republic's social transformation, its understanding of national identity, and its contemporary urban culture. However, beginning in the 1950s, Ankara's rapid growth, population increase, the widespread use of motor vehicles, and the pressure of intensive development in the city center significantly impacted the park system established during the early Republican era. As a result of transportation investments, road widening projects, new construction, and changing planning decisions, some parks have

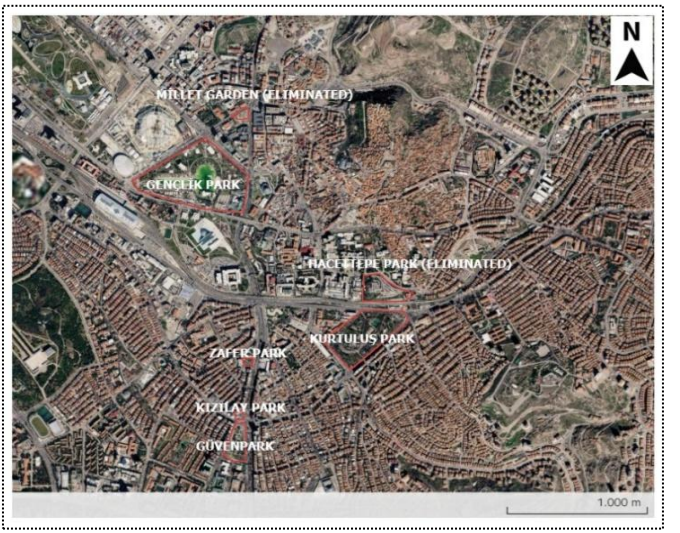
disappeared entirely, while others have lost significant areas and, consequently, much of their original design characteristics (Tekeli, 1998; Batuman, 2013). Nevertheless, these parks have continued to live on in Ankara's collective memory and remain important components of the cultural landscape heritage of the Republican era. Considering this historical development, Ankara's urban parks from the early Republican era can be viewed not merely as planning initiatives aimed at organizing the physical environment, but as spatial representations of the ideology of modernization, public life, and urban memory. For this reason, it is important to conduct a detailed examination of the historical development of these parks and their landscape values that have survived to the present day.

## An Evaluation of Ankara's Historic Urban Parks in Terms of Modernization, Public Life, and Urban Memory

The urban parks established in Ankara during the early years of the Republic were not planned solely to meet the need for green spaces; they were conceived as spatial manifestations of modernization policies. The park system developed in accordance with the Hermann Jansen Plan aimed not only to guide the physical development of the new capital but also to promote a culture of modern living, strengthen public life, and establish a contemporary urban identity (Tekeli, 1998; Cengizkan, 2004; Batuman, 2013). These parks served as public spaces where the Republic's goals of social transformation became visible in daily life. Within the scope of this study, Ankara's major historic urban parks from the Early Republican era—Millet Garden, Gençlik Park, Güvenpark, Kızılay Park, Zafer Square, Kurtuluş Park, and Hacettepe Park—have been evaluated in terms of the modernization process, public life, urban memory, and cultural landscape characteristics (Figure 1). Millet Garden, Gençlik Park, Güvenpark, Kızılay Park, Zafer Square, Kurtuluş Park, and Hacettepe Park were not used solely for rest and recreation; they contributed to the development of a new

understanding of public life through concerts, national holiday celebrations, open-air cinemas, sporting events, and cultural organizations. Thus, parks have served as an important interface between individuals' everyday life experiences and the Republic's ideals of modernization (Cranz, 1982; Gehl, 2011).

*Figure 1. Locations of Ankara's historic urban parks during the Early Republican Era within the city*




*Source: Created by the author*

Considering Lefebvre's (1991) approach to the production of space, Ankara's historic urban parks can be viewed not merely as planned physical environments, but as social spaces where social relationships are produced, reinterpreted, and constantly transformed. Similarly, while Jacobs (1961) emphasizes that the vitality of public life is made possible by people's active use of public spaces, Gehl (2011) states that high-quality public spaces strengthen urban life by increasing social interaction. With these characteristics, Ankara's early Republican-era parks played a decisive role in shaping the social life of the new capital.

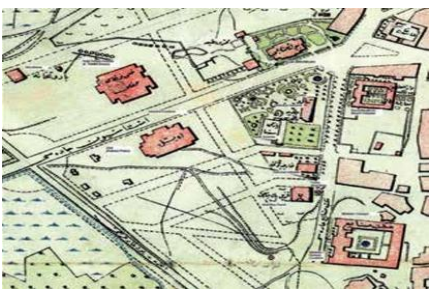
Research conducted in recent years has also demonstrated the positive effects of high-quality public green spaces on social integration, quality of life, and psychological well-being. UN-Habitat (2022) emphasizes that accessible urban parks are not only a key component of environmental sustainability but also of social sustainability. From this perspective, Ankara's historic parks continue to serve as important public spaces where city residents engage in social interaction, participate in physical activity, and develop a connection with the city. However, over the course of nearly a century, Ankara's rapid population growth, a planning approach focused on motorized transportation, intense pressure for development, and changing land-use decisions have led to significant transformations in these historic parks (Batuman, 2013). Some parks have lost area, some have partially lost their original design character, and certain public functions have changed over time. Nevertheless, these parks have largely preserved their historical and symbolic value in the city's collective memory. When Halbwachs's (1992) approach to collective memory is considered alongside Nora's (1989) concept of "places of memory," Ankara's historic urban parks are not merely physical landscape elements; they are significant cultural landscape areas that carry the social life, urban culture, and shared historical experiences of the Republic into the present day. ICOMOS (2025) also emphasize that the preservation of cultural landscapes requires consideration not only of physical integrity but also of social memory and place identity. In line with these assessments, Ankara's historic urban parks can be regarded not only as a planning legacy reflecting the Republic's modernization process but also as multi-layered cultural landscapes that contribute to the development of public life, support the formation of collective memory, and ensure the continuity of urban identity. Today, the preservation of these parks holds strategic importance not only from the perspective of landscape architecture but also in terms of the sustainable management of cultural heritage,

the strengthening of public life, and the transmission of urban memory to future generations (ICOMOS, 2025).

**Millet Garden**

Millet Garden, one of Ankara's first public parks, was established during the Ottoman period but played a particularly significant role in the development of a new culture of public life during the early Republican era. Located near Istasyon Street, the garden is one of the most important examples in Ankara of the "Millet Garden" tradition from the Ottoman period and became one of the primary venues that revitalized public life in the new capital through cultural and social events organized during the early years of the Republic (Tankut, 1993; Cengizkan, 2004) (Figure 2).

*Figure 2. Hakimiyet-i Milliye square and Millet Garden from the 1920s*



*Source: VEKAM, 1924*

Millet Garden continued to be used in the early years of the Republic to revitalize the public life of the new capital, bring together different social groups in a shared public space, and support the development of modern urban culture. The garden was not merely composed of open green spaces; with its botanical arrangements reflecting the landscape philosophy of the era, its circulation areas, and its social structures, it served as a multifunctional public space. An examination of maps and photographs from that period reveals that it had a layout resembling

a triangle, with its green fabric—defined by rows of trees and flower beds—integrated with rest and circulation areas (Tankut, 1993; Memlük, 1989). The walking paths, seating areas, and buildings serving as cafes and restaurants within the garden have not only met visitors' daily recreational needs but have also created important public hubs that foster social interaction (Figure 3). In this regard, Millet Garden has emerged not merely as a green recreational area but as one of the early Republican era's key public gathering places, bringing together diverse segments of society.

*Figure 3. People spending time in the Millet Garden in the 1940s*



*Source: Gürkaş, 2003*

For example, Kadriye Hüseyin (1999, pp. 41–42) describes Millet Garden and the building in question in her work "Letters from Sacred Ankara" as follows: "Across from the Parliament building lies Millet Garden, which, despite being neglected, retains its former soothing charm. It is a gathering place for everyone. This is because, in the center of this flower-adorned triangular space, there is a building housing a restaurant and a café."

These accounts demonstrate that Millet Garden was not merely a physical space for relaxation; it was an important gathering place that brought together different social groups and shaped public life during the early Republican era. The garden became a gathering place where statesmen of the era—most notably Gazi Mustafa

Kemal Atatürk—would relax amid their intense work schedules, hold informal meetings, and entertain important guests. Furthermore, concerts by the military band on important occasions and receptions organized by government officials demonstrate that the garden was one of the key centers of political and social life (Şimşir, 2008).

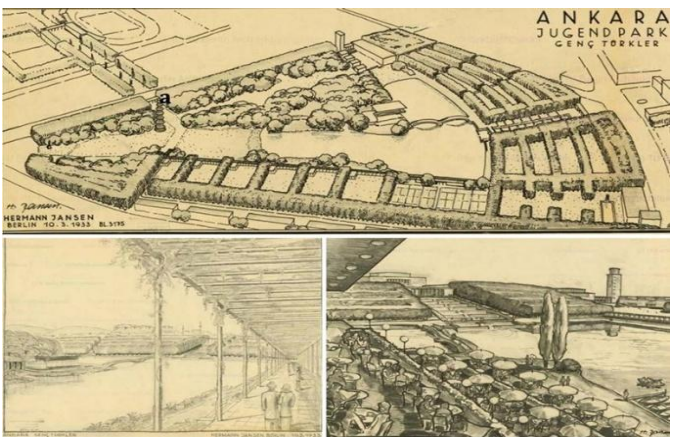
The garden was one of the first public spaces where the new capital's understanding of public life took shape, where different social groups could come together in a shared public space, and where modern lifestyle practices became visible. In this regard, Millet Garden can be regarded as one of the symbolic spaces where the Republic's modernization policies were reflected in everyday life. During the early Republican period, the planning of public open spaces was approached not merely for aesthetic and recreational purposes but as spatial tools that supported contemporary urban culture, social integration, and a new understanding of citizenship (Tekeli, 1998; Cengizkan, 2004; Batuman, 2013). In addition, plays were staged in the theater building by the Azm-i Millî organization, and it was in this building that Ahmet Hilmi Bey opened Ankara's first theater and movie theater (Tonga, 2014). It is noted that this hall, adorned with Turkish embroidery, was destroyed in a fire in 1929 (Aydın et. al., 2005). Thus, Millet Garden acquired the identity of a multifunctional public center where theater, cinema, concerts, and social gatherings took place. The open-air entertainment events, concerts, national holiday celebrations, and official ceremonies held in the garden were among the significant public events through which the Republican administration introduced the culture of modern life to society. By bringing together people of different ages and social groups in the same public space, these events contributed to the experience of a new understanding of citizenship within daily life (Tekeli, 1998; Batuman, 2013). However, in subsequent years, the garden's unique character changed significantly as a result of

intensive urban development in the city center, transportation investments, and the development of new public spaces. Although it has largely lost its physical presence today, Millet Garden retains its significance in Ankara's urban memory as one of the Republic's earliest public spaces. In this regard, the garden can be considered an important cultural landscape heritage that reflects the early Republican era's understanding of modernization, its culture of public life, and its social memory (ICOMOS, 2025).

**Gençlik Park**

Gençlik Park was designed during the Republican era as Ankara's most comprehensive recreational area and has become one of the most important public spaces reflecting the new capital's modern way of life. Planned as part of Hermann Jansen's 1932 Ankara Master Plan to transform the marshy area between Ankara Train Station and Ulus, construction of the park began in 1936, and after various modifications, it was opened to the public in 1943 (Tankut, 1993; Cengizkan, 2004) (Figure 4).

*Figure 4. The original 1935 plan of Gençlik Park, based on drawings by Herman Jansen, and drawings of various sections of the park*




*Source: Jansen, 1937*

The park was designed as one of the most significant implementations of Hermann Jansen's planning philosophy, which was based on a "green belt" and a system of public open spaces; it created an important recreational and transit area between Ulus and the newly developing city center (Jansen, 1937; Tankut, 1993). Spanning an area of approximately 28 hectares, the park—with its walking paths, children's play areas, amusement park, café, open-air theater, swimming pool, and dense vegetation—was designed not merely as a park but as a comprehensive recreational complex representing the modern urban life of the Republic (Tekeli, 1998). The artificial lake at the park's center is not merely a visual design element; through boat rides, water shows, and recreational activities, it has become the focal point of public life. The expansive lawns, groups of trees, landscape arrangements around the lake, and pedestrian paths created within the park are key components that reflect the modern landscape design philosophy of the era. The combined use of water features and plant compositions has enhanced both the aesthetic and recreational value of the park (Memlük, 1989). This historical spatial experience is vividly illustrated in the following account for 1930:

> Holding the little boy by the hand, his grandmother would take him to the park in a corner of the large green space between Hergelen Square and the train station, where they would sit on the park benches and watch the fountain with the statue in the middle. (Arcayürek, 2005).

The park's planning philosophy reflects the contemporary urban planning approach of the era. In line with a design philosophy inspired by European urban parks, green spaces, water features, rest areas, and recreational functions were brought together to create an inclusive public environment that could be shared by people of different ages and social groups. Thus, Gençlik Park was conceived not merely as an aesthetic landscape design but as a social

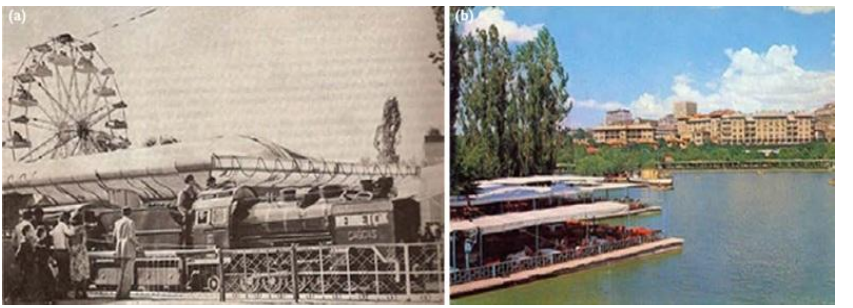
infrastructure supporting the daily practices of modern urban life (Cranz, 1982; Hall, 2002). Since its opening, the park has become one of Ankara's most important social gathering places. For many years, the park has hosted open-air concerts, theater performances, movie screenings, amusement park activities, sports events, national holiday celebrations, and a variety of cultural events. This long-standing recreational and entertainment function is also reflected in the memories and interpretations of local residents. As one interview participant recalled:

> I remember when I was a child, we'd make pastries at home, then go out to the lake and have a picnic right at the table by the water. But this paved the way for the commercialization of parks. This is the most significant problem in Turkey. Parks are viewed as places of entertainment. When you go abroad, you see that parks are places of relaxation—quiet, peaceful, secluded spots. But our parks were places that were extremely lively at night, filled with people walking around. This is because city dwellers here have a small-town mentality. They come to the city to have fun. Since they're already used to quiet, peaceful places from rural life, they've grown tired of them—which is why we've turned our parks into this. (Perçin, 2014).

By bringing together different social groups in the same public space, these events have made a significant contribution to the development of the Republic's understanding of public life. In this regard, Gençlik Park is regarded as one of the key public spaces where modern civic culture is experienced in everyday life (Batuman, 2013). When evaluated from the perspective of Lefebvre's (1991) approach to the production of space, Gençlik Park is not merely a planned physical environment; it is a social space that is constantly reproduced through the everyday experiences of its users. Similarly, in line with Halbwachs's (1992) approach to

collective memory, the park serves as an important memory space where shared memories of different generations are formed and urban memory is transmitted. For many generations living in Ankara, the amusement park, the artificial lake, boat rides, and outdoor activities have become symbolic elements of urban memory (Figure 5).

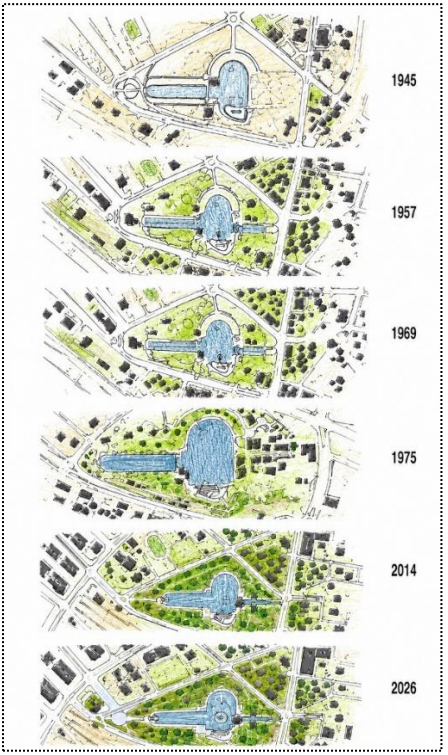
*Figure 5. The mini train and the Ferris wheel at Gençlik Park in the 1960s (a), and the cafes by the lake along with the surrounding green spaces and apartment buildings (b)*



*Source: Mimdap, 2009*

Gençlik Park has undergone various physical and functional changes from its establishment to the present day. It is evident that the recreational areas, which were initially concentrated around the lake, expanded over time, and that in later periods, significant changes occurred in the park's spatial organization due to new developments and changes in function. In the early years, the green spaces and recreational functions around the lake gradually expanded, and the park reached its peak of use in the 1970s. In contrast, various renovations, new developments, transportation decisions, and changes in usage carried out in subsequent years resulted in significant changes to the park's original design character (Figure 6). In particular, the diversification of recreational functions and the addition of certain structures have partially affected the park's historical landscape integrity (Memlük, 1989).

*Figure 6. The spatial development and environmental transformation of Gençlik Park between 1945 and 2026*




*Source: Created by the author*

Nevertheless, Gençlik Park continues to be one of Ankara's most important historic urban parks today. When evaluated in line with ICOMOS's (2025) principles for historic urban landscapes, the park is not merely a physical green space to be preserved; it constitutes an important cultural landscape heritage that carries the Republic's modernization process, the culture of public life, and Ankara's collective memory into the present day. For this reason, the preservation of Gençlik Park is not merely about maintaining the physical existence of a historic park; it is also important for passing on the culture of public life, the collective memory, and the modern urban identity of the Republican era to future generations.

**Güvenpark**

After 1925, as villas reminiscent of "feudal castles" began to spring up one after another in Yenişehir, social life in the area gradually took shape. Ankara residents began gathering in Kızılay Park, located directly in front of the Kızılay building. Kızılay Park, the most striking public space in this increasingly important part of the city, eventually gave way to Güvenpark, which was being built directly across the street. The Jansen Plan envisioned a park at the narrow end of the Vekaletler Neighborhood—positioned in a triangular shape—facing Sıhhiye-Ulus (Ertuna, 2005). Güvenpark is one of the most significant public open spaces created during the process of planning Kızılay as the new city center in the Early Republican era (Figure 7). Designed in accordance with Hermann Jansen's Ankara Master Plan, the park was conceived as a key transitional and meeting space between Ulus—the city's old center—and the newly developing administrative and commercial center.

*Figure 7. Güvenpark, 1935*



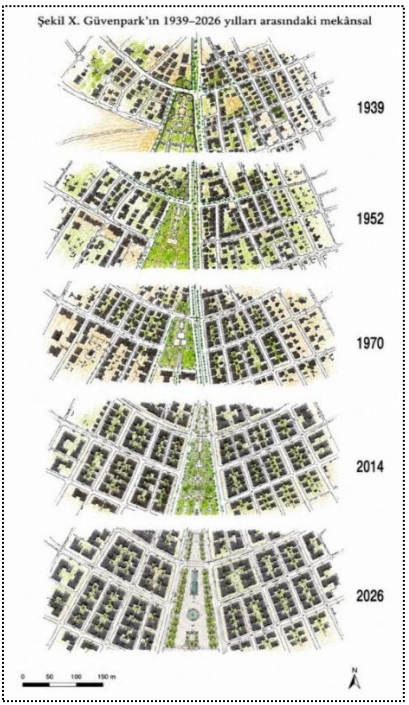
*Source: Ertuna, 2005*

The park, which took shape around the Güven Monument—completed in 1935—was planned as one of the symbolic public spaces reflecting the Republic's modern urban vision (Tankut, 1993;

Cengizkan, 2004). Thus, Güvenpark became not merely a green recreational area but one of the fundamental components of the planned open-space system supporting public life in the new capital.

The Güven Monument, which serves as the focal point of the park, was designed by Austrian sculptors Anton Hanak and Josef Thorak and is one of the most important works of public art symbolizing the Republic's commitment to security, modernization, and the relationship between the state and its citizens. The inscription on the monument, "Turk, take pride, work, trust," has reinforced the park's symbolic identity as a powerful ideological statement reflecting the Republic's social transformation and understanding of modern citizenship (Batuman, 2013). In this regard, Güvenpark is regarded as one of the significant examples from the early Republican era where public art and landscape design are seamlessly integrated. In the park's design, the Güven Monument was treated as the central focal point; a spacious, hard-surfaced plaza was arranged around the monument, and a holistic landscape composition was developed with surrounding lawns, rows of trees, seating areas, and pedestrian paths. The symmetrical spatial layout and unobstructed views enhance the monument's visibility while also reinforcing the park's representational function (Figure 8). Thanks to its strong visual and functional connection with Kızılay Square, Güvenpark was designed to serve as both a transit area and a space for waiting and gathering (Memlük, 1989).

*Figure 8. The spatial development and environmental transformation of Güvenpark from 1939 to 2026*




*Source: Created by the author*

This planning philosophy reflects a modern urbanism approach influenced by European urban parks of the era, while aiming to create an inclusive public environment where people of different ages and social groups can come together (Hall, 2002; Cranz, 1982). The park's central location, which blends seamlessly with Kızılay Square, has created an important public hub that supports the functions of relaxation, gathering, and socializing within everyday urban life. In a rapidly developing city, as a new urban park was defined alongside new buildings, Güvenpark played a major role in shaping Ankara's urban identity and collective memory through the philosophy it embodies and the sculptures that give it concrete form. Similarly, Sarıkulak (2013) noted that Güven

Park was developed as part of a public space strategy defined within the framework of the goal to create a modern, Western, and secular capital for the newly established Republic of Turkey. Consequently, when it comes to Ankara, the concept of “national identity” comes to the fore alongside that of “the identity of the place” in connection with Güven Park.

Since the early years of the Republic, Güvenpark has held an important place in Ankara's public life with official ceremonies, national holiday celebrations, social gatherings, and daily recreational activities. When evaluated in line with Lefebvre's (1991) approach to the production of space, the park is not merely a physically designed open space; it is a social space constantly reproduced through the daily experiences of its users. Similarly, within the framework of Halbwachs' (1992) approach to collective memory, Güvenpark can be considered an important memory space where shared memories of different generations are formed and the city's memory is transmitted. The area around the Güven Monument, in particular, has carried a strong symbolic meaning as a meeting point in Ankara's public life for many years. Over approximately ninety years, Güvenpark has undergone various physical and functional changes. Especially since the 1950s, with Kızılay becoming Ankara's main transportation hub, bus stops, metro entrances, underpasses, and heavy vehicular traffic have developed around the park (Figure 9); This situation has significantly affected the public use character and spatial integrity of the park (Tankut, 1993; Batuman, 2013).

