# JOURNAL OF DESIGN FOR RESILIENCE IN ARCHITECTURE & PLANNING

DRArch

APRIL 2025

Issue 01



vol 06

www.drarch.org

info@drarch.org editor@drarch.org

E-ISSN: 2757-6329

# *Editorial*

*Mehmet Topçu (Editor)*



The Journal of Design for Resilience in Architecture & Planning (DRArch) is proud to publish Volume 6, Issue 1, featuring articles of high scientific quality.

Staying true to our mission of fostering innovative, interdisciplinary, and resilient approaches to design and urban planning, this issue brings together a collection of scholarly articles that explore the dynamic intersections of architecture, resilience, urban transformation, and cultural continuity. Each contribution offers a critical reflection on the challenges and opportunities shaping our built environment today.

The issue opens with the article "**A Comparative Analysis of Space Efficiency in Skyscrapers: Case Studies from the Middle East, Asia, and North America**" by Özlem Nur Aslantamer and Hüseyin Emre Ilgın. This study offers a systematic review of spatial efficiency in supertall buildings across different regions, revealing significant regional differences and providing valuable insights for optimizing vertical design strategies.

The second paper, titled "**Silo Buildings: A New Image in the Urban Landscape**" by Zeynep Kerem Öztürk and Ahmet Kurnaz, focuses on silo buildings traditionally used for storing bulk commodities such as grain, cement, and seeds. Structural additions and interior reconfigurations were critical in helping these structures comply with modern building standards and accommodate new functions, including offices, residences, and cultural venues. The findings highlight how carefully balanced preservation and innovation can conserve industrial authenticity while meeting contemporary urban needs. Moreover, preserving a silo's cylindrical core while introducing modern features fosters a sense of continuity between past and present, reinforcing communal memory. Ultimately, the case studies underscore adaptive reuse as a practical, culturally sensitive pathway for reimagining silo buildings—merging historical significance, architectural creativity, and sustainable development to produce dynamic new landmarks in evolving urban landscapes.

In "**Earthquake Resilience of Densely Populated Settlements: A Strategic Approach to Mitigate Istanbul's Earthquake Risk**," Gülru Koca conducts a SWOT analysis of Istanbul's urban resilience. This paper emphasizes the urgent need for strategic urban planning to protect one of the world's most historically significant cities from the devastating effects of seismic activity.

An insightful contribution comes from Mümüne Selen Abbasoğlu and Fatma Bıldır with the article "**Assessment of Resilience in Rural Areas: The Case of Bağlıköy, Cyprus**" The research focuses on the cultural, economic, environmental, and social factors influencing rural resilience. It hypothesizes that the resilience of rural areas is significantly influenced by vulnerabilities resulting from regional transformations and both natural and artificial impacts. Bağlıköy village was selected as a case study to examine this hypothesis. A SWOT analysis identifies internal strengths and weaknesses, as well as external opportunities and threats affecting the area's ability to withstand and recover from challenges. In conclusion, the study evaluates rural resilience and provides recommendations to enhance sustainability and adaptive capacity.

The theme of resilience continues with "**The Importance of Water-Sensitive Planning and Design Approaches for Resilience to Flood Disaster Risk in Istanbul**" authored by Hale Mamunlu Kocabaş. By focusing on the Çatalca and Beykoz districts, this study critiques current practices and advocates for holistic, basin-scale, participatory strategies to enhance flood resilience.

Urban environmental challenges are also addressed in the study "**The CODASC Database for Analyzing the Impact of Morpho-Climatic Characteristics of Canyon Streets on Air Pollutant Concentrations**" by Loubna Khellaf, Meriem Naimi Ait-Aoudia, and Farid Rahal. Focusing on the city of Algiers, the study explains how urban canyon characteristics affect pollutant concentrations and offers strategic recommendations for pollution mitigation, providing valuable guidance for sustainable urban planning.

Turning to architectural heritage, "**A Traditional Trace in the Urban Fabric: Architectural Analysis of the Maltepe Mosque**" by Necdet Bekirhan Soy and Murat Karademir critically evaluates contemporary mosque design, balancing tradition with modern urban needs and proposing ideas for the future evolution of mosque architecture in Turkey.

In "**The Effects of Western Housing Practices on Turkey's Social Housing Experience**" Fatema Alhashemi and Mehmet Saner examine the influence of Western housing models on Turkey's social housing policies, highlighting both the opportunities and challenges arising from this cultural adaptation.

Anday Türkmen contributes with the article "**Analysing Morphogenetic Design Approaches in the Context of Hypothetical Housing Examples**" This study adopts a qualitative research methodology, employing a comprehensive literature review to address the research questions.The research sample consists of four hypothetical housing projects: Embryological House, Multistory Apartment Building, Molecular Engineered House, and The Fab Tree Hab.These projects, developed after 2000, exemplify the application of morphogenetic design approaches in contemporary housing design.



Finally, Kamil Güley and Nisan Akalın explore educational innovations in "**Conflict of Virtual and Reality in Interior Design Studio: Assessment of Student Success Rates**" Their research highlights the benefits of hybrid educational models, offering important insights for the future of interior architecture education.

As DRArch continues to provide a platform for critical discourse and research, this issue underscores the importance of resilience, adaptability, and innovation in the face of increasingly complex urban and environmental challenges.

We invite readers to engage with these studies, reflect upon their implications, and contribute to the ongoing dialogue shaping the future of resilient design and planning.

We extend our sincere thanks to all contributors for their outstanding work and dedication, and we hope this volume inspires further research, collaboration, and action across our shared fields.

Best regards...

Following names that provided valuable contribution as referees of articles in this issue are:



*Cover photo: Image copyright ©Sena Özfiliz, (2019). The image on the left is detail " Alsancak port, Silo, İzmir"*

JOURNAL OF DESIGN FOR RESILIENCE
IN ARCHITECTURE & PLANNING

E-ISSN: 2757-6329



## DRArch's objectives are:

*- to question how future building technologies are revolutionizing architectural design, city planning, urban design, landscape design, industrial design, interior design and education,*

*- to catalyze the processes that lean on interdisciplinary and collaborative design thinking, creating a resilient thinking culture,*

*- to improve the quality of built environment through encouraging greater sharing of academicians, analysts and specialists to share their experience and answer for issues in various areas, which distributes top-level work,*

*- to discover role of the designers and design disciplines -architecture, city planning, urban design, landscape design, industrial design, interior design, education and art in creating building and urban resilience,*

*- to retrofit the existing urban fabric to produce resilience appears and to support making and using technology within the building arts,*

*- to discuss academic issue about the digital life and its built-up environments, internet of space, digital in architecture, digital data in design, digital fabrication, software development in architecture, photogrammetry software, information technology in architecture, Archi-Walks, virtual design, cyber space, experiences through simulations, 3D technology in design, robotic construction, digital fabrication, parametric design and architecture, Building Information Management (BIM), extraterrestrial architecture, , artificial intelligence (AI) systems, Energy efficiency in buildings, digitization of human, the digitization of the construction, manufacturing, collaborative design, design integration, the accessibility of mobile devices and sensors, augmented reality apps, and GPS, emerging materials, new constructions techniques,*

*-to express new technology in architecture and planning for parametric urban design, real estate development and design, parametric smart planning (PSP), more human-centered products, sustainable development, sustainable cities, smart cities, vertical cities, urban morphology, urban aesthetics and townscape, urban structure and form, urban transformation, local and regional identity, design control and guidance, property development, practice and implementation.*

# *Editorial Team*

E-ISSN: 2757-6329

# Table of Contents

JOURNAL OF DESIGN FOR RESILIENCE
IN ARCHITECTURE & PLANNING

*Research Article*
*Online:* www.drarch.org
*Volume 6, Issue 1 (01-19), 2025*
*DOI: 10.47818/DRArch.2025.v6i1154*

# A comparative analysis of space efficiency in skyscrapers: Case studies from the Middle East, Asia, and North America

Özlem Nur Aslantamer*
Hüseyin Emre Ilgın **

## Abstract

This study conducts a critical comparative analysis of spatial efficiency in supertall buildings across three major geographic contexts: the Middle East, Asia, and North America. Through the examination of selected case studies representative of each region, the research investigates the interplay between architectural form, structural typology, and the distribution of usable floor area within vertical structures. The findings reveal significant regional variations in spatial efficiency metrics and core-to-GFA (gross floor area) proportions. In the Asian context, towers predominantly adopt a tapered morphological strategy combined with composite structural systems, resulting in an average spatial efficiency of approximately 68%, with vertical service cores occupying nearly 30% of the GFA. Conversely, Middle Eastern high-rises, typically defined by prismatic massing and monolithic concrete structures, demonstrate a higher spatial efficiency—averaging 76%—with a core-to-GFA ratio of around 21%. North American skyscrapers, frequently employing prismatic or setback configurations alongside reinforced concrete systems, exhibit comparable efficiency rates, with an average of 76% and a similarly proportioned core area. Despite these regional divergences, the analysis identifies a consistent inverse correlation between building height and spatial efficiency, underscoring the technical and spatial challenges associated with height-induced inefficiencies in high-rise design. By elucidating these interregional patterns, the study offers valuable insights into the optimization of vertical spatial organization, contributing to the evolving discourse on high-rise architecture and urban densification.

*Keywords:* space efficiency, comparison, Middle East, Asia, North America, skyscraper

## 1. Introduction

The modern urban landscape is increasingly defined by the presence of supertall skyscrapers—architectural feats that stand as testaments to human ingenuity, economic ambition, and technological progress (Radović, 2020). These structures, often exceeding 300 meters in height, have become central to the identity of major cities across the globe, symbolizing their status as hubs of global finance, culture, and innovation (Pitroda & Singh, 2016). However, the creation of such towering edifices is not without its challenges (Szołomicki & Golasz-Szołomicka, 2021). Among the most critical of these is the need to optimize space efficiency—a factor that plays a crucial role in determining the economic viability, functional utility, and environmental sustainability of these buildings (Saroglou et al., 2023).

Space efficiency, defined as the ratio of net floor area (NFA) to gross floor area (GFA), is a key metric in the design and operation of skyscrapers (Aslantamer & Ilgın, 2024a). High space efficiency indicates that a larger proportion of the building's total area is available for occupancy or use, which is essential for maximizing the economic returns on investment, particularly in urban environments where land costs are exorbitant. In the context of skyscrapers, achieving high space efficiency is a complex task that involves balancing the demands of structural integrity, safety, and aesthetic appeal with the need to provide functional and economically productive spaces.

*(Corresponding author), Lecturer Dr., Atilim University, Türkiye ozlem.aslantamer@atilim.edu.tr
**Dr., Tampere University, Finland emre.ilgin@tuni.fi
Article history: Received 2 August 2024, Accepted 11 April 2025, Published 30 April 2025

The pursuit of space efficiency in skyscraper design is influenced by a myriad of factors, including regional architectural traditions, local building codes, economic conditions, and environmental challenges. Each region where skyscrapers are built presents its own set of conditions and constraints that shape the approach to space efficiency. This paper focuses on three key regions: the Middle East (Ilgın, 2024), Asia (Ilgın, 2023b), and North America (Aslantamer & Ilgın, 2024b), each of which has emerged as a leader in skyscraper construction but with distinct approaches to addressing the challenges of space efficiency.

Examining these regions comparatively in the context of skyscraper space efficiency is significant because it allows for a nuanced understanding of how diverse environmental, cultural, and economic conditions shape architectural and engineering practices in different parts of the world. Each of these regions presents unique challenges and opportunities in skyscraper design. For instance, Asia's rapid urbanization and high population density necessitate innovative solutions to maximize space efficiency in extremely tall buildings, often within seismic zones, which imposes additional structural demands (Ilgın, 2023b). In contrast, North America, with its established history of skyscraper construction, operates under mature regulatory frameworks that balance safety, functionality, and economic return, leading to different prioritization in design strategies, such as the optimization of core configurations and the use of advanced materials (Aslantamer & Ilgın, 2024a). Meanwhile, the Middle East's architectural landscape is heavily influenced by harsh climatic conditions and a strong cultural emphasis on iconic design, requiring buildings to integrate sophisticated climate control systems and culturally significant features, which impact space efficiency in distinct ways (Ilgın, 2024).

By comparing these regions, we can uncover the interplay between local conditions and global architectural trends, identifying how regional contexts influence the adoption of certain structural systems, building forms, and space utilization strategies. This comparative analysis not only highlights regional innovations and adaptations but also reveals the potential for cross-regional application of best practices, offering insights into how strategies successful in one context might be adapted for use in another. Additionally, understanding these regional differences and commonalities provides a broader framework for addressing global challenges in skyscraper design, such as sustainability and resilience, by fostering a more holistic approach to the optimization of space efficiency. In essence, this comparative study enables a deeper comprehension of the complex dynamics that drive skyscraper design, offering valuable lessons for improving the functionality, sustainability, and economic viability of tall buildings worldwide.

In the Middle East, the rise of skyscrapers is often driven by a combination of factors, including economic diversification, cultural symbolism, and environmental adaptation (Botti, 2023). Cities like Dubai, Abu Dhabi, and Riyadh have become synonymous with ambitious architectural projects that not only push the boundaries of height but also incorporate elements of cultural significance and environmental sustainability. However, achieving space efficiency in this region presents unique challenges. The harsh climatic conditions, characterized by extreme heat and humidity, necessitate the integration of extensive climate control systems, which can reduce the amount of usable space. Additionally, the cultural and symbolic importance of these buildings often leads to design choices that prioritize aesthetic and cultural expression over pure space efficiency (Al-Kodmany, 2024).

In Asia, particularly in rapidly developing cities like Shanghai, Hong Kong, and Shenzhen, the demand for space has driven the construction of some of the tallest buildings in the world (Chaudhary, 2024). The rapid urbanization and economic expansion in these cities have necessitated vertical growth, making skyscrapers an essential solution to the challenge of accommodating large urban populations and commercial activities within limited land areas. However, the push for greater heights in these buildings has often resulted in compromises in space efficiency. The need for robust structural systems to withstand seismic activity and high wind loads, common in these regions, often leads to larger service cores and more complex building forms, which can reduce the usable floor area.

North America, with its longstanding history of skyscraper construction, particularly in cities like New York, Chicago, and Toronto, presents a contrasting approach to space efficiency (Barr & Jedwab, 2023). The skyscrapers in this region have historically been designed with a strong focus on balancing the maximization of usable space with the need to comply with stringent building codes and safety regulations. The evolution of structural systems in North America, such as the development of the tube structure and the use of offset cores, has allowed for the construction of tall buildings that maintain high levels of space efficiency. Additionally, the economic context of North American cities, where the return on investment is closely tied to the amount of leasable space, has driven innovations in building design that prioritize space efficiency.

This paper endeavors to provide a comprehensive exploration of regional variations in space efficiency through a detailed comparative analysis of iconic skyscrapers across the Middle East, Asia, and North America. By systematically examining the architectural designs, structural innovations, and engineering methodologies employed in these buildings, the study seeks to uncover the critical determinants of space efficiency. Furthermore, it aims to elucidate how these determinants are influenced by and adapted to the distinct cultural, economic, and environmental contexts of each region, thereby offering a nuanced understanding of the global diversity in skyscraper design and its implications for sustainable urban development.

The findings of this study are anticipated to offer crucial insights for architects, engineers, urban planners, and policymakers engaged in the design and development of skyscrapers. As urbanization accelerates globally, the demand for efficient and sustainable tall buildings is becoming increasingly urgent (Höjer & Mjörnell, 2018). By dissecting the factors that contribute to space efficiency within various regional contexts, this research aspires to inform and influence the future of skyscraper design. It aims to ensure that these towering structures not only fulfill their functional roles effectively but also continue to symbolize and drive urban progress in a manner that is environmentally responsible and contextually adaptable.

## 2. Literature Review

In the realm of architectural design, particularly concerning the optimization of interior spatial efficiency, a growing body of literature has investigated a variety of parameters and building typologies across diverse geographic and structural contexts. Tuure and Ilgın (2023) carried out a comprehensive evaluation of timber apartment buildings in Finland, identifying spatial efficiency rates ranging between 78% and 88%. These findings highlight the considerable potential of timber construction in achieving high levels of usable area efficiency, especially within mid-rise residential typologies.

On a broader scale, Ilgın (2021a, 2023a, 2023b, 2024) and Aslantamer and Ilgın (2024a) conducted empirical studies on supertall towers serving residential, commercial, hotel, and mixed-use functions. These investigations consistently point to the frequent application of outrigger systems and centrally positioned service cores as characteristic features, revealing a recurring relationship between increased verticality and the necessity for efficient spatial organization within the structural framework.

Exploring non-standardized building forms, Sev and Özgen (2009) analyzed spatial performance in unconventional office towers. Their research emphasized that architectural form—particularly conical geometries—can significantly enhance spatial efficiency, thereby underlining the critical impact of form-driven design strategies on internal space optimization. Similarly, Ibrahimy et al. (2023) examined residential projects in Kabul, where deviations from planning regulations and insufficient architectural oversight were found to contribute to notable inefficiencies in space utilization. This underscores the regulatory dimension of spatial performance and the importance of design governance in urban residential developments.

The role of emerging technologies in reshaping spatial efficiency paradigms is addressed by Goessler and Kaluarachchi (2023), who explored innovations in high-density urban housing solutions. Their study suggests that such technologies have the capacity to improve spatial efficiency by two to threefold when compared with conventional design practices, signaling a paradigm shift in the way space is conceived and managed in urban architecture. In a different yet related context, Hamid et al. (2022) demonstrated that strategic building placement—specifically positioning structures at corner plots—can significantly enhance land-use efficiency in Sudanese residential layouts, emphasizing the importance of site-responsive planning and context-sensitive design interventions.

Suga (2021) examined spatial utilization strategies within hotel architecture, emphasizing the operational advantages derived from effective space management in hospitality environments. In a structural context, Arslan Kılınç (2019) analyzed key determinants influencing the design of load-bearing systems in prismatic high-rise structures, offering valuable insights into how structural configuration affects usable space. Adopting a user-centered perspective, Von Both (2019) advocated for participatory design methodologies, emphasizing stakeholder collaboration during early design phases as a means to optimize spatial outcomes.

Concurrently, Höjer and Mjörnell (2018) explored the role of digital technologies in shaping interior spatial configurations, underlining the increasing relevance of digital integration in contemporary architectural practice. Addressing specific design variables, Nam and Shim (2016) evaluated the impact of corner articulation and lease span on spatial efficiency, concluding that while modifications to corner geometry had a limited effect, lease span played a more significant role in determining functional space allocation. In a related yet sustainability-oriented study, Zhang et al. (2016) proposed a computational model aimed at maximizing solar gain in cold climates, demonstrating the interdependence between environmental performance and spatial optimization.

Sev and Özgen (2009) contributed to the discourse by assessing spatial performance in office towers, particularly focusing on the influence of structural strategies and core placement in achieving efficient layouts. Saari et al. (2006) linked spatial optimization to project economics, demonstrating that higher space efficiency can directly reduce development costs in commercial high-rise projects. Similarly, Kim and Elnimeiri (2004) investigated spatial efficiency ratios in multifunctional skyscrapers, stressing the importance of structurally efficient systems and well-calibrated spatial layouts. Taken together, these studies reflect the multifaceted nature of spatial efficiency in architectural design, shaped by factors including formal innovation, digital tools, regulatory frameworks, and structural decision-making.

Despite this growing body of research, a notable gap persists in comparative analyses of spatial efficiency across skyscrapers situated in different global contexts. In response to this shortcoming, the present study aims to synthesize and critically assess data from 133 built case studies, focusing on the architectural and structural variables that inform spatial efficiency. Through this comprehensive evaluation, the research seeks to identify recurring patterns and generate insights that contribute to a deeper understanding of space utilization in the vertical architecture of the contemporary urban landscape.

## 3. Research Method

To collect and organize data from 133 skyscrapers, as shown in Figure 1, a case study methodology was employed. This method is widely used in research to gather both qualitative and quantitative data and to conduct extensive literature reviews (Opoku et al., 2016; Noor, 2008). It allows for a detailed examination of the architectural and structural elements of these projects, enabling a comprehensive investigation of real-world examples. Through this approach, each case can be thoroughly analyzed, providing valuable insights into the distinctive design features and structural characteristics of each tower. By focusing on specific cases, researchers can identify similarities and differences in contemporary skyscraper designs, uncovering new trends and patterns. This method's adaptability allows for the incorporation of a range of data sources, such as architectural drawings and other relevant documents, to achieve a complete understanding.

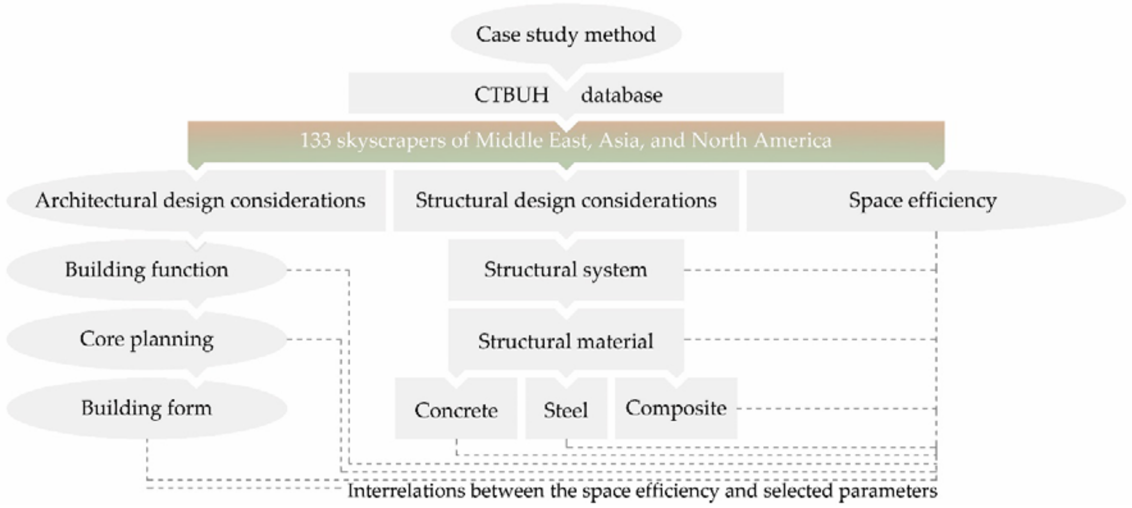



**Figure 1** Research method (By authors)

This study draws upon a dataset of 133 skyscrapers sourced from the authoritative Council on Tall Buildings and Urban Habitat (CTBUH) database (CTBUH, 2024), which served as the primary reference for identifying representative high-rise buildings situated across various urban centers in North America and beyond. CTBUH, a globally recognized non-profit institution, plays a critical role in advancing knowledge on vertical urbanism and promoting sustainable and resilient urban development in response to accelerating urbanization and the impacts of climate change. The organization is internationally acknowledged for establishing classification criteria for tall buildings and bestowing honors such as “The World’s Tallest Building” and “Buildings of Distinction,” thereby shaping global discourse on architectural excellence.