*Figure 9. Areas reduced from green spaces by constructing bus and minibus stops*



*Source: Ayoğlu, 2010*

However, the park remains one of Ankara's most heavily used public open spaces thanks to its central location and symbolic value. Today, when evaluated in accordance with ICOMOS's (2025) Historical Urban Landscape principles, Güvenpark is not only a physical park that needs to be preserved; it is also an important cultural landscape heritage that carries the modernization process of the Republic, its public life culture, urban identity, and social memory to the present day. Therefore, the preservation of Güvenpark is of great importance not only for ensuring the continuity of a historical public space but also for transmitting Ankara's cultural identity and collective memory of the Republican era to future generations.

**Kızılay Park**

Kızılay Park is one of the major public open spaces planned during the early Republican era as part of the process of establishing Ankara’s new city center. Shaped in accordance with Hermann Jansen’s Ankara Master Plan, the Kızılay district was developed as the administrative and commercial center of the Republic, and the

park was designed as one of the fundamental open spaces supporting public life in this new city center (Jansen, 1937; Tankut, 1993; Cengizkan, 2004). By creating a green transitional space between public buildings, residential areas, and commercial centers, the park served as a key landscape element that complemented the planned urban fabric of the modern capital (Figure 10).

*Figure 10. Kızılay Park, 1937*



*Source: Cengizkan, 2004*

In the design of Kızılay Park, in line with the modern urban planning philosophy of the time, expansive lawns, tree-lined pedestrian paths, rest areas, and seating areas were integrated as a cohesive whole. The park's central location, which integrates with Kızılay Square, has made it not only an aesthetically pleasing green space but also a vital public transit and gathering space that supports the heavy pedestrian traffic in the city center. Thanks to its open views and orderly plant compositions, the park has been regarded as one of the key components of the planned open-space system that reinforces the contemporary urban identity of the new capital (Tankut, 1993; Memlük, 1989).

During the early Republican era, Kızılay Park was one of the public spaces most heavily used by city residents in their daily lives for walking, relaxing, meeting, and socializing. Thanks to the strong connections it established with the surrounding public institutions, commercial areas, and residential neighborhoods, the park created a

vibrant public environment that brought together different groups of users at various times of the day. When evaluated in line with Lefebvre's (1991) approach to the production of space, Kızılay Park is not merely a planned physical open space; it functions as a social space that is constantly reproduced through the daily practices of its users. Similarly, from the perspective of Halbwachs' (1992) approach to collective memory, the park can be regarded as one of the key memory spaces of the urban culture and modern public life that developed during the early years of the Republic. However, with Ankara's rapid growth and the rise of transportation-focused planning decisions—particularly after the 1950s—Kızılay Square and its surroundings underwent significant physical transformations. As a result of square renovations, road widening, intensive construction, and increased vehicular traffic, a significant portion of the park has disappeared; its original landscape design and character as a public space have been largely lost (Tekeli, 1998; Batuman, 2013). Kızılay Park has shrunk significantly, taking on the character of an institutional garden; all that remains in the park is a playground for children and a snack bar selling goods to generate revenue for the Kızılay Institution (Çağlar et. al., 2006). Toward the spring of 1980, this structure was demolished overnight, taking the park with it (Memlük, 1989). Following the boulevard's widening project, not only was the historic building destroyed, but the Red Crescent's most beautiful park and garden were also wiped out (Dinçer, 2014). The consequences of this transformation are also reflected in contemporary accounts. As Uludağ (1998) observed:

> This area, which later became known through a competition, will remain a construction site for many years, and no trace of the park will remain in the city's collective memory. The shopping mall built in its place will, after a long period of looking like a construction site, make people forget that this area was once a park. It is worth questioning whether we

should continue to view this area—whose name's origin we cannot currently discern—as one of Ankara's most important green spaces. Land, park, garden, road, shopping mall…

Although the park's physical presence has largely disappeared today, historical documents, photographs, and plans highlight the importance of Kızılay Park in public life during the early years of the Republic. When evaluated in light of ICOMOS's (2025) Principles for Historic Urban Landscapes, Kızılay Park should be regarded not merely as a lost green space, but as a significant cultural landscape heritage representing the Republic's modern urban planning philosophy, the culture of public life, and Ankara's urban memory. Therefore, the fact that the physical presence of Kızılay Park has largely disappeared does not diminish its historical and social value; on the contrary, it continues to serve as an important reference point for understanding Ankara's planning history and the Republic's public space policies.

**Zafer Square/Park**

Zafer Square is one of the major public open spaces planned during the Early Republican period to symbolically reinforce Ankara's new administrative center. Shaped in accordance with Hermann Jansen's Master Plan for Ankara, the square is situated between Ulus and the newly developing Kızılay axis and was conceived as one of the Republic's representative spaces (Jansen, 1937; Tankut, 1993; Cengizkan, 2004). The primary objective in creating the square was to organize public life in the new capital, establish a highly symbolic open space to host official ceremonies, and make the Republic's national identity visible through the urban landscape. In this regard, Zafer Square was planned not merely as a transportation hub but also as one of the spatial representations of the Republic's ideology in the public sphere. The Zafer Monument, which serves as the focal point of the square, was designed by the Austrian sculptor Heinrich Krippel and unveiled in 1927 (Figure 11).

Depicting Atatürk in his military uniform, the monument is regarded as one of the most significant works of public art symbolizing the achievements of the War of Independence and the founding of the Republic (Bozdoğan, 2001; Batuman, 2013).

*Figure 11. Zafer Square and Atatürk Monument*



*Source: SALT Research, 2018*

The landscape design of the square incorporates wide pedestrian areas, symmetrical walkways, lawns, rows of trees, and an open square layout created around the monument. This enhances the visual impact of the monument while creating a high-quality public environment where citizens can relax and gather. The strong spatial relationship the square establishes with Atatürk Boulevard and the surrounding public buildings is considered one of the characteristic features of early Republican urban planning (Tankut, 1993; Memlük, 1989).

From the early years of the Republic, Zafer Square has held an important place in Ankara's social life by hosting national holiday celebrations, military ceremonies, parades, and various public events. The square is not only a representative space where state ceremonies are held; it is also used as a public open space where citizens meet, relax, and engage in social interaction in their daily lives. When evaluated in line with Lefebvre's (1991) approach to the production of space, Zafer Square possesses the quality of a social

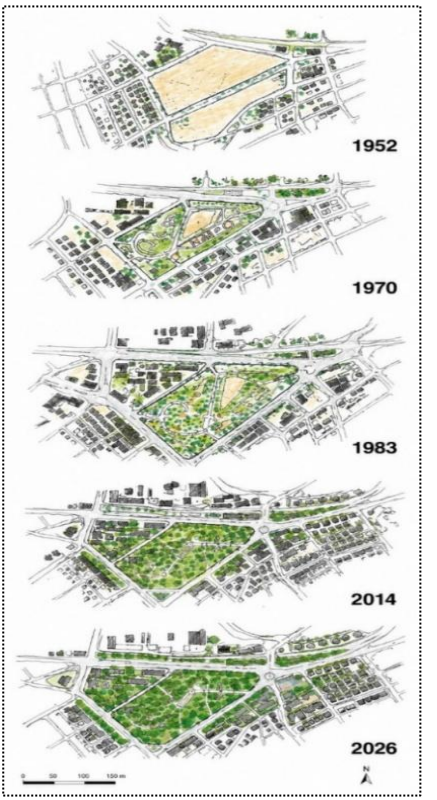
space that is constantly reproduced through its physical design as well as the daily practices and public events that take place there. From Halbwachs' (1992) perspective of collective memory, the square can be considered one of the symbolic spaces where the shared social memory regarding the founding process of the Republic is kept alive. Official ceremonies and commemorative events held around the Zafer Monument, in particular, have strengthened the square's place in Ankara's collective memory. From its founding to the present day, Zafer Square has undergone various physical and functional changes. Especially after the 1950s, the increased use of motor vehicles, the widening of Atatürk Boulevard, and intersection arrangements resulted in a reduction in the areas allocated for pedestrian use; the green spaces and open area integrity were significantly affected (Tankut, 1993; Batuman, 2013). Although the intense transportation infrastructure and urban development pressure around the square have partially weakened its initial public use character, its monumental identity and central location have been preserved. Nonetheless, Zafer Square continues to be one of Ankara's most important historical public spaces today. When evaluated in line with ICOMOS's (2025) Historical Urban Landscape principles, the square is not only a physical open space that needs to be preserved; it is also an important cultural landscape heritage that carries the Republic's modernization process, national identity understanding, public life culture, and Ankara's collective memory to the present day. Therefore, the preservation of Zafer Square is of great importance not only in terms of maintaining its monumental and physical features, but also in terms of transmitting the public life culture and historical identity represented by the early Republican period to future generations.

**Kurtuluş Park**

Kurtuluş Park was established during the Early Republican era as one of the key components of Ankara’s planned green space

system and has become one of the largest public recreational areas in the city center. The area where the park is located was used as a cemetery during the Ottoman period but was converted into a public green space in line with the Republic's modern urbanization philosophy; thus, an important open space was gained that would both contribute to the city's healthy development and support a new lifestyle (Tankut, 1993; Cengizkan, 2004). This transformation is regarded as one of the key examples of the Republican administration's approach to urban planning, which prioritized health, hygiene, and public life (Tekeli, 1998) (Figure 12).

*Figure 12. Spatial development and environmental transformation of Kurtuluş Park between 1952–2026*




*Source: Created by the author*

The primary objective in planning Kurtuluş Park was to create a large green space that would meet the needs of people of all ages for rest, recreation, and social interaction in the rapidly developing capital. Shaped in accordance with Hermann Jansen's green belt and open space system, the park was designed as a major recreational hub that integrates with the surrounding residential areas (Jansen, 1937; Tankut, 1993). Covering an area of approximately 11 hectares, the park has become one of Ankara's most comprehensive urban parks, featuring a dense canopy of trees, expansive lawns, walking paths, children's play areas, sports fields, rest areas, and open green spaces. Its natural landscape character, dominated by vegetation, is one of the key features that distinguishes the park from other public spaces in the city center (Memlük,1989). Since its opening, the park has served as an important recreational and social gathering space in the daily lives of Ankara's residents. By facilitating a wide variety of uses—such as walking, relaxation, sports, children's play, and outdoor activities—it has become an inclusive open space that brings together people of different ages and social groups within the same public environment. In line with the Republic's understanding of public life, the park has functioned not merely as a space for leisure, but as a vital public space where city dwellers encounter one another, develop social relationships, and experience urban culture as part of their daily lives (Gehl, 2011; Jacobs, 1961) (Figure 13). When evaluated from the perspective of Lefebvre's (1991) approach to the production of space, Kurtuluş Park is a vibrant public space that is constantly reproduced through the everyday practices of its users. Similarly, in line with Halbwachs's (1992) approach to collective memory, the park can be regarded as an important urban memory space that has long housed the shared experiences and memories of different generations. Although Kurtuluş Park has undergone various maintenance and renovation projects since its establishment, it has largely managed to preserve its unique spatial character compared to many of Ankara's

historic parks. Over time, children's play areas, sports facilities, and recreational amenities within the park have been renovated; however, the main walking paths, dense tree canopy, and open green space system have been largely preserved (Memlük, 1989). In this regard, Kurtuluş Park is considered one of the most successful surviving examples of the green infrastructure established during the Republican era. Although maintenance and management requirements have increased due to growing urbanization pressures and heavy use, the park continues to hold strategic importance for ecological continuity and the public open space system in the heart of Ankara.

*Figure 13. Kurtuluş Park, 1975*



*Source: Atılım University Archieve, 1975*

When evaluated in light of ICOMOS's (2025) Principles of Historic Urban Landscapes, Kurtuluş Park is not merely a physical green space in need of preservation; it constitutes a significant cultural landscape heritage that carries forward the Republic's understanding of public life, ideals of a healthy city, and modern landscape planning approaches to the present day. At the same time, with its mature tree canopy and green infrastructure functions, the park contributes to Ankara's ecological resilience; it also provides important ecosystem services in terms of biodiversity, urban climate regulation, and improving quality of life (Ahern, 2013). For this reason, the preservation of Kurtuluş Park is not only crucial for

ensuring the continuity of a historic urban park but also holds great significance for passing on the planning heritage of the Republican era, the culture of public life, and Ankara's natural-cultural landscape identity to future generations.

**Hacettepe Park**

Hacettepe Park is one of the major public green spaces planned within Ankara's historic city center during the early Republican era. Known as Keltepe before the Republic, Hacettepe was used as a cemetery for a long time. Located along the Ulus-Hacettepe axis, the park was designed as part of the open green space system envisioned by the Republic for the capital city of Ankara; it serves as a recreational area that supports public life within the densely built-up historic urban fabric (Tankut, 1993; Tekeli, 1998; Cengizkan, 2004).

The primary objective in establishing the park was to create a high-quality open space between the surrounding residential areas and public buildings, to meet the residents' needs for relaxation and social interaction, and to enhance the quality of life in the developing capital. Particularly with the development of health and educational facilities in subsequent years, the park has become one of the key components of public life in the Hacettepe area.

The park's design integrates well-organized walking paths, seating areas, lawns, groups of trees, and plant arrangements, reflecting the modern landscape planning philosophy of the era. The balanced use of open green spaces and shaded tree cover has enhanced the park's aesthetic and functional value, creating a high-quality public environment where visitors can relax, walk, and engage in outdoor activities (Memlük, 1989). Despite its location in the historic city center, the park was planned as a key green focal point that provides a breathing space within the dense urban fabric and was integrated into an open-space system that connects with

surrounding public institutions. Since the early years of the Republic, Hacettepe Park has served as a heavily used recreational area not only for local residents but also for students, public employees, and individuals using nearby healthcare facilities. By hosting a wide variety of public activities—such as daily relaxation, walking, social gatherings, and outdoor events—the park has become an integral part of urban life. This role is also reflected in the memories of long-time residents. As Memlük (2014) recalled:

> Of course, there was a pool culture. You'd find them in the gardens of both restaurants and homes. It really was a beautiful sight—I'll never forget how they'd have ping-pong balls floating on the fountains; they created such a lovely scene. These pools were quite common; you'd find one in about every five or ten homes. There was a culture like that in Ankara. However, unfortunately—even though I'm a long-time resident of Ankara—I don't recall there being very many pools in the city as a whole. The most important one was Hacettepe—or rather, before it became Hacettepe University, there was Hacettepe Park. There was a truly lovely pool there, surrounded by statues and such. Hacettepe Park was also a very beautiful park. People would go there with their families; they'd sit by the poolside and have a really nice time.

When evaluated in line with Lefebvre's (1991) approach to the production of space, Hacettepe Park is not merely a planned physical green space; it functions as a social public space that is constantly reproduced through the everyday practices of its users. From the perspective of Halbwachs's (1992) approach to collective memory, the park can be regarded as an important memory space that houses the shared experiences of different generations and carries the social memory of the historic city center into the present.

Hacettepe Park has undergone significant physical and functional changes. In particular, as a result of the expansion of Hacettepe University, the growth of the health campus, new road layouts, and increasing development pressure in the surrounding area, the park's original size and spatial integrity have changed significantly over time (Tankut, 1993; Batuman, 2013). Today, the area where Hacettepe Faculty of Medicine is located has been transformed into a park in accordance with Atatürk's instructions (Ateş, 1989). As a result, it has become a large park that meets the daily recreational needs not only of nearby residents but also of the entire Atpazarı, Ulucanlar, and Samanpazarı neighborhoods. Later, a fountain, viewing terraces, and a statue were added to the park (Figure 14).

*Figure 14. Superili Pool in Hacettepe Park, 1940s*

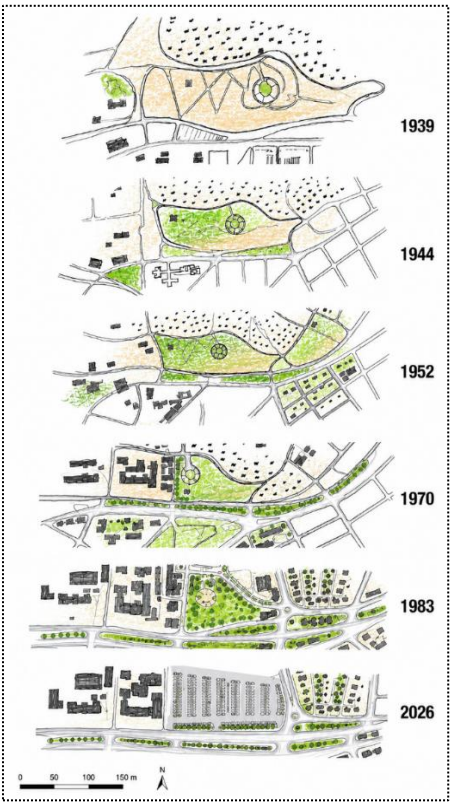



*Source: Türkyılmaz, 2015*

It managed to retain its status as a park until the late 1940s. The first steps toward rendering the park unusable were taken with the launch of the initial initiative regarding Hacettepe Hospital and University in 1954 and 1955, and the construction of the first building in 1958 (Çağlar, 1986). Hacettepe Medical School, which began as a Children's Hospital, continued to expand its campus—as a prime example of haphazard planning—after occupying a large portion of Hacettepe Park (Yavuz, 1952). Most of the trees in the park were destroyed during the university's construction, and the

park began to lose its character as a park. By the 1980s, Hacettepe Park had become a neglected hill where trash and construction debris were dumped, with only a few trees remaining; the Ankara Municipality's Parks and Gardens Directorate continued its efforts to restore the park to the city of Ankara (Çağlar, 1986) (Figure 15).

*Figure 15. The spatial development and environmental transformation of Hacettepe Park between 1939 and 2026*




*Source: Created by the author*

The intensive urban development surrounding the park has partially diminished the continuity of open green spaces; nevertheless, the park has managed to remain one of the few public green spaces still in existence in the historic center. This process also

clearly demonstrates the impact of urban densification and changes in function—observed in many early Republican-era parks in Ankara—on Hacettepe Park. Nevertheless, Hacettepe Park continues to be one of the key components of Ankara's historic public open space system today. When evaluated in line with ICOMOS's (2025) Principles for Historic Urban Landscapes, the park is not merely a physical green space to be preserved; it constitutes an important cultural landscape heritage that carries forward the Republic's planning philosophy, culture of public life, and the legacy of green spaces in the historic city center to the present day. At the same time, thanks to the ecological continuity it provides in the historic city center, its function as an open green space, and the opportunities it offers for social use, it plays a significant role in Ankara's sustainable urban development (Ahern, 2013). For this reason, the preservation of Hacettepe Park is of great importance not only for ensuring the continuity of a historic urban park but also for passing on the planning heritage of the Republican era, the culture of public life, and Ankara's historic green infrastructure to future generations.

**Discussion**

The findings of this study reveal that the historic urban parks established in Ankara during the Early Republican period were not merely public green spaces planned for recreational purposes; rather, they were multifunctional cultural landscapes conceived as spatial manifestations of the Republic's modernization policies. The parks under examination were designed as fundamental components of the city's open and green space system in line with Hermann Jansen's holistic approach to planning; together with residential areas, public buildings, transportation corridors, and squares, they formed a spatial network that supported public life in the new capital. In this regard, Ankara's Early Republican-era parks should be evaluated not merely as spaces that meet aesthetic or recreational needs, but as

public spaces where modern urban life, a contemporary understanding of citizenship, and new social relationships were produced (Tekeli, 1998; Cengizkan, 2004; Batuman, 2013).

Although the parks examined in this study were developed in accordance with common planning principles, they differ from one another in terms of the functions they serve. While Millet Park represents the transformation of the culture of public life inherited from the Ottoman period into the Republic era, Youth Park constitutes the most comprehensive example of the modern concept of recreation. Güvenpark and Zafer Square stand out for their symbolic and ideological functions as representative spaces of the Republic, while Kurtuluş Park and Hacettepe Park have primarily taken on functions related to daily recreation, relaxation, and neighborhood-scale public use. Kızılay Park, despite being an important open space supporting public life in the new city center, has largely lost its original character due to the physical transformations it has undergone over time. These differences demonstrate that the open-space system established during the Republican era was not based on a uniform concept of parks; rather, it consisted of complementary public spaces of varying scales and functions. Similarly, Cengizkan (2004) notes that Ankara's early Republican-era open-space system was conceived as a holistic green infrastructure system rather than as a collection of individual park designs. The findings of this study also corroborate this planning approach; however, they reveal that the parks underwent different preservation and transformation processes in subsequent periods. When compared in terms of their founding purposes, public functions, contributions to urban memory, and current preservation status, the parks examined exhibit significant differences (Table 1).

*Tablo 1. Comparison of the Functional and Conservation Characteristics of Historic Urban Parks in Early Republican Ankara*

| Park | Main Purpose | Function | Public Life | Urban Memory | Current Condition |
|---|---|---|---|---|---|
| **Millet Garden** | The first public green space | Social gathering and cultural events | Very high | Very high | Largely lost |
| **Gençlik Park** | Modern recreation | Entertainment and recreation | Very high | Very high | Largely preserved |
| **Güvenpark** | Representation and public square | Monument, gathering place, and transit | High | Very high | Partially preserved |
| **Kızılay Park** | Supporting the new city center | Resting and transit | High | High | Largely lost |
| **Zafer Square** | Republican representative space | Ceremonies and monument | Moderate | Very high | Partially preserved |
| **Kurtuluş Park** | Neighborhood-scale recreation | Recreation and sports | High | High | Largely preserved |
| **Hacettepe Park** | Serving the health and education district | Recreation | Moderate | Moderate–High | Partially preserved |

*Source: Created by the author*

An examination of Table 1 reveals that there is no direct correlation between the parks' original purposes and their current state of preservation. In particular, while Gençlik Park and Kurtuluş Park have largely maintained their physical integrity, Millet Garden and Kızılay Park have largely disappeared due to intensive urban renewal processes.

Considering Lefebvre's (1991) approach to the production of space, the research findings reveal that the value of these parks does

not stem solely from their physical designs. The parks have become public spaces that are constantly reproduced by users through organized cultural events, national holiday celebrations, concerts, daily recreational activities, and social interactions. This aligns with Jacobs' (1961) approach to the vitality of public life and Gehl's (2011) assessments based on the intensity of use of public open spaces. Consequently, the success of Ankara's historic urban parks can be attributed not only to their design qualities but also to their long-standing role in fostering a vibrant public life that has brought together diverse social groups over the years.