In alignment with CTBUH standards, this research adopts the designation “supertall” for buildings exceeding 300 meters in height, emphasizing the complex design and engineering competencies required for such vertical structures. The selection process for case studies was conducted with methodological rigor to ensure a balanced and meaningful representation of skyscrapers with varied programmatic functions and regional contexts. While access and data availability posed certain geographical constraints, the final sample was strategically curated to enable a comprehensive evaluation of spatial efficiency patterns and design typologies across different high-rise environments.

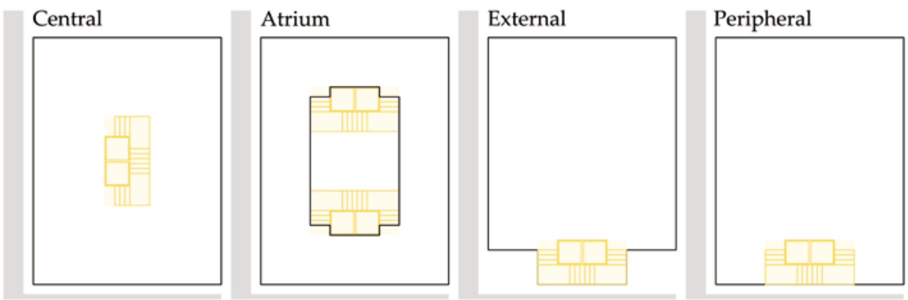
The dataset encompasses a geographically diverse distribution of supertall buildings: 57 located in China, 26 in the United States, 21 in the United Arab Emirates, 5 each from Malaysia and South Korea, 3 each from Saudi Arabia and Canada, 2 each from Mexico, Kuwait, Mumbai, and Vietnam, and one building each from Qatar, India, Japan, Taiwan, and Indonesia. This global sampling—illustrated in Figure 2—provides a robust foundation for cross-regional comparative analysis, facilitating a deeper understanding of contemporary skyscraper morphology and the spatial strategies employed in diverse urban settings.


**Figure 2** Case studies on the world map (By authors)

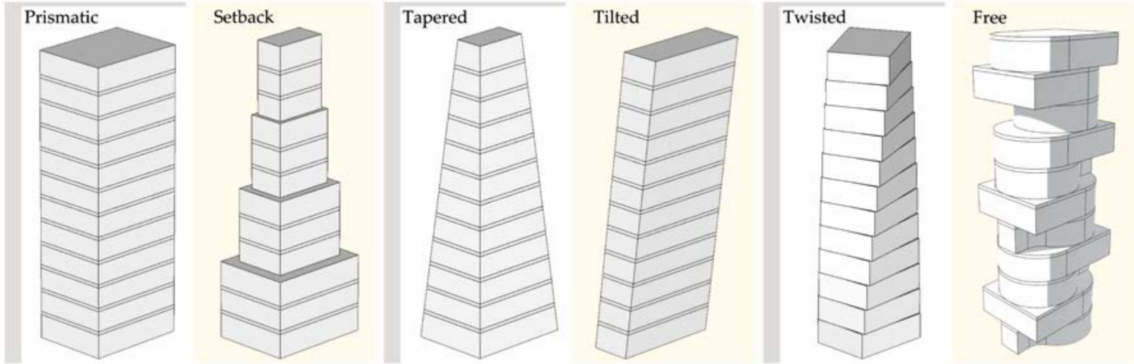
The design of skyscrapers is governed by a dynamic interplay between architectural intent and structural imperatives, with key determinants including core configuration, building function and morphology, as well as the selection of structural systems and materials. From an architectural standpoint, this study adopts the core typology framework proposed by Aslantamer and Ilgın (2024a), which delineates four principal categories of core arrangements (see Figure 3a). In parallel, building massing is classified into a range of formal typologies (see Figure 3b), reflecting diverse design strategies across supertall typologies.

The selection of an appropriate structural system plays a pivotal role in optimizing spatial efficiency within high-rise architecture, as it directly influences the spatial distribution and scale of load-bearing elements. This research draws on the structural classification model articulated by Ilgın (2023a) for the categorization of skyscraper systems (see Figure 3c). Equally critical is the choice of structural material—whether steel, concrete, or hybrid composite systems—which significantly shapes the dimensional properties and spatial layout of structural components, thereby impacting the efficiency of usable floor area.

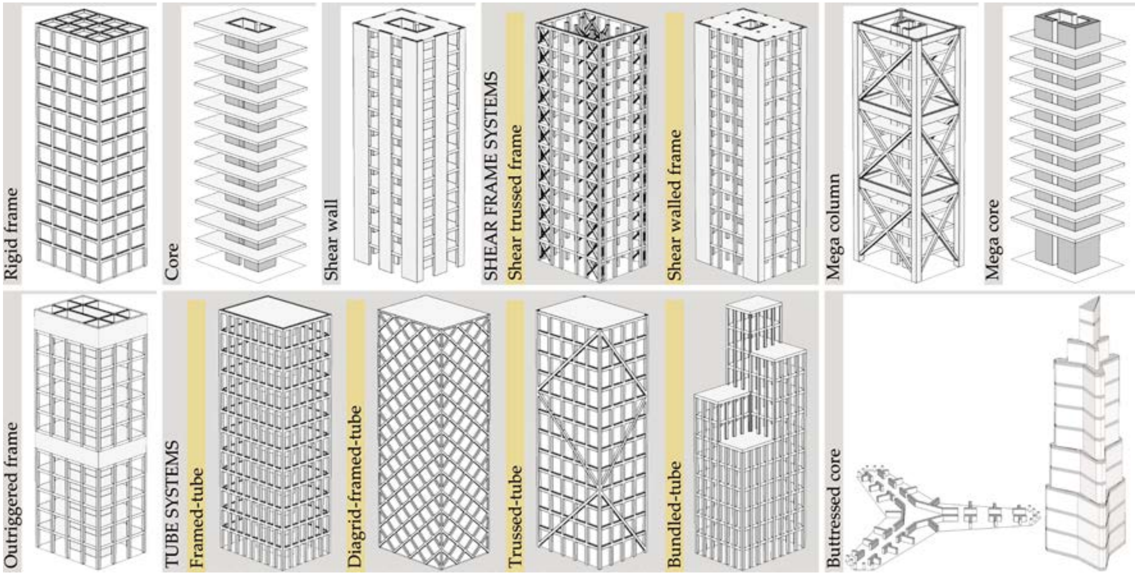
In the context of this study, the term "composite" refers specifically to skyscrapers employing a hybrid configuration of vertical structural elements, such as shear walls and columns, constructed from steel, concrete, or an integrated combination of both. This material strategy is particularly relevant in addressing both load-bearing requirements and spatial performance within supertall buildings.




(a)




(b)




(c)

**Figure 3** Classifications by (a) core planning; (b) form; and (c) structural system (By authors)

## 4. Results

### *4.1. Main Design Parameters*

Across the different regions examined, the choice of building function and core typology emerges as a crucial factor in the design of supertall towers. In Asian skyscrapers, there is a strong preference for a central core typology, particularly in mixed-use and office buildings. This typology is favored due to its compact nature, which contributes significantly to structural integrity and provides efficient pathways for fire evacuation and other emergency services (Ilgın, 2023b).

In North America, similar trends are observed. Central core design is predominant in high-rise office and residential buildings, reflecting a preference for structural efficiency and safety. The core houses vital services, including elevators, stairwells, and mechanical systems, which are central to the functionality of the building (Aslantamer & Ilgın, 2024b). This centralized approach helps in reducing the overall footprint of service areas, thereby enhancing usable space.

In contrast, while the Middle Eastern towers also predominantly use central cores, there is a notable trend toward innovative core designs that accommodate the unique aesthetic and functional demands of the region. These include more fluid and adaptable core structures that allow for varied floor plate configurations, catering to a mix of residential, commercial, and hospitality uses within the same tower (Botti, 2023; Al-Kodmany, 2024).

The form of supertall towers is greatly influenced by regional environmental conditions, cultural preferences, and technological advancements. In Asia, a considerable number of skyscrapers adopt tapered forms, which are particularly advantageous in regions where wind loads significantly impact structural design. The tapered form reduces the wind load by decreasing the exposed surface area at higher elevations, thereby enhancing stability and reducing structural material costs. This aerodynamic consideration is crucial in cities like Hong Kong and Shanghai, where high wind speeds can be a major concern (Chaudhary, 2024).



In North America, the architectural design of supertall towers tends to favor more traditional forms such as setback, prismatic, and cylindrical shapes. These forms are not only aesthetically pleasing but also functionally versatile, allowing for a variety of uses from residential to commercial. Setback design, in particular, is employed to reduce wind forces acting on the building and to create a visually appealing step-like appearance that integrates well with the urban skyline (Barr & Jedwab, 2023).

The Middle East, characterized by its unique blend of modernity and tradition, often showcases innovative and bold building forms. Freeform designs and prismatic shapes are particularly popular, reflecting the region's penchant for iconic and symbolic architecture. These forms are often employed to create landmark buildings that stand out in the skyline, serving as cultural and economic symbols (Al-Kodmany, 2024; Botti, 2023). (See Table 1 for a comparative summary of architectural design parameters across the studied regions).

**Table 1** Comparison of Architectural Design Parameters

| Findings | Middle East | Asia | North America |
|---|---|---|---|
| Function | **Residential (45%)**<br>Office (22%)<br>Mixed-use (33%) | Residential (5%)<br>Office (38%)<br>**Mixed-use (57%)** | Residential (23%)<br>Office (29%)<br>**Mixed-use (48%)** |
| Core type | **Central (96%)**<br>External (4%) | **Central (99%)**<br>External (1%) | **Central (90%)**<br>Peripheral (10%) |
| Form | **Prismatic (45%)**<br>Setback (7%)<br>Tapered (7%)<br>Twisted (4%)<br>Free (37%) | Prismatic (23%)<br>Setback (13%)<br>**Tapered (36%)**<br>Twisted (1%)<br>Free (27%) | Prismatic (26%)<br>**Setback (29%)**<br>Tapered (26%)<br>Free (19%) |

The choice of structural system in supertall towers is a critical decision that influences both the building's stability and space efficiency. In Asia, the most common structural system is the outriggered frame system, utilized in over 75% of the cases analyzed. This system involves the use of outrigger trusses that connect the building's core to the outer columns, effectively distributing lateral loads caused by wind or seismic activity across the building's framework. The outriggered frame system provides a high degree of stability and allows for a more flexible placement of outer columns, which is particularly beneficial in maximizing the usable floor space (Ilgın, 2023b).

North American skyscrapers also frequently employ outrigger systems, along with tube systems and mega-columns, depending on the specific requirements of the building. The tube system, for example, forms a rigid structural "tube" by connecting closely spaced perimeter columns with spandrel beams. This configuration is particularly effective in resisting lateral forces, making it ideal for tall buildings in earthquake-prone areas or regions with high wind loads (Ilgın, 2023b; Barr & Jedwab, 2023).

In the Middle East, the structural systems of choice include reinforced concrete cores combined with outrigger frames or diagrids. The use of concrete provides excellent fire resistance and thermal mass, which is advantageous in the region's hot climate. Additionally, the diagrid system, which uses a network of diagonally intersecting beams, allows for greater flexibility in the building's facade design, facilitating the creation of the region's distinctive, iconic tower shapes (Botti, 2023; Al-Kodmany, 2024).

The materials used in the construction of supertall towers play a pivotal role in determining both the structural integrity and space efficiency of the building. In Asia, composite materials—combinations of steel and concrete—are predominant. The steel provides high tensile strength, while the concrete offers compressive strength and fire resistance, creating a robust framework that can withstand the high stresses associated with supertall structures. This combination also allows for thinner floor slabs and reduced column sizes, enhancing the overall space efficiency (Ilgın, 2023b).

North American skyscrapers exhibit a diverse use of materials, including pure steel, reinforced concrete, and composite materials. The choice of material often depends on the building's location, function, and height. Steel is favored for its high strength-to-weight ratio and ease of construction, while reinforced concrete is preferred for its durability and fire resistance. Composite materials are increasingly being used for their ability to provide the benefits of both steel and concrete, optimizing both strength and space (Ilgın, 2021a).

In the Middle East, reinforced concrete remains the material of choice for most supertall towers. This preference is driven by the material's thermal mass, which helps in maintaining stable indoor temperatures in the region's hot climate. Additionally, concrete's fire-resistant properties are critical for ensuring safety in high-rise buildings. Some towers also incorporate steel into their designs to enhance structural flexibility and reduce overall weight, particularly in taller structures where these attributes are essential (Aslantamer & Ilgın, 2024b; Sev & Özgen, 2009) (See Table 2 for a regional comparison of structural systems and material preferences).

**Table 2** Comparison of Structural Design Parameters

| Findings | Middle East | Asia | North America |
|---|---|---|---|
| Material | **Concrete (70%)**<br>Composite (30%) | Concrete (18%)<br>**Composite (79%)**<br>Steel (3%) | **Concrete (55%)**<br>Composite (39%)<br>Steel (6%) |
| System | **Outriggered frame (44%)**<br>Tube (26%)<br>Mega column & core (15%)<br>Shear-frame (11%)<br>Buttressed core (4%) | **Outriggered frame (76%)**<br>Tube (17%)<br>Buttressed core (3%)<br>Mega column & core (3%)<br>Shear-frame (1%) | **Outriggered frame (42%)**<br>Tube (16%)<br>Mega column & core (3%)<br>Shear-frame (39%) |

### *4.2. Space Efficiency in Towers in Different Locations*

Average space efficiencies of Middle Eastern, Asian, North American towers were 75.5%, 67.5%, and 76%, respectively, whereas core area to GFA ratio were 21.3%, 29.5%, and 21%, respectively. Values fluctuated from the lowest of 55% and 11% to the highest of 84% and 38%, respectively. Table 3 shows the findings on average space efficiency and ratio of core to GFA with those of Middle Eastern, Asian, North American towers.

**Table 3** Comparison of Space Efficiency and Ratio of Core to GFA

| Findings | Middle East | Asia | North America |
|---|---|---|---|
| Space efficiency | 75.5%<br>(max. 84%,<br>min. 63%) | 67.5%<br>(max. 82%,<br>min. 55%) | 76%<br>(max. 84%,<br>min. 62%) |
| Core to GFA | 21.3%<br>(max. 36%,<br>min. 11%) | 29.5%<br>(max. 38%,<br>min. 14%) | 21%<br>(max. 31%,<br>min. 13%) |

The space efficiency of tall buildings in the Middle East, Asia, and North America varies significantly due to a combination of structural systems, building forms, material choices, and regional environmental, economic, and cultural factors. In Asia, supertall towers often employ outriggered frame systems and composite materials. These systems provide the necessary lateral stability to withstand seismic activities and high winds, which are common in many parts of the region. However, the need for robust structural elements, such as large cores and additional supports, reduces the usable floor area, thereby impacting space efficiency. Additionally, the high density of urban development in Asian cities necessitates mixed-use skyscrapers that combine residential, office, and commercial spaces within a single building. This mix of functions requires diverse floor plans and service core arrangements, which can further limit the efficiency of space use. As a result, the average space efficiency in Asian skyscrapers tends to be lower, around 67.5%, as designers balance the need for structural integrity and functionality with the challenges of optimizing usable space.



In North America, tall buildings typically achieve higher space efficiency, averaging around 76%, due to different architectural and structural design approaches. The prevalent use of tube systems, outrigger systems, and mega-columns allows for maximizing interior space while ensuring the building's stability. The tube system, for instance, forms a rigid structural "tube" around the building's perimeter, which efficiently resists lateral forces such as wind and seismic loads. This design strategy minimizes the need for internal structural elements, allowing for more open and flexible floor plans. Moreover, North American skyscrapers often utilize regular, prismatic, and setback forms that are conducive to efficient space planning. These shapes reduce wind loads and create uniform floor plates, facilitating higher space efficiency. The strategic use of high-strength materials like steel and concrete further enhances the ability to optimize floor space, as these materials allow for thinner walls and smaller columns without compromising structural integrity.

In contrast, the architectural and structural design of tall buildings in the Middle East is often driven by a desire to create iconic landmarks that reflect cultural values and economic ambition. As a result, space efficiency may be lower due to the emphasis on unique and often complex building forms, such as freeform and prismatic designs. These forms are chosen not only for their aesthetic appeal but also for their ability to make bold architectural statements in the skyline. However, these designs typically involve irregular floor plates and require additional structural supports to maintain stability, which can significantly reduce usable space. Additionally, the Middle East's harsh climate necessitates the use of reinforced concrete for its excellent thermal mass and fire resistance. While effective for creating comfortable indoor environments and ensuring safety, reinforced concrete often results in thicker walls and larger columns, which occupy more floor space. Consequently, the average space efficiency in Middle Eastern skyscrapers is often lower compared to North American counterparts, as designers prioritize aesthetics and cultural symbolism over maximizing usable space.

Overall, the differences in space efficiency among tall buildings in Asia, North America, and the Middle East are a reflection of the diverse design philosophies and regional needs. In North America, there is a strong emphasis on maximizing return on investment through efficient use of space, leading to the adoption of regular forms and advanced structural systems that optimize both strength and space. In Asia, the rapid urbanization and high population densities drive the need for multifunctional buildings that can accommodate various uses within a single structure, often at the expense of space efficiency due to the need for robust structural systems and diverse floor layouts. Meanwhile, in the Middle East, the cultural emphasis on creating landmark buildings results in a focus on unique architectural forms and robust structural systems to handle the extreme climate, which can reduce space efficiency. Understanding these regional differences is crucial for architects and engineers as they design super-tall buildings that meet the unique environmental, economic, and cultural requirements of each area, balancing the need for efficient space use with other design priorities.

Relation of Space Efficiency and Location, Core Typology, Form, Structural Material, and System Figures 4, 5, 6, 7, 8 present a detailed analysis of empirical data, illustrating the intricate relationship between spatial efficiency and the various architectural and structural elements that influence it. In these figures, a bar chart on the right side effectively shows the total number of towers grouped by relevant classifications, offering a clear overview of data distribution. Colored dots indicate the spatial efficiency of individual towers across different regions in relation to their specific design features, creating a compelling visual representation of this complex interaction. Moreover, bars highlight the frequency of buildings within the sample that share the same design characteristics.

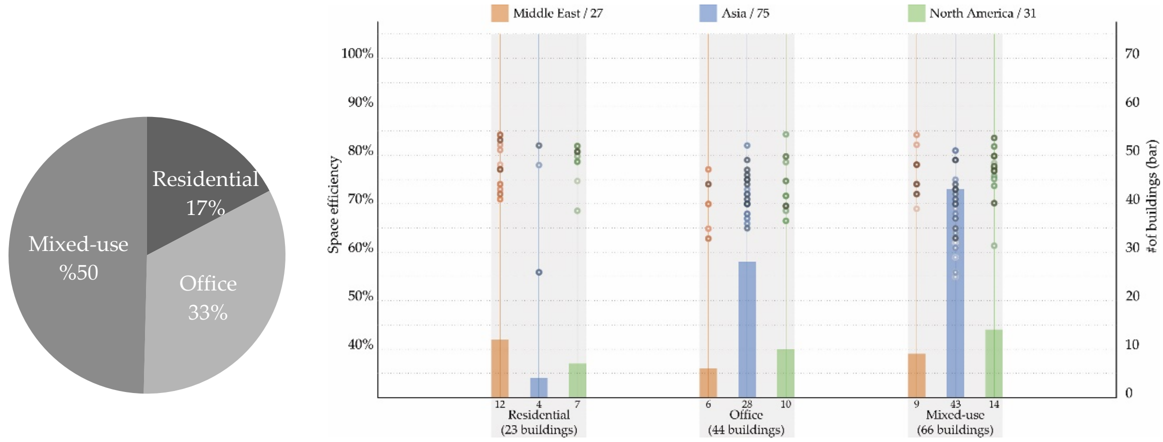



**Figure 4** Different locations by function

Figure 4 presents a comparative analysis of space efficiency in skyscrapers, categorized by function across three regions. In the Middle East, residential buildings exhibit a notably high space efficiency, predominantly clustering around 70% to 80%, which suggests a design focus on maximizing usable space, potentially driven by regional standards or economic considerations. Office buildings in the Middle East dis-play a slightly lower space efficiency range, mostly between 60% and 70%, indicating some variation but generally maintaining a high standard.

In contrast, Asia shows a broader distribution of space efficiency across all building functions. Residential buildings in Asia have space efficiencies ranging from 40% to 80%, with a median around 60%, reflecting diverse architectural designs and possibly varied building codes or market demands. Asian office buildings exhibit a wide efficiency range from 40% to 80%, with a significant concentration around 50% to 60%, highlighting varied approaches to core design and space allocation. Mixed-use buildings in Asia have efficiencies ranging widely, from 50% to nearly 90%, with a dense clustering around 60% to 70%, suggesting flexibility in design strategies to accommodate multiple uses.

North American skyscrapers also show variability in space efficiency, but with less dispersion than in Asia. Residential buildings in North America have efficiencies ranging from 50% to 70%, with a significant number around 60%, indicating a balance between design flexibility and efficiency. Office buildings show a similar pattern, with efficiencies mostly between 50% and 70%, aligning closely with residential buildings. Mixed-use buildings in North America exhibit space efficiencies ranging from 50% to 80%, with a notable concentration around 60% to 70%, suggesting a common approach to multi-use space planning.

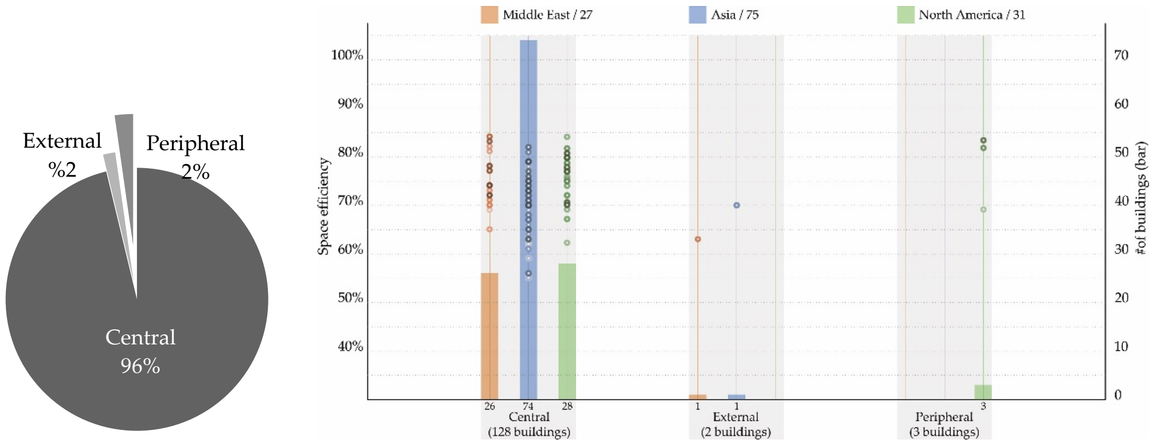


**Figure 5** Different locations by core type

Figure 5 illustrates the relationship between core types and space efficiency across skyscrapers in the Middle East, Asia, and North America. The majority of the buildings in the dataset utilize a central core, with 128 buildings represented. Among these, Asian buildings exhibit a wide range of space efficiencies, from approximately 40% to 90%, with a significant clustering between 50% and 70%. This broad distribution suggests a variety of architectural approaches and core configurations, potentially influenced by diverse building regulations and market demands in Asia. In the Middle East, buildings with central cores show a more concentrated range of space efficiencies, mostly between 60% and 80%, indicating a regional preference for maximizing usable space within this core type, possibly due to stricter building codes or design practices favoring higher efficiency. North American skyscrapers with central cores demonstrate space efficiencies ranging from around 50% to 80%, with a noticeable cluster around 60% to 70%, reflecting a balanced approach to core placement and space utilization that aligns closely with both Asian and Middle Eastern practices.



Figure 5 also highlights the less common core types external and peripheral. The data for buildings with external cores is minimal, with only two buildings represented: one in the Middle East with a space efficiency of approximately 50% and one in Asia with a slightly higher efficiency around 60%. This limited data suggests that external core designs may not be widely adopted or could indicate specific architectural or functional requirements that affect their space efficiency. For buildings with peripheral cores, all three represented are located in North America, showing space efficiencies ranging from 40% to 60%. This indicates that peripheral cores may offer lower space efficiency compared to central cores, possibly due to the increased perimeter circulation space required. The concentration of peripheral core buildings in North America and their relatively lower efficiency might reflect regional architectural trends or design strategies that prioritize different aspects of building functionality over maximizing usable space.

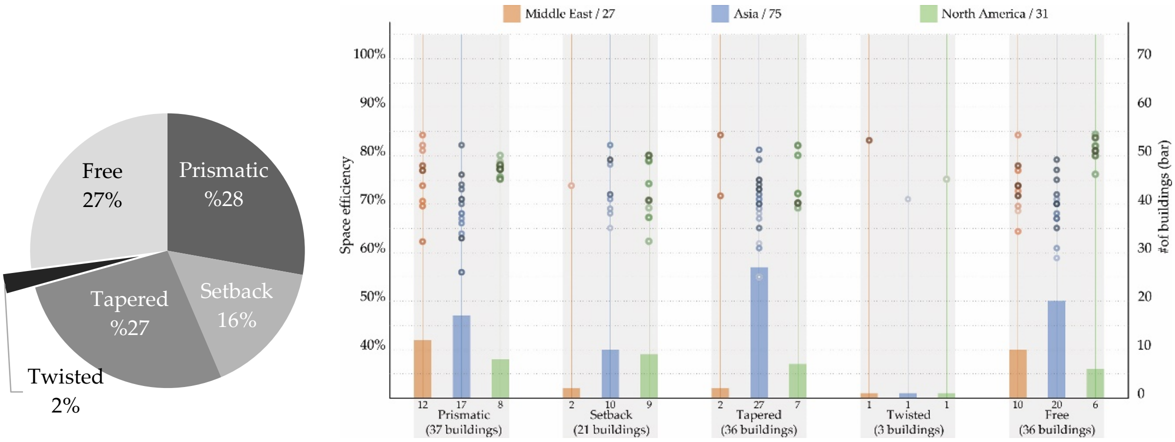



**Figure 6** Different locations by form

Figure 6 provides a detailed analysis of the relationship between building forms prismatic, setback, tapered, twisted, and free and space efficiency across skyscrapers in the Middle East, Asia, and North America. Space efficiency, shown as a percentage on the y-axis, represents the ratio of usable floor area to the total floor area, serving as an indicator of how effectively space is utilized within different building forms.

Prismatic buildings, the most common form with 37 buildings represented, dis-play significant regional differences in space efficiency. In the Middle East, prismatic buildings show high space efficiency, predominantly ranging from 60% to 80%, with a notable clustering around 70% to 80%. This suggests a regional emphasis on maximizing usable space through straightforward, vertical designs. In Asia, prismatic buildings have a broader distribution, with space efficiencies ranging from 40% to 80%, but with a concentration between 50% and 70%. This variability reflects a wide range of design practices and possibly more diverse building regulations or market needs. North

American prismatic buildings exhibit efficiencies predominantly between 60% and 80%, indicating a consistent approach to balancing space utilization and building form.

Setback buildings, which are less common with only 21 examples, show regional variation in space efficiency. In the Middle East, setback buildings have a narrow efficiency range, mostly between 60% and 70%, while in Asia, the efficiencies are more varied, ranging from 40% to 70%, with a concentration around 50%. In North America, setback buildings demonstrate a broader efficiency range from 50% to 80%, indicating more flexibility or variation in design strategies that balance aesthetic considerations with functional space.

Tapered buildings, represented by 36 examples, show significant variation, especially in Asia. Asian tapered buildings have space efficiencies ranging from 40% to nearly 80%, with a substantial concentration around 50% to 60%, reflecting diverse architectural strategies and potentially different design priorities. In contrast, North American and Middle Eastern tapered buildings generally show higher space efficiencies, clustering around 60% to 80%, suggesting a more uniform approach to this form that prioritizes space utilization.

Twisted forms are the least common, with only three buildings represented across the regions. These buildings show a range of space efficiencies from around 40% to 70%, indicating that the twisted form, while architecturally distinctive, may pose challenges to achieving high space efficiency due to its complex geometry and structural requirements.

Free forms, with 36 buildings, exhibit the widest range of space efficiencies across all regions. In the Middle East, free-form buildings have efficiencies ranging from 60% to 80%, reflecting a focus on maintaining high space efficiency even with more flexible and unique designs. In Asia, the space efficiency of free-form buildings varies significantly, from 40% to 80%, indicating diverse design approaches and a wide range of architectural expressions. North American free-form buildings have space efficiencies ranging from 50% to 80%, suggesting that while this form allows for creative freedom, there is also an effort to optimize space utilization.

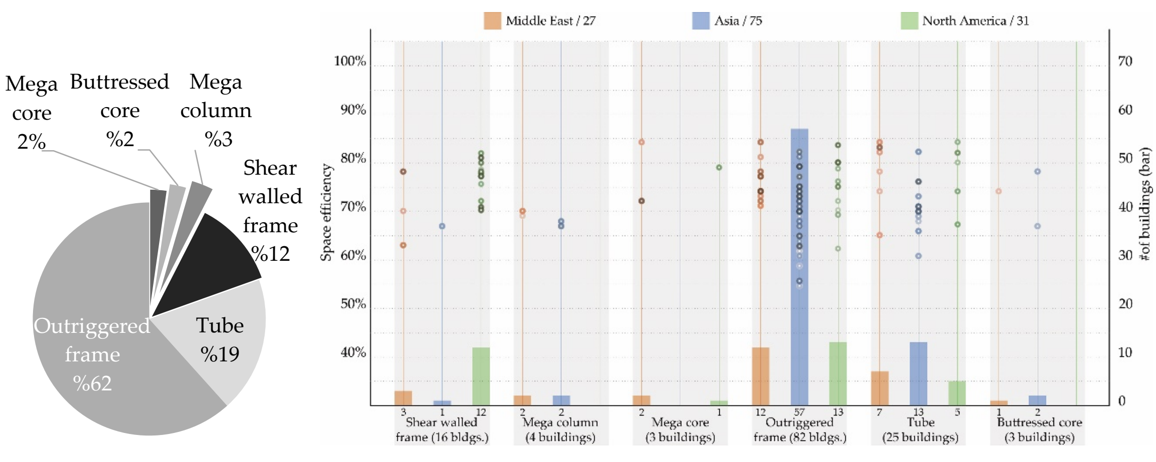



**Figure 7** Different locations by system

Figure 7 provides a detailed analysis of the relationship between different structural systems and space efficiency in skyscrapers across the Middle East, Asia, and North America. Shear walled frame systems, represented by 16 buildings, show significant regional variations in space efficiency. In North America, these buildings demonstrate high space efficiency, ranging from approximately 70% to 80%, suggesting a design emphasis on maximizing usable space within this structural configuration. In contrast, the Middle East and Asia show broader ranges for shear walled frames, with the Middle East ranging from about 60% to 80% and Asia from 60% to 70%. This variation indicates diverse design practices and regional preferences in optimizing space with shear walled frames, reflecting different architectural standards or construction techniques.

Mega column systems, with only four buildings represented, have consistent space efficiency in the Middle East and Asia, with efficiencies ranging from around 60% to 70%. This consistency suggests that the use of mega columns in these regions focuses on balancing structural capacity with space optimization, potentially due to the system's ability to support large open spaces and accommodate varied floor plans. The absence of North American buildings with mega column systems in the dataset might indicate a regional preference for other structural systems that align more closely with local building codes and architectural trends.

Mega core systems, although represented by only three buildings, show varied space efficiencies across regions. In North America, mega core systems achieve high space efficiency, with values around 70% to 80%, indicating a strong focus on space utilization in conjunction with structural stability. In the Middle East, the efficiency of mega core systems is slightly lower, around 60%, suggesting regional differences in de-sign strategies or structural demands.

Outriggered frames, the most common structural system in the dataset with 82 buildings, exhibit a wide range of space efficiencies across all regions. In Asia, these buildings show a broad efficiency range from 40% to 80%, with a significant clustering around 50% to 70%, highlighting a variety of design approaches and engineering solutions to optimize space. The Middle East demonstrates a narrower range for outriggered frames, from 60% to 80%, with many buildings concentrated around 70%, reflecting a regional emphasis on achieving high space efficiency through this structural system. North American buildings with outriggered frames also show a wide range of efficiencies from 50% to 80%, suggesting diverse architectural strategies and a balance between structural robustness and space optimization.

Tube systems, represented by 25 buildings, show diverse space efficiency out-comes across regions. In Asia, buildings with tube structures have space efficiencies ranging from 40% to 70%, with a concentration around 50% to 60%, indicating varied architectural practices and structural requirements. North American and Middle Eastern tube-structured buildings exhibit higher efficiencies, predominantly between 60% and 80%, suggesting that in these regions, tube systems are optimized to maximize usable space while maintaining structural integrity.

Buttressed core systems, represented by three buildings, show distinct regional variations in space efficiency. The single building in the Middle East has a space efficiency around 50%, while the two buildings in North America exhibit higher efficiencies, around 70% to 80%. This indicates that buttressed core systems, though less common, can achieve high space efficiency depending on regional design practices and specific structural needs.

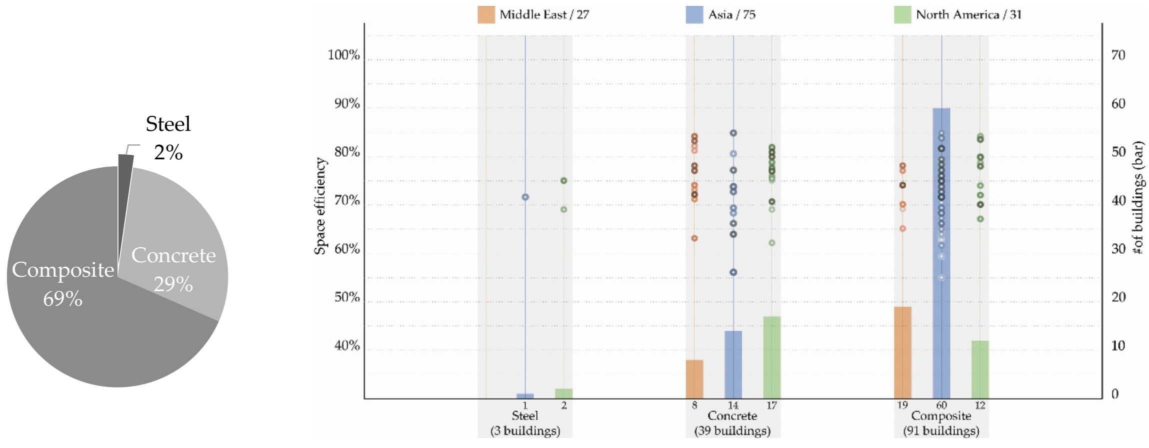



**Figure 8** Different locations by material

Figure 8 provides a comprehensive analysis of the relationship between structural materials steel, concrete, and composite and space efficiency in skyscrapers across three regions: the Middle East, Asia, and North America. Space efficiency, depicted on the y-axis as a percentage, measures the proportion of usable floor area relative to the total floor area, serving as a key indicator of how effectively different structural mate-rials contribute to maximizing functional space within tall buildings.



Steel, represented by only three buildings, demonstrates relatively high space efficiencies, with the buildings in Asia and North America both achieving efficiencies around 70%. This suggests that steel, although less commonly used in this dataset, can provide substantial space efficiency. The high efficiency is likely due to steel's excellent strength-to-weight ratio, which allows for larger spans and more open floor plans, thus maximizing usable space. The limited data points for steel may reflect its specialized use in specific regional contexts where structural advantages such as flexibility and high load-bearing capacity are prioritized.

Concrete, a more prevalent material with 39 buildings represented, exhibits a wide range of space efficiencies across all regions. In Asia, concrete buildings have space efficiencies ranging from approximately 40% to 80%, with a notable clustering around 60% to 70%. This variability suggests diverse architectural strategies and potentially varying regulatory environments that influence space utilization. The data indicates that Asian concrete buildings are designed with a broad spectrum of efficiency considerations, from highly efficient designs to those with more modest efficiencies, possibly due to different construction practices and economic factors. Middle Eastern concrete buildings show a similar range, primarily between 60% and 80%, with a significant concentration around 70%. This reflects a consistent approach to optimizing space with concrete, potentially driven by regional design standards or material availability that favors efficient space use. North American concrete buildings dis-play a comparable efficiency range from about 50% to 80%, clustering mostly around 60% to 70%. This suggests a balanced approach in North America, utilizing concrete's structural properties to enhance space efficiency while adhering to local building codes and architectural norms.

Composite materials, which combine different structural elements to optimize strength, flexibility, and material efficiency, are the most common in the dataset, with 91 buildings represented. Buildings using composite materials display a broad range of space efficiencies, especially in Asia, where efficiencies range from 40% to 80%, with a concentration around 60% to 70%. This wide distribution indicates a variety of design practices and the versatility of composite materials in accommodating different architectural and functional requirements. In the Middle East, composite buildings generally show higher efficiencies, clustering between 60% and 80%, suggesting a regional emphasis on maximizing usable space while leveraging the adaptability and strength of composite materials. This efficiency range indicates that the Middle East may prioritize structural systems that provide both flexibility and high space utilization, aligning with regional construction practices and climate considerations. North American buildings using composites also exhibit a broad efficiency range from 50% to 80%, reflecting flexibility in design approaches and a focus on achieving high space efficiency with these materials. The concentration around 60% to 70% in North America high-lights a trend toward optimizing space through the strategic use of composite materials, which can offer tailored structural solutions to meet varied design and regulatory needs.

## 5. Discussion

The comparative analysis of space efficiency in skyscrapers from the Middle East, Asia, and North America provides valuable insights into regional architectural practices, structural engineering approaches, and the economic drivers influencing the design of supertall buildings. By examining the space utilization strategies and design philosophies across these diverse regions, this study uncovers both commonalities and unique aspects that shape skyscraper development globally.

Space efficiency in Asian skyscrapers averages around 67.5%, with a range from 55% to 82%. This relatively wide range reflects the diversity of design approaches and building functions in Asia, where rapid urbanization and high population densities necessitate innovative architectural solutions. The lower average space efficiency compared to other regions may be attributed to the complex mixed-use designs prevalent in Asia, which integrate residential, commercial, and public spaces within a single structure. These multifunctional layouts, while beneficial for urban density, can lead to compromises in spatial efficiency due to the need for larger core areas and diverse circulation spaces.

Skyscrapers in the Middle East exhibit a slightly higher average space efficiency of 75.5%, ranging from 63% to 84%. This efficiency can be linked to the region's emphasis on luxurious and spacious designs that cater to the socio-economic expectations of the market. The use of advanced structural systems and materials, combined with the relatively recent development of skyscrapers in the region, allows for more optimized space planning. In the Middle East, iconic designs and large-scale mixed-use functions often prioritize aesthetic appeal and symbolic value, which sometimes leads to larger service cores and structural elements, reducing available usable space.



In North America, skyscrapers demonstrate an average space efficiency of 76%, with values ranging from 62% to 84%. The consistency in space efficiency can be attributed to the long history of skyscraper development in the region, where optimization techniques have been refined over decades. North American skyscrapers often prioritize office spaces, which generally have more straightforward space requirements than mixed-use or residential buildings. The use of well-established structural systems and an emphasis on maximizing leasable floor space in commercial developments contribute to this relatively high and consistent efficiency.

These variations in space efficiency outcomes highlight how regional differences in economic conditions, cultural expectations, and urban planning strategies influence skyscraper design. While Asia’s high-density urban environments push for innovative and multifunctional designs, the Middle East’s focus on luxury and iconic architecture results in space-efficient yet grandiose designs. North America’s long-standing tradition of skyscraper construction reflects a more refined approach to optimizing office spaces, with a strong focus on financial returns and practical efficiency.

The central core configuration is the predominant choice in skyscrapers across all three regions—Asia, the Middle East, and North America—due to its compact nature, structural efficiency, and its ability to support flexible facade design and enhance fire safety. This choice is particularly pronounced in Asian skyscrapers, where central cores are crucial for supporting the varied requirements of mixed-use and office buildings. In North America, central cores are favored for their role in maximizing usable space along the building's perimeter, improving natural light access and fire safety. The efficiency of central cores is well-documented in the literature, as they consolidate vertical circulation elements (such as elevators and stairwells) and essential services (such as utilities and HVAC systems) into a single, centralized area. This design frees up the perimeter for leasable space, thereby enhancing the building's overall space efficiency.

The choice of building form also significantly impacts space efficiency and is influenced by local climatic conditions, aesthetic preferences, and structural considerations. In Asia, tapered forms are most common, offering aerodynamic advantages essential for regions with high wind loads. This form reduces wind forces acting on the structure, minimizing sway and increasing overall stability—critical factors for supertall buildings in wind-prone cities. In contrast, the Middle East and North America predominantly feature prismatic and setback forms. Prismatic forms provide straightforward solutions for maximizing interior space, while setback forms offer tiered designs that enhance structural stability and reduce wind loads at higher levels.

In terms of structural systems, Asia primarily uses outrigger frame systems, which balance strength and flexibility. Outrigger systems enhance lateral stiffness by linking the central core to external columns, effectively distributing wind and seismic loads. This system is particularly suited to high-rise, mixed-use buildings typical in Asian metropolises, where both structural integrity and spatial efficiency are essential. Middle Eastern skyscrapers also favor outrigger systems, often in combination with concrete shear walls, which provide additional support against lateral forces. North American skyscrapers commonly use a mix of outrigger and shear wall frame systems, emphasizing both structural robustness and cost-effectiveness.

Regarding materials, composite materials—combining steel and concrete—are widely used in Asian skyscrapers due to their synergistic benefits. Steel provides tensile strength, while concrete offers compressive strength and fire resistance, making this combination ideal for the tall, slender profiles of many Asian skyscrapers. In the Middle East, reinforced concrete remains the material of choice, largely due to its durability and thermal mass, which helps regulate indoor temperatures in hot climates. North American skyscrapers typically employ steel or composite materials, reflecting a balance between strength, flexibility, and cost considerations, which are crucial in a market where both structural performance and financial feasibility are prioritized.

An inverse relationship between building height and space efficiency is observed across all regions, highlighting the challenges of maintaining high space efficiency ratios as buildings increase in height. Taller buildings require larger cores and more substantial structural elements to withstand wind and seismic forces, reducing the proportion of usable floor area. This relationship is particularly pronounced in supertall buildings, where structural demands significantly impact design choices and space allocation.