One of the major findings of this study is the significant role that historical urban parks have played in shaping Ankara's collective memory. From the perspectives of Halbwachs' (1992) theory of collective memory and Nora's (1989) concept of *lieux de mémoire* (sites of memory), these parks should be understood not merely as physical environments but as places of memory that preserve and convey the everyday life, social interactions, and modernization experience of the Republican era. The fact that areas such as Millet Garden and Kızılay Park, despite having largely disappeared physically, continue to exist through historical documents, archival photographs, and collective memory demonstrates that the cultural landscape value of these spaces cannot be explained solely by their physical integrity. In contrast, parks such as Gençlik Park, Güvenpark, and Kurtuluş Park, where both physical continuity and collective memory have been largely preserved, continue to make a substantial contribution to Ankara's urban identity.

A comparative assessment of the spatial transformations experienced by these parks reveals distinct conservation trajectories. Gençlik Park and Kurtuluş Park have largely maintained their original spatial character, whereas Millet Garden and Kızılay Park have been substantially lost due to transportation investments, intensive urban development, and changing land-use decisions.

Güvenpark, Zafer Square, and Hacettepe Park have retained parts of their original identity but have nevertheless been significantly affected by surrounding transportation infrastructure and urbanization pressures. This divergence reflects the gradual shift in Ankara's planning paradigm after the 1950s, from a human-oriented planning approach toward one increasingly dominated by transportation infrastructure and urban development priorities (Tekeli, 1998; Batuman, 2013). Consequently, the physical transformation of these parks represents not only changes in landscape design but also broader shifts in urban planning philosophy from the early Republican period to the present day. These differences further demonstrate that the parks vary considerably in terms of their contribution to the modernization process, their capacity to support public life, and the cultural landscape values that have survived to the present (Table 2).

*Table 2. Analytical Assessment of Ankara's Historic Urban Parks from the Early Republican Era in Terms of Modernization, Public Life, and Cultural Landscape*

| Park | Representation of Modernization | Public Life | Collective Memory | Physical Integrity | Cultural Landscape Value |
|---|---|---|---|---|---|
| **Millet Garden** | ●●● | ●●● | ●●● | ● | ●●● |
| **Gençlik Parkı** | ●●● | ●●● | ●●● | ●●● | ●●● |
| **Güvenpark** | ●●● | ●● | ●●● | ●● | ●●● |
| **Kızılay Parkı** | ●● | ●● | ●● | ● | ●● |
| **Zafer Square** | ●●● | ●● | ●●● | ●● | ●●● |
| **Kurtuluş Parkı** | ●● | ●●● | ●● | ●●● | ●●● |
| **Hacettepe Parkı** | ●● | ●● | ●● | ●● | ●● |
| **Legend:** ● = Low ●● = Moderate ●●● = High | | | | | |

*Source: Created by the author*

As shown in Table 2, the preservation of physical integrity does not always exhibit a linear relationship with cultural landscape

value. Although Millet Garden has been largely lost in physical terms, it continues to occupy a strong place in the collective memory. Conversely, some parks have retained much of their physical fabric but have partially lost their historical functions due to changes in the intensity and patterns of public use. These findings demonstrate that cultural landscapes cannot be evaluated solely on the basis of physical conservation. Therefore, the conservation of cultural landscapes requires the integration of intangible cultural values into management processes alongside the protection of tangible heritage.

The findings of the study are largely consistent with the international literature on cultural landscapes. Conservation principles published in recent years (ICOMOS, 2025) emphasizes that historic public open spaces must be preserved not only for their physical characteristics but also for their historical continuity, social memory, sense of place, and ecological functions. In this context, Ankara's Early Republican-era parks can be regarded as important components of the Republic's green heritage. These parks not only represent a historical approach to planning but also continue to support public life today, strengthen urban identity, contribute to biodiversity, and support the continuity of the historic city center's green infrastructure. These assessments demonstrate that Ankara's Early Republican-era parks are not merely physical landscape elements; they are multilayered cultural landscape components that carry the process of modernization, public life, and collective memory into the present. At the same time, it is clear that approaches to the preservation of historic urban parks should not be limited to physical restoration efforts alone. Preservation policies must be developed within the framework of a holistic management approach that addresses the historical landscape character, collective memory, continuity of public use, and ecological functions collectively. Such an approach will not only help preserve the planning legacy of the Republican era but will also make significant contributions to

Ankara's sustainable urban development, the strengthening of public life, and the transmission of cultural landscape values to future generations.

This study not only documented Ankara's historic urban parks from the Early Republican period from a historical perspective but also developed an analytical approach that evaluates the concepts of modernization, public life, collective memory, and cultural landscape together within a holistic framework. Thus, by demonstrating that Early Republican-era parks should be treated not merely as objects of physical preservation but as multilayered components of the cultural landscape, this study offers a conceptually and methodologically original contribution to the existing literature on cultural landscape and urban conservation.

**Conclusions and Recommendations**

By conducting a holistic assessment of Ankara's historic urban parks—established during the Early Republican period—from a cultural landscape perspective, this study has demonstrated that these parks are not merely recreational areas but rather multilayered public spaces that reflect the Republic's modernization process in the built environment. Millet Garden, Gençlik Park, Güvenpark, Kızılay Park, Zafer Square, Kurtuluş Park, and Hacettepe Park were examined comparatively in terms of their historical development, planning principles, public functions, contributions to collective memory, and current state of preservation. The findings indicate that, although the parks were designed according to a common planning philosophy, they have undergone different spatial transformation processes over time and have reached the present day in varying states of preservation. These results are consistent with studies demonstrating that Ankara's open-green space system during the Early Republican period was shaped by a holistic planning approach (Tekeli, 1998; Cengizkan, 2004; Batuman, 2013). The research has revealed that the value of historic urban parks cannot be explained

solely by their physical integrity. Even examples such as Millet Park, which has largely lost its physical form, retain their significance in terms of collective memory, historical identity, and cultural landscape. In contrast, changes in patterns of public use in some physically preserved parks demonstrate the dynamic and multilayered nature of the cultural landscape. This aligns with UNESCO's approach to Historic Urban Landscapes, which emphasizes that the cultural landscape must be evaluated in conjunction with historical continuity, collective memory, and user experience.

One of the study's significant contributions is that it analytically reveals the relationships between representations of modernization, public life, collective memory, physical integrity, and cultural landscape value by comparing historical urban parks from the Early Republican era under common evaluation criteria. Thus, the study demonstrates that the historic parks in Ankara's city center should be evaluated not merely on an individual basis, but as part of a complementary, holistic system of public open spaces. This approach is also consistent with international conservation approaches that emphasize the multilayered structure of the cultural landscape (ICOMOS, 2025).

In light of the findings, approaches to the preservation of historic urban parks should not be limited to physical restoration efforts alone. It is important to develop preservation policies within the framework of holistic management models that address the historical landscape character, original design features, continuity of public use, collective memory, and ecological functions collectively. In particular, making the historical traces of park areas that have largely lost their physical integrity visible—and reintegrating them into the city's collective memory through information panels, digital documentation efforts, augmented reality applications, cultural route systems, and landscape interpretation methods—will make

significant contributions to the conservation process. Such holistic conservation approaches are also consistent with the principles of sustainable heritage management proposed by ICOMOS (2025).

Finally, this study provides a methodological framework that can be applied not only to Ankara but also to comparative studies evaluating historic parks in other cities planned during the Early Republican period. In future research, the combined use of user perception studies, Geographic Information Systems (GIS), historical aerial photographs, remote sensing techniques, and three-dimensional digital reconstruction methods will contribute to a more detailed understanding of the temporal transformation processes of historic urban parks. This will enable the development of science-based conservation strategies for documenting, preserving, and sustainably passing on the green heritage of the Republican era to future generations (ICOMOS, 2025). In this regard, the study presents one of the first comprehensive assessments systematically comparing Early Republican-era urban parks within the framework of cultural landscapes, thereby making a unique conceptual and methodological contribution to both the literature on urban history and landscape planning in Turkey and to international research on historic urban landscapes.

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# CHAPTER 3

# RAINWATER MANAGEMENT IN ROOF SYSTEMS OF BUILDINGS: BUILDING MATERIALS, PERFORMANCE CRITERIA AND TECHNOLOGICAL DEVELOPMENTS

**AHMET CİHAT ARI**[1]

## Introduction

Due to increasing urban populations, industrialization, and rising temperatures caused by climate change, existing clean water resources are becoming insufficient. Additionally, the decrease in rainfall patterns and the increase in drought events in many regions are causing environmental and social problems. The high cost of traditional water supply systems and the ever-increasing demand for water in urban areas also lead to greater problems (Borah, 2025). To solve these problems, alternative water sources are being evaluated within the framework of sustainable development policies (Campisano et al., 2017). Furthermore, rainwater management strategies are being developed using innovative designs and materials in the roof systems of buildings (Figure 1) (Almeida et al., 2023; Mao et al., 2021; Portillo Noriega et al.,

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2026). In this context, solutions are being developed to ensure water management in buildings and to protect clean water resources by collecting, storing, and reusing rainwater (Ssekyanzi et al., 2024).

*Figure 1 Developing management strategies for the use of rainwater in building roof systems.*




*Reference: Campisano et al., 2017*

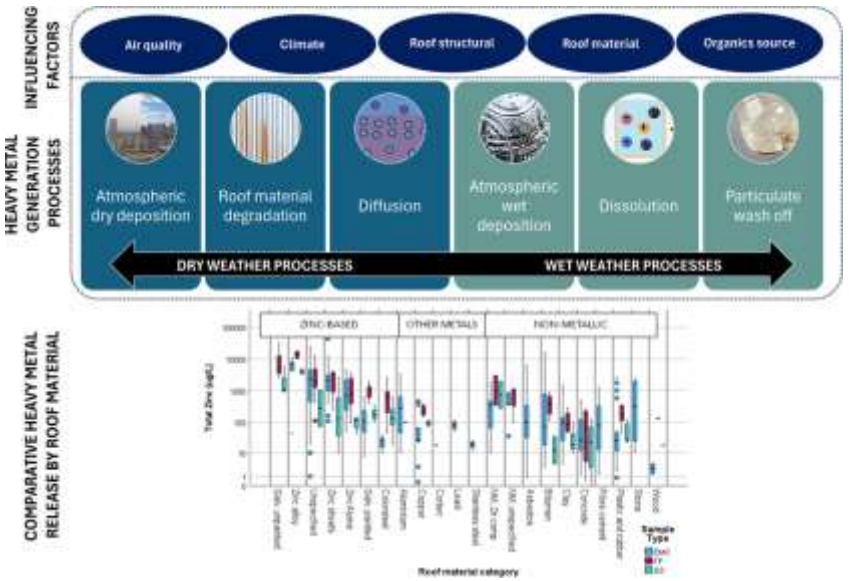
In addition to contributing to sustainable water management, rainwater harvesting in buildings also prevents flooding by reducing surface runoff in cities and ensures more efficient use of groundwater resources (Sepehri et al., 2018). Many scientific studies in recent years have indicated that roof systems of

buildings have significant potential for collecting rainwater and also contribute to the conservation of natural water resources in regions with low rainfall (Kim et al., 2023; Xie et al., 2023). Moreover, such sustainable roofing systems contribute to increasing the amount of clean water in the global environment, reducing water waste, and lowering environmental pollution and water costs (Abuseif, 2023).

In buildings, the first place rainwater comes into contact with and collects is the roof. Therefore, roof design and materials play a significant role in rainwater management in buildings. Furthermore, the amount and quality of rainwater accumulating on the roof surface varies depending on the roof's slope, surface area, morphology, and the properties of the building materials used (Campisano et al., 2017; Mendez et al., 2011; Farreny et al., 2011). Roof types such as metal roofs, concrete tile roofs, asphalt fiberglass shingle roofs, and green roof systems have been studied by many researchers for their rainwater harvesting efficiency (Cui et al., 2024; Cristiano et al., 2023; Mendez et al., 2011). When these studies in the literature are examined, it is seen that dust particles, inorganic and organic residues due to air pollution are carried to storage systems in the water collected on roof surfaces, negatively affecting the water quality (Castiglia Feitosa et al., 2026; Macher et al., 2025; Ogarekpe et al., 2025). Furthermore, studies have determined that roofing materials release heavy metals or various chemical compounds into the water due to environmental and atmospheric effects, increasing water pollution (Figure 2) (Charters et al., 2025; Mendez et al., 2011). Studies have highlighted that, due to pollution from roofing materials, various treatment processes may be necessary for rainwater depending on its intended use (Mendez et al., 2011; Hamilton et al., 2019). Therefore, in addition to the structural properties of roofing

materials, the pollution levels of collected rainwater also need to be evaluated.

*Figure 2 Heavy metal composition in materials used in building roof systems*




*Reference: Charters et al., 2025*

Nowadays, thanks to advances in materials science and technology, systems are being developed to efficiently utilize rainwater collected on roofs. For example, the use of innovative materials such as self-cleaning surfaces, superhydrophobic coatings, and photocatalytic materials on building roofs increases rainwater harvesting efficiency (Fernando et al., 2022). Additionally, the pollution levels of rainwater accumulating on building roofs are assessed using methods such as data analysis and risk modeling (Carprio-Vallejo et al., 2025). Alongside advancements in innovative materials technology, green roof systems have become a priority area of research in improving the sustainable and ecological performance of building roof systems. A review of the literature reveals that while numerous studies focus

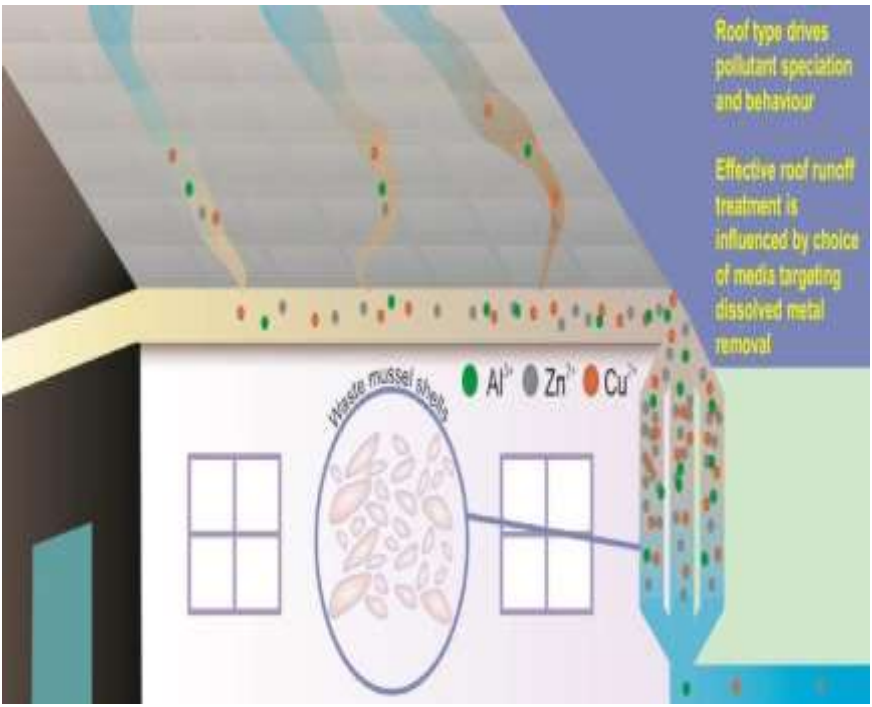
on rainwater harvesting, there is a lack of sufficient research that comprehensively evaluates the structural behavior of building materials used in roof systems, water pollution levels, and innovative material technology approaches. This study examines the properties and technological approaches of building materials used in roof systems for rainwater management in buildings. This study examines technological approaches developed to address the amount of rainwater accumulating on the roof surface and the pollution levels of rainwater in roofing systems, using both traditional and innovative building materials.

## The Effect of Roofing Materials on Rainwater Pollution Levels and Collection Efficiency

The aesthetic and structural performance characteristics of traditional roofing systems play a decisive role in design criteria. However, nowadays, in addition to being an architectural design requirement, it is also considered in terms of recovering rainwater collected on the roof surface and ensuring sustainable urban water management. In this context, multi-functional roofing systems are emerging. New roofing materials are being developed for rainwater harvesting on these types of roofs. The literature shows that studies have been conducted on the use of different roofing materials for rainwater recovery. For example, in their study, Zhang et al. (2014) examined the quality characteristics of rainwater obtained from concrete, asphalt, ceramic tile, and green roof surfaces. The same study determined that ceramic tile roofs have the lowest levels of water pollutants on roof surfaces compared to other roofing materials. Furthermore, it has been reported that since roofing materials significantly affect the pollution level of rainwater, water treatment is necessary for direct use. In their research, Mendez et al. (2011) determined that the levels of fecal indicator bacteria were lower on metal surfaces compared to other roofing materials due to the low emission properties of the metal surface. In another study

conducted by Souza de Carvalho et al. (2025), they showed that the load of heavy metals such as zinc, copper and aluminum formed by rainwater runoff is affected by the roofing material (Figure 3).

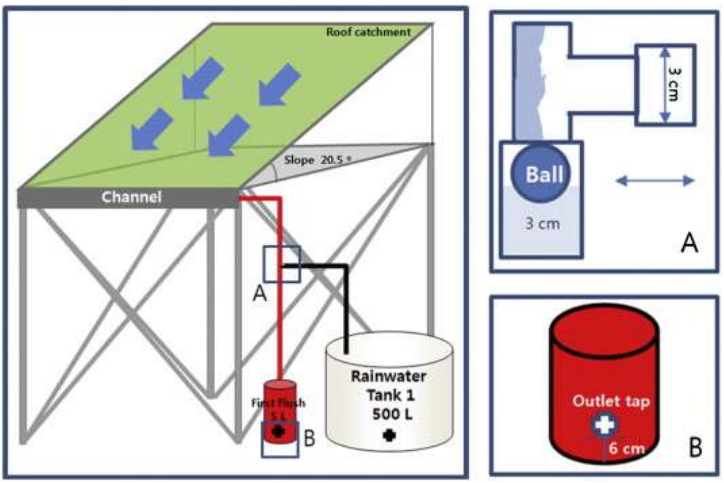
*Figure 3 Schematic diagram showing the impact of roof type on the heavy metal load in rainwater runoff*




*Reference: Souza de Carvalho et al., 2025*

In their research, Lee et al. (2012) examined the levels of rainwater pollution caused by different roofing materials (Figure 4). The same study determined that the water pollution level on galvanized steel roofs was lower compared to that on wooden shingle, concrete tile, and clay tile roofs. It has also been suggested that the lower water pollution levels on these metal roofs compared to other roofs may be due to the natural disinfection effect of sunlight and high temperatures.

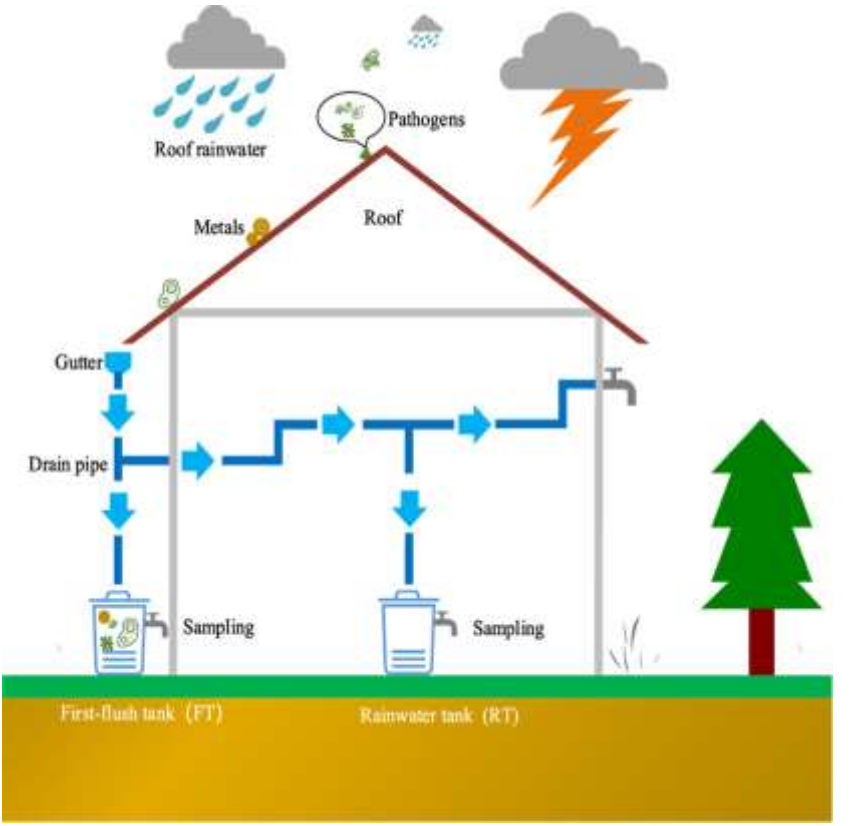
*Figure 4 Schematic representation of the rainwater collection system on the roof*




*Reference: Lee et al., 2012*

In the study conducted by Mao et al. (2021), the pollution levels of rainwater accumulating on roofs under different roofing materials (galvanized metal, ceramic tile, concrete and asphalt roof) and meteorological conditions were examined in Shanghai (China). In the same study, it was determined that ceramic tile roofing material had the lowest level of pollution from rainwater accumulating on its surface, while asphalt tile roofing material had the highest level of pollution from rainwater accumulating on its surface. The study also found that rainfall amount and meteorological conditions have a significant impact on the pollution level of water accumulating on the roof (Figure 5). When all these studies in the literature are evaluated, it is revealed that roofing materials are an important structural element in terms of rainwater pollution level and collection efficiency. In this context, the selection of roofing material is one of the most fundamental components in producing sustainable building designs.