Each region's unique socio-economic context, climate, and cultural values significantly influence skyscraper design trends and space efficiency. In Asia, rapid urbanization, high population densities, and economic growth drive skyscraper development. The focus is on high-density, mixed-use developments that integrate residential, commercial, and public spaces to accommodate diverse needs within limited urban footprints. This approach reflects a pragmatic response to land scarcity and the demand for multifunctional urban spaces. In the Middle East, skyscraper development is driven by economic diversification and the desire to create iconic structures that enhance global competitiveness. The emphasis on luxury and spaciousness in skyscraper design reflects the region's socio-economic status and cultural expectations, often resulting in higher space efficiency metrics compared to Asia. North American skyscrapers reflect a balance between maximizing floor area and ensuring structural and environmental sustainability in densely populated urban areas. The region's long history of skyscraper development has led to a mature understanding of space optimization techniques, integrating advanced materials and systems to enhance building performance.

Future research could further explore these variations by examining additional factors such as environmental impact, cultural influences, and economic contexts, providing a more comprehensive understanding of global skyscraper design trends. Expanding the study to include other regions, such as Europe or South America, could also offer new insights into how different contexts shape skyscraper design and space efficiency.

This synthesis of findings from Asia, the Middle East, and North America serves as a valuable resource for architects, engineers, and urban planners aiming to optimize space efficiency in skyscrapers. Adapting strategies to fit the unique demands and opportunities of different regions will be essential. As the global skyline continues to evolve, understanding these regional nuances will be crucial for developing innovative, efficient, and sustainable skyscrapers.

## 6. Conclusion

This comparative analysis of space efficiency in skyscrapers across the Middle East, Asia, and North America highlights significant regional differences and similarities in architectural strategies and structural innovations.

In the Middle East, Asia, and North America, skyscrapers are designed with both regional characteristics and shared strategies. Middle Eastern skyscrapers typically use prismatic forms with central cores, focusing on residential and mixed-use functions, and often employ concrete and outrigger frame systems to balance structural stability with space efficiency. However, as building height increases, space efficiency tends to decrease due to the need for larger core areas and more robust structural elements. Similarly, in Asia, supertall towers frequently feature tapered forms and central cores, aiming to balance aesthetics with practical considerations such as wind resistance. Here too, space efficiency decreases with height for the same reasons. In North America, skyscrapers often employ setback, prismatic, and tapered configurations, combined with advanced core planning and structural systems like outrigger and shear-walled frames. This approach balances space utilization with structural integrity, reflecting a focus on financial viability and efficient land use, particularly in cities with high land costs. Overall, these regions exhibit a mature approach to skyscraper construction that emphasizes both economic and ecological considerations.



There is a need for further research focusing on integrating sustainability measures with space efficiency strategies. This could help create buildings that are both spatially optimized and environmentally friendly. Exploring the impact of emerging construction technologies and materials, such as 3D printing and advanced composites, could provide insights into how to reduce the size of structural elements and core areas without compromising safety. Detailed cross-regional comparisons of skyscrapers, including those in emerging markets, could reveal how different cultural, economic, and environmental contexts influence design decisions and efficiency outcomes. Additionally, examining how space efficiency affects the comfort, productivity, and satisfaction of building occupants would be valuable in balancing space utilization with high-quality indoor environments.

Based on the findings of this study, architects and engineers involved in skyscraper design should prioritize optimizing the size and layout of service cores. This could involve exploring new configurations that minimize the space taken up by elevators, stairwells, and mechanical systems, thereby increasing usable floor space. Incorporating innovative structural systems, such as hybrid or advanced composite materials, can also allow for slimmer structural elements, reducing the overall footprint and improving space efficiency. It is important to tailor skyscraper designs to local environmental conditions and building codes, considering factors like wind loads and seismic activity. Emphasizing mixed-use developments can maximize space efficiency while meeting diverse urban needs. Additionally, integrating sustainable practices, such as green roofs and energy-efficient facades, can enhance a building's overall performance and appeal.

By continuing to explore the complex interplay of factors influencing skyscraper design and implementing these recommendations, architects and engineers can enhance both the efficiency and sustainability of high-rise buildings, better meeting the evolving needs of urban environments worldwide.

## References

Al-Kodmany, K. (2024). Refashioning cities in the Middle East: The case of Dubai. *International Journal of High-Rise Buildings*, *13*(1), 11–32.

Arslan Kılınç, G. (2019). *Improving a model for determining space efficiency of tall office buildings*. Ph.D. Thesis, Department of Architecture, Mimar Sinan Fine Art University, Istanbul, Turkey. (In Turkish).

Aslantamer, Ö. N., & Ilgın, H. E. (2024a). Evaluating space efficiency of tall buildings in Turkey. *Buildings*, *14*(7), 2138.

Aslantamer, Ö. N., & Ilgın, H. E. (2024b). Space efficiency in tall hotel towers. *Buildings*, *14*, 2051.

Barr, J., & Jedwab, R. (2023). Exciting, boring, and nonexistent skylines: Vertical building gaps in global perspective. *Real Estate Economics*, *51*(6), 1512–1546.

Botti, G. (2023). The skyscraper: Go East, go high, go hybrid. *In Designing Emerging Markets: A Quantitative History of Architectural Globalisation* (pp. 163–248). Singapore: Springer Nature Singapore.

Chaudhary, N. (2024). Construction of skyscrapers: Boon or bane from an economic perspective. *Journal of Tikapur Multiple Campus*, *7*(1–2), 69–84.

CTBUH Council on Tall Buildings and Urban Habitat. (2024). Illinois Institute of Technology, S.R. Crown Hall, 3360 South State Street, Chicago, Illinois, USA. Available online: www.ctbuh.org (Accessed on 26 August 2024).

Goessler, T., & Kaluarachchi, Y. (2023). Smart adaptive homes and their potential to improve space efficiency and personalisation. *Buildings*, *13*, 1132.

Hamid, G. M., Elsawi, M., & Yusra, O. (2022). The impacts of spatial parameters on space efficiency in hybrid villa-apartments in Greater Khartoum, Sudan. *Journal of Architecture and Planning*, *34*, 425–440.

Höjer, M., & Mjörnell, K. (2018). Measures and steps for more efficient use of buildings. *Sustainability*, *10*(1949).

Ibrahimy, R., Mohmmand, M. A., & Elham, F. A. (2023). An evaluation of space use efficiency in residential houses, Kabul City. *Journal of Research in Applied Sciences and Biotechnology*, *2*, 1–6.

Ilgın, H. E. (2021a). Space efficiency in contemporary supertall residential buildings. *Architecture*, *1*, 25–37.

Ilgın, H. E. (2021b). Space efficiency in contemporary supertall office buildings. *Journal of Architectural Engineering*, *27*, 4021024.

Ilgın, H. E. (2023a). An analysis of space efficiency in Asian supertall towers. *International Journal of Building Pathology and Adaptation*, *41*, 237–253.

Ilgın, H. E. (2023b). A study on space efficiency in contemporary supertall mixed-use buildings. *Journal of Building Engineering*, *69*, 106223.

Ilgın, H. E. (2024). Examination of spatial efficiency in super-tall towers within the Middle Eastern context. *Open House International*. (E-pub ahead of print).

Ilgın, H. E., & Aslantamer, Ö. N. (2024). Space efficiency in North American skyscrapers. *Buildings*, *14*, 2382.

Kim, H., & Elnimeiri, M. (2004). Space efficiency in multi-use tall buildings. *In Proceedings of the Tall Buildings in Historical Cities-Culture and Technology for Sustainable Cities*, Seoul, Republic of Korea (10–13 October 2004).

Nam, H. J., & Shim, J. H. (2016). An analysis of the change in space efficiency based on various tall building corner shapes and lease spans. *Journal of the Architectural Institute of Korea: Planning and Design*, *32*, 13–20.

Noor, K. B. M. (2008). Case study: A strategic research methodology. *American Journal of Applied Sciences*, *5*(11), 1602–1604.

Opoku, A., Ahmed, V., & Akotia, J. (2016). Research methodology in the built environment. *Choosing an Appropriate Research Method*, 32–49.

Pitroda, J., & Singh, J. R. (2016). Evolution of super tall and super slender skyscrapers structural systems in conjunction with architectural forms and aesthetics. *In Proceedings of International Conference on Engineering: Issues, Opportunities, and Challenges for Development* (Vol. 9, pp. 206–222).

Radović, V. (2020). Density through the prism of supertall residential skyscrapers: Urbo-architectural type in global megacities. *Sustainability*, *12*(4), 1314.

Saari, A., Tissari, T., Valkama, E., & Seppänen, O. (2006). The effect of a redesigned floor plan, occupant density, and the quality of indoor climate on the cost of space, productivity, and sick leave in an office building: A case study. *Building and Environment*, *41*, 1961–1972.

Saroglou, T., Theodosiou, T., Itzhak-Ben-Shalom, H., Vanunu, A. Y., Multanen, V., Isaac, S., & Meir, I. A. (2023). Skyscrapers and the city: How tall buildings interact with their users and urban environment. *In E3S Web of Conferences* (Vol. 436, p. 01005). EDP Sciences.

Sev, A., & Özgen, A. (2009). Space efficiency in high-rise office buildings. *METU Journal of the Faculty of Architecture*, *26*, 69–89.

Suga, R. (2021). *Space efficiency in hotel development*. Master's Thesis, MODUL University Vienna, Austria.

Szołomicki, J., & Golasz-Szołomicka, H. (2021). Analysis of technical problems in modern super-slim high-rise residential buildings. *Budownictwo i Architektura*, *20*(1), 083–116.

Tuure, A., & Ilgın, H. E. (2023). Space efficiency in Finnish mid-rise timber apartment buildings. *Buildings*, *13*, 2094.

Von Both, P. (2019). A stakeholder-and function-based planning method for space-efficient buildings. *IOP Conference Series: Earth and Environmental Science*, *323*, 012040.

Zhang, L., Zhang, L., & Wang, Y. (2016). Shape optimization of free-form buildings based on solar radiation gain and space efficiency using a multi-objective genetic algorithm in the severe cold zones of China. *Solar Energy*, *132*, 38–50.


## Resume


*Özlem Nur Aslantamer completed her Ph.D. in Landscape Architecture at the School of Natural and Applied Sciences, Ankara University, in 2021. With 26 years of combined experience in academia and the professional field of interior architecture & environmental design, she has established a robust foundation in her field. Since 2021, she has been serving as a full-time instructor at Atılım University, dedicating her expertise to both teaching and research endeavors.*

*Hüseyin Emre Ilgın received his Ph.D. (2018) in Building Sciences about tall building design in Architecture from METU in Ankara. Since December 2019, he has been conducting post-doctoral research on wood construction at Tampere University. Dr. Ilgın worked as a Marie Skłodowska-Curie postdoctoral research fellow on dovetailed massive wood board elements for 2 years between 2021-2023.*

JOURNAL OF DESIGN FOR RESILIENCE
IN ARCHITECTURE & PLANNING

*Research Article*
*Online:* www.drarch.org
*Volume 6, Issue 1 (20-39), 2025*
*DOI: 10.47818/DRArch.2025.v6i1155*

# Silo buildings: A new image in the urban landscape

Zeynep Kerem Öztürk*
Ahmet Kurnaz**

## Abstract

Silo buildings, traditionally used for storing bulk commodities such as grain, cement, and seeds, have become emblematic of industrial heritage while increasingly facing obsolescence in modern cities. Their cylindrical forms, dictated initially by utilitarian priorities, have made them prominent landmarks in urban and rural landscapes. With advancements in agricultural technology, shifts in logistics, and urban expansion, many silos lost their primary functions, leading to their abandonment or demolition. Recognizing the cultural, historical, and architectural significance of these structures, this study examines the potential of adaptive reuse—mainly through façade modifications and structural alterations—to transform silo buildings into vibrant elements of the contemporary urban fabric. A qualitative multiple-case study methodology was adopted to analyze four exemplary projects: Portland Towers, The Silo, Gemini Residence in Copenhagen, and Sugar City in Amsterdam. Data collection involved the review of architectural documentation, historical records, and visual media, with site observations and, where possible, stakeholder interviews. This approach enabled an in-depth exploration of the strategies employed to convert monumental, monolithic silos into fully functional environments. Central to these transformations were façade interventions—such as the introduction of windows, balconies, and new cladding materials—that humanized previously austere exteriors and improved interior light and ventilation. Structural additions and interior reconfigurations were also critical, helping silo buildings comply with modern building standards and accommodate a range of new functions, including offices, residences, and cultural venues. Findings highlight how carefully balanced preservation and innovation can conserve industrial authenticity while meeting contemporary urban needs. These projects illustrate how adaptive reuse revitalizes obsolete buildings and contributes to urban regeneration by attracting economic investment, enhancing local identity, and promoting sustainability through the conservation of embodied energy. Moreover, preserving a silo's cylindrical core while introducing modern features fosters a sense of continuity between past and present, reinforcing communal memory. Ultimately, the case studies underscore adaptive reuse as a practical, culturally sensitive pathway for reimagining silo buildings—one that merges historical significance, architectural creativity, and sustainable development to produce dynamic new landmarks in evolving urban landscapes.

*Keywords:* adaptive reuse, architectural interventions, industrial heritage preservation, silo buildings, urban regeneration

## 1. Introduction

Silo buildings have long been emblematic features of industrial and agricultural landscapes, standing as towering testaments to the ingenuity and economic importance of the storage and distribution systems of agricultural products, seeds, cement, and fuel. Constructed between the late 19th and mid-20th centuries, these large, cylindrical structures were engineered to store bulk quantities of agricultural products such as grain, seeds, and other commodities essential to both local and global economies (Fernández-Fernández et al., 2017). Often strategically located near railways, ports, and urban centers, silos served as critical nodes in the agricultural supply chain, facilitating efficient storage, processing, and transport of goods.

Architecturally, silos are characterized by their imposing verticality, minimalist design, and robust construction materials like reinforced concrete and steel (Brooker & Stone, 2019). Their

*Assist. Prof. Dr., Istanbul Sabahattin Zaim University, Türkiye zeynep.keremozturk@izu.edu.tr
**(Corresponding author), Assist. Prof. Dr., Istanbul Sabahattin Zaim University, Türkiye ahmet.kurnaz@izu.edu.tr
*Article history: Received 24 January 2025, Accepted 04 April 2025, Published 30 April 2025*

utilitarian aesthetics reflect the functional priorities of the industrial era. However, many silos possess a stark monumental beauty that has made them significant landmarks within both rural and urban settings. These structures' sheer scale and distinctive forms have ingrained them into the collective memory and identity of the communities they once served.



However, the latter half of the 20th century brought significant changes that led to the obsolescence of many silo buildings. Advancements in agricultural technology, shifts in logistics and transportation methods, and the globalization of trade reduced the need for localized storage facilities (Bullen & Love, 2011). Additionally, urban expansion and changes in land use priorities rendered many silo sites prime targets for redevelopment (Shipley et al., 2006). As a result, numerous silos were decommissioned, leaving behind vacant structures that posed challenges related to safety, maintenance, and land utilization.

The abandonment of silo buildings presents a complex dilemma for urban planners, architects, and preservationists. On the one hand, these structures are industrial relics that embody historical, cultural, and architectural values worthy of preservation (Cantell, 2005; Edwards & Llurdés I Coit, 1996). On the other hand, their sheer size and specialized construction make it challenging to repurpose them without significant intervention (Douglas, 2006). Demolition, while clearing valuable land for new development, results in the loss of industrial heritage and contributes to environmental concerns related to waste and resource consumption (Bullen & Love, 2011).

Adaptive reuse has emerged as a sustainable and culturally sensitive strategy to address the challenges posed by obsolete industrial structures like silos (Plevoets & Van Cleempoel, 2012). This approach involves repurposing existing buildings for new functions, conserving resources, reducing environmental impact, and preserving historical identity (Bullen & Love, 2011). Adaptive reuse aligns with contemporary urban development principles emphasizing sustainability, heritage preservation, minimal intervention, and efficient utilization of existing building stock (Brooker & Stone, 2019).

In the context of silo buildings, adaptive reuse often necessitates innovative architectural interventions to make these structures suitable for new functions (Douglas, 2006). Façade modifications and structural additions enhance usability while retaining the building's historical authenticity. Façade changes play a pivotal role in transforming the image of silos within the urban environment. Architects can humanize these monolithic structures by introducing elements such as windows, balconies, and contemporary façade elements, improving their interaction with the surrounding urban fabric and altering public perception (Brooker & Stone, 2019).

The transformation of silo buildings through adaptive reuse has broader implications for urban identity and regeneration (Heath et al., 2013). As cities evolve, integrating repurposed industrial structures can contribute to a sense of continuity and place, bridging the past with the present (Yung & Chan, 2012). Such projects can revitalize neighborhoods and economic activity in the area and enhance cultural offerings, strengthening the city's unique character and charm (Couch et al., 2008).

This paper aims to explore the multifaceted process of transforming silo buildings within urban contexts through adaptive reuse, with a particular focus on architectural interventions to the façade. By examining detailed case studies of Portland Towers (DGA Architects, 2014), Gemini Residence/Frosilo (MVRDV, 2005) and The Silo (COBE, 2017) in Copenhagen, and Sugar City (SugarCity, 2007) in Amsterdam, the study seeks to:

- Understand the impact of adaptive reuse on the urban identity of silo buildings. This involves analyzing how the transformation of these structures influences their role as landmarks and their integration into the urban narrative.
- Identify the specific architectural interventions employed in these transformations. The focus is on façade modifications and structural additions that facilitate new functions while respecting the building's historical significance.

- Assess how these changes alter the perception of silo buildings within the urban landscape. The study examines public reception, cultural significance, and the contribution of these projects to urban regeneration efforts.

Through this exploration, the paper contributes to the broader discourse on sustainable urban development, heritage preservation, and architectural innovation (UNESCO, 2013). It highlights the potential of adaptive reuse as a practical solution for dealing with obsolete industrial structures and enriching the urban environment. By preserving the monumental presence of silo buildings and reimagining their purpose, cities can honor their industrial heritage while fostering new opportunities for cultural and economic growth (Cantell, 2005).



In an era where sustainability and heritage conservation are increasingly important, the adaptive reuse of silo buildings serves as a compelling example of how cities can navigate the challenges of modernization (Plevoets & Van Cleempoel, 2012). These projects demonstrate that with thoughtful design and strategic interventions, even the most utilitarian structures can find new life and relevance, becoming integral parts of the contemporary urban tapestry (Brooker & Stone, 2019).

Furthermore, recent scholarly debates have emphasized the importance of urban resilience in the context of adaptive reuse, particularly how post-industrial transformations can enhance the adaptive capacities of cities facing economic, social, and environmental challenges (Meerow et al., 2016). In addition, emerging digital heritage strategies, such as 3D scanning, Building Information Modelling (BIM), and virtual reality applications, have significantly impacted how industrial heritage structures are documented, conserved, and integrated into contemporary urban contexts (Affleck & Kvan, 2008; Logothetis et al., 2015). These innovative techniques facilitate the preservation and interpretation of heritage sites, enhancing public engagement and urban identity (Barbara et al., 2021).

## 2. Research Aims

The primary objective of this study is to investigate how the adaptive reuse of silo buildings, through significant architectural interventions, contributes to their transformation into functional and culturally significant elements within urban landscapes. Focusing on façade modifications and structural additions, the research seeks to understand the multifaceted impact of these changes on the buildings and the cities they inhabit.

Specifically, the study aims to:

- Analyze the influence of adaptive reuse projects on the urban identity of silo buildings. This involves examining how the conversion of silos from industrial storage facilities to new functions reshapes their roles as urban landmarks, affects public perception, and integrates them into the cultural and historical narratives of their surroundings (Heath et al., 2013; Carmona, 2021).
- Identify and critically assess the architectural interventions employed in the transformation of silo buildings. By detailing the specific design strategies—such as façade modifications and adding new structural elements—the research aims to highlight how these interventions balance the preservation of historical significance with introducing contemporary uses (Brooker & Stone, 2019; Douglas, 2006).
- Evaluate the impact of these architectural changes on the perception and experience of silo buildings within the urban landscape. This includes exploring how modifications influence the buildings' visual prominence, their interaction with the surrounding urban fabric, and their ability to engage the community and contribute to urban regeneration (Lynch, 1960; Couch et al., 2008).

Through this comprehensive examination, the study seeks to contribute to the broader discourse on sustainable urban development, industrial heritage preservation, and architectural innovation (UNESCO, 2011; Bullen & Love, 2011). The research aims to provide insights and best practices for integrating repurposed industrial structures into contemporary urban environments by analyzing detailed case studies from diverse geographical and cultural contexts. The findings aspire to inform future projects involving transforming obsolete industrial buildings, emphasizing the importance of thoughtful design, cultural sensitivity, and the sustainable revitalization of architectural heritage.



## 3. Materials and Methods

This study adopts a qualitative research methodology, utilizing a multiple-case study approach to explore the adaptive reuse of silo buildings within urban environments (Creswell, 2013; Yin, 2009). The qualitative approach is appropriate for this research as it allows for an in-depth examination of complex phenomena, providing rich, contextual insights into the processes and outcomes associated with transforming industrial structures into functional and culturally significant urban landmarks. By focusing on specific instances of silo reuse, the study aims to identify patterns, strategies, and unique features that contribute to successful adaptive reuse projects.

The selection of case studies was conducted through purposeful sampling, focusing on projects that exemplify significant architectural interventions and represent a diversity of new functions and geographical contexts (Patton, 2014). The three silo buildings chosen for analysis are Portland Towers, Gemini Residence/Frosilo and The Silo in Copenhagen, and Sugar City in Amsterdam (Table 1). The criteria for selecting these case studies included the degree and clarity of available architectural documentation to allow comprehensive spatial analysis; projects demonstrating a clear integration of façade modifications, interior spatial configurations, and structural interventions; examples from diverse functional contexts (residential, office, mixed-use) to provide broader applicability and comparability; and cases which had demonstrable urban impacts through their regeneration roles within their respective urban settings.

**Table 1** Case Studies on Adaptive Reuse of Silo Buildings (Author(s), 2024)

| Name of Building | Location | Original Function | Year of Transformation | New Function |
|---|---|---|---|---|
| Portland Towers | Copenhagen-Nordhavn, Denmark | Cement storage silos | 2014 | Office spaces |
| The Silo | Copenhagen-Nordhavn, Denmark | Grain storage silos | 2017 | Mixed-use residential and cultural space |
| Gemini Residence | Brygge, Copenhagen, Denmark | Seed silos | 2005 | Luxury apartments |
| Sugar City | Halfweg, Netherlands | Sugar beet factory silos | 2007 | Modern office buildings and mixed-use space |

Data collection involved gathering information from multiple sources to understand each case (Yin, 2009) comprehensively. Architectural plans, including detailed drawings, sections, elevations, and renderings, were analyzed to comprehend the design interventions and spatial reconfigurations implemented during the adaptive reuse. Project documentation, such as official descriptions, planning reports, and press releases, provided context on each transformation's objectives, methodologies, and challenges.

Historical records and archival materials were examined to offer insights into the original functions, construction techniques, and historical significance of the silo buildings (Ashworth, 2011). This historical context is essential for understanding each structure's architectural heritage and cultural values. A thorough review of existing literature—including scholarly articles, books, and reports on industrial heritage, adaptive reuse, and urban regeneration—was conducted to inform the study's theoretical framework and to situate the findings within the broader discourse on sustainable urban development.

Visual media, such as photographs and videos documenting the buildings before, during, and after their transformations, were analyzed on-site to observe the physical changes and their impact on the structures and their surrounding urban landscapes. Where accessible, interviews with architects, planners, or stakeholders involved in the projects were conducted to gain firsthand perspectives on the adaptive reuse initiatives' design decisions, implementation processes, and outcomes (Kvale & Brinkmann, 2009).

The data analysis focused on evaluating the architectural interventions and their influence on the functionality, aesthetics, and urban integration of the silo buildings. Particular attention was given to façade modifications, assessing how changes to the exterior—such as the introduction of windows, terraces, and modern cladding systems—enhanced the buildings' aesthetic appeal and usability while respecting their historical essence (Brand, 1995). Structural additions and interior reconfigurations were analyzed to understand how the internal spaces were reorganized to accommodate new functions, improve circulation, and enhance user experience.



The study also examined the functional adaptation of each silo building, analyzing the success of integrating new uses within the existing structures and their urban contexts. Factors such as user accessibility, contribution to the local community, and the buildings' roles in stimulating economic and cultural activities were considered. By synthesizing findings across the different cases, the research aimed to identify best practices and critical factors that contribute to the successful adaptive reuse of silo buildings.

Throughout the research process, measures were taken to ensure the rigor and validity of the study. Data triangulation was employed by cross-referencing information from multiple sources, including architectural documentation, historical records, literature, visual media, and interviews (Denzin, 2009; Flick, 2022). This approach enhanced the credibility of the findings and provided a holistic understanding of each case. Ethical considerations were addressed by attributing all sources, respecting intellectual property rights, and ensuring the confidentiality of any interview participants (Israel & Hay, 2006).

This study utilized a qualitative multiple-case study approach to explore the adaptive reuse of silo buildings, focusing on the architectural interventions that facilitate their transformation into functional and culturally significant elements within urban landscapes. The research provides valuable insights into how industrial heritage structures can be effectively integrated into contemporary urban environments by examining detailed cases from diverse geographical and cultural contexts and employing comprehensive data collection and analysis methods.

A critical holistic perspective guided the methodological framework of this study. Architectural interventions, particularly façade modifications, were analyzed for their aesthetic contribution and in relation to internal spatial organization, structural coherence, and functional adaptability.

## 4. Theoretical Background

### *4.1. Industrial Heritage and Adaptive Reuse*

Industrial heritage refers to the physical remnants of industrialization, including buildings, machinery, sites, and landscapes with historical, technological, social, architectural, or scientific value (Douet, 2012). These structures are tangible representations of past industrial activities and are integral to understanding the socio-economic evolution of societies (Edwards & Llurdés i Coit, 1996). Despite falling into disuse, industrial heritage sites like silo buildings embody the technological advancements and cultural narratives of their time, offering insights into historical production methods, labor relations, and economic conditions (Palmer, 1998; Douet, 2012).

Adaptive reuse has emerged as a pivotal strategy for conserving industrial heritage by repurposing obsolete buildings for new functions while retaining their historical and architectural significance (Bullen & Love, 2011; Plevoets & Van Cleempoel, 2012; Cantell, 2005). This approach aligns with sustainable development principles by minimizing environmental impacts associated with demolition and new construction, such as waste generation, energy consumption, and resource depletion (Bullen & Love, 2011). Adaptive reuse conserves the embodied energy within existing structures, reduces material waste, and preserves cultural heritage, thereby contributing to environmental, economic, and social sustainability (Shipley et al., 2006; Yung & Chan, 2012).



In the context of silo buildings, adaptive reuse presents unique challenges and opportunities due to their monumental scale, robust construction, and specialized design (Cantell, 2005; Shipley et al., 2006). Transforming silos into functional spaces requires innovative architectural interventions that address issues of accessibility, lighting, spatial layout, and compliance with contemporary building codes (Douglas, 2006; Plevoets & Van Cleempoel, 2012). Common adaptive reuse projects for silos include conversions into residential units, hotels, museums, cultural centers, and mixed-use developments (Xie, 2015). These projects often necessitate significant modifications, such as introducing new floor levels, creating openings for windows and doors, and installing new structural and mechanical systems while striving to maintain the building's historical integrity (Bullen & Love, 2011).

Conservation theory provides crucial guidance for balancing historical preservation with contemporary functionality in adaptive reuse projects. According to Feilden's conservation principles, it is essential to preserve not only the physical fabric of the building but also its historical authenticity and symbolic meanings (Feilden, 2003). Additionally, Jokilehto highlights that a successful conservation approach should evaluate the extent of interventions carefully, ensuring minimal yet effective modifications (Jokilehto, 2017). Thus, assessing conservation-use balance becomes pivotal, and case studies can illuminate how this balance is practically implemented.

### *4.2. The Role of Silos as Urban Landmarks*

Urban landmarks are prominent physical features within a city that serve as reference points, contribute to its identity, and aid in spatial orientation. In his seminal work, "The Image of the City," Kevin Lynch emphasizes the importance of landmarks in enhancing the legibility of urban environments, fostering a sense of place, and facilitating navigation (Lynch, 1960). Landmarks are distinguished by their unique form, scale, historical significance, or visual prominence within the urban context.

Silo buildings inherently possess qualities that make them natural urban landmarks. Their towering height, distinctive cylindrical forms, and robust construction materials like concrete and steel set them apart within the urban skyline (Stratton, 2003; Martinat et al., 2018). Historically, silos were often situated near transportation hubs such as railways, ports, and industrial districts, making them focal points within the urban fabric (Edwards & Llurdés i Coit, 1996). As functional structures, they symbolized industrial progress and economic vitality, contributing to the collective memory and identity of the communities they served (Xie, 2015).

Through adaptive reuse, silos can retain and even enhance their status as urban landmarks by acquiring new meanings and functions that resonate with contemporary urban life (Rautenberg, 2012). The transformation of silos into publicly accessible spaces like museums, cultural centers, or residential complexes allows these structures to continue contributing to the city's identity and cultural narrative (Plevoets & Van Cleempoel, 2019). By integrating modern architectural elements while preserving historical features, adaptive reuse projects can create visually compelling landmarks that bridge the past and present, enriching the urban landscape and fostering a sense of continuity (Bullen & Love, 2011).

### *4.3. Façade Modifications and Urban Perception*

The façade of a building serves as the interface between the internal and external environments, playing a critical role in shaping aesthetic appeal, functional performance, and symbolic expression (Schittich, 2012). In the adaptive reuse of silo buildings, façade modifications are often essential to accommodate new functions, improve environmental performance, and enhance visual integration with the surrounding urban context (Wong, 2017).

Initially designed for utilitarian purposes, silo façades typically lack fenestration and ornamentation, presenting blank, monolithic surfaces that can be perceived as imposing or inaccessible (Martinat et at., 2018). To transform these structures into habitable and inviting spaces, architects often introduce new openings such as windows, balconies, and entrances, allowing natural light penetration, providing views, and establishing connections with the urban environment (Brooker & Stone, 2019). Adding contemporary cladding materials or façade treatments can update the building's appearance, reflecting modern design aesthetics while respecting the original industrial character (Douglas, 2006).

Façade modifications significantly influence urban perception by altering how the building is experienced visually and spatially (Schittich, 2012). Thoughtful design interventions can humanize the scale of silos, making them more relatable and engaging to pedestrians (Wong, 2017). Enhancing transparency and permeability, façade changes encourage public interaction and integration with surrounding urban activities (Heath et al., 2013). The juxtaposition of old and new architectural elements creates a dynamic visual narrative that celebrates the building's history while highlighting contemporary design innovation (Plevoets & Van Cleempoel, 2019).

In the context of urban regeneration, transforming silo façades can catalyze revitalization in adjacent areas, attract investment, and foster community pride (Roberts, 2000). Successful façade interventions not only improve the functionality and aesthetics of the building itself but also contribute positively to the streetscape and urban realm, enhancing the overall quality and experience of the urban environment (Couch et al., 2008). By redefining the visual and functional attributes of silos, façade modifications play a pivotal role in their integration into the contemporary urban fabric and in altering public perception from obsolete industrial relics to vibrant urban assets (Bullen & Love, 2011).

## 5. Case Studies: Transforming Silos into Urban Icons

This section examines four exemplary cases where silo buildings have been successfully transformed through adaptive reuse into vibrant urban landmarks. These case studies—Portland Towers, The Silo, Gemini Residence/Frosilo in Copenhagen, and Sugar City in Amsterdam—demonstrate how architectural interventions can revitalize obsolete industrial structures and integrate them into the contemporary urban fabric while preserving their historical significance.

### *5.1. Portland Towers, Copenhagen-Nordhavn, Denmark*

Portland Towers are in the new neighborhood of Århusgadekvarteret in Nordhavn, Copenhagen, and stand as one of the area's tallest and most iconic buildings. Initially built in 1979 by Aalborg Portland for cement storage, these former industrial silos were transformed into office spaces between 2013 and 2014 by NCC Property Development and Design Group Architects (DGA Architects, 2014) (Figure 1).

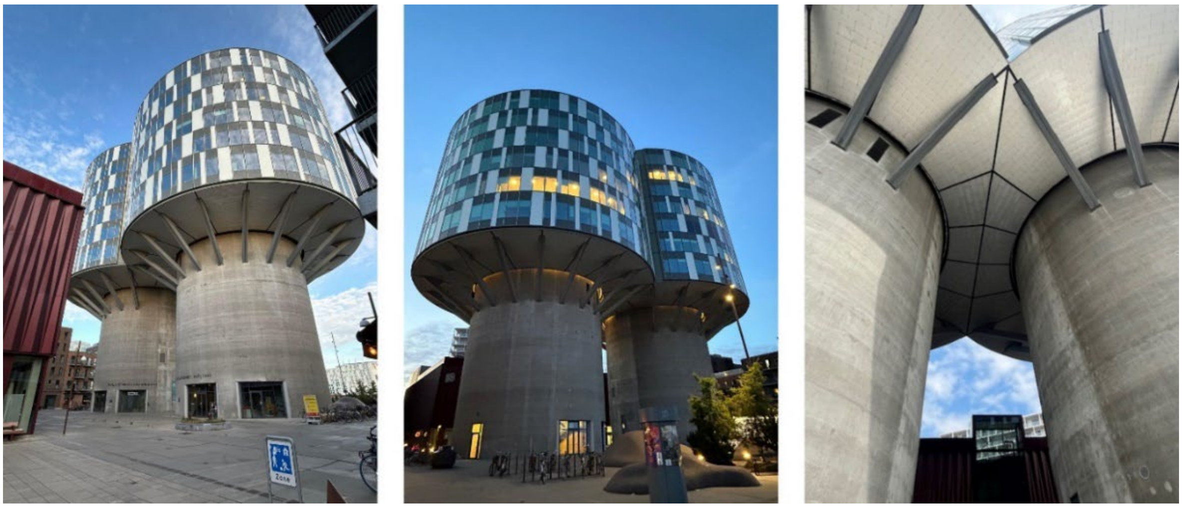


**Figure 1** Portland Towers (Author(s), 2024)

#### 5.1.1. Architectural Interventions

The transformation concept preserved the cylindrical shape of the silos while adding a light glass structure surrounding the concrete silos (DGA Architects, 2014). This circular glass structure emphasizes the industrial form, while the façade's composition, inspired by clouds in the blue sky, creates a transparent and modern office building. A significant architectural intervention was the addition of seven floors, beginning twenty-four meters above ground, adding 12,727 m² of office space. The buildings also achieved BREEAM certification, indicating their high level of sustainability, particularly in energy efficiency and material selection (NCC Property Development, 2014).

#### 5.1.2. Functional Transformation and Urban Impact

Portland Towers have become a landmark of Copenhagen's sustainable urban development, especially in the context of the Nordhavn district, which aims to balance economic, social, and environmental aspects in its development (The Housing Agency, 2024). The office complex now hosts multiple companies, contributing to the district's revitalization as a business hub. The silos' industrial roots, reflected in their design, add a layer of cultural memory to this modernized area.

### 5.2. The Silo, Copenhagen-Nordhavn, Denmark

The Silo in Copenhagen is another prime example of a silo's adaptive reuse, where a former grain storage facility was converted into a mixed-use residential and cultural space. Designed by COBE Architects and completed in 2017, this 17-story, 62-meter-tall silo is a key feature of the Nordhavn district's urban redevelopment (COBE, 2017) (Figure 2).

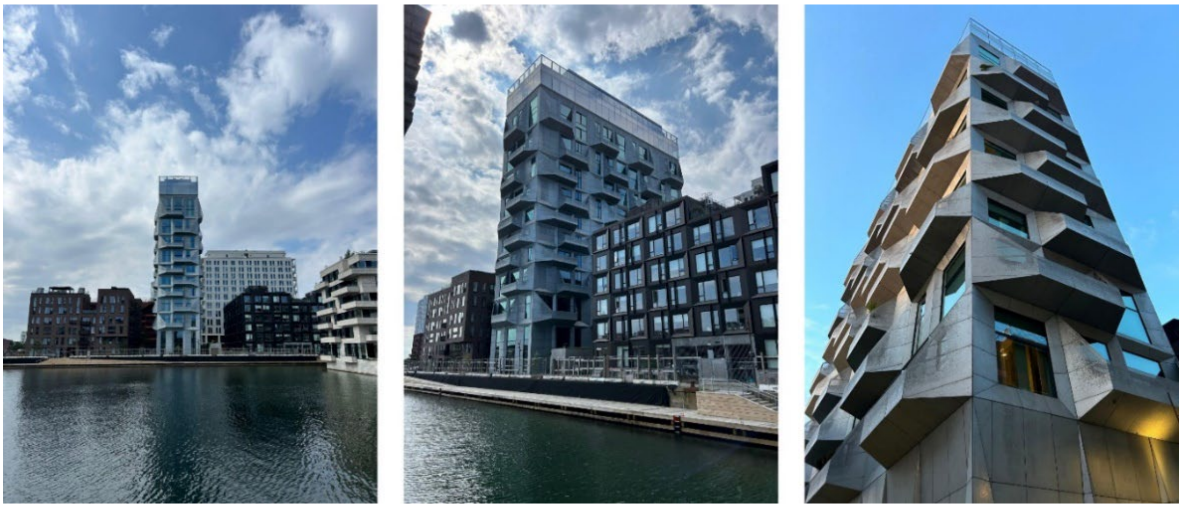


**Figure 2** The Silo (Author(s), 2024)

#### 5.2.1. Architectural Interventions

The Silo's brutalist concrete exterior was preserved while galvanic steel panels were added to the façade, giving it a modern, industrial look (COBE, 2017). The building's unique architectural approach involved maintaining the original grain storage bins inside while converting them into various apartment layouts (ArchDaily, 2017). Each floor differs in design due to the structural challenges posed by the silo's original use, creating a rich spatial diversity. The top floor was also transformed into a public restaurant, offering panoramic views of Copenhagen and Sweden (COBE, 2017).

#### 5.2.2. Functional Transformation and Urban Impact

As part of a broader redevelopment of Nordhavn, The Silo has become an urban landmark, admired for its blend of modern design and industrial heritage (Griffiths, 2017). The public restaurant and event spaces ensure that the building is accessible despite being primarily residential. The Silo serves as a model for combining luxury living with cultural spaces, enhancing

Copenhagen's urban identity while promoting the adaptive reuse of industrial structures (COBE, 2017).

### *5.3. Gemini Residence/Frosilo, Brygge, Denmark*

Gemini Residence, formerly known as Frosilo, is a conversion of two seed silos in the Brygge harbor district of Copenhagen. Initially built in 1963 for the Dansk Soyakagefabrik company, the twin silos were transformed into luxury apartments between 2003 and 2005 by MVDRV Architects (MVRDV, 2005) (Figure 3).



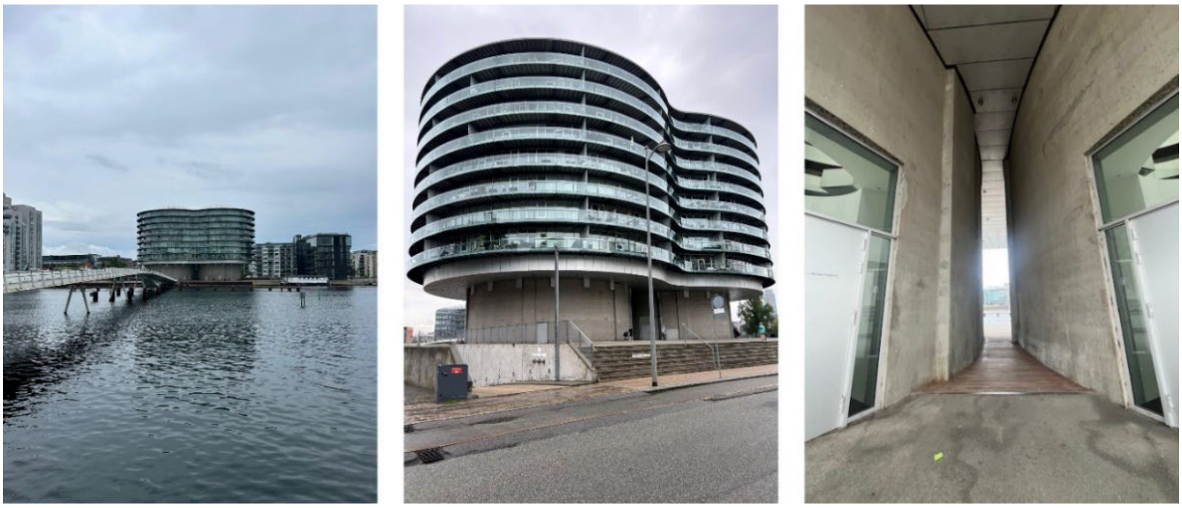


**Figure 3** Gemini Residence/Frosilo (Author(s), 2024)

#### *5.3.1. Architectural Interventions*

The architectural challenge of converting these 42-meter-high silos was met by cutting large openings in the concrete structure to allow for balconies and windows (MVRDV, 2005). The apartments were built outside the silos' original cores, while the central silos were preserved as circulation spaces housing elevators and staircases (Archello, 2005; Frearson, 2015). The design maintains the industrial essence of the building while integrating contemporary elements like glass-clad balconies that offer stunning views of the city.

#### *5.3.2. Functional Transformation and Urban Impact*

The Gemini Residence is now one of Copenhagen's most sought-after residential buildings, combining its industrial heritage with modern luxury (Copenhagen Architecture, 2016). The project won the "Best Building" award from the City of Copenhagen in 2005, demonstrating the successful fusion of functionality and design (MVRDV, 2005). Its transformation has significantly contributed to the regeneration of the Brygge area, reinforcing the role of adaptive reuse in urban development (Couch et al., 2008).

### *5.4. Sugar City, Halfweg, Netherlands*

The Sugar City complex, located in Halfweg, Netherlands, is a former sugar beet factory that closed in 1992 and was later redeveloped into a mixed-use space by Soeters van Eldonk Architects. Two prominent silos within the complex were converted into modern office buildings (SugarCity, 2007) (Figure 4).

**Figure 4** Silo buildings in Sugar City (Author(s), 2024)

### 5.4.1. Architectural Interventions

The silos underwent both interior and exterior modifications, including the addition of elevators, staircases, and facilities to meet contemporary office standards (SugarCity, 2007). The exterior retained its industrial character, with aluminum and glass cladding emphasizing the cylindrical shape (World Aluminium, 2007). Diamond-shaped windows framed in aluminum allow natural light to flood the interior while maintaining the original silhouette. At night, the silos are illuminated by LED lights, adding to their iconic status within the urban landscape.

### 5.4.2. Functional Transformation and Urban Impact

The transformation of Sugar City has garnered international recognition for its contribution to industrial heritage preservation. It has received numerous awards, including the Prix d'Excellence for Environmental Preservation 2012 (FIABCI, 2012). Sugar City is now a thriving hub for offices, retail, and events, demonstrating the potential of adaptive reuse to breathe new life into industrial structures while promoting economic and cultural growth in the surrounding area (SugarCity, 2007).

## 5.5. Comparative Insights

The transformation of industrial silos into functional urban landmarks highlights the potential of adaptive reuse in enriching the urban landscape while preserving historical significance (Bullen & Love, 2011). In examining Portland Towers, The Silo, Gemini Residence/Frosilo, and Sugar City, several key themes emerge regarding the role of architectural interventions, sustainability, and urban regeneration. Despite the differences in geographic location, cultural context, and intended use, these projects share common strategies for preserving the essence of the original structures while integrating them into modern urban life.