*Figure 5 Schematic diagram showing the effect of rainfall amount and meteorological conditions on the pollution level of water accumulated on the roof*




*Reference: Mao et al., 2021*

The type of roof on buildings has a significant impact on the quality and collection efficiency of rainwater. Roof surface performance characteristics such as slope, hydrophobicity, roughness, chemical release potential, and biofilm formation alter the level and quantity of rainwater pollution (Charters et al., 2025; Galster & Helmreich, 2022; Hachoumi et al., 2021). Environmental and climatic factors also directly affect the quality of rainwater (Mao et al., 2021). One of the parameters used in the rainwater

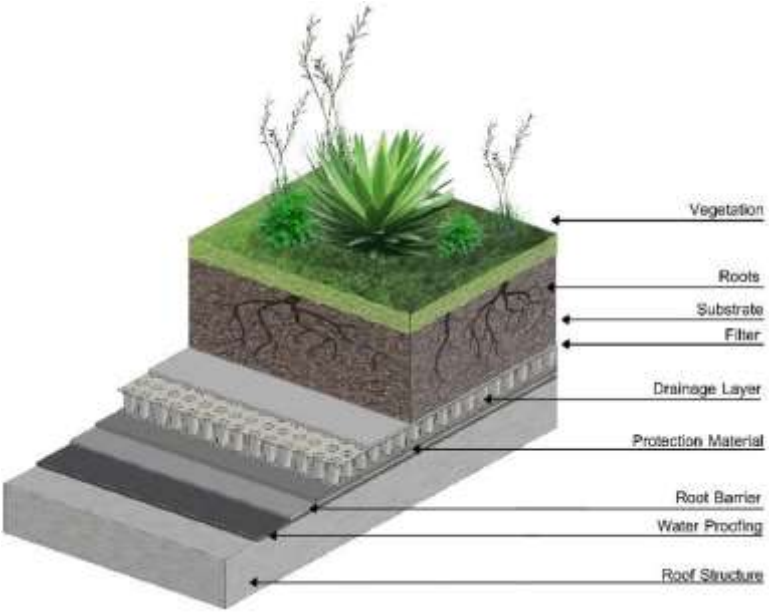
harvesting performance of roof surfaces is the runoff coefficient (RC) (Mehrabadi et al., 2013; Yu et al., 2026). This coefficient has a high value due to the low surface roughness of metal roofs. Therefore, metal roofs provide high flow efficiency (Yu et al., 2026).

**Innovative Technologies and Design Approaches in Sustainable Roofing Systems**

Climate change, caused by global warming, is rendering infrastructure systems inadequate for rainwater management. Therefore, new design approaches are needed for rainwater management in building roof systems. One of these design approaches, sustainable roofing systems, stands out in rainwater management. Sustainable roofing systems offer greater advantages over traditional roofing systems in rainwater management, such as harvesting, delaying, storing, and reusing rainwater (Abuseif, 2023; Teston et al., 2022). Additionally, sustainable roof systems offer multifaceted benefits such as reducing surface runoff, thereby lowering flood risk, ensuring efficient use of water resources, saving energy, and contributing to the protection of the environment and nature (Mihalakakou et al., 2023; Monteiro et al., 2023).

Sustainable and innovative technologies on the roofs of buildings, green roof systems, have a multi-layered feature consisting of filter layer, drainage layer and waterproofing systems (Figure 6) (Mihalakakou et al., 2023). Moreover, green roof systems reduce total runoff and peak flows volume by storing a large portion of the precipitation (Johannessen et al., 2017). Although green roofs are one of the most effective environmentally friendly solutions for rainwater management, substrate thickness, plant type, and drainage design cause variations in hydraulic performance (Monteiro et al., 2023; Abuseif, 2023).

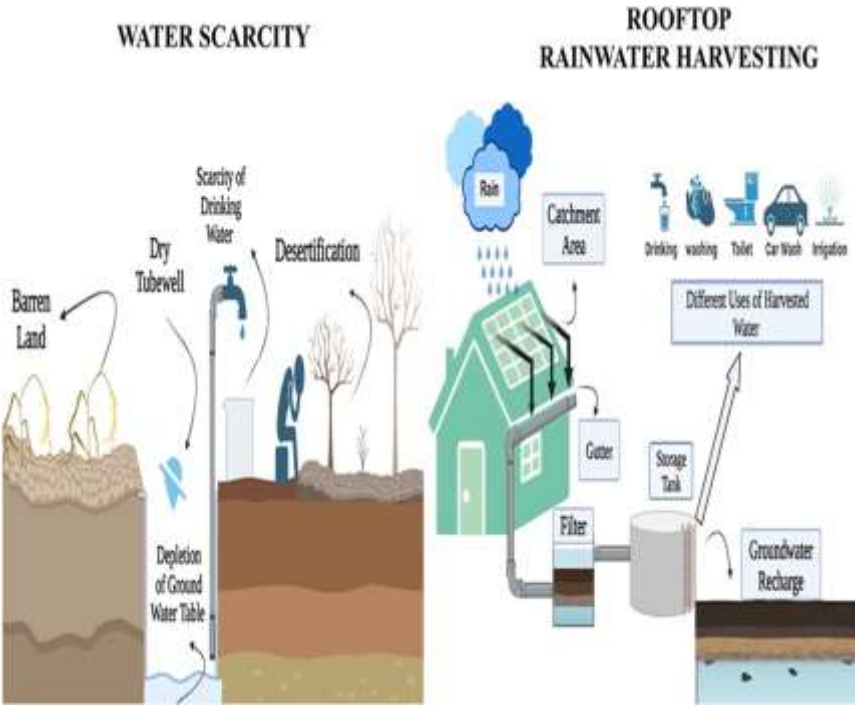
*Figure 6 Layers used in rainwater management on green roofs*




*Reference: Abuseif et al., 2021*

In sustainable roof systems, rainwater harvesting plays a significant role in water recovery. In this context, rainwater collected on roof surfaces needs to be separated, filtered, and stored (Figure 7) (Lepcha et al., 2024). The stored water is used for watering landscaped areas, flushing toilets, and in other applications that do not require drinking water, such as laundry (GhaffarianHoseini et al., 2016). However, in recent years, modular storage systems have incorporated controlled drainage elements and variable volume reservoir solutions (Martin & Kaye, 2020). Moreover, smart sensors used in storage systems enable roof systems to operate dynamically based on rainfall forecasts, in addition to storing water (Shetty et al., 2022). Another advantage of this system is that it helps control flooding by reducing the amount of sudden runoff reaching the drainage infrastructure during short-term heavy rainfall events (Shetty et al., 2022).

*Figure 7 Schematic diagram showing rainwater harvesting and water recycling in sustainable roof systems*




*Reference: Lepcha et al., 2024*

Today's advancements in materials science are making significant contributions to improving the performance of sustainable roofing systems. For example, titanium dioxide ($TiO_2$)-based photocatalytic coatings reduce rainwater pollution by giving surfaces self-cleaning properties (Marszałek et al., 2024). These coatings break down organic pollutants under the influence of sunlight (Figure 8) (Wei et al., 2023). This allows pollutants to be easily removed from the roof surface, reducing maintenance costs (Wei et al., 2023). Another benefit of these coatings is that they allow roof surfaces to be used for longer periods by cleaning the layers formed due to air pollution (Marszałek et al., 2024; Wei et al., 2023).

*Figure 8 Schematic diagram showing how $TiO_2$ based photocatalytic coatings break down organic pollutants on the roof surface under the influence of sunlight*

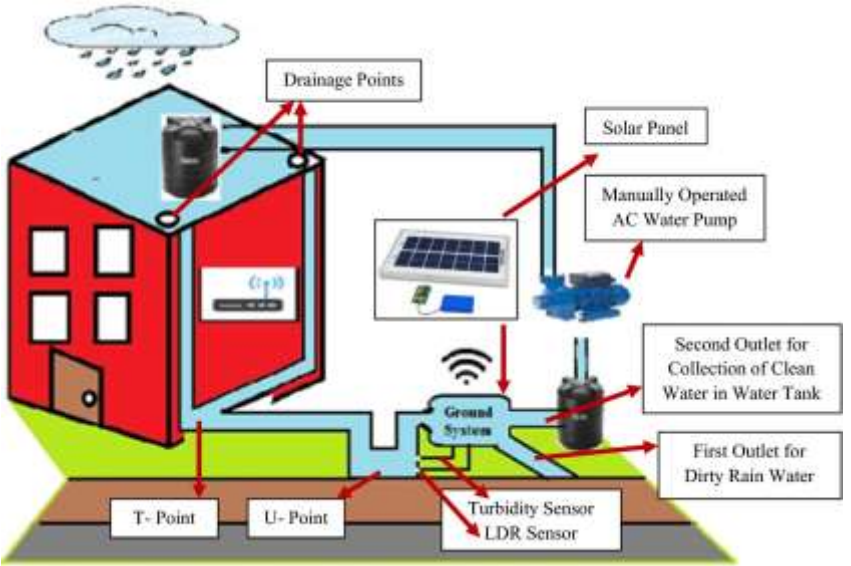



*Reference: Wei et al., 2023*

The development of technological systems has brought automated and efficient water management to the forefront in sustainable roofs. For example, rainfall, humidity, temperature, irrigation optimization, and storage capacity are automatically controlled using the Internet of Things (IoT), smart sensor, digital technologies, and artificial intelligence systems (Shetty et al., 2022; Tsang & Jim, 2016; Tseng et al., 2022; Verma, 2022). Furthermore, these technological systems make it possible to optimize storage tanks and irrigation systems (Shetty et al., 2022). Thus, the efficiency of rainwater utilization collected on roofs is increased (Figure 9) (Verma, 2022). Recent studies on sustainable roofing

systems highlight that digital technologies significantly improve roof performance and contribute to the production of roofing systems adapted to environmental conditions (Abuseif, 2023).

*Figure 9 Schematic diagram showing how to achieve automated and efficient water management on a roof using IoT technology*

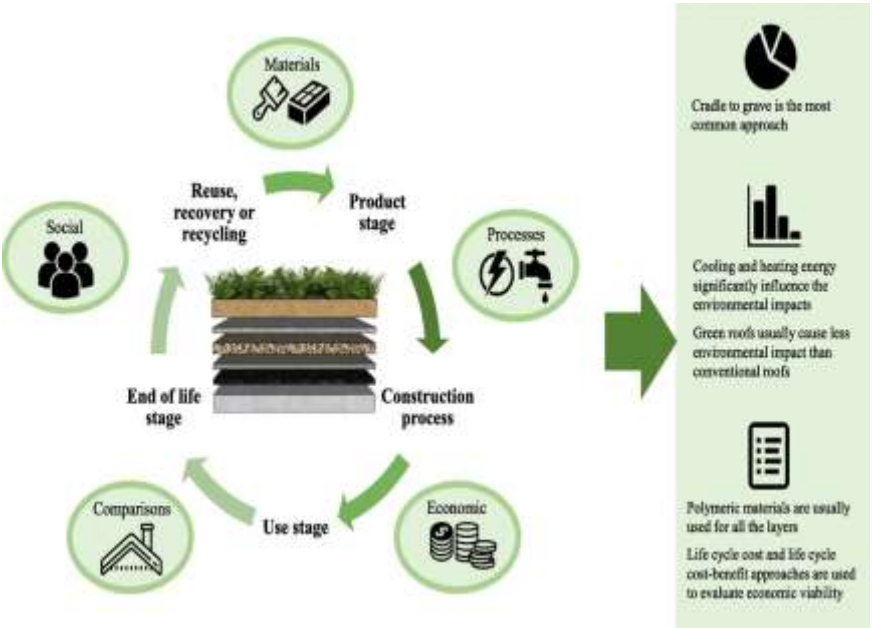



*Reference: Verma, 2022*

Sustainable roof systems are evaluated not only for their rainwater harvesting performance but also for their environmental impact throughout their life cycle (Balasbaneh et al., 2024). In this context, Life Cycle Analysis (LCA) is performed for the environmental impacts of sustainable roofing systems (Figure 10). The materials used in the production of green roofs are more diverse than those used in traditional roofs (Scolaro & Ghisi, 2022). However, the fact that green roofs consume less energy than traditional roofs increases their usability in terms of environmental performance (Scolaro & Ghisi, 2022). Studies on LCA in the literature indicate the need to develop a standard methodology. Furthermore, researchers emphasize that developing a standard

methodology significantly contributes to the evaluation of LCA parameter results for sustainable roofs (Balasbaneh et al., 2024; Fiorentin et al., 2024; Scolaro & Ghisi, 2022).

*Figure 10 LCA should be conducted to evaluate the environmental impact of green roofs*




*Reference: Scolaro & Ghisi, 2022*

In green roofs, carbon is stored in plant biomass, reducing the building's energy consumption and thus lowering carbon emissions (Seyedabadi et al., 2021). Additionally, green roofs contribute to energy savings in buildings by using Heating, Ventilation, and Cooling (HVAC) systems (Zheng & Weng, 2020). However, the amount of energy saved and the carbon performance of green roofs vary depending on climate conditions (Ivan et al., 2026; Jamei et al., 2023). In this context, it is necessary to conduct analyses aimed at reducing carbon emissions in sustainable roof design (Mihalakakou et al., 2023).

## Conclusion and Recommendations

This study focuses on building materials, performance criteria, and technological advancements in rainwater management of building roof systems. According to the literature review conducted within the scope of this study, sustainable architectural design approaches have been developed for rainwater management in building roof systems due to climate change and urbanization caused by global warming. Sustainable roof systems contribute to the preservation of the building as well as the storage, retention, and reuse of rainwater. In sustainable roofing technologies, specifically green roof applications, photocatalytic coatings, digital technologies, and artificial intelligence systems help reduce rainwater pollution levels. Moreover, these technological systems contribute to more efficient use of rainwater, energy savings, and reduction of carbon emissions. The covering material used on the roof is effective in reducing the pollution level of rainwater. In metal roofs, heavy metals such as zinc, iron, and copper are transferred to rainwater through surface runoff. In bituminous roofing materials, organic compounds and hydrocarbon derivatives are released into rainwater through surface runoff, leading to water pollution. Ceramic/clay tile roofs have lower pollutant emissions in surface runoff compared to other roofing types, and are considered the most suitable material for rainwater harvesting. In sustainable roofing systems, a holistic approach that considers innovative technologies, material selection, climate conditions, and architectural design decisions is crucial for successful rainwater management. Therefore, it is predicted that future roof systems will evolve into multifunctional building components that are adaptable to environmental conditions, have high rainwater performance efficiency, and are not harmful to the environment or nature.

The following recommendations are presented to improve the efficiency and quality of rainwater collection in building roof

systems and to ensure this improvement is achieved in a sustainable manner.

- It is recommended that the roof systems of buildings be planned from the early stages of architectural design, taking into account the climatic characteristics of the location, the type of building, and user requirements.
- It is recommended that roof systems be designed sustainably based on criteria such as life cycle performance, rainwater harvesting efficiency, the level of rainwater pollution from building materials, and carbon footprint.
- It is recommended that efforts to integrate digital technologies and artificial intelligence systems into sustainable roofs be increased.
- It is recommended to increase research into automated and efficient water management in sustainable roofs by developing low-carbon materials.
- It is recommended that interdisciplinary collaboration be strengthened to develop sustainable roofing technologies and to make rainwater management on roofs more efficient.

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# CHAPTER 4

# STRIKING A BALANCE BETWEEN INNOVATION AND TRADITION IN HISTORICAL SETTINGS

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**TUANA SULUKAYA**[2]

## INTRODUCTION

The architectural value of a building is influenced by its functionality and structural features, as well as its aesthetic, cultural, and artistic expression. The relationship between modern architecture and its historical context has become a complex issue that is gaining significance in contemporary architectural discourse, both aesthetically and culturally. In densely populated areas, old buildings need to be maintained and new ones built around them. This is because user needs are changing, growing, or new technical problems are emerging. This raises one of the most discussed problems of our time: How can a new building look modern while still fitting in with the old buildings around it?

The Venice Charter is a clear example of the international conservation approach at the heart of this debate. The Venice Charter

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states that new interventions must "leave a contemporary mark," meaning there must be a clear distinction between the new and the old (ICOMOS, 1964). It also holds that these changes must not alter the building's original value. This approach gives us two tasks: to preserve the old building and to ensure that the new design is true to the style of the time. The Venice Charter does not prohibit the complete imitation of modern design in historical contexts; however, it considers excessively confrontational and context-disregarding methodologies perilous.

Steven W. Semes' work is now an important part of modern sources. Semes (2009) outlines four primary strategies for integrating new design within a historic context: precise replication, reinterpretation in a similar style, abstract reference, and intentional contrast. Semes' approach emphasizes preserving the historic environment's unique identity while contending that new design must express a modern vernacular. In this regard, Semes' concepts align with a context-sensitive architectural methodology that emphasizes continuity (Semes, 2009).

However, some architects disagree with Semes' views on this matter. For example, John Ruskin is almost completely opposed to adding new buildings to old ones or altering them. He says that the most important feature of an old building is the traces of life that have accumulated over time. Adding something new would disturb this natural process. On the other hand, Viollet-le-Duc supports the creative restoration and reconstruction of old buildings as they were in the past. These two perspectives show how difficult it can be to design in a historical environment.

The modernist approach, exemplified by architects such as Norman Foster and Daniel Libeskind, deliberately creates contrast. This perspective holds that new designs must be clearly distinct from historical structures and must symbolize the progress of modern architecture. Consequently, major changes using modern materials

such as steel and glass, even if they appear out of place, are a normal part of being modern.

There are many ways to blend modern design with an old building, which is an important point. Instead, a fair and well-thought-out decision must be made, taking into account the needs of the time, the needs of the function, and the values of the culture.

This research is situated at this complex intersection. The main goal is to understand how current design fits into the historical context and to determine which types of changes lead to good results and which ones cause problems. The goal is to provide a thorough and critical evaluation of how modern design, which confidently showcases its current identity while honoring the past, can be understood in a historical context.

## METHODOLOGY

This study is a qualitative examination of different approaches to modern extension design in historic environments. Because the study does not aim to produce quantitative data, the methodology is primarily based on literature review, discussion and evaluation, spatial analysis, and comparative case studies.

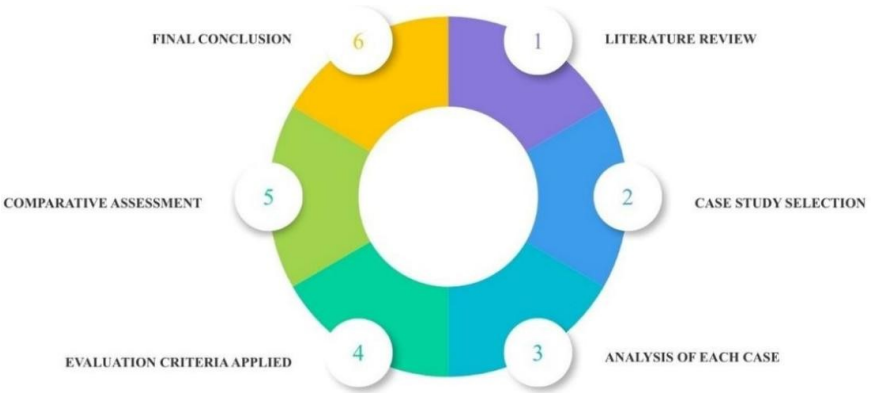



*Figure 1. Methodology (Prepared by the author)*

The first phase of the research examined the perspectives of John Ruskin and Eugène Viollet-le-Duc on interventions in historic structures, the 1964 Venice Charter, and current conservation literature. Additionally, contemporary interventions in historic settings by architects such as Norman Foster and Daniel Libeskind were assessed, and the classification formulated by Steven W. Semes on integrating new design within historic contexts was used as the study's theoretical framework. This literature formed the foundation of the discussion presented in the introduction.

The second phase of the study employs a comparative case study to analyze the practical application of contemporary extension design. In this context, three international examples illustrating various forms of the relationship between a historic building and a contemporary extension were chosen: Carlo Scarpa's Castelvecchio Museum, David Chipperfield's Neues Museum intervention, and I. M. Pei's Louvre Pyramid. These three projects were selected because they are often cited in international literature and demonstrate different approaches to modern design in a historic setting. Another reason for choosing these buildings is that each clearly shows how the new part interacts with the old, making it possible to examine the design strategy in detail.

Before examining the selected buildings, we reviewed the history of each and the reasons for the intervention. Next, we examined the design, construction methods, materials, and formal language to see how the old-new divide was handled. After these steps, the three example buildings were compared using the established evaluation criteria. This demonstrated that modern extension design is understood differently across historical periods.

## THEORETICAL AND HISTORICAL BACKGROUND

For almost 200 years, there has been extensive discussion about how to adapt old buildings and add new ones. The opposing

views of Eugène Viollet-le-Duc and John Ruskin in the 19th century led people to question the very idea of restoration. The Venice Charter later established guidelines that could be followed worldwide to guide these activities. This long-running debate has continued more recently with radical modern additions, such as those by architects Norman Foster and Daniel Libeskind. These interventions are very different from the context-sensitive, continuity-focused approach that Steven W. Semes supports (Semes, 2009).

**The Contrasting Views of Ruskin and Viollet-le-Duc**

Eugène Viollet-le-Duc had a very different approach. In his well-known book Dictionnaire Raisonné de l'architecture Française, he wrote, "Restoring a building is not keeping it the same or fixing it; it is reintegrating it." Viollet-le-Duc believed that restoration was more than merely fixing a building; it also meant bringing back its imagined "ideal integrity," even if that state had never been reached (Viollet-le-Duc, 1858). This understanding aligned with what is often called stylistic integrity or stylistic unity in literature. It was acceptable to add new elements, creatively fill in missing parts, or strengthen the structure when needed.

John Ruskin, on the other hand, held the opposite view. In his books The Seven Lamps of Architecture (1849) and The Stones of Venice (1851–1853), he emphasized that a building's value comes from the experiences accumulated over time, not its shape. In his famous quote, "the greatest splendor of a building lies in its age," he meant that a building's true value lies not in the materials used to build it but in the marks left by time (Ruskin, 1849). Because of this, Ruskin believed that most forms of restoration threatened a building's historical authenticity and advocated a conservationist approach that called for as little intervention as possible.

Ruskin and Viollet-le-Duc are two very different thinkers when it comes to restoring historic buildings. Ruskin's approach is to preserve the building's current state and patina, while Viollet-le-Duc's approach is to creatively restore the building to make it look like a perfect whole. This conflict between them was an important intellectual backdrop for the writing of later international conservation documents (Ruskin, 1849; Viollet-le-Duc, 1858; Jokilehto, 2007).

The differing ideas of Ruskin and Viollet-le-Duc in the 1800s formed the main theoretical basis for conservation thinking. By the 1900s, these debates had shifted toward an institutional framework. The establishment of national conservation laws in several European nations, the evolution of archaeology and art history into contemporary academic fields, and the swift alterations in the built environment required the formulation of unified principles (Choay, 2001).

The Athens Charter, published in 1931, was the first international step taken during this period. The International Museums Office drafted this document, which marked the beginning of modern conservation thinking. It set out guidelines for the conservation of historical monuments, including the use of scientific methods, record-keeping, and respect for original materials (International Museums Office, 1931). However, the Athens Charter didn't establish a consistent international practice because it focused primarily on individual monuments.

Because World War II caused so much damage, conservation became even more important. The stresses of rebuilding necessitated the protection not only of important buildings but also of entire cities and social settings (Jokilehto, 1999). The establishment of education- and research-oriented institutions such as ICCROM (ICCROM, 1959) and the globalization of professional networks in the conservation field during this period strengthened the field's

institutional foundations. The founding of ICOMOS in 1965 enabled people from diverse fields to discuss the principles of conservation (ICOMOS, 1965).

These changes indicate that the methods used across countries should be consistent. The Venice Charter was adopted in 1964 to meet this need. For the first time, it clearly articulated the framework of the modern conservation discipline. The Charter brought together the long-standing debate between Ruskin's conservation methods and Viollet-le-Duc's creative restoration philosophy by creating an international set of rules. These rules included basic principles such as preserving authenticity, documenting changes, and making it clear which additions are new (Jokilehto, 2007).

**Venice Charter and International Protection Principles**

The Venice Charter of 1964 remains one of the most influential documents on how to preserve and restore historic buildings. The Charter doesn't define a "historic monument" as a single building. It also recognizes that the monument's location, whether in a city or the countryside, is part of the whole. Thus, conservation isn't just about one building; it's also about the "historic environment" (ICOMOS, 1964; Jokilehto, 2007). The Charter describes a monument as both a work of art and a historical record. It cautions that new interventions shouldn't give people a false sense of history by mixing the old with the new (ICOMOS, 1964). At the same time, new additions should be clearly contemporary without diminishing the historic structure's original value. These principles serve as a foundational framework for education and law in many countries (Delafons, 1999; Jokilehto, 2007). They also serve as a moral and practical guide when making modern additions.

**New Design / Infill Approaches in Historic Settings**

Since the middle of the 20th century, people have been arguing about how to design new buildings in historic neighborhoods. Much of this debate centers on the idea of "infill architecture." In the past, infill architecture was mostly about filling gaps in the urban fabric. Today, though, it's not just about filling a physical void. There is broad agreement that design should take into account the location's character, rhythm, and overall identity (Demiri, 2013; Tiesdell, Oc, & Heath, 1996). So, it's important to view a new building on a historic street as part of the street, not as a separate thing.

Filling approaches are usually judged on a scale from similar to different. Designs that aim for a uniform appearance try to create an image that fits the fabric of the place as well as possible. Facade proportions, rooflines, window arrangements, and material choices often mirror the surrounding landscape (Rahmat, Yuli, & Maharika, 2022). However, some researchers argue that making too many changes can obscure the distinction between old and new and make it harder to see how a place has changed over time (Pendlebury, 2009).

There is a more interpretive way to view both similarities and differences. The goal of these designs is not to copy the past exactly but to give some of its basic ideas, such as scale, mass balance, or facade rhythm, a new twist that fits modern language. This lets the building show a modern style while still keeping the street's character (Demiri, 2013). Neutral approaches, on the other hand, take a more measured approach to design. They favor simple formal solutions that fit in with the surroundings and offer heights and volumes that work with them.

At the other end of this range are designs that rely on contrast. The point of these projects is to stand out from the rest of the world, not to make everything look the same. This style often uses new

materials, sharper shapes, or unusual arrangements of the facade. Demiri (2013) notes that people sometimes use these kinds of apps on purpose to make the situation tense. But in well-designed examples, basic elements like silhouette or height are taken into account. This prevents the new building from becoming a completely separate object from its surroundings.

Today, sources say that relying solely on formal similarity or difference to judge infill schemes is insufficient. Material transitions, the clarity of the relationship between the old and new, scale, façade layout, and the integration of functions are all factors that can help you better judge how good a design is (Rahmat et al., 2022; English Heritage, 2008). Various infill methods can be evaluated not only by appearance but also through a more systematic approach. There is no one "right" way to design new additions in historic places, after all. Some projects preserve the old structure unchanged, while others give the area a new look using a modern style. Some designs deliberately place old and new elements side by side to show how time has changed the space. Next, we'll look at Steven W. Semes' classification, which is a useful way to make this wide range easier to understand.

Over the years, discussions about adding more buildings to historic areas have taken many directions, guided by the rules set out in the Venice Charter. Since the 1970s, the most significant change in international documents is that conservation is no longer limited to protecting individual sites. The European Architectural Heritage Declaration (1975) also began to consider the layout of streets, the size of neighborhoods, and how people use them every day as important parts of history (Council of Europe, 1975).

So, the question "Does it look like the old one?" is no longer the only thing people talk about when judging new buildings. The 1987 Washington Charter said that old cities must preserve their social and cultural connections. It also said that design should be

judged not only by how well it fits in with the rest of the city, but also by how it improves life and adds to the city's identity.

**Modernist Interventions**

In the second half of the 20th century, especially with the rise of high technology and deconstructivist ideas, the relationship between modern architecture and historic buildings changed significantly. Architects such as Norman Foster and Daniel Libeskind began to consider modifications that were less substantial yet had a significant impact on aesthetics. These changes often used glass, steel, and transparent roof systems. These additions often stood out from the existing stone walls on purpose, a marked departure from past practices (Foster + Partners, undated; Libeskind, 2004). In many ways, this period brought about a new way of thinking. Architects became more comfortable displaying the modern layer rather than concealing it.

The Reichstag dome in Berlin and Foster's Great Court at the British Museum are two of the most widely discussed examples in this context. Both projects show how a modern addition can fit into a historic setting without copying it. They also change how visitors experience the space by adding light, openness, and new paths. The reasoning behind these designs is that each era should showcase its own technological advances, making the architectural timeline honest and clear. In other words, "each era should leave its mark" (Foster + Partners, undated). These additions don't try to change the historic building; instead, they change how it is framed and bring modern life into the space.

This method, on the other hand, hasn't been accepted by everyone. Much conservation literature criticizes projects that overemphasize contrast and underemphasize important issues such as scale, proportion, and the big picture (Delafons, 1999; Semes, 2009). When a new addition becomes an iconic object rather than a

response to its surroundings, it can obscure the historical structure rather than reveal it. Therefore, many academics emphasize that designing in a historical context is not just about making objects look different. They say the design process should not only be about appearance but also about how people perceive it, how it fits into the culture, and how easy it is to read the old and the new. Thus, the debate about how to evaluate new buildings has moved beyond the question of “Does it look like the old one?” The 1987 Washington Charter stated that historic cities must maintain strong social and cultural ties. It also stated that design should be evaluated not only in terms of how well it fits in with the rest of the city but also in terms of how it improves life and the city's identity (ICOMOS, 1987).

The 1994 Nara Document redefined authenticity by taking cultural differences into account. It demonstrated that no single viewpoint is universally applicable (ICOMOS, 1994). This approach has made discussions about designing new additions and infill structures more open and complex. The inclusion of concepts such as sustainability, urban landscape, public space, and community participation in conservation documents in the 2000s has also facilitated the evaluation of new designs (ICOMOS, 2011; UNESCO, 2013). It is also necessary to consider how a new building contributes to its surrounding context, how it fits into the story of that place, and how people perceive it.

These changes not only made infill architectural styles more diverse but also provided architects with a supportive environment to discuss their work in the late 20th century, enabling them to make bolder and more visible changes. During this period, modern features such as advanced technology, lightweight structures, glass-and-steel shells, and other elements began to be incorporated into historic buildings.

This broader perspective helps you understand why modernist interventions occurred and why people still talk about

them so much. In this context, by examining the work of architects such as Foster and Libeskind, as discussed in the next section, we can better understand where modern design created opportunities and where it created tensions within the historical environment.

**Steven W. Semes and the Search for Balance**

Steven W. Semes, especially in his book The Future of the Past: A Conservation Ethic for Architecture, Urbanism, and Historic Preservation, offers a more balanced view of new designs in historic settings (Semes, 2009). Semes contends that in the discourse on the interplay between conservation ethics and architectural design, new additions must honor the existing context while clearly conveying their modern identity; thus, he advocates against both an entirely "invisible" addition and a drastic intervention that is detached from the context. Semes (2009) lists four main ways to design something new in an old place: exact replication, reinterpretation in the same style, abstract reference, and deliberate contrast.

He says that exact replication may create a sense of unity in the short term, but in the long term it can make it hard to tell "which part is really old and which is new." Reinterpretation in the same style and with abstract references, on the other hand, provides modern solutions in the details while preserving basic features such as proportion, rhythm, and the language of materials. Deliberate contrast is not wholly dismissed; however, instances that are disparate solely for the sake of distinction, without regard for context, are assessed with critical detachment (Semes, 2009). In this regard, Semes's methodology presents a compromise between Ruskin's stringent conservationism, which largely eschews intervention, and the drastic discontinuity exemplified by Viollet-le-Duc and certain modernist initiatives. This search for balance, which can be summed up as "neither complete imitation nor complete

break," will be the main idea behind this article when it comes to making modern additions to old buildings.

## CASE STUDIES

### Case Selection

This study selected three exemplary structures:

- Carlo Scarpa's Castelvecchio Museum (Verona),
- David Chipperfield's Neues Museum intervention (Berlin),
- M. Pei's Louvre Pyramid (Paris).

The reason for selecting these projects is clear. First, these three structures are often used in studies that examine how modern additions affect historical environments, which makes comparison easier. Second, each one represents a different approach to how old and new elements fit together. Scarpa's method is more focused on details and makes the structure feel more connected to it. Chipperfield's method is more subdued and is based on finding a balance between intervention and restoration. Pei, on the other hand, makes the difference stand out more clearly. So, the study offers a variety that lets us see how different design methods affect old buildings. Finally, we can see how design choices change depending on the situation because they come from different countries and cultures.

All projects were evaluated within the same framework. The following points were considered for each example:

- the building's historical background and original function,
- its condition and needs prior to intervention,

- the location, general layout, and design language of the extension,
- the relationship between old and new (in terms of spatial, formal, and material aspects),
- user experience and public perception.

Following these explanations, each project was evaluated using the fundamental criteria commonly used in modern annex building design. These are:

- **Contextual harmony:** the relationship of the extension to the surrounding scale, street fabric, and overall silhouette,
- **Scale and proportion:** the hierarchy established between the new addition and the historic building,
- **Materials and details:** the harmony or contrast of the materials used with the historic building,
- **Legibility of old and new:** whether the intervention is distinguishable and whether it creates a false historical effect,
- **Reversibility and respect:** how well the intervention is implemented without damaging the building.

These criteria are based on the Venice Charter's emphasis on authenticity and distinctiveness and on Semes' approach of avoiding either complete imitation or complete disconnection. Rather than suggesting a single “correct” approach, this assessment method allows us to see in which situations different applications have been successful and in which they have produced problematic results.

This enables evaluation of modern additions to historical environments in a context-sensitive manner.

## Castelvecchio – Carlo Scarpa

***"Reinterpretation in the same style + abstract reference"***

Carlo Scarpa's intervention at Castelvecchio (1959–1973) is widely regarded as a balanced example of how modern design can coexist harmoniously with a historic structure without resorting to imitation. Semes' classification places the project primarily in the "Reinterpretation in the same style" category and partially in the "abstract reference" category. This is because Scarpa responds to the building's character while also creating a modern architectural language (Semes, 2009).

*Table 1 Semes's Strategies in Castelvecchio*

| **Semes's Strategy** | **Castelvecchio Application** | **Explanation** |
|---|---|---|
| **Replication** | ❌ Not applied | Scarpa avoids imitation; no element tries to appear "historic." |
| **Invention within the Same Style** | ✔️ Strongly applied | Historic principles of proportion, rhythm, and materiality are reinterpreted in a contemporary way. |
| **Abstract Reference** | ✔️ Partially applied | Modern elements reference the historic building through alignment, scale, and tone—without direct mimicry. |
| **Contrasting Approach** | ❌ Minimally applied | Differences between old and new exist but are subtle; Scarpa avoids dramatic or disruptive contrast. |

*Source: Prepared by the author*

## Visual and Spatial Analysis

Scarpa creates a deliberate visual dialogue between the old and the new. The historic stone texture is left exposed, with its layers and flaws clearly visible. Small gaps separate the new architectural features, such as floors, platforms, and metal rails, from the old

structure. This helps visitors understand how the two periods of construction relate (Alba, 2007). The key visual features are:

- **Layered depth:** Scarpa makes slight changes to floor levels and wall surfaces to provide a multi-layered reading of the interior space (Figure 2,3).



*Figure 2. Scarpa's use of layered spatial depth at Castelvecchio (URL-1)*



*Figure 3. Scarpa's use of ramps, platforms, and recessed wall planes to create layered depth within the historic structure (URL-2)*

- **Openings:** Window openings and passageways have been redesigned to frame key views, particularly toward the courtyard and works of art (Figure 4).



*Figure 4. Scarpa's redesigned openings (URL-3, URL-4)*

- **Contrast:** The weight of medieval walls is juxtaposed with delicate steel profiles or thin stone slabs, creating a controlled contrast rather than an unsettling one (Figure 5,6).



*Figure 5. Contrast (URL-5)*



*Figure 6. Scarpa's modern insertion visible between the medieval brick walls of Castelvecchio (URL-6)*

- **Cangrande installation:** The repositioning of the Cangrande statue—raised, illuminated, and surrounded by layered surfaces—is often discussed as the best example of Scarpa's staging methods (Rab, 1996) (Figure 7).



*Figure 7. Scarpa's repositioning of the Cangrande statue on an elevated platform (URL-7)*

In this way, the visitor moves through the museum step by step, encountering a series of carefully framed spaces rather than one continuous, neutral background.

**Material and Detail Analysis**

It's easy to see how Scarpa thinks about Castelvecchio in the way he uses materials and details. Instead of trying to make the new parts visually fit in with the old building, he preferred to make his work clear by using different materials and careful details.

**Distinction between old and new materials:**

Existing materials such as stone, brick, and plaster have been preserved and left visible. On the other hand, new elements have been added using steel, concrete, and wood (Figure 8). This allows visitors to easily understand which sections belong to the original structure and which were added later.



*Figure 8. Distinction between old and new materials (URL-8)*

**Handling of joints and connections:**

A striking feature of Scarpa's design is how new elements are integrated with the old structure. Rather than adding new materials directly to the historic walls, Scarpa leaves small gaps or recesses between them (Figure 9). These differences make the transition between old and new clearer and prevent visual confusion between construction periods (Alba, 2007).

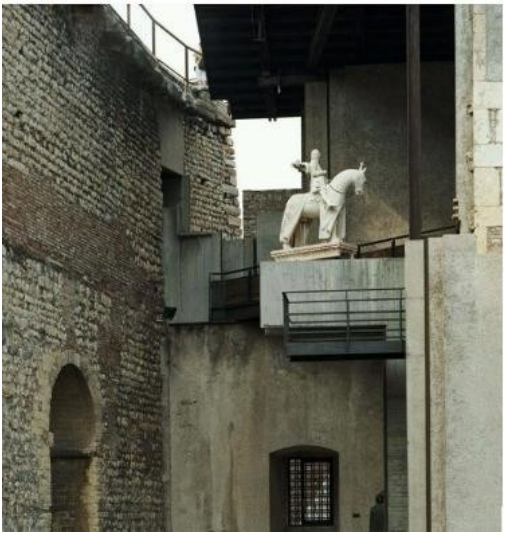


*Figure 9. Handling of joints and connections (URL-9)*

**Emphasis on craftsmanship:**

Scarpa places a strong emphasis on quality and detail. Railings, steps, display supports, and borders are carefully planned and often built to order. These features are not only decorative; they help define movement, organize the space, and guide people through the museum (Figure 10). The quality of craftsmanship plays a crucial role in the overall clarity of the intervention (McCarter, 2013).



*Figure 10. Stair (URL-10)*

**Controlled use of materials:**

The number of materials used during the intervention is limited. The same materials and details have been used across different sections of the museum to create a consistent design language. This repetition helps the modern additions feel connected to one another rather than appearing as separate or unrelated additions (Figure 11).



*Figure 11. Material usage (URL-11)*

**Texture and physical experience:**

Scarpa pays attention not only to the appearance of materials but also to their texture. Historic stone surfaces are used alongside smooth concrete, polished stone, or finely crafted metal. This contrast enhances the visitor's perception of the space, transforming the building into a more physical and sensory experience.

In general, Scarpa uses materials and details to make a clear but respectful connection between the old building and the new work. The new parts are easy to see and read, but they don't compete with the old ones. (Figure 12)



*Figure 12. Material contrasts (URL-12)*

**User Experience**

Scarpa's work at Castelvecchio has a significant effect on how people think about the museum by making them move more slowly and look more closely. Ramps, level changes, and small tunnels make it hard to walk straight. Instead, visitors move through the space in a series of steps, which helps them learn about the art and the building's history (Alba, 2007). Rather than an open plan that goes on forever, the spaces are arranged in a sequence. This creates periods of congestion and openness that shape how people perceive and attend to certain views (Rab, 1996). Most of the time, art is

displayed on separate supports rather than leaning against old walls. This makes it easier to distinguish the building from the objects inside it (McCarter, 2013). Scarpa allows visitors to see different periods of history simultaneously by keeping old surfaces visible and slightly separating new ones, transforming the museum visit from a passive experience into an active one that makes visitors more aware of space and history (Figure 13).

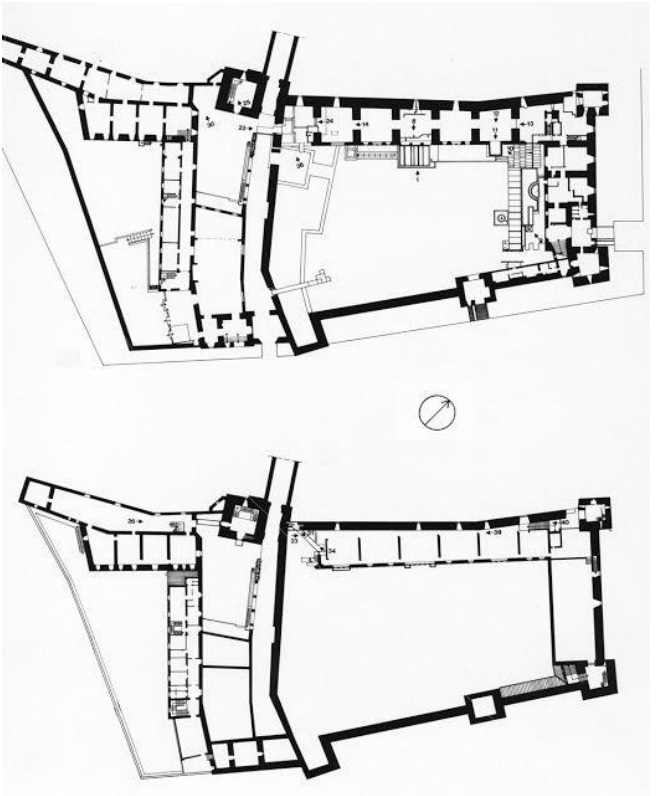


*Figure 13. Ground floor and first floor plan (URL-13)*

**Evaluation According to Semes's Strategies**

Semes divides Carlo Scarpa's work at Castelvecchio into two main groups: reinterpretation in the same style and abstract reference strategies. Scarpa does not simply copy the fabric of history. Instead,

he alters the scale, rhythm, and material logic of the space using modern methods. This ensures that the new intervention is distinct from the old. Carefully measured contrasts prevent the old and new from separating too quickly. I argue that Castelvecchio demonstrates that modern design can be distinctive without relying heavily on contrast. Scarpa's method, on the other hand, teaches how to honor the past while creating a new architectural style that is all your own. This is a great example of Semes's "balanced" approach, where the design doesn't rely too much on either copying everything or making things look very different.

**Neues Museum – David Chipperfield**

*"Abstract reference / controlled contrast"*

One of the closest examples of Semes's "abstract reference" strategy, the Neues Museum embodies the characteristics of "critical reconstruction" in that it makes the traces of war visible and creates a controlled contrast between the historical structure and the neutral, serene new additions (Table 2).

*Table 2 Semes's Strategies in Neues Museum*

| **Semes's Strategy** | **Neues Museum Application** | **Explanation** |
|---|---|---|
| **Replication** | ❌ Not applied | Missing or damaged parts have not been recreated through imitation or stylistic copying. |
| **Invention within the Same Style** | ✔️Partially applied | The original proportions and spatial logic have been respected, but the historical decorations have not been repeated. |
| **Abstract Reference** | ✔️Strongly applied | The new elements reference the historic building in terms of scale, alignment, and material tone, rather than form. |
| **Contrasting Approach** | ❌ Controlled | Contrast exists between old and new materials, but it is restrained and avoids visual dominance. |

*Source: Prepared by the author*

**Visual and Spatial Analysis**

Chipperfield's intervention at the Neues Museum is marked by visual restraint and continuity. Rather than aiming for a complete restoration, the design leaves historical damage and deficiencies visible, while new spatial elements are placed in a calm, distinct manner (Curtis, 2011). The key visual features are:

**Layered depth:**

The depth of space at the Neues Museum arises from the coexistence of original walls, damaged surfaces, and new planes within the same space. Depth is not created by sudden changes in level or strong differences in space. Instead, it arises from gradual changes between the building's old and new parts (Figure 14). This layered design lets visitors see different periods of history in the same space.



*Figure 14. Using both the original wall and the new additions together (URL-14)*

**Openings:**

Doors, passageways, and openings are treated with moderation and consistency. Existing openings are largely reused or subtly redefined rather than reinterpreted with new formal gestures.

These openings support visual continuity between spaces and reinforce a clear, legible circulation path throughout the museum (Curtis, 2011) (Figure 15).



*Figure 15. The openings were interpreted similarly (URL-15)*

**Contrast:**

There is a visual contrast between old and new, but this contrast is carefully controlled. Differences are expressed through material texture and surface condition rather than form (Figure 16). While the rough surfaces of historic walls remain visually dominant, smooth contemporary surfaces serve as a neutral backdrop that supports spatial clarity without competing with the historic fabric.



*Figure 16. Contrast (URL-16)*

Through these strategies, the Neues Museum offers a spatial experience grounded in balance and legibility. The relationship between old and new is clearly legible yet deliberately understated, allowing historical remnants to remain central to the visual experience.

**Material and Detail Analysis**

The use of materials at the Neues Museum is highly restrained. Rather than reconstructing damaged sections, Chipperfield introduces new materials that remain clearly distinguishable from the original texture while preserving clarity and continuity (Chipperfield, 2009).

**Distinction between old and new materials:**

Old materials like stone, plaster, and decorative elements have been kept even though they are broken or missing parts. The new materials, which are mostly smooth plaster surfaces and brick infill, are clearly modern and don't try to look like the old ones that are missing (Figure 17). This clear difference makes it easy for visitors to see the building's historical layers.



*Figure 17. Distinction between old and new materials (URL-17)*

**Processing of joints and connections:**

The connections between the new and old parts have been carefully made. Instead of drawing attention to the changes, the transitions have been kept calm and quiet. This approach makes the intervention easy to read and keeps the place open (Figure 18).