### 5.5.1. Preservation of Historical Identity

All four case studies demonstrate a deep respect for the historical integrity of the original silo structures. Each project prioritized retaining key elements such as the cylindrical form and robust concrete façades, recognizing these features as integral to the silos' industrial heritage. This approach allowed the buildings to maintain a tangible connection to their past functions while serving new purposes.

In the case of Portland Towers and The Silo, the cylindrical forms of the silos were carefully preserved. At the same time, contemporary materials like glass and steel were introduced to give the buildings a modern aesthetic without erasing their industrial roots. Similarly, Gemini Residence retained the concrete cores of the twin silos as central circulation spaces, highlighting their historical significance. Sugar City kept the towering silos intact, using them as visual landmarks within a broader industrial complex.

By retaining these key elements, the projects honored the industrial past and contributed to the urban memory of their respective locations (Lynch, 1960). This balance between preservation and transformation illustrates how adaptive reuse can safeguard industrial heritage while allowing buildings to evolve.



### 5.5.2. Innovative Architectural Interventions

Façade modifications played a crucial role in redefining the visual identity of each silo. Architects introduced modern design elements such as windows, balconies, and cladding systems to humanize the silos' monolithic forms and make them more relatable to their urban contexts.

Portland Towers and The Silo both used glass and steel additions to introduce transparency and light, enhancing the interaction between the buildings and their surroundings. In the case of Gemini Residence, glass balconies were attached to the exterior of the silos, offering residents expansive views while preserving the cylindrical form. Sugar City used aluminum cladding and distinctive diamond-shaped windows to modernize the silos without obscuring their industrial character.

These interventions were not only aesthetic but also functional. The addition of balconies, windows, and new façade treatments allowed for natural light and ventilation to penetrate deep into previously dark interiors, transforming the silos into habitable and inviting spaces (Wong, 2017). Structural modifications, such as adding new floor slabs and elevators, ensured that the buildings complied with contemporary building codes and accessibility standards while maintaining their industrial essence (Douglas, 2006) (Table 2).

**Table 2** Architectural Interventions (Author(s), 2024)

| Name of Building | Façade Modifications | Structural Additions | Preservation of Historical Elements |
|---|---|---|---|
| Portland Towers | Added light glass structure; façade inspired by clouds | Added seven floors starting 24 meters above ground | Preserved cylindrical shape of silos |
| The Silo | Added galvanized steel panels to façade | Maintained original grain bins; unique apartment layouts | Preserved brutalist concrete exterior |
| Gemini Residence | Cut large openings for balconies/windows; glass-clad balconies | Built apartments outside original cores; central silos as circulation spaces | Retained industrial essence of silos |
| Sugar City | Aluminum and glass cladding; diamond-shaped windows | Added elevators, staircases, modern facilities | Retained industrial character and original silhouette |

### 5.5.3. Functional Adaptation and Urban Regeneration

Each of the adaptive reuse projects transformed the silos into new, functional spaces that contributed to the economic, social, and cultural vitality of their urban environments (Langston et al., 2008).

Portland Towers and The Silo were both repurposed as office and residential spaces, respectively, injecting new life into the Nordhavn district of Copenhagen, which has undergone significant redevelopment. These projects not only preserved the silos but also enhanced the area's appeal as a vibrant, sustainable neighborhood. Through its transformation into luxury apartments, Gemini Residence played a similar role in revitalizing the Brygge harbor district, making it one of Copenhagen's most sought-after residential areas.

In the case of Sugar City, the silos were converted into office spaces, and the surrounding industrial complex was transformed into a mixed-use development. This adaptive reuse project contributed to the economic revitalization of Halfweg, turning a previously derelict site into a thriving commercial and cultural hub. The development of Sugar City demonstrated how adaptive reuse can stimulate economic growth by attracting new businesses, residents, and tourists to previously underutilized areas.

### 5.5.4. Sustainability and Environmental Impact

Adaptive reuse inherently supports sustainability by conserving resources, reducing waste, and minimizing the environmental impact of new construction. All four case studies adhered to sustainable development principles, incorporating energy-efficient systems, sustainable materials, and strategies to reduce the buildings' environmental footprints.

Portland Towers achieved BREEAM certification for their energy-efficient designs, emphasizing the importance of sustainable building practices in contemporary urban development. Using lightweight materials like aluminum and glass in Sugar City and Gemini Residence helped reduce the buildings' energy consumption. At the same time, retaining the original concrete structures conserved embodied energy and reduced the need for new construction materials.

These projects also exemplified the environmental benefits of adaptive reuse. By repurposing existing buildings rather than demolishing them, they avoided the significant waste generation and carbon emissions associated with demolition and new construction (Bullen & Love, 2011). This sustainable approach not only contributed to environmental goals but also aligned with broader urban policies focused on reducing the carbon footprint of cities (UNESCO, 2011).

### 5.5.5. Integration into the Urban Fabric

The successful integration of these repurposed silos into their urban environments was another shared characteristic of the projects. Each project aligned with local development goals and urban policies that supported sustainability, heritage preservation, and economic growth.

Portland Towers and The Silo became iconic landmarks within the Nordhavn district, contributing to the area's identity as a forward-thinking, sustainable urban neighborhood. Similarly, Gemini Residence was seamlessly integrated into the Brygge harbor area, reinforcing the district's character as a modern, upscale residential area. Sugar City stood as a symbol of industrial heritage within Halfweg while offering the region new economic opportunities and cultural experiences.

These projects underscore the importance of considering the broader urban context when undertaking adaptive reuse initiatives. By aligning with local development objectives, the transformations not only revitalized the individual silos but also contributed to the cultural, economic, and social vitality of their surrounding areas.

In summary, the adaptive reuse of silo buildings, as seen in Portland Towers, The Silo, Gemini Residence, and Sugar City, demonstrates the transformative potential of architectural interventions to breathe new life into obsolete industrial structures. These projects succeeded by balancing preserving historical identity with introducing innovative design elements, enhancing functionality, promoting sustainability, and integrating into the urban fabric. They stand as powerful examples of how cities can honor their industrial heritage while meeting the needs of contemporary urban development (Table 3).

**Table 3** Comparative Analysis of Architectural Interventions (Author(s), 2024)

| Aspect | Portland Towers | The Silo | Gemini Residence | Sugar City |
|---|---|---|---|---|
| **Façade Treatment** | Glass structure inspired by clouds | Galvanized steel panels | Glass-clad balconies | Aluminum and glass cladding |
| **Structural Changes** | Added seven floors | Unique layouts due to original bins | Apartments built outside cores | Added elevators and staircases |
| **Interior Reconfiguration** | Modern office spaces | Diverse apartment designs | Luxury apartments | Modern office facilities |
| **Public Accessibility** | Office complex | Public restaurant on top floor | Residential building | Offices, retail, and event spaces |

However, it is crucial to critically assess the extent to which these case studies observe a balanced conservation-use approach. For instance, Portland Towers preserved the external form substantially, yet extensive additions could be perceived as diminishing its industrial authenticity. Conversely, The Silo project demonstrates a more careful balance by retaining significant structural elements, such as internal grain bins, thus preserving historical authenticity. Similarly, Sugar City's use of adaptive digital methods facilitated minimal intrusion into the original structure, enhancing both preservation and usability. These examples illustrate the varying degrees of conservation strategies employed, underscoring the importance of clearly defining conservation prerequisites in adaptive reuse projects.



Moreover, critical comparative discussions reveal notable differences regarding how effectively spatial coherence and function-structure harmony were achieved. With its externalized residential modules, Gemini Residence managed to retain internal coherence and clearly delineated functional spaces. In contrast, Portland Towers faced challenges regarding internal spatial clarity due to the extensive additions above the original structure, potentially affecting the integrity of its industrial identity. The Silo, by preserving internal grain bins, established a direct structural-functional harmony between old and new. Sugar City's minimal but strategically placed structural additions allowed clear functional integration, representing an optimal example of spatial and structural harmony.

## 6. Results

The adaptive reuse of silo buildings, as demonstrated in the case studies of Portland Towers, The Silo, Gemini Residence, and Sugar City, illustrates how industrial heritage structures can be successfully transformed into functional urban landmarks. These transformations reveal the potential of architectural interventions, particularly façade modifications and structural additions, in reshaping the identity and functionality of these imposing structures.

In The Silo, the application of galvanized steel cassettes to the façade resulted in expansive panoramic windows and balconies. Consequently, the monotony of the concrete façade was broken, allowing natural light to reach the interior spaces effortlessly. Updating the façade in this manner facilitated the transformation of the silo from a monumental and cold-surfaced industrial structure into a glamorous residential complex that can harmoniously integrate with the surrounding urban fabric.

In Portland Towers, adding a circular, cantilevered glass structure modernized the visual appeal, creating a transparent and dynamic façade and introducing critical spatial coherence challenges. The extensive structural addition altered the original industrial scale, affecting the building's internal spatial harmony and historical authenticity. Although visually appealing, the intervention raises questions regarding the balance between aesthetic modernization and structural integration, reflecting a potential misalignment with conservation theory principles advocating minimal intervention.

In the Frosilo-Gemini Residence, two silos were connected at the upper levels, transforming them into a residential complex that appears as a single building. The apartments were suspended outside the existing silo structure due to limited and complex possibilities for openings in the concrete rings. This approach allowed each room to benefit from maximum views and plan flexibility while creating two enormous atriums (Mies Award, 2007). There are floor-to-ceiling windows and balconies. Both cores are covered with a glazed roof, and at the base of the silos, the raw concrete was left exposed to highlight the building's history. The gap between the two silos connects the street with the harbor.

Nevertheless, the primary emphasis on façade aesthetics and externalized apartment modules highlights a potential oversight in fully addressing structural coherence, a critical aspect of adaptive reuse according to conservation and resilience theories. This focus on external imagery could imply a limited integration of deeper theoretical principles related to structural adaptation and internal spatial functionality.

In the conversion of the Sugar Silos into offices at Halfweg Sugar City, sustainability was at the forefront of the agenda. For example, the Sugar Silos were awarded an 'A' energy rating, and sustainable energy is utilized thanks to the ATES system. The Sugar Silos provide a dazzling array of colors through hundreds of colored LED lights installed in the window frames. In the silos' repurposing project, the exterior façade was characterized by the buildings' round shape, and this process could be conducted seamlessly thanks to the high flexibility of aluminum. The glass and aluminum cladding were specially molded to fit the curved surface. A more refined approach was adopted by adding rhombus-shaped windows made of solar-control glass surrounded by aluminum frames to the original façade (World Aluminium, 2007).



As observed in the four case studies, structural additions and interior reconfigurations were crucial in adapting the silos to accommodate new functions while respecting their historical essence. The inherent architectural challenges, such as vast, uninterrupted interior volumes and lack of accessibility arising from the silos' original designs, were skillfully addressed with innovative solutions (Figure 5).

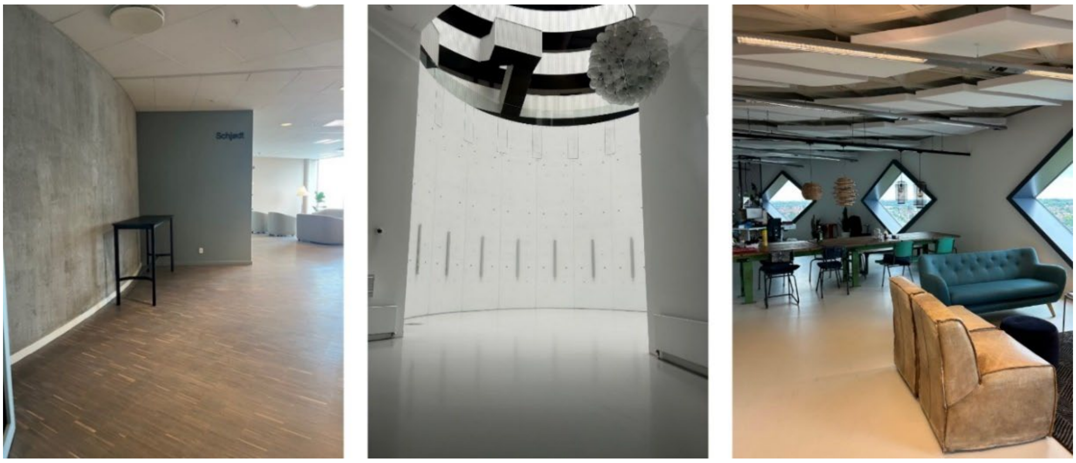


**Figure 5** Interiors of Portland Towers (left), Gemini Residence (center), and Sugar City (right) (Author(s), 2024)

A significant outcome of these projects is the role that façade modifications played in altering the perception of the silos. Designed initially with utilitarian, monolithic exteriors, these buildings underwent substantial visual changes that enhanced their aesthetic appeal and improved their interaction with the urban environment (DGA Architects, 2014; MVRDV, 2005; COBE, 2017; SugarCity, 2007). The introduction of windows, balconies, and contemporary cladding materials helped humanize the scale of these once-imposing structures, allowing them to blend seamlessly into their modern contexts. For example, the glass and steel façade of Portland Towers transformed the silo into a transparent, dynamic office space, while the galvanized steel panels added to The Silo in Copenhagen helped preserve its industrial character while creating a modern residential and public space.

In terms of functional transformation, these projects demonstrate how silo buildings can be repurposed to meet contemporary urban needs. The adaptive reuse of these structures as office spaces, residences, or cultural venues has revitalized their surrounding areas, contributing to economic growth and urban regeneration. Portland Towers and The Silo both played critical roles in the redevelopment of the Nordhavn district in Copenhagen, bringing new life to the area through their commercial and residential functions. Similarly, transforming Gemini Residence into luxury apartments elevated the Brygge harbor district into one of Copenhagen's most desirable residential neighborhoods. The Sugar City project, with its conversion of sugar storage silos into office spaces, has also become a key driver of economic activity and cultural engagement in Halfweg.

The transformation of The Silo and Portland Silo into mixed-use complexes has enhanced the attractiveness of the Nordhavn region, promoting sustainable urban living and encouraging further investment. In Halfweg Sugar City, the two iconic silo structures converted into offices, along with other historic buildings in the area still undergoing transformations and new constructions to be built, have brought mixed-use development to its pinnacle. These projects demonstrate how adaptive reuse revitalizes individual buildings and contributes to the broader urban environment by enhancing cultural amenities, increasing social cohesion, and stimulating economic growth.

However, a deeper critical analysis of these cases reveals varying degrees of success in integrating theoretical frameworks such as conservation theory, urban resilience, and digital heritage approaches. Despite significant aesthetic appeal and energy efficiency, Portland Towers struggled to fully integrate structural coherence with spatial functionality, highlighting a potential gap in aligning conservation theory with actual architectural interventions. In contrast, The Silo exhibited a more holistic implementation of conservation theory, balancing minimal intervention principles with innovative spatial reuse. Gemini Residence's approach successfully integrated urban resilience principles by creating flexible residential spaces adaptable to changing urban demands, yet it relied heavily on façade aesthetics, potentially overlooking deeper structural harmony. Sugar City uniquely incorporated digital heritage techniques through advanced façade treatments and energy-efficient adaptations, setting a benchmark for balancing contemporary functionality and industrial authenticity. These comparisons underscore the necessity of comprehensive theoretical integration to achieve sustainable and culturally meaningful adaptive reuse outcomes.

A critical factor in the success of these transformations is the careful balance between preservation and innovation (Cantell, 2005). In each case, the core identity of the silo buildings—their cylindrical forms and robust concrete structures—was retained, ensuring a strong connection to their industrial heritage. However, these historical elements were enhanced with modern design features, such as glass facades and steel structures, which aligned the buildings with contemporary architectural standards. This delicate balance allowed the silos to maintain their historical significance while serving new, functional roles in modern urban environments (Bullen & Love, 2011).

Another important outcome is these adaptive reuse projects' cultural and economic impact. By repurposing industrial structures, cities can preserve important historical landmarks while promoting economic activity (Shipley et al., 2006). These transformed silos have become focal points for urban regeneration, attracting businesses, residents, and tourists alike. The adaptive reuse of silo buildings has also fostered greater cultural engagement, as seen in The Silo's public restaurant and event spaces, which allow the public to interact with the building and its history in new ways. The Sugar City project, which includes office spaces and event venues, demonstrates how adaptive reuse can create multifunctional spaces that benefit the local economy and cultural life.

Sustainability is another significant result of these transformations. By reusing existing structures, these projects have minimized the environmental impact of demolition and new construction (Langston et al., 2008). The retention of the silos' original concrete cores conserved embodied energy, while the introduction of energy-efficient systems and materials further reduced the buildings' environmental footprints. Portland Towers achieved BREEAM certification, underscoring the importance of sustainability in these adaptive reuse projects.

Overall, the results of these case studies highlight the transformative power of adaptive reuse in preserving industrial heritage while contributing to the cultural, economic, and environmental sustainability of cities (Plevoets & Van Cleempoel, 2019). Through thoughtful architectural interventions, silo buildings can be successfully integrated into modern urban contexts, enriching the urban landscape while honoring their historical roots (Table 4). These projects demonstrate that adaptive reuse is a practical solution for dealing with obsolete structures and a powerful tool for urban regeneration and cultural preservation.

**Table 4** Theoretical Concepts Applied in Case Studies (Author(s), 2024)

| **Theoretical Concept** | **Description** | **Examples from Case Studies** |
|---|---|---|
| Preservation of Historical Identity | Retaining key historical elements to maintain connection to the past | All projects preserved silos' forms and concrete structures |
| Innovative Architectural Interventions | Introducing contemporary design elements to adapt buildings for new uses | Façade modifications, structural additions, modern materials used in all cases |

| | | |
|---|---|---|
| Functional Adaptation and Urban Regeneration | Repurposing structures to meet contemporary needs and revitalize areas | Silo buildings transformed into offices, residences, cultural spaces |
| Sustainability and Environmental Impact | Minimizing environmental footprint through adaptive reuse | Achieved BREEAM certification, conserved embodied energy, reduced waste |
| Integration into Urban Fabric | Blending repurposed structures into modern urban contexts | Projects aligned with local development goals, contributed to urban identity |

## 7. Discussion

The analysis of the adaptive reuse of silo buildings highlights the transformative potential of architectural interventions in revitalizing obsolete industrial structures. The projects explored—Portland Towers, The Silo, Gemini Residence, and Sugar City—demonstrate that adaptive reuse is not merely a practical solution to dealing with redundant industrial buildings but also a powerful tool for preserving industrial heritage and contributing to urban regeneration. By reimagining these monumental structures, cities can maintain a tangible connection to their industrial past while addressing contemporary urban needs (Cantell, 2005).

One of the central themes emerging from the case studies is the delicate balance between preservation and innovation. Preserving key historical elements of silo buildings, such as their distinctive cylindrical forms and robust concrete façades, is essential for maintaining their historical significance and identity within the urban landscape. At the same time, innovative architectural interventions are necessary to adapt these structures for new functions and to integrate them seamlessly into modern urban contexts. The façade modifications observed in the case studies played a pivotal role in this transformation. By introducing windows, balconies, terraces, and contemporary cladding materials, creating new horizontal and vertical circulations, and creating different spaces for new functions, architects were able to humanize the scale of the silos, enhance their aesthetic appeal, and improve their functionality. These changes allowed natural light and ventilation into previously dark and inaccessible interiors while creating visually engaging façades that contribute positively to the surrounding urban fabric. It has been observed that good coordination is needed for the mutual exchange of information between different disciplines during the study process and for the maximum utilization of technological products.

Functional adaptation was another crucial element of these transformations. The structural reconfigurations needed to accommodate new uses, such as office spaces, residential units, and cultural venues, required significant architectural creativity. For example, in the case of Gemini Residence, the conversion of seed silos into luxury apartments involved cutting large openings into the concrete structure for windows and balconies while preserving the core circulation spaces. These interventions enabled the creation of functional, modern living spaces while retaining the industrial essence of the building. Similarly, The Silo in Copenhagen preserved the original grain storage bins while transforming the internal spaces into unique residential layouts that reflect the building's industrial heritage. These projects demonstrate how innovative design solutions can overcome the challenges of repurposing large industrial structures, ensuring they remain relevant and functional in contemporary urban environments.

The economic and cultural impacts of adaptive reuse projects are significant. By repurposing silo buildings, cities can preserve important landmarks that embody their industrial heritage, reinforcing a sense of place and historical continuity. These transformed structures become focal points within the urban landscape, fostering community pride and engagement (Lynch, 1960; Carmona, 2021). The case studies illustrate how adaptive reuse can stimulate economic activity by attracting new residents, businesses, and tourists. For example, the transformation of Sugar City into office spaces and event venues revitalized the Halfweg area, turning it into a thriving hub for business and cultural activity. Similarly, Portland Towers and The Silo played a key role in the regeneration of Copenhagen's Nordhavn district, contributing to its emergence as a vibrant and sustainable urban neighborhood.

Sustainability is another important consideration in the adaptive reuse of silo buildings. By reusing existing structures rather than demolishing them, these projects minimize the environmental impact of new construction. Retaining the original concrete structures conserves embodied energy while introducing energy-efficient systems and materials further reduces the buildings' environmental footprints (Langston et al., 2008). Portland Towers achieved BREEAM certification, highlighting their commitment to sustainable building practices. These projects demonstrate that adaptive reuse is a culturally sensitive approach to urban development and an environmentally responsible one.

However, adaptive reuse projects are not without challenges. Financial constraints, technical difficulties, and the complexity of working with large, structurally unique buildings can pose significant hurdles (Douglas, 2006). The case studies reveal that the success of such projects often depends on collaborative efforts between public and private stakeholders, supportive urban policies, and careful planning. For example, the success of Sugar City and The Silo was facilitated by local government support, which provided the necessary incentives and regulatory frameworks to make these projects viable. Additionally, the technical expertise required to retrofit industrial buildings for new uses underscores the importance of collaboration between architects, engineers, and urban planners.