*Figure 18. Handling of joints and connections (URL-18)*

**Emphasis on craftsmanship:**

Craftsmanship is shown by how accurate and clear the work is, not by how pretty it is. Brickwork, surface treatments, and structural elements are carefully made to last and look the same. The change makes sense from an architectural point of view, and the work is of high quality without harming the historical remains.

**Controlled use of materials:**

Material choices are very limited. The building uses the same materials over and over again (brick, concrete, plaster, and stone), which keeps the style consistent. This intentional repetition balances the fragmented structure and prevents the eyes from taking in too much information at once (Figure 19).



*Figure 19. Controlled use of materials (URL-19)*

**Texture and physical experience:**

The difference between smooth, modern finishes and rough, old surfaces has a big effect on how the space feels. Visitors can see and feel the building because of the different textures that show that there are several historical layers (Figure 20).



*Figure 20. Texture and physical experience (URL-20)*

This material strategy enables the Neues Museum to balance preservation and modern intervention. The new materials contribute to the historical fabric without dominating it, supporting an approach grounded in openness, moderation, and respect for the existing structure.

**User Experience**

The addition to the Neues Museum significantly shapes how people use the museum. When people enter the building, they do not see a completely renovated and “smooth” museum. Instead, they see a layered space where traces of war, missing surfaces, and new alterations are visible together. Visitors can learn about the building's history and the exhibited works through the damage still visible on the walls, the simple and understated language of the new additions, and the new circulation routes. Thus, the building becomes more than just a place to display things; it becomes a space that reminds us of the past, shows us the present, and deliberately guides the user between the two.

**Evaluation According to Semes' Strategies**

According to Semes' ideas, the Neues Museum is more balanced than a completely imitative approach or a radical contrast approach. Chipperfield prefers to leave the historical building's flaws, traces, and lived-in characteristics visible rather than copying it entirely. He designs the new sections in a simple, neutral, and understated manner. This prevents a sharp conflict between the old and the new, yet you can still sense the presence of both periods. In this way, the Neues Museum exemplifies Seme's idea of "establishing a balanced relationship rather than completely imitating or completely breaking away."

**Louvre Pyramid – I. M. Pei**

*"Controlled contrast"*

On the other hand, the Louvre Pyramid is considered an iconic and radical modern addition that could be placed in the "controlled contrast" category within the strategies defined by Semes (Table 3).

*Table 3 Semes's Strategies in Louvre Pyramid*

| **Semes's Strategy** | **Application in Louvre Pyramid** | **Explanation** |
|---|---|---|
| **Replication** | ❌ Not applied | The intervention does not imitate the historic Louvre architecture or classical language. |
| **Reinterpretation in the same style** | ❌ Not applied | No attempt is made to reinterpret classical forms; instead, a radically contemporary expression is used. |
| **Abstract reference** | ✔️Partially present | The pyramid geometry references historical symbolism and order (geometry, axis, symmetry), but not stylistic features. |
| **Intentional contrast** | ✔️ Strongly applied | The glass-and-steel pyramid forms a clear, deliberate contrast with the historic stone palace and classical facades. |

*Source: Prepared by the author*

**Visual and Spatial Analysis**

The Louvre Pyramid by I. M. Pei changes the Louvre courtyard in a big way, both visually and spatially. The pyramid is a modern building that stands out in a historical setting. It does not try to blend in with the historical fabric.

Its fundamental visual characteristics are as follows:

**Layered depth**

This project doesn't use complicated internal layering to create depth. Instead, it uses the interaction between the clear pyramid and the surrounding thick historical courtyard (Figure 21). The light, crystal-like shape, surrounded by massive stone walls, gives the impression of being both solid and transparent. The underground hall beneath the pyramid provides an additional space that connects the courtyard to the museum's interior. This enables people to move between the two levels continuously.



*Figure 21. The layered perception created between the glass pyramid and the historic stone courtyard surrounding it (URL-21)*

**Openings**

The pyramid does not function merely as an object; it becomes the main entrance to the Louvre. Unlike traditional facade openings, circulation is concentrated at a single central access point. Thanks to the transparency of the glass cladding, the surrounding historic facades remain visually apparent even as they descend into the new spaces below. In this way, the visual communication between old and new is never interrupted (Figure 22).



*Figure 22. The glass pyramid maintains visual continuity with the historic facades while serving as a central transparent entry point (URL-22)*

**Contrast**

The design is defined by its use of contrast. The Louvre's heavy stone buildings are markedly different from the light glass-and-steel pyramid. This difference is shown through geometry (a sharp pyramid in a classical setting with layers of horizontal lines), materials (glass and stone), and atmosphere (light and transparent versus monumental and dense) (Figure 23). However, symmetry,

alignment with the main axis, and proportional harmony carefully control this contrast so that the pyramid doesn't look out of place or uninterested in its surroundings.



*Figure 23. A strong yet controlled contrast between the transparent pyramid and the Louvre's monumental stone facades (URL-23)*

**Material and Detail Analysis**

**The difference between old and new materials**

At the Louvre, the difference in materials between the historic structure and the new intervention is one of the most striking details. While the palace is defined by its striking heavy stone facades, the pyramid is constructed entirely of glass and steel (Figure 24). This stark contrast enables visitors to readily distinguish which sections pertain to the past and which are contemporary additions (Rustow, 1990).

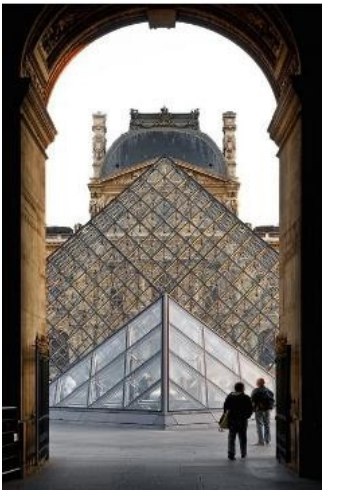


*Figure 24. The difference between old and new materials (URL-24)*

**Treatment of joints and connections**

The point where the pyramid meets the historic courtyard has been handled with sensitivity and clarity. Rather than attempting to "blend" the old and new surfaces, Pei has kept the connections clean, sharp, and technically explicit (Figure 25). The glass structure does not appear to merge with the stone walls; instead, the connection lines remain fully legible and clarify the boundary between interventions for users.



*Figure 25. Connections (URL-25)*

**Emphasis on craftsmanship**

The pyramid was constructed with a high level of technical workmanship and craftsmanship. The careful alignment of the glass panels, the accuracy of the steel connections, and the overall precision of the structure reflect advanced engineering and design discipline. This results in a contemporary form of craftsmanship that is distinct from traditional stonework yet shares similar architectural value.

**Controlled use of materials**

The use of materials is intentionally limited. Pei doesn't use a variety of surfaces or decorative elements. Instead, he mostly uses glass and steel. This limited color scheme makes the courtyard appear calm and prevents it from appearing overly busy. The simplicity of the material expression makes the intervention clearer and helps the architecture be more readable (Rustow, 1990).

**Texture and physical experience**

The Louvre's smooth, shiny glass surfaces and rough, weathered stone facades are meant to look different from each other. This contrast shapes how people feel about the space: the pyramid feels lighter, more open, and more temporary, while the palace feels huge and permanent (Figure 26). Users always feel both historical depth and modern presence because of this tactile and atmospheric contrast.



*Figure 26. Textures (URL-26)*

**User Experience**

The Louvre Pyramid is more than just a way in; it's an experience. The pyramid is a strong focal point in the courtyard that visitors see first. However, because the glass is clear, the historic palace facades are never lost. So, moving from the large foyer to the underground area is not just a physical movement; it's also a visual and sensory experience. The light, clear pyramid next to the heavy, monumental stone blocks creates an atmosphere that makes the visitor feel both the past and the present in the same space. So, the pyramid is more than just a functional entrance; it becomes part of the experience of being in the historic building.

**Evaluation According to Semes' Strategies**

Semes believes the Louvre Pyramid is the best example of the "conscious contrast" strategy. The pyramid doesn't attempt to resemble or replicate the historic building; instead, it uses glass and steel to create a modern architectural language. However, it is not a

building that is completely separate from the surrounding area. The courtyard's symmetry, axial arrangement, and connection to the overall spatial design create a strong contrast, yet they also establish a harmonious balance with the rest of the space. So, the pyramid doesn't take a stance based only on "harmony" or "disconnection." Instead, it can be seen as a controlled yet bold modern addition that stands out from the historic setting.

## CONCLUSION

The goal of this study was to examine how new buildings can integrate with existing ones. As noted in this study, the success of a modern addition cannot be determined solely by whether it is harmonious or contrasting. What really matters is how well the intervention fits the setting, how clearly the choices of scale and materials are made, and how the old and the new are read together. In this case, the Castelvecchio, Neues Museum, and Louvre Pyramid are all good examples. Scarpa's approach follows a line that connects to the historical structure and explains it. Chipperfield, by contrast, has made a more balanced change that preserves traces of the past.

Pei's pyramid has a bolder, more pronounced contrast, yet it still connects with the historical surroundings through order and symmetry. Even though these three examples take different paths, they all share one thing in common: they achieve good results through design choices that are respectful, thoughtful, and well-reasoned.

This study shows that there is no single right way to add to historical environments; each structure must be considered in its own context and cultural background. Through these well-established relationships, historical structures can become more than merely buildings kept in good condition; they can become architectural entities that connect with the present and endure.

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# CHAPTER 5

# ASSESSING SUSTAINABLE URBAN DIGITAL TWIN READINESS: CASE STUDIES OF SINGAPORE, TOKYO, AND DUBAI

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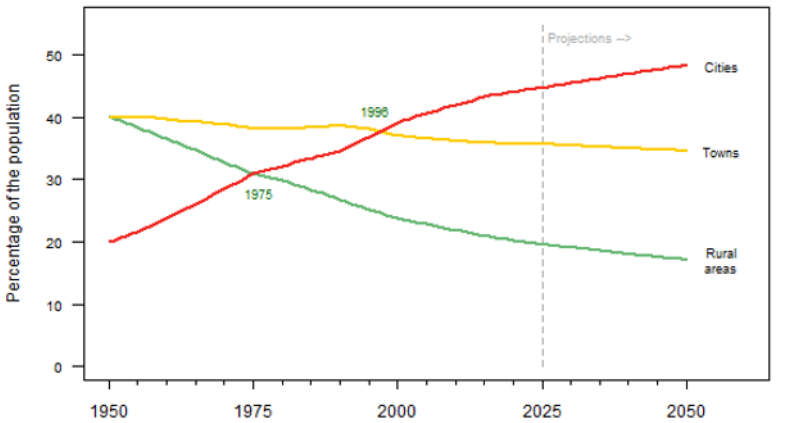
## Introduction

Need for sustainable practices has become highly critical in the context of urbanization, climate change, complex infrastructure, and increasing demands for data-based governance. Currently, more people live in urban areas than those living in villages and small towns. As depicted by the graph in Figure 1, while 20% of the world's population lived in urban areas in 1950, 45% were living in urban areas by 2025 (United Nations, 2025). With the increasing pace of urbanization around the world, the increasing population

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gives rise to increasing demands concerning the issues of climate change, complexities of infrastructures, and the effective use of public services (The World Bank, 2010; World Cities Report, 2024). The concept of the smart city model in this case aims at improving the measurability, traceability, and manageability of urban services using technology such as sensor networks, big data, artificial intelligence (AI), and geographic information systems (GIS).

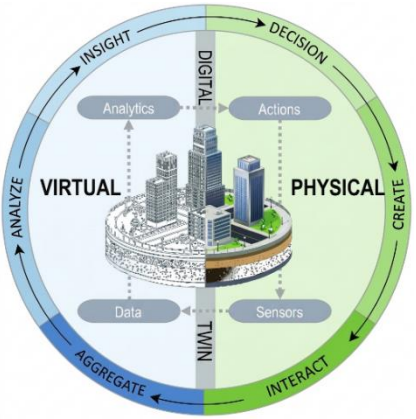
*Figure 1. Distribution of the world population by settlement type*




*Reference: United Nations, 2025*

A Digital Twin (DT) is based on a vast amount of collected, accumulated, and real-time data from the physical world, hence creating a DT of the physical city to optimize the urban performance of the latter (Figure 2). This data helps to build digital models of cities which give us an insight about urban performance. In turn, this model supports interventions in the physical world including the change in modes of transport or urban planning (Petrova-Antonova & Ilieva, 2019).

*Figure 2. Digital Twin (DT)*




*Reference: Petrova-Antonova & Ilieva, 2019*

There have been various scientific inquiries about virtual urban models, which are viewed as Digital Twins (DTs), in the fields of performance evaluation and digital transformation of smart cities. Weil et al. (2023) in their research explain that an urban digital twin is not just a three-dimensional model of a city, but rather a dynamically changing digital model of an urban physical system that includes semantic data, live streaming sensors, physical modeling, and simulations. The popularity and significance of the DT concept in an urban environment can be explained by its transformative impact on smart city infrastructure planning and management. Bibliometric analysis done by Omrany et al. (2025) regarding the built environment reveals that existing implementations of the concept are just "lite" versions of the same without many features as opposed to full DTs. VanDerHorn & Mahadevan (2021) brought together different viewpoints related to the term DT concept. Through analyzing the theory of design thinking DT from both scientific and cultural perspectives, Caprari et al. (2022) define the intersection between international policy structures and the local requirements or desires. For that purpose, they provide a comparative study of six cases of DT and show its practical use and

focus areas. In his work on Urban Digital Twins (UDTs), Mazzetto (2024) highlights the important role of UDTs as an instrument for achieving smarter cities, emphasizing sustainable planning in particular. Additionally, Peldon et al. (2024) examine the dynamics of DTs, the multi-layered technological aspect of DTs, and their ability to impact the sustainability of urban futures. According to Lifelo et al. (2024), an AI-powered metaverse is revolutionary in terms of fostering the growth of sustainable smart cities.

As part of the review of the literature, urban digital twins UDTs can be defined as a system that is able to integrate information, modeling, simulation, and feedback to facilitate adaptive decision-making processes in urban settings. In this research, an approach is developed for comparing sustainable urban digital twins (SUDTs) through the case studies of three leading smart cities: Singapore, Tokyo, and Dubai. The aim of this study is to evaluate smart city systems in terms of their SUDT readiness level using a document-based qualitative comparative case analysis methodology. Singapore, Tokyo, and Dubai were selected as they represent frequently cited benchmarks in the smart city domain while exemplifying distinct governance traditions and climatic contexts. The evaluation was conducted across five dimensions: data integration and digital twin architecture; open data, governance, and institutional capacity; analytics, scenario modeling, and decision support; smart built environment and urban energy; climate and sustainability nexus (mitigation/adaptation); and overall sustainable urban digital twin readiness. Each dimension was classified as High, Medium, or Limited based on the directness and consistency of the empirical evidence: High indicates instances where direct, consistent evidence is corroborated across multiple sources, establishing an explicit link between the digital system and decision support, public service, or sustainability targets. Medium denotes cases where direct or indirect evidence is present, yet ambiguities persist regarding

scale, integration, continuity, or tangible environmental outcomes. Limited designates conditions where only policy intent, isolated pilot implementations, or indirect evidence can be substantiated.

## Methodology

This study uses a document-based qualitative comparative case analysis approach to investigate the readiness level of urban DTs within the sustainability paradigm. Based on such an approach, the research comparatively analyzes the prospects of smart urban digital twins (SUDTs) in the implementation of cities in Singapore, Tokyo, and Dubai. The choice of these cities is explained by the international recognition of these places regarding data-driven urban governance, digital infrastructure, smart mobility, built environment technologies, and sustainability policies, but at the same time, it represents different contexts administratively, geographically, and technologically. Data used in the research were developed based on tables created by the authors on the basis of an extensive analysis of peer-reviewed indexed journal articles, official strategies of municipalities, open data platforms, DT and 3D city models projects and other reports. In the study conducted by Weil et al. (2023), the fundamental challenges encountered in the implementation of DTs were outlined as interoperability and semantics; infrastructure, including storage, computation, network; data acquisition and actuation; data quality and harmonization; modeling, simulation and decision-support; data visualization and information display; resources (human, capital etc.); and governance, organizational and social aspects. Based on the analyses conducted in this study, assessments were executed for each city grounded in these evaluation dimensions and the examined indicators. Throughout the evaluation process, the empirical findings obtained for each city were classified according to the evaluation parameters delineated in Table 1. As presented in Table 2, the evaluation dimensions for each city were qualitatively rated as High, Medium, or Limited,

contingent upon the scope and depth of evidence identified across the reviewed sources.

*Table 1. Layered evaluation dimensions and indicators considered as evidence*

| Dimension | Evaluation Dimension | Examined Indicators |
|---|---|---|
| D1 | Data integration & digital twin architecture | Data synthesis using data gathered from various sources within a single context; use of semantic data modeling and data interoperability standards such as IFC, CityGML, and API specifications; provision for ongoing maintenance of model updating; and definition of the spatial or evidential scale at which the data are produced. |
| D2 | Open data, governance & institutional capacity | Data portals, data sharing, e-government, coordination among agencies, citizen involvement, and data governance. |
| D3 | Analysis, scenario assessment & decision support | Capabilities demonstration regarding simulations or optimizations; comparisons in various scenarios; combination of results from analysis with decision making processes in planning or policy areas; and feedback loops from the real world into the virtual world. |
| D4 | Smart built environment & urban energy | The monitoring and management of building and infrastructure stock using DT technologies; carrying out energy modeling, solar potential assessment, and retrofits analysis at building and urban levels; incorporation of all these in the decision-making of asset management; and defining clearly the level of application. |
| D5 | Climate–sustainability linkage (mitigation / adaptation) | Testing climate targets as model-based scenarios; quantification of carbon, urban heat, flood, water, or air quality metrics; distinct labeling of mitigation and adaptation evidence; and explicit delineation of sectoral components (e.g., low-carbon mobility). |
| S | Overall sustainable urban digital twin readiness | Derived from cells D1–D5 according to the rule defined in Table 2; no separate empirical evidence is collected. The governing dimension and the predominant scale of evidence are reported concurrently. |

*Table 2. Evidence level definitions*

| Level | Definition |
|---|---|
| High (H) | Direct and consistent evidence corroborated across multiple peer-reviewed sources; evidence generated at the city scale; and an explicit link established between the digital system and decision support, public services, or sustainability targets. |
| Medium (M) | Presence of direct or indirect evidence; however, persistent ambiguities regarding scale (building/district-level), integration, continuity, or tangible environmental outcomes. |
| Limited (L) | Presence of only policy intent, isolated pilot implementations, or indirect evidence; or reliance of evidence solely on non-peer-reviewed institutional documents. |

## Results & Discussion

### Singapore

The foundational steps in Singapore were initiated during the 1980s under an information technology master plan aimed at enhancing public services within the framework of the government's vision to pioneer quality of life. This initiative unlocked expanding opportunities across technology, industry, governance, and socioeconomic collaborations (Foo & Pan, 2016). With the help of innovative initiatives and contributions towards the policymaking process, the country has crossed the conventional limits of a smart city and is moving forward to achieve its goal of becoming the first 'Smart Nation' (Cavada et al., 2019). Technologically-assisted solutions have been created in response to changing needs, facilitating smooth engagement and transactions between citizens and government, as well as among citizens (Kemeç, 2022). These strong policies led to Singapore becoming a significant global player in terms of commerce, finances, and transportation (Hoe, 2016).

CODEX (Core Operations, Development Environment, and eXchange), a digital government system, was developed through the use of Information and Communication Technologies (ICT) to enhance public service delivery and increase government effectiveness. To make public data understandable and available to

citizens, the Open Government Data portal in Singapore was introduced, featuring datasets from seventy public agencies covering a variety of sectors such as finance, infrastructure, community, and environment (Chan, 2013; Jiang et al., 2023). Driven by the proliferation of big data, an array of 'analytics and design' tools were developed to gather, process, and analyze information, laying the groundwork for comprehensive investigations and implementations, alongside Spatial Data Analytics designed to support multidimensional urban planning assessments. Furthermore, AI Singapore was initiated to integrate the entire ecosystem—comprising Singapore-based artificial intelligence enterprises, researchers, universities, and AI startups—into entrepreneurial innovation (Teddy-Ang & Toh, 2020; Jiang et al., 2023). The assessment of Singapore's UDT dimensions is presented in Table 3.

*Table 3. Assessment of Singapore's UDT dimensions*

| Dimension | Literature Review | Scale of evidence | Level of evidence |
|---|---|---|---|
| D1 | Lu and Li (2026) examined urban systems at the city scale by proposing a digital-twin-driven urban life-cycle paradigm. Their study encompasses sensing, data platforms, analytical modeling, service integration, and application scenarios. Nazım and Joyce (2024) emphasized that City Digital Twins (CDTs) play a pivotal role in aggregating and visualizing complex urban big data. Focusing on the Virtual Singapore (VSg) CDT platform, their research investigated how the platform's existing data, interaction, and 3D visualization capabilities could facilitate rapid prototyping through generative machine learning techniques trained on the city's unique planning fabric. | City; (Indirect) | High |
| D2 | Diaz-Sarachaga (2025) applied a governance evaluation framework developed for urban DTs to the case of Singapore, identifying a high level of governance maturity. Lu and Li (2026) emphasized how digital twins can transcend isolated pilot projects to function as an enabling infrastructure for coordinated urban governance. Jiang et al. (2023) stated that Singapore's open government data portal was established to render public sector data accessible and intelligible to citizens, thereby empowering private enterprises, research institutions, and individuals to drive civic innovation and creative campaigns; they noted that the repository aggregates datasets from 70 public agencies spanning domains such as finance, infrastructure, society, and the environment. | City; Neighborhood/ District | High |

| | | | |
|---|---|---|---|
| | Furthermore, Ho (2017) highlighted that Singapore adopts a hybrid governance approach—combining technocratic oversight with platform-driven mechanisms—to address urban challenges. | | |
| D3 | Papyshev and Yarime (2021) proposed a task-based approach to urban mobility data generation. Alva et al. (2024) introduced an UDT—GHG Application designed for decision-makers to support decarbonization initiatives and the reduction of operational building greenhouse gas emissions in Singapore. Jiang et al. (2023) noted that institutional planning analytics units inform planning decisions through analyses of accessibility, mobility patterns, and public amenity distribution. Ignatius et al. (2019) demonstrated that testing both empirical and physics-based models contributes to the formulation of urban cooling strategies; they emphasized a workflow methodology integrating a 3D model retrieved from a city-scale DT database with urban canopy modeling and building energy simulation, aiming to establish a platform capable of conducting building-scale energy simulations. Furthermore, Nazım and Joyce (2024) demonstrated at the neighborhood scale how design options generated via deep learning can be conveyed to decision-makers through in-platform analytics and collaborative functionalities. | City; Building | High |
| D4 | Alva et al. (2024) presented an UDT—GHG Application tailored for decision-makers to support Singapore's building greenhouse gas emission reduction and decarbonization initiatives. Gobeawan et al. (2018) proposed a tree-modeling framework for VSg, articulating a comprehensive methodology for data acquisition via LiDAR (Light Detection and Ranging) and satellite imagery, tree extraction and digitization, and 3D tree reconstruction. Furthermore, Ignatius et al. (2019) leveraged the VSg database to investigate the development of an integrated simulation platform, termed BESCAM, for climate assessment and district-scale energy demand. Accounting for microclimatic conditions, their work focuses on urban canopy modeling and building energy simulation. | City; Building | High |
| D5 | Alva et al. (2024) focused on quantifying operational greenhouse gas emissions, establishing emission benchmarks, and evaluating decarbonization pathways within the built environment sector. Cavada et al. (2019) identified 52 initiatives deployed toward realizing Singapore's ambition of becoming a 'smart' city. Employing their proprietary SMART analytical framework across four core assessment domains—Society, Environment, Economy & Finance, and Governance & Policy—they evaluated these 52 smart initiatives, concluding that environmental and climatic dimensions lag behind the social dimension within Singapore's smart city agenda. | City; Neighborhood/ District | High |

**Tokyo**

Being a populous city, there are several transportation problems that have been solved by Tokyo using smart mobility. It is an important aspect of the smart mobility concept through its highly integrated public transport system. With the help of an efficient and comprehensive transportation system of trains, subways, and buses, a lot of importance is laid upon multimodal integration, which is helped by synchronized timetables and transit hubs. Sustainability serves as one of the critical components of the smart city of Tokyo; therefore, the adoption of electric vehicles (EVs) is encouraged in order to curb carbon emission and air pollution. Besides, there are smart parking systems that are made through the use of sensors and digital signs. The government, in partnership with transport operators and research centers, aims at providing efficient and environmentally friendly means of transport by utilizing modern technology, improving transport services, and encouraging innovation (Wolniak & Grebski, 2023).

As a DT and smart city initiative, the Tokyo Smart Resilience Platform is led by the Tokyo Metropolitan Government. Aiming to enhance urban resilience, this initiative enables the development of emergency response plans by synthesizing three-dimensional (3D) digital urban models, transportation networks, real-time river water levels, and other infrastructural datasets. Furthermore, the system accommodates social dimensions, such as the spatial analysis of transit accessibility and safety (Sarıışık & Ercoşkun, 2026). The assessment of Tokyo's UDT dimensions is presented in Table 4.

*Table 4. Assessment of Tokyo's UDT dimensions*

| Dimension | Literature Review | Scale of evidence | Level of evidence |
|---|---|---|---|
| D1 | Zeng et al. (2025) presented an urban heat management model for the Nihonbashi district of Tokyo by utilizing urban DTs—dynamic virtual replicas that integrate real-time data to simulate and optimize urban systems. Focusing likewise on Tokyo's Nihonbashi district, Ramnarine et al. (2025) proposed an urban DT framework incorporating an interactive platform for digital | Neighborhood/ District | Medium |

| | | | |
|---|---|---|---|
| | representation, performance modeling, and design interventions and decisions; they introduced a system-architecture-based methodological framework to model urban regeneration pathways aimed at achieving carbon neutrality. Furthermore, treating Tokyo's Nihonbashi District as a case study, Alorabi et al. (2025) presented a data-driven framework designed to transition high-density urban areas toward carbon neutrality through the integration of generative design, multi-objective optimization, and interactive UDT. | | |
| D2 | Drawing on interviews conducted with smart community stakeholders, Granier and Kudo (2016) comparatively analyzed how citizen engagement is structured within energy projects. Goonesekera and Olazabal (2022) focused on a multi-city evaluation system assessing adaptation indicators and metrics within urban climate plans across several global cities, including Tokyo. | City | Medium |
| D3 | For the Nihonbashi district in Tokyo, Zeng et al. (2025) formulated a four-stage scenario planning methodology to comparatively simulate thermal risk scenarios through the deployment of urban DTs. Investigating the Nihonbashi District of Tokyo as a case study, Alorabi et al. (2025) presented a data-driven framework aimed at transforming high-density urban areas toward carbon neutrality by integrating Generative Design, Multi-Objective Optimization, and interactive UDT. Furthermore, within a system architecture approach, Ramnarine et al. (2025) evaluated alternative pathways toward achieving carbon neutrality. | Neighborhood/ District | Medium |
| D4 | Targeting carbon neutrality, Ramnarine et al. (2025) modeled district-scale retrofits and operational enhancements through a system architecture approach. Alorabi et al. (2025) optimized building-scale energy decisions at the district level through a generative-design-driven net-zero district framework. The study conducted by Zeng et al. (2025) incorporates thermal risk, resilience hub occupancy rates, and open space variables. Furthermore, based on interviews conducted with smart community stakeholders, Granier and Kudo (2016) examined building- and neighborhood-level energy systems in conjunction with participatory processes in energy projects. | Neighborhood/ District | Medium |
| D5 | Ramnarine et al. (2025) indicated that energy use intensity could be significantly curtailed at the scale of Tokyo's Nihonbashi district in line with carbon neutrality targets. In the study by Alorabi et al. (2025), scenarios targeting carbon neutrality were generated via multi-objective optimization. Zeng et al. (2025) resolved the intra-district distribution of thermal risk and vulnerability through the deployment of an UDT, although empirical carbon reductions were not reported. Furthermore, Goonesekera and Olazabal (2022) conducted a multi-city evaluation of the operationalization of adaptation indicators and metrics across urban climate action plans. | City; Neighborhood/ District | Medium |

**Dubai**

Dubai's innovation policy is strategically structured to cultivate an institutional culture of innovation across organizational and work environments. Numerous science parks and technological free zones have been created in the bid to encourage innovation and attract entrepreneurial firms into the city. Concurrently, to foster emerging technologies and startup ventures, the Smart Dubai Entrepreneurship Initiative was deployed, encompassing three flagship programs: (i) the Global Blockchain Challenge, (ii) the Dubai Smart City Accelerator, and (iii) the Dubai Future Accelerators. Serving as a central backbone for data ingestion and utilization, 'Dubai Pulse' operates as an integrated platform delivering compute, storage, and analytics services tailored to diverse departmental requirements across municipal and governmental entities. Furthermore, the Smart Dubai Office channels analytical data and public digital services through a unified mobile application titled 'Dubai Now,' which enables citizens to manage utility bills, track visa statuses, renew commercial trade licenses, register vehicles, plan multimodal transit routes, and monitor health-related metrics (Noori et al., 2020).

The effective use of smart mobility solutions, which can contribute significantly to improving urban mobility, necessitates a well-balanced blend of social, environmental, and technical aspects (Almheiri et al., 2026). Focusing on issues such as safety, efficiency, sustainability, and improving accessibility, intelligent transportation systems seek to increase safety, decrease congestion, and minimize the negative effects on the environment (Nikitas et al., 2017). Furthermore, the synthesis of the Internet of Things (IoT), big data analytics, and AI enables an advanced transit safety ecosystem capable of analyzing user behaviors and urban mobility dynamics in real time (Papageorgiou et al., 2024). The evaluation of Dubai's UDT dimensions is presented in Table 5.

*Table 5. Assessment of Dubai's UDT dimensions*

| Dimension | Literature Review | Scale of evidence | Level of evidence |
|---|---|---|---|
| D1 | Abuhani (2025) investigated the city of Dubai by leveraging open datasets to analyze the impact of city-scale flood events on critical infrastructure accessibility; however, the study does not present an integrated DT system. Addressing the Urban Heat Island effect—a major urban climatic challenge—Tarkhan et al. (2025) utilized zero-shot learning paradigms to map facade materials, with the primary focus directed toward data acquisition rather than an integrated DT architecture. Furthermore, Mazzetto (2024) examined critical drivers in the development of smart cities, placing central emphasis on CDTs and their capacity to foster more sustainable, well-planned urban environments. | City (Indirect) | Medium |
| D2 | The city-scale flood analysis in the study by Abuhani (2025) relies on the integration of heterogeneous open datasets. Biygautane and Clegg (2024) analyzed Dubai's smart city paradigm through a public policy lens, highlighting the critical role that institutional capacity plays in operationalizing public-private partnership models. Furthermore, Almheiri et al. (2026) evaluated smart city implementations in Dubai across sustainable development dimensions, assessing initiatives such as e-government and clean mobility through a system archetypes methodology. | City | Medium |
| D3 | Abuhani (2025) demonstrates an analytical capability at the city scale through flood impact analysis. However, it is noted that the study does not incorporate hydraulic simulations, dynamic scenario evaluations, or closed-loop feedback mechanisms; the methodology relies strictly on open-source datasets derived from a single historical event, deferring such simulation frameworks to future research. Similarly, while Tarkhan et al. (2025) discuss the potential of facade material mapping to inform decision-making processes for urban climate adaptation policies, their study does not integrate an operational decision-support component. | City; Building | Limited |
| D4 | In the study conducted by Tarkhan et al. (2025), facade material mapping provides spatial inputs for microclimate modeling at the city scale. Mankani et al. (2025) examined thermal retrofits and the comfort–energy trade-off in a LEED Gold-certified campus building by leveraging a calibrated digital twin developed using thermal modeling software. | City; Building | Medium |
| D5 | Abuhani (2025) modeled the impacts of flood events on critical infrastructure at the city scale. Tarkhan et al. (2025) generated surface attribute layers for urban heat island analysis. Furthermore, Almheiri et al. (2026) correlated carbon emission and air pollution patterns with clean mobility and e-government initiatives, evaluating them through qualitative system analysis. | City; Building | Medium |

## Comparative Evaluation of Case Studies

When the evaluation dimensions across the three investigated cities are considered collectively, distinct disparities in their readiness levels emerge. In Singapore, a mature infrastructure underpinned by multimodal integration and dynamic data management (Wolniak & Grebski, 2023), coupled with national-scale DT platforms such as VSg that synthesize the built environment with urban simulations (Papyshev & Yarime, 2021), substantially enhances its SUDT potential. Smart mobility and smart cities in Tokyo, along with the climate change adaptation strategies, have good technological capacity owing to institutional alignment and smart grid systems. However, despite this institutional and infrastructural robustness, methodological constraints in monitoring mechanisms hinder the development of a comprehensive SUDT ecosystem in Tokyo (Goonesekera & Olazabal, 2022; Granier & Kudo, 2016). Dubai, while supported by strong leadership vision and institutional-scale DT initiatives (Almheiri et al., 2026; Mazzetto, 2024), exhibits moderate potential for developing a holistic SUDT due to infrastructural strains driven by rapid demographic growth (Almheiri et al., 2026; Tarkhan et al., 2025), coupled with cybersecurity and data privacy constraints (Mazzetto, 2024). A consolidated assessment of these findings is presented in Table 6.

*Table 6. Summary evaluation matrix*

| City | D1 | D2 | D3 | D4 | D5 | Synthesis | Governing dimension | Dominant spatial scale of evidence |
|---|---|---|---|---|---|---|---|---|
| Singapore | H | H | H | H | H | H | - | City |
| Tokyo | M | M | M | M | M | M | Neighborhood/ district scale of evidence | Neighborhood/ District |
| Dubai | M | M | L | M | M | M | D3 (Limited) | City; Building |

The data synthesized above and presented in Table 6 have been analyzed to reveal that within the five dimensional evaluation

model used to determine the SUDT readiness levels and evidence scales of the three selected metropolises, Singapore appears to be the only city ranked at the High readiness level, as it shows clear and concrete evidence on every dimension examined at the city level: data integration (D1), open data, governance (D2), analysis scenerio and decision support (D3), smart built environment (D4), and climate-sustainability linkage (D5). Tokyo, on the other hand, was rated as Medium on all evaluated dimensions, as well as on the overall synthesis. The key constraint associated with Tokyo is based on the fact that despite the use of advanced energy management systems, microclimate simulations, and generative design applications, the resultant data is largely confined to the neighborhood/district level (Nihonbashi). Dubai, while classified within the 'Medium' category in terms of overall readiness, represents the case where cross-dimensional asymmetry is most pronounced. Although the city demonstrates a 'Medium' capacity across dimensions D1, D2, D4, and D5—underpinned by a strong institutional vision, e-government integration, and three-dimensional urban models—it is rated as 'Limited' in the analytics and decision support (D3) dimension. The governing dimension constraining Dubai's SUDT potential lies in the fact that dynamic scenario assessment for urban risks, hydraulic/climatological simulations, and empirical evidence of closed-loop feedback directly informing decision-making processes have not yet been institutionalized into operational workflows.

## Conclusion & Future Work

This study comparatively evaluated the smart city systems of Singapore, Tokyo, and Dubai through a five-dimensional analytical framework in terms of SUDT readiness levels. The empirical findings reveal marked disparities between the cities' technological capabilities and their maturity in governance and decision support:

- Singapore (High): Achieved the highest readiness level by demonstrating direct, city-scale empirical evidence across all evaluated dimensions. The flagships that include VSg and GHG App have implemented the end-to-end closed loop feedback system by linking the built environment, energy, and carbon mitigation models directly to the decision-makers.
- Tokyo (Moderate): Despite the presence of an extensive smart grid network system and integrated transport systems, the level of readiness potential for Tokyo is moderate. The reason for this is that climate and energy modeling for urban heat and building performance is constrained to the district scale (Nihonbashi).
- Dubai (Medium): Though Dubai demonstrates good levels of decisive leadership by the government, integration of e-government services and implementation of 3D twin at enterprise level, it is at a medium level of preparedness. The factors contributing to this are absence of scenario modeling and feedback loops, traffic congestion caused due to increase in population, and issues with cybersecurity and privacy of data.

In conclusion, the sustainability and effectiveness of SUDT ecosystem are not only contingent upon the availability of sophisticated sensor networks and 3D modeling technologies, but more importantly upon the ability to scale up simulations to the city level, their integration into decision making processes, and the creation of data governance mechanisms that will ensure security and transparency of data use. Future research should focus on scaling up this analysis to the metropolitan scale within different geographical settings and degrees of development, as well as

empirical validation of city-scale microclimate simulations and generative design models.

## Declaration of AI and AI-assisted technologies in the writing process

During the preparation of this work the authors used AI in order to improve several important aspects of writing, such as readability, grammar, spelling, and tone of the text.

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# CHAPTER 6

# NEURO-MORPHOLOGY THE RELATIONSHIP BETWEEN URBAN FORM, SPATIAL COGNITION, AND HUMAN EXPERIENCE

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## Introduction

### The Cognitive Shift in Urban Disciplines: The Epistemological Framework of Neuro-Morphology

Traditional urban planning and design paradigms have historically conceptualized urban space primarily through static macro-level indicators, such as land-use zoning, floor area ratios, physical density, infrastructure capacity, and transportation accessibility (Yang et al., 2026). However, the intensive urbanization of the 21st century coupled with escalating urban psychosocial stressors, anxiety disorders, and cognitive exhaustion has exposed the profound limitations of purely functionalist frameworks (UN-Habitat, 2022). In response, the emerging interdisciplinary paradigms of neurourbanism and neuroarchitecture have asserted that the built environment must be systematically evaluated through its direct, real-time impacts on human neurophysiology, autonomic nervous system (ANS) regulation, and brain network activation (Adli et al., 2017; Ancora et al., 2022).

Within this paradigm shift, Neuro-Morphology is defined as an integrative scientific sub-field examining how the specific spatial, geometric, volumetric, and compositional attributes of the built environment such as urban fabric porosity, solid-to-void ratios, street enclosure, facade ornamentation, and fractal dimensions modulate neuronal circuitries, endocrine responses, and autonomic nervous system dynamics (Lavdas, 2026). This epistemological transition redefines the city from an inert physical container into a dynamic, active cognitive infrastructure that continuously shapes human perception, stress regulation, emotional valence, and spatial memory (Marvin & Zhang, 2026).

**Neuro-Affective Theories of Human-Space Interaction**

The neurobiological mechanisms connecting urban geometry to physiological and mental states are grounded in three complementary theoretical models:

Stress Reduction Theory (SRT): Developed by Ulrich (1983), this evolutionary psycho-biological model posits that visual exposure to natural geometries and harmonious spatial configurations triggers an immediate, pre-attentive affective response in the autonomic nervous system. Before conscious cognitive processing occurs, biophilic and visually coherent spatial features induce rapid sympathetic downregulation, reducing heart rate, blood pressure, and circulating cortisol levels (Aghanejad et al., 2026; Brunner et al., 2026; Lavdas, 2026). Human evolutionary biology adapted to natural 'living geometries'; consequently, built environments exhibiting non-Euclidean, organic visual patterns significantly alleviating cardiovascular load.

**Attention Restoration Theory (ART):** Formulated by Kaplan and Kaplan (1989), ART focuses on prefrontal cortical cognitive architecture. Modern urban environments demand continuous, highly focused attention to navigate complex traffic,

visual clutter, and artificial signals. This prolonged expenditure depletes top-down executive control resources in the prefrontal cortex (PFC), culminating in directed attention fatigue. Environments offering 'soft fascination', visual legibility, and a sense of 'being away' allow executive neural networks to rest and restore cognitive capacity (Aghanejad et al., 2026; Brunner et al., 2026).

Somatic Marker Hypothesis and Approach-Avoidance Mechanisms: Damasio's (1996) neuro-cognitive model explains how spatial navigation decisions are directed by emotional processing within the amygdala-hippocampal axis. Morphological cues such as sightline obstruction, ceiling height, and lighting gradients generate subconscious somatic markers (visceral bodily reactions) that dictate instinctive approach or avoidance behaviors long before explicit rational deliberation takes place (Choi & Cheng, 2026).

## Multi-Scale Perceptual Architecture: From Macro-Structures to Micro-Spatial Scenes

Human spatial perception operates non-homogeneously across distinct spatial scales, eliciting fundamentally different neuro-cognitive responses (Nguyen et al., 2026; Yang et al., 2026). Urban perceptual architecture is hierarchically modeled across three primary tiers:

**Macro-Scale (City/Network Level):** Involves regional street networks, urban macro-form, and structural spines. Cognitive engagement at this scale relies heavily on active wayfinding, topological mental mapping, and hippocampal spatial memory consolidation (Yang et al., 2026).

**Meso-Scale (Neighborhood Level):** Defined by land-use mix, service accessibility, and street connectivity. It governs sustained environmental exposure, community cohesion, and place attachment over extended temporal horizons.

**Micro-Scale (Public Space/Scene Level):** The immediate human-body sensory interface, characterized by street enclosure, sidewalk width, facade textures, lighting, noise, and green view indices. This scale directly triggers instinctive autonomic nervous system reactions.

Empirical findings demonstrate that emotional and neuro-physiological intensity follows a U-shaped non-linear pattern across scales, peaking at the immediate micro-scale (unconscious sensory exposure) and the macro-scale (symbolic legibility and identity) (Nguyen et al., 2026). Consequently, urban morphological interventions must account for spatial non-stationarity and non-linear threshold effects rather than assuming uniform linear relationships across scales.

## Morphological Metrics of Urban Form and Their Neuro-Cognitive Repercussions

### Vertical and Horizontal Scale Morphology: Building Heights, Enclosure, and Width/Height Ratios

Vertical massing (building height) and horizontal spatial containment (street width and enclosure) represent fundamental geometric parameters directly modulating cerebral arousal and autonomic stress levels. Electroencephalographic (EEG) investigations reveal that dense vertical massing and high-rise street canyons induce a significant power spectral density (PSD) increase in the Beta (β) frequency band (13–30 Hz) across frontal and parietal cortical regions (Nakata et al., 2026). Elevated Beta activity reflects heightened visual search, active vigilance, and increased cognitive load. When combined with environmental stressors such as vehicular traffic and narrow sidewalks, this high-arousal state manifests as elevated Galvanic Skin Response (GSR/EDA), signaling sympathetic autonomic stress (Er et al., 2026). Conversely,

low-rise, pedestrian-oriented street corridors suppress sympathetic tone and promote parasympathetic relaxation.

The Spatial Openness Level (SOL) and street enclosure ratio strongly predict psychological comfort and emotional valence. In neuro-cognitive studies examining older adults exposed to diverse streetscapes, spatial openness accounted for a highly significant proportion of variance in emotional state ($R^2=0.7262, p<0.01$). Balanced spatial enclosure provides an evolutionary sense of 'refuge', dampening threat-detection neural circuits centered in the amygdala.

Furthermore, non-linear relationships exist between the Street Width-to-Height (W/H) Ratio and brainwave oscillations. Functional neuro-physiological comparisons between traditional human-scale streetscapes (Beijing Hutongs) and modern high-density avenues show that traditional streets with $W/H<0.64$ significantly elevate Alpha (α) wave activity (8–12 Hz), indicative of mental calmness and restful alertness. In contrast, modern avenues require a balanced W/H range between 0.29 and 1.58 to induce Alpha salience; excessively wide, uncontained avenues cause visual focal dissolution and agoraphobic arousal, suppressing Alpha waves and escalating stress.

## Fractal Geometry, Ordered Complexity, and the Fractal Fluency Hypothesis

The human visual cortex evolved to process the self-similar, hierarchical fractal geometries abundant in natural environments. Modernist urban planning, dominated by rigid Euclidean grids, smooth glass curtains, and repetitive right angles, imposes severe computational overload on visual processing pathways, driving chronic cognitive fatigue (Taylor & Spehar, 2016; Zhou, 2026). The Fractal Fluency Hypothesis asserts that human visual systems process mid-range fractal dimensions ($1.3<D<1.5$) with maximal

perceptual fluency, triggering immediate physiological resonance (Taylor & Spehar, 2016; Zhou, 2026).

Urban building facades displaying mid-range fractal complexity reduce sympathetic autonomic arousal, lower salivary cortisol, and enhance cortical Alpha power (Lavdas, 2026; Zhou, 2026). Machine learning evaluations (XGBoost-SHAP) of street-level emotional mapping in Shanghai identified Visual Entropy as the single strongest predictor of the Psychological and Emotional Index (PEI) (Hu et al., 2026). However, this effect is non-linear: an entropy threshold exists at 7.50, beyond which visual chaos degrades perceptual fluency. Human cognitive systems firmly prefer ordered complexity structured fractal richness over both visual monotony and unstructured chaos.