In conclusion, the adaptive reuse of silo buildings demonstrates a progressive approach to urban development that honors the past while embracing the future. By preserving the core identity of these industrial structures and integrating them into the modern urban fabric, cities can create meaningful and functional spaces. These transformed silos become living monuments that tell the story of a city's evolution, fostering a sense of continuity and belonging among residents. The case studies of Portland Towers, The Silo, Gemini Residence, and Sugar City provide valuable insights into how adaptive reuse can contribute to sustainable urban development, cultural preservation, and economic growth. As cities continue to face the challenges of modernization and sustainability, the adaptive reuse of silo buildings offers a compelling model for how heritage and progress can coexist in the creation of dynamic, culturally rich, and sustainable urban environments.

## 8. Conclusion

The adaptive reuse of silo buildings stands as a compelling example of how obsolete industrial structures can be transformed into vibrant, functional, and culturally significant urban landmarks. Through innovative architectural interventions, particularly façade modifications and structural reconfigurations, these buildings have been repurposed to meet contemporary needs while preserving their historical essence. The case studies of Portland Towers, The Silo, Gemini Residence, and Sugar City demonstrate that the transformation of these monumental structures is not only possible but also beneficial for cities aiming to balance heritage preservation with urban development. Thus, they created a rich texture in the urban environment by combining a historical building with contemporary architectural elements.

One of the most significant revelations from these projects is the transformative power of façade modifications. Designed initially with imposing and utilitarian exteriors, silos often lacked visual and spatial engagement with their surroundings (Schittich, 2012). However, the introduction of windows, balconies, terraces, and contemporary cladding materials in these case studies humanized the silos and made them more relatable to their urban environments. These interventions allowed for natural light to penetrate interiors and created visually compelling façades that harmonized with modern urban aesthetics while retaining the industrial character of the structures. Such changes revitalized the buildings and contributed positively to the surrounding urban landscape, fostering a connection between the past and the present.

The functional transformation of silos into office spaces, residential units, and cultural venues further emphasizes the versatility of these industrial structures. By reimagining their purpose, these projects injected new life into previously derelict areas, contributing to economic growth, urban regeneration, and cultural enrichment. Portland Towers and The Silo played key roles in the revitalization of Copenhagen's Nordhavn district. At the same time, Gemini Residence and Sugar City similarly contributed to the regeneration of their respective urban areas. These projects demonstrate that adaptive reuse can catalyze broader urban renewal, turning abandoned industrial buildings into dynamic components of the contemporary urban fabric.

Sustainability is another critical outcome of adaptive reuse. By repurposing existing buildings rather than demolishing them, these projects minimized the environmental impact of new construction, conserving embodied energy and reducing waste (Langston et al., 2008). The retention of the original concrete cores in all the case studies exemplifies the environmental benefits of adaptive reuse. In addition, integrating energy-efficient systems and sustainable materials in the transformations of Portland Towers, which achieved BREEAM certification, underscores the importance of sustainable practices in contemporary architectural projects. These projects demonstrate that adaptive reuse can align with broader environmental goals, making it a viable and responsible strategy for urban development.

Despite the challenges associated with adaptive reuse—such as financial constraints, technical difficulties, and the complexity of working with large industrial structures—the case studies reveal that these hurdles can be overcome through innovative design solutions and collaborative efforts. The successful transformation of these silos was facilitated by supportive urban policies, financial incentives, and the collaboration of architects, planners, and stakeholders who recognized the cultural and economic value of preserving these industrial relics. These examples highlight the importance of creating frameworks that encourage the preservation and repurposing of industrial heritage within urban planning agendas.

In conclusion, the adaptive reuse of silo buildings offers a progressive approach to urban development that respects the past while addressing the needs of the present. By preserving the core identity of these industrial structures and integrating them into the modern urban context, architects and planners can create functional and meaningful spaces. These transformed silos not only serve as living monuments to a city's industrial heritage but also contribute to the cultural, economic, and environmental sustainability of urban environments. The insights gained from the case studies of Portland Towers, The Silo, Gemini Residence, and Sugar City provide valuable guidance for future projects, illustrating how adaptive reuse can foster a harmonious balance between heritage and progress. The transformation of silo buildings represents a vision for urban development that is inclusive, dynamic, and reflective of a city's unique historical narrative, ensuring that these structures continue to serve as vital elements of the urban landscape.

## References


Affleck, J., & Kvan, T. (2008). A virtual community as the context for discursive interpretation: A role in cultural heritage engagement. *International Journal of Heritage Studies*, *14*(3), 268 280. https://doi.org/10.1080/13527250801953751

ArchDaily. (2017). The Silo / Cobe. Retrieved August 15, 2024, from https://www.archdaily.com/874698/the-silo-cobe

Archello. (2005). Gemini Residences / Frosilo. Retrieved May 5, 2024, from https://archello.com/project/gemini-residences-frosilo

Ashworth, G. (2011). Preservation, conservation and heritage: Approaches to the past in the present through the built environment. *Asian Anthropology*, *10*(1), 1 18. https://doi.org/10.1080/1683478X.2011.10552601

Barbara, J., Koenitz, H., & Bakk, Á. K. (2021). The ethics of virtual reality interactive digital narratives in cultural heritage. *In International Conference on Interactive Digital Storytelling* (pp. 288-292). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-030-92300-6_27

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

Brooker, G., & Stone, S. (2019). *Re-readings: 2: Interior Architecture and the principles of remodelling existing buildings* (1st ed.). RIBA Publishing. https://doi.org/10.4324/9780367814601

Bullen, P. A., & Love, P. E. (2011). Adaptive reuse of heritage buildings. *Structural Survey*, *29*(5), 411-421. https://doi.org/10.1108/02630801111182439

Cantell, S. F. (2005). *The adaptive reuse of historic industrial buildings: Regulation barriers, best practices and case studies* (Master's thesis). Virginia Polytechnic Institute and State University.

Carmona, M. (2021). *Public places urban spaces: The dimensions of urban design*. Routledge. https://doi.org/10.4324/9781315158457

COBE. (2017). The Silo. Retrieved August 7, 2024, from https://www.cobe.dk/projects/the-silo

Copenhagen Architecture. (2016). Gemini Residence by MVRDV. Retrieved July 9, 2024, from https://copenhagenarchitecture.dk/gemini-residence-by-mvrdv/

Couch, C., Fraser, C., & Percy, S. (Eds.). (2008). *Urban regeneration in Europe*. John Wiley & Sons.

Creswell, J. W. (2013). *Qualitative inquiry and research design: Choosing among five approaches* (3rd ed.). Sage Publications.

Denzin, N. K. (2009). *The research act: A theoretical introduction to sociological methods* (1st ed.). Routledge. https://doi.org/10.4324/9781315134543

DGA Architects. (2014). Portland Siloerne. Retrieved September 21, 2024, from https://dga.dk/project/portland-siloerne/

Douet, J. (2012). *Industrial heritage re-tooled: The TICCIH guide to industrial heritage conservation*. Routledge.

Douglas, J. (2006). *Building adaptation*. Routledge. https://doi.org/10.4324/9780080458519

Edwards, J. A., & Llurdés i Coit, J. (1996). Mines and quarries: Industrial heritage tourism. *Annals of Tourism Research*, *23*(2), 341-363. https://doi.org/10.1016/0160-7383(95)00067-4

Feilden, B. M. (2003). *Conservation of historic buildings*. Routledge. https://doi.org/10.4324/9780080502915

Fernández-Fernández, M. V., Marcelo, V., Valenciano, J. B., & López-Díez, F. J. (2017). History, construction characteristics and possible reuse of Spain's network of silos and granaries. *Land Use Policy*, *63*, 298-311. https://doi.org/10.1016/j.landusepol.2017.01.017

FIABCI. (2012). Prix d'Excellence. Runner up: SugarCity Silos (The Netherlands). Retrieved July 8, 2024, from https://fiabciprix.com/past-winner/?id=134

Flick, U. (2022). *An introduction to qualitative research*. Sage Publications.

Frearson, A. (2015). Frosilo apartments offer a "great combination of old and new" says MVRDV's Jacob van Rijs. Dezeen. Retrieved August 3, 2024, from https://www.dezeen.com/2015/08/14/frosilo-apartments-offer-great-combination-old-new-mvrdv-movie-jacob-van-rijs-copenhagen/

Griffiths, A. (2017). Cobe transforms Copenhagen grain silo into apartment block with faceted facades. Dezeen. Retrieved September 3, 2024, from https://www.dezeen.com/2017/06/28/cobe-transforms-copenhagen-grain-silo-apartment-block-faceted-facades/

Heath, T., Oc, T., & Tiesdell, S. (2013). *Revitalising historic urban quarters*. Routledge. https://doi.org/10.4324/9780080516271

Israel, M., & Hay, I. (2006). *Research ethics for social scientists*. Sage Publications.

Jokilehto J. (2017). *A history of architectural conservation*. Routledge. https://doi.org/10.4324/9781315636931

Kvale, S., & Brinkmann, S. (2009). *InterViews: Learning the craft of qualitative research interviewing* (2nd ed.). Sage Publications.

Langston, C., Wong, F. K., Hui, E. C., & Shen, L. Y. (2008). Strategic assessment of building adaptive reuse opportunities in Hong Kong. *Building and Environment*, *43*(10), 1709 1718. https://doi.org/10.1016/j.buildenv.2007.10.017

Logothetis, S., Delinasiou, A., & Stylianidis, E. (2015). Building information modelling for cultural heritage: a review. *ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, *2*, 177-183. https://doi.org/10.5194/isprsannals-II-5-W3-177-2015

Lynch, K. (1960). *The image of the city*. MIT Press.

Martinat, S., Navratil, J., Hollander, J. B., Trojan, J., Klapka, P., Klusacek, P., & Kalok, D. (2018). Re-reuse of regenerated brownfields: Lessons from an Eastern European post-industrial city. *Journal of Cleaner Production*, *188*, 536-545. https://doi.org/10.1016/j.jclepro.2018.03.313

Meerow, S., Newell, J. P., & Stults, M. (2016). Defining urban resilience: A review. *Landscape and Urban Planning*, *147*, 38-49. https://doi.org/10.1016/j.landurbplan.2015.11.011

Mies Award. (2007). Gemini Residence. Retrieved July 18, 2024, from https://miesarch.com/work/1487

MVRDV. (2005). Frøsilo. Retrieved July 11, 2024, from https://www.mvrdv.com/projects/143/fr%C3%B8silo

NCC Property Development. (2014). Portland Towers. Retrieved September 21, 2024, from https://www.ncc.com/our-projects/portland-towers/

Palmer, M. (1998). *Industrial archaeology: Principles and practice*. Routledge. https://doi.org/10.4324/9780203022993

Patton, M. Q. (2014). *Qualitative research & evaluation methods: Integrating theory and practice*. Sage Publications.

Plevoets, B., & Van Cleempoel, K. (2012). Adaptive reuse as a strategy towards conservation of cultural heritage: A survey of 19th and 20th century theories. *In Proceedings of the 2012 International Conference Reinventing Architecture and Interiors: the past, the present and the future* (RIE).

Plevoets, B., & Van Cleempoel, K. (2019). *Adaptive reuse of the built heritage: Concepts and cases of an emerging discipline*. Routledge. https://doi.org/10.4324/9781315161440

Rautenberg, M. (2012). Industrial heritage, regeneration of cities and public policies in the 1990s: elements of a French/British comparison. *International Journal of Heritage Studies*, *18*(5), 513 525. https://doi.org/10.1080/13527258.2011.637945

Roberts, P. (2000). *The evolution, definition and purpose of urban regeneration*. In P. Roberts & H. Sykes (Eds.), Urban Regeneration: A Handbook (pp. 9 36). Sage Publications. https://doi.org/10.4135/9781446219980.n2

Schittich, C. (Ed.). (2012). *Building in existing fabric: Refurbishment, extensions, new design*. Walter de Gruyter.

Shipley, R., Utz, S., & Parsons, M. (2006). Does adaptive reuse pay? A study of the business of building renovation in Ontario, Canada. *International Journal of Heritage Studies*, *12*(6), 505–520. https://doi.org/10.1080/13527250600940181

Stratton, M. (2003). *Industrial buildings: Conservation and regeneration*. Taylor & Francis. https://doi.org/10.4324/9780203362471

SugarCity. (2007). About SugarCity. Retrieved July 17, 2024, from https://www.sugarcity.com/en/about-sugarcity/

The Housing Agency. (2024). Sustainable Compact Development - International Case Study Analysis. Retrieved November 7, 2024, from https://www.housingagency.ie/sites/default/files/202411/Sustainable_Compact_Development_International_Case_Study_Analysis.pdf

UNESCO. (2011). Recommendation on the historic urban landscape. UNESCO. Retrieved April 17, 2024, from https://whc.unesco.org/uploads/activities/documents/activity-638-98.pdf

UNESCO. (2013). New life for historic cities: The historic urban landscape approach explained. United Nations Educational, Scientific and Cultural Organization (UNESCO).

Wong, L. (2017). Adaptive Reuse: Extending the Lives of Buildings. Birkhäuser.

World Aluminium. (2007). Sugar City Silos. Green Building. Retrieved June 27, 2024, from https://greenbuilding.world-aluminium.org/benefits/flexible/sugar-city-silos/

Xie, P. F. (2015). *Industrial heritage tourism* (Vol. 43). Channel View Publications.

Yin, R. K. (2009). *Case study research: Design and methods* (5th ed.). Sage Publications.

Yung, E. H., & Chan, E. H. (2012). Critical social sustainability factors in urban conservation: The case of the Central Police Station Compound in Hong Kong. *Facilities*, *30*(9/10), 396 416. https://doi.org/10.1108/02632771211235224

## Resume

*Zeynep Kerem Ozturk was born in Istanbul. After attending primary, secondary, and high school at Kultur College, she graduated from the ITU Department of Architecture in 1978. 1993 she completed her PhD in Urban and Regional Planning at ITU Institute of Science and Technology. She worked in Istanbul Metropolitan Municipality between 1980-2008. She worked as a Manager in the Directorate of Housing and Squatter Affairs and as a Control Engineer in the Directorate of Structural Affairs and retired in 2008. After working as a construction site chief in a private company related to antiquities, she has been an assistant professor at Istanbul Sabahattin Zaim University Department of Architecture since 2015. Her areas of interest are urbanism and zoning Law, urban and regional planning, urban conservation, urban sociology, urban planning, urban transformation, and industrial and historical building re-functionalization. Her hobbies include oil painting and watercolor painting.*

*Ahmet Kurnaz graduated from Kabatas High School in 2008, received his bachelor's degree from the Middle East Technical University Department of Architecture in 2013, Master's degree from Yildiz Technical University Department of Architecture in 2021, and PhD degree from Istanbul Sabahattin Zaim University Department of Architecture in 2024. He is an assistant professor in the Architecture Department at the Istanbul Sabahattin Zaim University. His research interests include conservation, architectural design, heritage, interior design, sustainable design, refunctioning historical buildings, architectural tourism, and museums.*

JOURNAL OF DESIGN FOR RESILIENCE
IN ARCHITECTURE & PLANNING

*Research Article*
*Online:* www.drarch.org
*Volume 6, Issue 1 (40-56), 2025*
*DOI: 10.47818/DRArch.2025.v6i1156*

# Earthquake resilience of densely populated settlements: A strategic approach to mitigate Istanbul's earthquake risk

Gülru Koca*

## Abstract

One of the most significant challenges confronted by earthquake-prone cities results from the urban planning strategies and interventions preferred during the construction and development efforts. The planning of infrastructure that will serve the increasing population is even more important, especially in cities that have historical importance and have evolved into large metropolises in a short time. Proper planning and renewal efforts that align with earthquake-resistant urban development strategies not only add value for all stakeholders but also help avoid significant material and moral losses caused by poorly planned urban development. Although earthquake-prone settlements have thousands of years of construction traditions, these traditions have often been replaced by modern construction techniques nowadays. In cities where the transformation from traditional to modern construction techniques is rapid and uncontrolled, a severe earthquake is more likely to cause a significant damage. Türkiye has a high earthquake risk due to its geographical location. The Main Marmara Fault is an active fault line that poses a serious threat to Istanbul. The devastating earthquake series along the East Anatolian Fault in February 2023 have once again highlighted the urgency of taking necessary precautions and preparations for the anticipated Marmara earthquake. Istanbul is one of the most historically significant metropolises in the world. Accordingly, the city has expanded by receiving immigration since the last major earthquake. Given its unique place in world history and its centuries-old role as the capital of great civilizations, it is crucial to ensure the seismic resilience in Istanbul to protect both the lives and property of its dense population and to safeguard its cultural heritage sites. The aims of this paper are to evaluate the current characteristics of Istanbul in the event of a possible earthquake, to identify potential challenges of the city and to put forward a strategic approach to improve seismic resistance of the city. The evaluation was carried out by conducting a SWOT analysis based on the physical, environmental, social and economic conditions of the city. For this purpose, firstly the previous and current urban design practices adopted in the city was evaluated. The key features effective in the construction of an earthquake resilient settlement was emphasized and taken into consideration. Besides, the crucial stakeholders and their potential contributions were also evaluated. In this context, the problems that needs to be improved are revealed and a conceptual framework of an urban planning strategy is presented to construct an earthquake resilient city that provides satisfaction to all its stakeholders.

*Keywords:* densely populated settlements, earthquake prone cities, earthquake resilience, sustainable settlements, strategic urban planning

## 1. Introduction

The construction of sustainable settlements has become one of the most crucial targets of our time, due to many different reasons. One of the most important reasons for this is the rapid and often uncontrollable population growth in urban areas. Rapid population growth creates an

**(Corresponding author), Assoc. Prof. Dr., Isik University, Türkiye* *gulru.koca@isikun.edu.tr*
*Article history: Received 11 October 2024, Accepted 15 April 2025, Published 30 April 2025*

increased demand for housing. However, urban development efforts to meet this demand often brings about a range of challenges in different regions of urban areas. Rapid urbanization frequently leads to construction of high-density, multi-story buildings lacking green areas in regions inhabited by middle and high-income groups. Nevertheless, regions which are inhabited by low-income groups face issues such as unplanned construction and informal settlements.



Uncontrolled population growth and urbanization efforts carried out without following proper planning strategies, has become a significant problem for many major cities today. In addition to these problems, Istanbul also faces the looming threat of high seismic risk. Istanbul is a city that has experienced devastating earthquakes in the past and, a considerable amount of time has passed since its last major seismic event. Although the city has implemented appropriate urban planning strategies after the last major earthquake, the long period of time that has passed since the earthquake has caused these practices to become outdated, forgotten, and disregarded. As the memories of past earthquakes fade, the city continues to grow through migration due to its historical and touristic significance. This situation makes it difficult to implement practices to enhance and maintain earthquake resilience.

There are numerous factors that take active role in the effectiveness of the seismic resilience of crowded cities. The more frequent preference for vertical architectural applications to accommodate the increasing population, the formation of illegal housing, the decrease in green areas as a result of expansion and the existence of densely populated building blocks are important topics that need to be carefully examined in cities with high earthquake risk. The quality of urban transformation efforts, the current seismic resilience of buildings that have been intervened for different purposes over time, and the unknowns regarding the earthquake resistance of buildings with historical and cultural value also gain importance in this context.

This study aims to evaluate the current characteristics of Istanbul in the event of a possible earthquake, to identify potential challenges of the city and to put forward a strategic approach to strengthen the city against potential future seismic events.

## 2. Key Physical Factors Affecting Urban Vulnerability to Earthquakes

There are many factors that determine the behaviour of cities during earthquakes. These factors create a total effect at the time of the earthquake. The most important of these factors is the city's "physical characteristics", which include its geological features, urbanization-related features, and building-related features. These physical characteristics collectively shape a city's seismic response and different configurations of these factors alter the level of earthquake risk. When viewed from this perspective, it becomes evident that two settlements located within the same seismic zone may face the same earthquake hazard yet experience vastly different levels of earthquake risk due to variations in their physical characteristics. This disparity emphasizes the importance of a detailed understanding of how a city's unique physical attributes interact to influence its seismic resilience (Balyemez & Berköz, 2005).

### *2.1. Geological Features and Seismic Characteristics of the City*

Earthquake damage in urban areas depends on the strength, ductility, and integrity of structures. However, the stiffness of the ground on which the building will be built is another important factor affecting the extent of earthquake damage (Arya et al., 2014).

The above-mentioned characteristics of both the structure and the ground collectively determine the seismic behaviour of cities. The effectiveness of efforts to enhance Istanbul’s earthquake resistance is dependent on the city's geological structure, the seismic characteristics and the features of the buildings constructed on this ground.

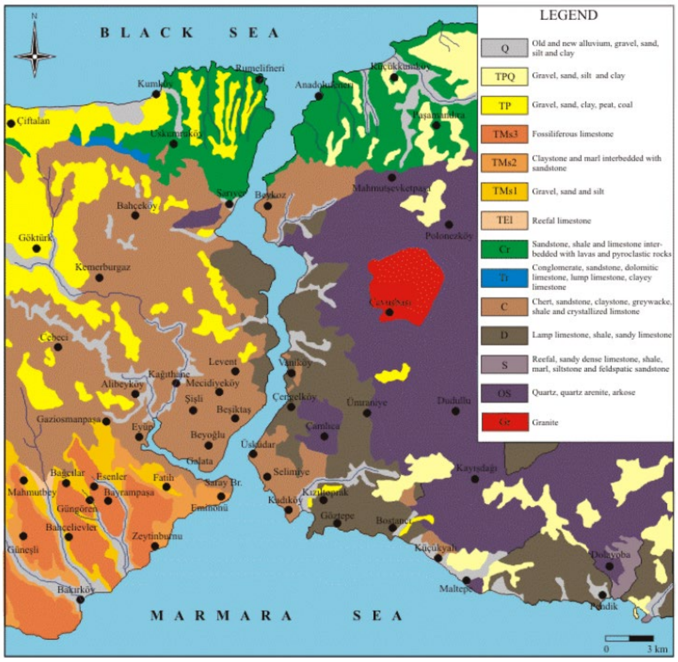



**Figure 1** Geological units in Istanbul (Ündül & Tuğrul, 2006)

The geological features of Istanbul can be seen in Figure 1. Chronologically, rock formations belonging to the Palaeozoic, Mesozoic, and Cenozoic periods are observed in the city. The oldest among these, the Palaeozoic rocks, are predominantly clastic and carbonate in nature. A significant part of Istanbul is composed of these Palaeozoic rocks (Ündül & Tuğrul, 2006).