Zhou (2026) conceptualizes fractal urban organization as a form of Spatial Pharmacology, a spatial mechanism restoring perceptual autonomy. Morphological analysis of Tokyo's urban fabric demonstrates how polycentric macro-networks, porous meso-scale alleyway networks (shitamachi/roji), and highly fragmented micro-scale facade interfaces generate essential 'perceptual friction'. This fiction counters the sensory numbness induced by hyper-algorithmic, smooth modern cities, sustaining active enactive embodied cognition.

## Spatial Configuration and Visibility Analyses: Space Syntax, VGA, and 3D Volumetric Approaches

The topological layout of urban space constitutes a 'genotype' that dictates movement patterns, visual encounter rates, and emotional legibility (Mihyawi et al., 2026). According to Space Syntax theory, Visibility Graph Analysis (VGA) metrics—specifically Global Integration and Connectivity quantify the cognitive legibility of street networks. Highly integrated public squares and parks foster a sense of security, social cohesion, and reduce the Visual Pollution

Index (VPI). Conversely, isolated cul-de-sacs with low integration induce cognitive disorientation, perceived vulnerability, and heightened anxiety.

However, traditional 2D Space Syntax exhibits severe limitations in complex Urban Interior Environments (UIE) and multi-level high-density urban developments, causing up to 40% data loss by flattening volumetric spatial complexity (Choi & Cheng, 2026). To overcome this, the Cognitive-Emotional Volumetric Agent-Based Model (CEVABM) integrates neuroscientific parameters (amygdala-hippocampal somatic markers) into 3D volumetric simulations (Choi & Cheng, 2026). Implemented in New York's Hudson Yards, 3D Isovist simulations established the following empirical regression for spatial avoidance:

"Avoidance Probability"=0.41×"Ceiling Height"+0.29×"Chromatic Variance"-0.18×"Sightline Depth"

The model proved that low vertical clearance increases spatial avoidance by 53%, whereas deep sightlines and warm color gradients promote spatial approach behaviors by 37% (Choi & Cheng, 2026).

## Gray-Green Space Ratio (GER) and Non-Linear Threshold Effects

The Gray-Green Space Exposure Ratio (GER) and Green View Index (GVI) modulate neural resting-state networks. However, electroencephalographic studies reveal that biophilic restorative benefits follow non-linear, context-dependent threshold mechanisms rather than simple linear progression.

*Table 1. Summary of Neuro-Physiological Thresholds Across Urban Typologies and Morphological Metrics*

| Urban Typology | Metric / Feature | Empirical Threshold | Target EEG Band | Neuro-Cognitive Impact |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| Traditional Street (Hutong) | Green View Index (GVI) | GVI > 5.57% | Alpha ($\alpha$) Increase | Triggers serenity & restful mental calmness |
| Traditional Street (Hutong) | Width/Height Ratio | W/H < 0.64 | Alpha ($\alpha$) Elevation | Human-scale enclosure & refuge security |
| Modern Urban Avenue | Green View Index (GVI) | GVI > 15.46% | Alpha ($\alpha$) & Theta ($\theta$) | Restores directed attention amidst high noise |
| Modern Urban Avenue | Floor Area Ratio (FAR) | FAR > 3.21 | Beta ($\beta$) Surge | Elevates mental arousal & vigilance load |
| Modern Urban Avenue | Floor Area Ratio (FAR) | FAR > 2.28 | Theta ($\theta$) Suppression | Loss of deep relaxation & emotional fatigue |

Additionally, biophilic exposure interacts significantly with Spatial Openness (SOL). Among older adults, high green view indices yield maximum emotional restoration (Relative Alpha/Beta ratio - RAB) only when coupled with high spatial openness (Scene L-3); dense vegetation within highly enclosed, narrow gray corridors increases disorientation and perceived threat.

## Neuroscientific and Biometric Methodologies: Real-Time and Virtual Reality (VR) Experiments

### Neuroimaging and Measurement Technologies: fNIRS, EEG, and fMRI Comparison

Capturing real-time neuro-cognitive responses to urban environments has driven a methodological transition from post-hoc

subjective surveys to objective, high-resolution neuroscientific tools (Brunner et al., 2026). Three primary central nervous system imaging modalities are employed in neurourbanism:

**Functional Near-Infrared Spectroscopy (fNIRS):** A portable, optical imaging technique measuring cortical hemodynamic responses by tracking oxygenated (HbO) and deoxygenated (HbR) hemoglobin changes via neurovascular coupling (Brunner et al., 2026). fNIRS provides ~3 cm spatial resolution and offers exceptional robustness against motion artifacts, making it the gold standard for mobile pedestrian walking studies. Outdoor fNIRS experiments reveal that monotonous, grey urban environments induce significant PFC oxygenation surges (elevated cognitive load), whereas biophilic, aesthetically rich walking routes lower PFC activation, confirming cortical restoration (Brunner et al., 2026). Its primary limitation is a ~3 cm depth ceiling, preventing imaging of deep limbic structures like the amygdala.

**Electroencephalography (EEG):** Records cortical electrical potentials with millisecond temporal resolution (Lavdas, 2026; Brunner et al., 2026). Frequency band power spectral density Alpha (restoration/calmness), Beta (active vigilance/stress), and Theta (deep relaxation) serves as a real-time proxy for emotional valence and arousal (Nakata et al., 2026). Mobile wireless EEG headsets enable field deployment but require rigorous artifact filtering (ICA) to remove ocular, muscle, and gait noise (Qamili & Cenameri, 2026).

**Functional Magnetic Resonance Imaging (fMRI):** Provides millimeter-scale 3D spatial resolution of blood-oxygen-level-dependent (BOLD) signals across deep subcortical structures (amygdala, hippocampus) (Brunner et al., 2026; Choi & Cheng, 2026). However, its ecological validity is exceptionally low due to scanner noise, high cost, and the strict requirement for total physical immobility in a supine position (Brunner et al., 2026).

## Autonomic Nervous System and Biometric Indicators: EDA/GSR, HRV, and Pupillometry

In addition to central nervous system imaging, autonomic nervous system (ANS) responses capture unconscious physiological stress and emotional arousal:

**Electrodermal Activity (EDA / GSR):** Measures sympathetic sweat gland innervation via skin conductance (Aghanejad et al., 2026; Er et al., 2026). EDA is decomposed into slowly varying Skin Conductance Level (SCL - tonic) and rapid event-related Skin Conductance Responses (SCR - phasic). Immersive VR experiments demonstrate that narrow sidewalks, heavy traffic, and towering building facades trigger sharp SCL spikes, whereas wide pedestrian greenways suppress sympathetic arousal (Er et al., 2026).

**Heart Rate Variability (HRV / ECG / PPG):** Evaluates inter-beat (R-R) interval fluctuations (Maninetti et al., 2026; Rodrigues et al., 2026). The Root Mean Square of Successive Differences (RMSSD) reflects vagal/parasympathetic tone, while the Low Frequency to High Frequency (LF/HF) ratio indicates sympathetic-parasympathetic balance. A 90-participant real-time ambulatory study in Lisbon established that traffic noise, high ambient temperatures, and grey infrastructure elevate LF/HF ratios (sympathetic dominance), whereas quiet, vegetated corridors foster parasympathetic recovery (Rodrigues et al., 2026).

**Pupillometry and Eye-Tracking:** Integrated into Head-Mounted Displays (HMDs) or mobile eye-tracking glasses. Normalizing for ambient illuminance, pupil dilation tracks sympathetic arousal and visual fascination, while gaze fixations identify specific environmental stress triggers (Aghanejad et al., 2026).

## Ecological Validity Dilemma and Immersive Technologies

A persistent methodological tension exists between internal validity (laboratory control) and ecological validity (real-world complexity) (Aghanejad et al., 2026; Brunner et al., 2026). Static 2D monitor displays offer total environmental control but lack the embodied, multi-sensory richness of actual urban locomotion. Conversely, field studies offer high realism but introduce uncontrolled confounders (weather, unexpected crowds, traffic noise) and motion noise.

Hybrid experimental protocols resolve this dilemma by pairing Immersive Virtual Environments (IVEs) with Omnidirectional Treadmills and Multimodal Biosensing Fusion (Aghanejad et al., 2026). Active walking within high-fidelity VR provides proprioceptive feedback, maximizes sense of presence, and eliminates simulator sickness. Crucially, this setup enables pre-construction neuro-cognitive evaluation of proposed urban designs prior to physical capital expenditure (Olszewska-Guizzo et al., 2026).

**Emerging Frameworks: Digital Exposome, NUIX, and Closed-Loop Systems**

The Digital Exposome captures an individual's total environmental exposure profile (microclimate, air quality, noise, vegetation, crowd density) via wearable sensors paired with Geographic Information Systems (GIS) and Local Climate Zones (LCZs) (Qamili & Cenameri, 2026; Rodrigues et al., 2026). Simultaneously, the Neurourbanism Index (NUIX) developed under the Horizon Europe GreenInCities initiative provides a citizen-science diagnostic framework evaluating neighborhood mental health potential across neurophysiological, psychological, social, lifestyle, and environmental domains (Olszewska-Guizzo et al., 2026).

*Table 2. Methodological Comparison of Neuroscientific and Biometric Toolkits in Urban Research*

| Technology | Primary Neuro-Parameter | Spatial Resolution | Ecological Validity | Core Strengths & Trade-offs |
|---|---|---|---|---|
| fNIRS | Prefrontal HbO/HbR Hemodynamics | Moderate (~3 cm) | Very High (Mobile Walking) | Robust against gait motion artifacts; limited to outer cerebral cortex |
| EEG | Cortical $\alpha, \beta, \theta$ Spectral Power | Low (Scalp-level) | High (Mobile Headsets) | Millisecond temporal resolution; highly sensitive to motion/ocular noise |
| fMRI | 3D BOLD Deep Limbic Activation | Very High (mm-level) | Very Low (Lab-bound) | Maps amygdala/hippocampus; prohibits movement & lacks realistic locomotion |
| EDA / GSR | Skin Conductance (SCL / SCR) | Systemic (Autonomic) | Very High (Wrist/Finger) | Tracks sympathetic arousal spikes; cannot distinguish positive vs negative valence |
| HRV (ECG/PPG) | R-R Intervals, RMSSD, LF/HF | Systemic (Autonomic) | Very High (Wearables) | Measures vagal parasympathetic tone; modulated by physical exercise effort |
| Pupillometry | Pupil Diameter & Gaze Fixations | Ocular Tracking | High (VR/HMD Integrated) | Captures visual fascination & cognitive load; requires illuminance normalization |

## Spatial Heterogeneity, Typological Differences, and Psycho-Social Well-Being

### Public Space Typologies and Psychological Well-Being

Public spaces do not offer uniform restorative benefits; rather, psychological outcomes are strongly differentiated by spatial typology. Empirical investigation across seven public space typologies in Tehran evaluated through Ryff's Psychological Well-Being Scale (environmental mastery, autonomy, personal growth,

positive relations, purpose in life, self-acceptance) revealed a clear statistical hierarchy (Bahadori et al., 2026):

1. **Multifunctional Public Spaces (Abbasabad District):** Highest overall psychological well-being and environmental satisfaction scores due to flexible integration of nature, culture, and active/passive recreation.
2. **River Valleys / Blue-Green Corridors (Darband Valley):** Second most restorative typology, providing natural topography and acoustic masking via water features.
3. **Urban Parks (Laleh Park):** Promotes sustained biophilic attention restoration and positive affect.
4. **Urban Squares and Plazas:** Supports social encounters but exhibits moderate stress due to high hardscape ratios.
5. **Pedestrian Pathways and Urban Streets:** Lowest contribution to psychological well-being owing to continuous exposure to traffic, noise, and vehicular dominance.

Structural Equation Modeling (SEM) established that environmental satisfaction acts as a key mediator between physical spatial attributes and psychological well-being (Bahadori et al., 2026). Furthermore, individual cognitive focus moderates these outcomes: transit environments induce an 'instrumental focus' where spatial obstacles lower happiness indices by 15.2%, whereas social gathering areas trigger 'social buffering', rendering equivalent environmental noise non-stressful (Maninetti et al., 2026).

## Micro-Spatial Fractures and Leftover Spaces: Urban Corners and Plutchik Emotion Mapping

Urban corners represent critical micro-spatial thresholds regulating circulation, sightlines, and street-level encounters. Poorly designed corners frequently degenerate into leftover spaces neglected urban

voids generating negative neuro-affective hotspots (Yılmaz & Arabacıoğlu, 2026). An empirical investigation along Söğütlüçeşme Street in Istanbul classified 41 corner points across five morphological typologies, mapping user emotional responses via Plutchik's Wheel of Emotions and GIS Inverse Distance Weighting (IDW) interpolation (Yılmaz & Arabacıoğlu, 2026).

*Table 3. Urban Corner Morphological Typologies and Emotional Character Analysis*

| Corner Typology | Geometric Definition | Dominant Emotion | Mean Score (M) | Neuro-Spatial Logic |
|---|---|---|---|---|
| A.3 Wide-Angle | Obtuse angle (>90°) boundary expansion | Joy & Trust | M = +1.2060 | High visual permeability, zero blind spots, natural surveillance |
| A.1 Right-Angle | Standard 90° orthogonal corner | Ambivalent | M = -0.0531 | Mild visual blind spot offset by defined commercial active edge |
| A.2 Acute-Angle | Sharp constriction (<90°) | Anxiety & Sadness | M = -0.3496 | Visual compression, claustrophobic arousal, spatial squeezing |
| B.1 Recessed Void | Setback void recessed into mass | Anxiety & Distress | M = -0.7044 | Lack of natural surveillance, crime fear, perceived insecurity |
| B.2 Protruding Mass | Cantilevered mass extending outward | Neutral / Mild Positive | M = +0.2979 | Interrupts flow but acts as legible landmark anchor |

Friedman and Durbin-Conover post-hoc tests confirmed that A.3 wide-angle corners score significantly higher in positive emotional

valence ($p<0.001$) by maximizing line-of-sight continuity, supporting Jane Jacobs' 'eyes on the street' natural surveillance framework (Yılmaz & Arabacıoğlu, 2026). Similarly, guided storytelling walks along post-socialist urban routes in Budapest significantly elevated positive arousal and selfie-based spatial emotion scores (sSPoE) compared to unguided walks (Klaniczay & Kádár, 2026).

**Demographic and Age-Dependent Cognitive Sensitivities**

Neuro-morphological impacts vary substantially across life stages. Applying the Homo urbanicus framework across 36 neighborhoods in Shanghai (N=882), Guo et al. (2026) established the Four-Quadrant Model of Spatial Contact Opportunities (Ideal Contact, Spatial Deprivation, Idle Resources, Dual Decline), revealing distinct neuro-cognitive pathways between age cohorts:

**Young-Old Cohort (Ages 60–69):** Maintain broad spatial mobility. Environmental quality influences psychological well-being indirectly, fully mediated by Perceived Environmental Restorativeness. They seek biophilic aesthetics, social gathering spaces, and walking trails (Guo et al., 2026).

**Oldest-Old Cohort (Ages 80+):** Constrained by declining physical mobility. Environmental quality acts directly on psychological well-being. Aesthetic restoration is secondary; smooth pavement, non-slip surfaces, step-free access, continuous street lighting, and closely spaced benches generate direct ontological security and mental peace (Guo et al., 2026).

In Wuhan, EEG experiments on older adults demonstrated that the Relative Alpha/Beta (RAB) ratio is maximized by high greenery paired with high spatial openness (Scene L-3), whereas dense enclosed grey corridors induce severe cognitive load (Lu & Shang, 2026).

### Gender-Sensitive Neuro-Urban Design

Gender moderate's neuro-physiological stress responses to urban design features. Evaluating streetscapes in Nagpur, India using the Psychological Well-Being Index (PWI), Dhanorkar and Deshmukh (2026) identified critical gender-differentiated preferences:

1. **Artificial Night Lighting & Safety:** Inadequately illuminated streets induce statistically higher sympathetic stress and spatial avoidance in women compared to men, activating amygdala threat-detection pathways. Uniform, high-quality lighting dramatically restores night-time public space utilization.
2. **Seating Configuration & Privacy:** Women prefer semi-enclosed, shaded, refuge-like seating that offers shelter from visual scrutiny; men prefer open, outward-facing seating oriented toward active public encounter.
3. **EEG Moderation:** In Wuhan EEG trials, green space exposure (GER) significantly moderated the RAB ratio in women ($R^2=0.6262, p<0.01$), confirming higher female neuro-physiological sensitivity to visual enclosure, vegetation density, and environmental security cues (Lu & Shang, 2026).

## Cognitive Cities, Artificial Intelligence, and Critical Neuro-Governance

### From Smart Cities to 'Thinking Cities': AI, Urban Digital Twins, and Two-Way Frameworks

Urbanization is undergoing a paradigm shift from efficiency-driven 'smart city' models toward cognitive urbanism envisioning cities as self-learning, adaptive environments responsive to human mental states (Adli et al., 2017; Cugurullo et al., 2024). Traditional smart cities focused heavily on traffic flow, energy grids, and sensor

efficiency, omitting human neuro-cognitive well-being (Elazab & Eltawil, 2026). In response, Elazab and Eltawil (2026) created an AI-driven Sustainable Neuro-Urbanism Framework in Ras Elbar, Egypt, integrating 12 urban design elements, AI digital twins, and sustainability goals (urban cooling, biodiversity).

However, critical scholars challenge consultancy-led cognitive urbanism promoted by global tech corporations (e.g., Siemens, PwC, TONOMUS/NEOM) (Cugurullo et al., 2024; Marvin & Zhang, 2026). They argue that re-locating cognition into digital platforms and algorithmic management dashboards risk reducing citizens from active political agents to passive data-generating nodes.

### Closed-Loop Neuromodulation and Context-Aware Environmental Signaling

The frontier of neuro-urbanism lies in Closed-Loop Neuromodulation systems establishing real-time bi-directional feedback between human neural activity and urban infrastructure (Qamili & Cenameri, 2026). The Context-Aware Neuromodulation Framework structures this interaction across four layers:

1. **Layer 1 (Urban Exposure):** Tracks Local Climate Zones (LCZs), microclimate, noise, and crowd density via GIS and IoT sensors.
2. **Layer 2 (Human Sensing):** Captures mobile EEG, HRV, EDA, and GPS location in real time.
3. **Layer 3 (AI Fusion):** Uses multimodal machine learning to isolate whether physiological arousal stems from environmental stressors versus internal emotional states.
4. **Layer 4 (Adaptive Response):** Delivers personalized neuro-feedback adjusting ambient soundscapes, smart lighting, or recommending low-stress pedestrian navigation routes.

When combined with the Neurourbanism Index (NUIX), these closed-loop systems allow planners to diagnose psychosocial tension hotspots at the neighborhood scale prior to physical construction (Olszewska-Guizzo et al., 2026).

## Digital Citizen Participation and the 'Emotional Disconnect': Lefebvre and Activity Theory

Despite widespread adoption of Public Participation GIS (PPGIS), emotion-mapping apps, and digital urban diaries, a profound Emotional Disconnect persists between crowdsourced citizen emotional data and formal urban design execution (Kaarivuo et al., 2026). Kaarivuo et al. (2026) theorize this failure by synthesizing Henri Lefebvre's Production of Space (1991) with Engeström's (2009) Activity Theory.

In Lefebvre's spatial triad, citizens' emotional experiences represent Lived Space, whereas institutional planners operate strictly within Conceived Space (abstract technical codes) (Kaarivuo et al., 2026). Digital PPGIS tools capture lived emotional data, but planning bureaucracies lack translation mechanisms to convert qualitative affect into formal spatial zoning. Activity Theory reveals that citizens and planners form disjointed activity systems with conflicting motives; emotional data becomes an algorithmic 'runaway object' discarded during formal design (Engeström, 2009; Kaarivuo et al., 2026). Bridging this disconnect requires establishing a shared common emotional vocabulary and legally binding participatory translation protocols.

## Biopolitical Governance of the Mind, Neurorights, and Mental Sovereignty

Integrating neuro-technology into urban space represents a biopolitical shift toward the governance of the mind. Marvin and Zhang (2026) classify cognitive urbanism across three sociotechnical imaginaries:

*Table 4. Sociotechnical Imaginaries of Cognitive Urbanism and Associated Biopolitical Risks*

| Imaginary Model | Key Alliances | Dominant Infrastructure | Governance Logic | Core Biopolitical Risk |
|---|---|---|---|---|
| Therapeutic Neurourbanism | Neuroscientists, EU Consortia, Planners | Mobile EEG/fNIRS, Biophilic Facades | Optimize public mental health via spatial design | Biopolitical paternalism, medicalizing subjective emotional states |
| Consultancy-Led Cognitive Urbanism | Tech Corporations, Real Estate | AI Platforms, City Twins, IoT Dashboards | City as self-learning commercial platform | Algorithmic control, loss of democratic oversight, citizen data extraction |
| Neurotechnical Governance | State Apparatus, Security Bureaucracy | BCI, Emotion Recognition, City Brains | Authoritarian surveillance & order maintenance | Erosion of mental privacy, cognitive surveillance, emotional nudging |

These risks necessitate establishing robust legal frameworks for Neurourban Rights, protecting Mental Sovereignty and Cognitive Liberty in public space. Urban neural data must be protected against unauthorized extraction and manipulative 'neuromodulator nudging' through the creation of democratic Neurourban Commons (Marvin & Zhang, 2026).

## Conclusion and Core Neuro-Morphological Design Principles

Neuro-morphology demonstrates that urban form acts as a powerful 'Spatial Pharmacology' continuously modulating neural activity, autonomic balance, and social well-being. Five core design principles synthesize this monographic work (Elazab & Eltawil, 2026; Marvin & Zhang, 2026; Qamili & Cenameri, 2026):

1. **Multi-Scale Fractal Geometric Balance:** Replace Euclidean monotony with mid-range fractal complexity ($1.3 < D < 1.5$) across building facades to maximize visual fluency and cortical Alpha power.
2. **Human-Scale Enclosure and Permeable Corners:** Mitigate high-rise Beta arousal by maintaining human-scale street ratios (W/H) and designing wide-angle (>90°) corner geometries to enhance visual permeability and natural surveillance.
3. **Non-Linear Threshold Biophilic Integration:** Implement biophilic elements above empirical context thresholds (e.g., Green View Index GVI > 15.46% in modern avenues), ensuring greenery is paired with high spatial openness.
4. **Inclusive and Age-Sensitive Physical Safety:** Prioritize direct physical accessibility (step-free pavement, non-slip surfaces, uniform lighting, shaded benches) for oldest-old cohorts to generate direct ontological security.
5. **Environmental Data Democratization and Neurourban Commons:** Protect mental sovereignty by establishing community-governed data commons, ensuring AI and biometric sensors serve citizen well-being rather than commercial or biopolitical surveillance.

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