The Palaeozoic rocks are covered by unconformable Mesozoic units. These rocks cover large areas in the northern parts of both the Anatolian and European sides of Istanbul. Mesozoic rock formations are represented by conglomerates, sandstones, dolomites, and limestones (Ündül & Tuğrul, 2006).

The Mesozoic rock formations are covered by Tertiary units from the early part of the Cenozoic era. These units generally consist of organic limestones, clayey limestones, marls, loose sands, silt, and clays (Ündül & Tuğrul, 2006).

The sediments along the Golden Horn and Bosporus coasts include both old and new alluvium and artificial fill cover. The thickness of these layers ranges from 5 to 13 meters at the Marmara Sea coasts. However, the thickness reaches 60 to 70 meters along the Golden Horn coasts. On the European side, old and new alluvium layers are present in the valleys of İstinye, Baltalimanı, and Bebek. They are found in the Kuşdili and Maltepe-Cevizli regions on the Asian side (Ündül & Tuğrul, 2006).

When the geological features of the region are evaluated, it is mentioned that the earthquake risk of Istanbul gradually decreases from south to the north. This variation is attributed to both the characteristics of the rock types of the region and the position and shape of the fault.

When the geological structure of the city is evaluated, it can be mentioned that lithological units can be classified into two as rocks and soil units. Soil units are predominantly observed in the south-eastern parts of the European side of Istanbul. In the remaining areas of the city there are rock units. Generally, the occurrence of weak rock and soil units decreases from south to north in Istanbul (Ündül & Tuğrul, 2006).

Tertiary units, formed at the end of Cenozoic era, cover large areas of Istanbul at shallow depths. These rocks are frequently represented by organic limestone, clayey limestone, uncemented sand, alluvium, or clay. Although tertiary layers do not typically cause bearing capacity problems, they experience some stability problems. This is particularly evident in the south-western parts of the city, in regions such as Avcılar, Küçükçekmece, Büyükçekmece, and Beylikdüzü. The soil structure in these areas can lead to decrease in structural stability and accelerate ground motion after an earthquake (Ündül & Tuğrul, 2006).

The shores of the Golden Horn, the Marmara Sea and the Bosporus consists old and new alluvial layers and artificial infills. The bearing capacity of alluvium, which is frequently encountered on the city's old and current water beds, is very low. Additionally, the artificial fills have negligible bearing capacity. The structures in regions, which consist this type of soil, may face instability and settlement problems (Ündül & Tuğrul, 2006).

Factors related to seismic characteristics of the city such as the proximity to faults, earthquake history and accompanying natural events during an earthquake are also very important factors in determining the effects of seismic activity.

Istanbul is located on the western part of the North Anatolian Fault Line and has experienced numerous earthquakes since the beginning of urban settlement. The North Anatolian Shear Zone, including its most prominent part, the North Anatolian Fault, was initiated 11 million years ago. It is an active, rapidly moving strike-slip fault stretching from Bingöl to the Sea of Marmara. The westward migrating fault has had a remarkable seismic activity between 1939 and 1999 and has generated surface ruptures amounting to about two-thirds of its 1600 km length. The only unbroken segment today is the Marmara Segment (Ambraseys & Finkel, 1991; Şengör & Zabcı, 2019).

As the North Anatolian Fault approaches its western end, it bifurcates into northern and southern branches probably resulting from structures formed during the extension of the Aegean. The northern branch is known as the "Main Marmara Fault" (Ambraseys & Finkel, 1991; Şengör & Kındap, 2019; Şengör & Zabcı, 2019).

The Main Marmara Fault traverses the Sea of Marmara from Gulf of İzmit to Tekirdağ. The fault curves northwards in the west of the Gulf of İzmit and approaches the coast of Istanbul. Although the distance between the fault and various districts in the south of Istanbul changes, there are regions where it comes very close to the shore, particularly along the European side. This distance is mentioned to be 10–15 km between Bakırköy and Avcılar. The southern branch of the fault traverses developed settlements in the Marmara Region, including Bursa, Balıkesir, Çanakkale, and Edremit (Ambraseys & Finkel, 1991; Şengör & Kındap, 2019; Şengör & Zabcı, 2019).

Given its location, Istanbul is considered doubly unfortunate in various seismic scenarios. While a rupture oriented "west-south-west" heavily impacts the "east side of the Bosporus", a "west-north-west" oriented rupture causes more damage to the "west side of the Bosporus". Occasionally, as seen in the 1509 earthquake, the Main Marmara Fault experiences an entire rupture, resulting in widespread destruction from Adapazarı to Thessaloniki (Şengör & Kındap, 2019).

When the return periods of Istanbul earthquakes are examined, it is stated that the city experiences a moderate earthquake (epicentral intensity, Io=VII–VIII) approximately every 50 years and a high-intensity earthquake (epicentral intensity, Io=VIII–IX) about every 300 years (Erdik, 2005).

Various sources indicate that throughout history three earthquakes that have occurred in Istanbul was followed by tsunamis. Considering the Sea of Marmara as a basin, there is a possibility that a large fracture at the basin's floor could trigger a tsunami. However, current seismic scenarios suggest that it is unlikely for a tsunami to accompany a destructive earthquake in the city (Angell, 2015).

Historical sources suggest that even during the most severe earthquakes, the areas which are close to the Black Sea coast and the deepest regions of the Bosporus did not suffer substantial damage. This is likely due to the shape and slip direction of the fault (Şengör & Kındap, 2019).

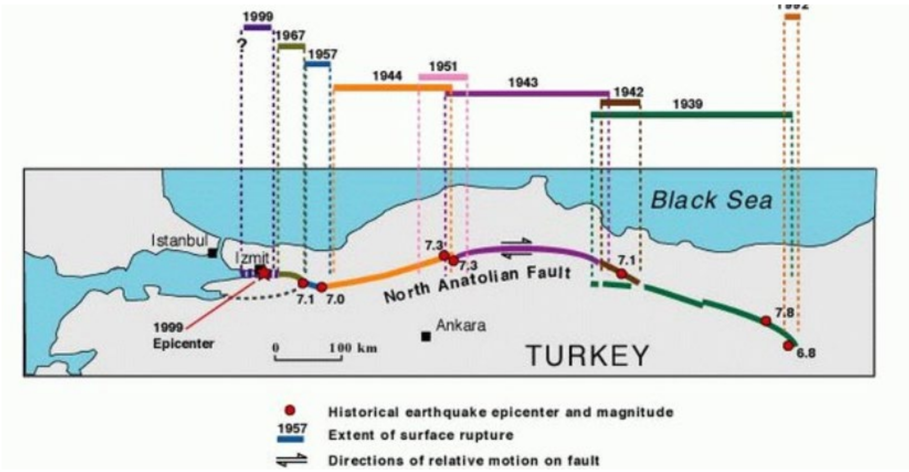



**Figure 2** Severe earthquakes occurred on the North Anatolian Fault Line (Sarıbıyık et al., 2003)

The North Anatolian Fault Line has generated numerous earthquakes some of which exceeding a magnitude of 7.0 on the Richter scale over the past 2000 years. Each rupture of the fault transfers stress westward. Consequently, the risk increases at the western end of the fault following each earthquake. The Erzincan earthquake that occurred in the first half of the 20$^{th}$ century and the 1999 Gölcük earthquake strengthen the possibility that the next major earthquake will occur at the western end of the fault, close to Istanbul. Figure 2 shows the significant earthquakes that occurred on the North Anatolian Fault Line.

### *2.2. Urbanization-Related Features*

Urbanization, which started with the Industrial Revolution, remains one of the most important reasons contributing to the challenges of living in many cities today. Urban planning practices that do not keep pace with population growth in densely populated cities give rise to different problems. These problems sometimes manifest themselves as unplanned and illegal construction practices, and sometimes as vertical architectural solutions to accommodate more population. Besides, during the expansion efforts green spaces are often damaged as well. As a city with significant migration, Istanbul faces all these urbanization-related challenges.

Istanbul, which acts as a bridge between Europe and Asia, has served as the capital of the Roman, Byzantine, and Ottoman Empires from past to present due to its location, climatic characteristics and topography. In addition to its strategic location and favourable climatic characteristics, Istanbul is distinguished by its topographical features and is often referred to as "the city built on seven hills".

Due to economic, social, and environmental reasons, Istanbul has been Türkiye's most populous city for many years. TÜİK data for 2023 states that the city's population is 15,655,924 people. Istanbul, with a larger population than many European countries, hosts approximately one-eighth of the country's population and according to economic data accounts for over 50% of the country's exports. In this context, Istanbul causes an imbalance in Türkiye's population density and economy (Erdik & Durukal, 2008; TÜİK, 2024).

Covering a total area of 5461 km², with parts in both Asia and Europe, Istanbul's urban area spans approximately 2577 km². According to these data, the population density of the city is calculated as 2867 people/km² when calculated according to entire surface area. Nevertheless, it is 6075 people/km²when calculated according to its urban area borders (Türkiye İmar Kadastro, 2014).

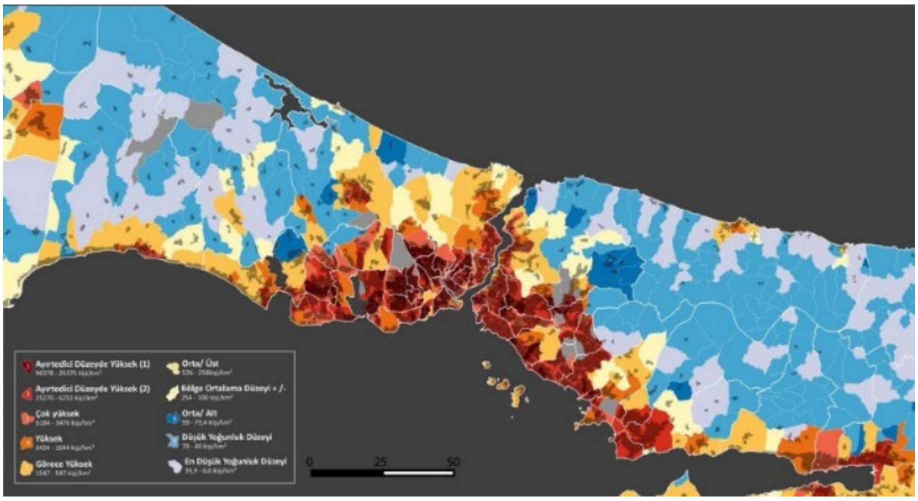


**Figure 3** Population density map of Istanbul and its surroundings (Kadıköy Akademi, 2020)

When the population distribution maps of Istanbul and its surroundings are examined, it is observed that the surrounding areas of Istanbul exhibit relatively low density (Figure 3). In contrast, the population density is very high within the city centre. Besides, in certain areas it reaches to distinctly noticeable levels (Figure 4).

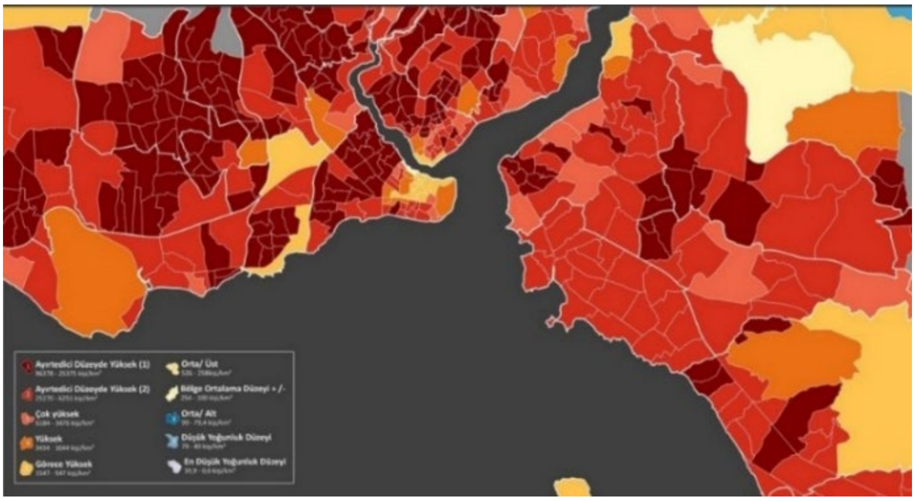


**Figure 4** Partial population density map of Istanbul (Kadıköy Akademi, 2020)

Extensive construction activities are carried out to accommodate the growing population in densely populated regions of Istanbul. This situation adversely affects both the life quality of the local residents and the resilience of the region against various risks.

### *2.3. Building-Related Features*

Although nowadays mostly reinforced concrete structures are being built in Istanbul, different traditional building practices have been developed in the city from past to present. The most distinctive characteristic of traditional building practices is that they produce solutions that resist the region's specific problems. Accordingly, the primary purpose of traditional buildings constructed in earthquake-prone regions is to increase the earthquake resistance of the building. As Istanbul has always been a city with a high earthquake risk, traditional construction techniques which have been developed in Istanbul aimed to improve the earthquake resilience.

**Figure 5** Traditional Turkish House (Gayatri, 2023)

The wooden framed buildings of Istanbul, which are also known as the "Turkish House" or "Ottoman House" in world architecture, is characterized by distinctive features such as its unique room layout, plan scheme, roof type, and construction type (either infill or wattle-and-daub walls). The Turkish House is constructed with *hımış* technique. Although it is possible to determine three more local techniques in Anatolia, *hımış* is the most common technique within the Ottoman territory, particularly within Constantinople (Güçhan, 2018).

The Turkish House, whose typological development began in Anatolia in the 16th century, was constructed with a hybrid technique. While the foundations and ground-floor walls are constructed with stone, the upper floors are typically constructed with timber and adobe infill (Figure 5). The wooden frame, which was completed with adobe infill in the early periods, later completed with region-specific local materials. The wooden roof is covered with tiles (Günay, 2017; Kuban, 2017).

The traditional Turkish House has been designed with practices aimed at increasing earthquake resistance. Using wooden bond beams, constructing the ground floor with masonry stone walls to move the centre of gravity of the structure closer to the ground, using wood to enlighten the building and using nails to increase flexibility are some key practices which are used in similar systems in many parts of the world to enhance earthquake resilience (Correia et al., 2014; Güçhan, 2007; Langenbach, 2010).

Due to wood's fire sensitivity and the Westernization ideas that began in the 19th century, although they are very beneficial in case of an earthquake, traditional wooden-framed structures were gradually replaced by masonry, and later by reinforced concrete buildings leading to the abandonment of the Turkish House tradition.

It is stated that there are approximately 1,200,000 buildings in Istanbul as of the beginning of 2023. The building density is notably high in the city's coastal areas, in the easy-to-access areas close to commercial centres, and in the historical settlement areas (Figure 6).

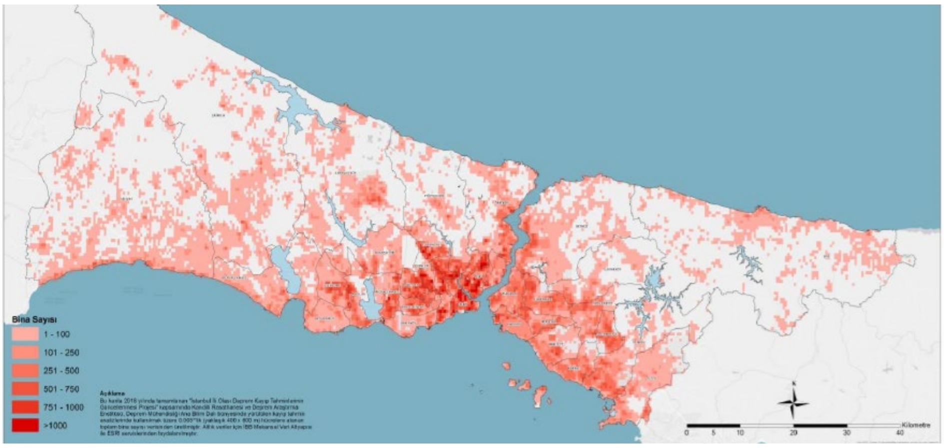



**Figure 6** Building density in Istanbul (Kandilli Observatory, 2021)

According to the "Istanbul Earthquake Rapid Response and Early Warning System Report" prepared by Istanbul Metropolitan Municipality (IBB) in collaboration with Boğaziçi University and the Kandilli Observatory, 84% of the building stock is constructed with reinforced concrete systems, 15% with masonry systems, and the remaining 1% with wood, steel, and prefabricated systems (Figure 7). It is noted that 32% of the buildings were constructed after 2000, 46% were built between 1980 – 2000, and 22% were built before 1980. While 2% of the building stock consists of high-rise buildings, 32% consists of mid-rise buildings, and 66% low-rise buildings (Kandilli Observatory, 2021).

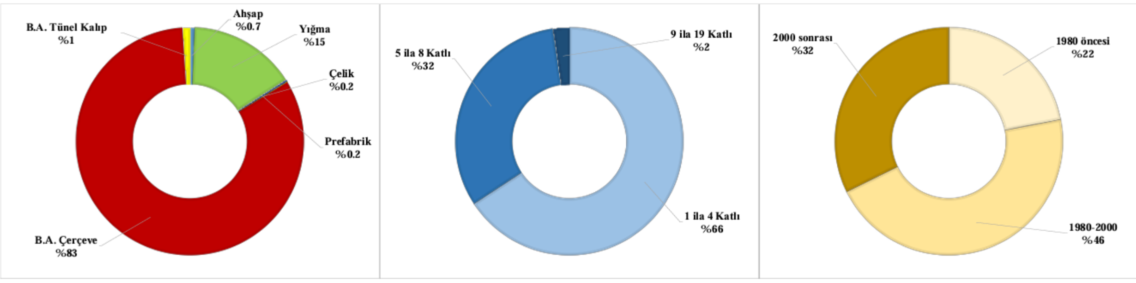



**Figure 7** The structural system, number of floors and construction year of the buildings in the Istanbul building inventory (Kandilli Observatory, 2021)

Although the current building stock in Istanbul predominantly consists of reinforced concrete structures, wooden and masonry structures remain prevalent in the city's historic neighbourhoods and tourist areas with buildings of historical significance.

Wooden-framed structures offer high earthquake resistance. However, they also present risks such as fire and biological deterioration. Masonry buildings, on the other hand, may have varying degrees of seismic risk due to structural and architectural interventions encountered over their lifespan. The presence of these traditional buildings alongside reinforced concrete buildings within the city and that the reinforced concrete structures built in these regions are often of low quality, poses a significant threat to all structures in regions with high seismic risk.

The earthquake resistance of monumental buildings is typically higher due to their construction methods and material properties. Nonetheless, the behaviour of these monumental structures during a potential earthquake is not entirely predictable. This uncertainty arises because these buildings have been subjected to environmental factors and previous earthquakes over their lifespan, which may have introduced some weaknesses (Ambraseys & Finkel, 1991; Ferah, 2009).

## 3. Earthquake Loss and Damage Prediction for Istanbul

The significant amount of time that has passed since Istanbul's last earthquake suggests that a future seismic event may not be too far. Earthquakes primarily lead to loss of life due to the destruction of buildings. Additionally, they cause damage to industrial areas, educational facilities, transportation networks, and historical monuments, impacting cities socially, culturally, and economically. In cities like Istanbul, which serves as a key economic engine for the country, a major earthquake has the potential to affect the entire nation economically and socially, and to erase a significant portion of the collective memory.

"Updating the Earthquake Loss Estimation for Istanbul Report" published in 2019, includes projections for expected building, population, and infrastructure damage and losses in Istanbul. Three recurrence periods were used in the estimation of seismic risk and the scenario was designed with a magnitude of Mw = 7.5 earthquake. These components were integrated using various sources and calculation methods to create 15 earthquake simulations. The project covers the municipal borders of Istanbul. The provided estimations are based on empirical models developed using analytical studies and experiences in the earthquake engineering literature (KOERI, 2019).

The report analyses a total of 1,166,130 buildings in Istanbul and estimates that 57% of these buildings will not be damaged, 26% will be slightly, 13% will be moderately, 3% will be severely, and

1% will be very severely damaged. Severe and very severely damaged buildings will need to be demolished and rebuilt. It is also suggested that it would be more appropriate to demolish and rebuild moderately damaged buildings. Accordingly, approximately 17% of all buildings (around 194,000 structures) will need to be rebuilt. The financial losses due to structural damage are anticipated to be around 12 billion USD (KOERI, 2019).



In separate scenarios created for both day and night, the estimated number of casualties is approximately 14,150 for night and 12,400 for day. It is estimated that approximately 8,100 people will be seriously injured in the night earthquake, and 7,450 people will be seriously injured in the day earthquake (KOERI, 2019).

Determining the urgent shelter needs that arise due to the loss of habitable buildings is crucial for densely populated cities like Istanbul. After an earthquake, residents often prefer not to enter buildings even if they are not damaged, which can exacerbate the consequences of the disaster. The scenario estimates that a significant amount of emergency shelter will be needed in order to host nearly 640,000 households (KOERI, 2019).

The report also states that since monumental structures and historical artifacts are important in terms of earthquakes, the evaluation, analysis and improvement studies of these structures should be carried out more carefully (KOERI, 2019).

The above-mentioned predictions are done by using modern technology and by taking into consideration the magnitude and intensity of previous earthquakes, seismic characteristics of the region, fault location and fault's frequency of generating earthquakes.

### *3.1. History and Earthquake History of the City*

Istanbul has hosted many important civilizations during its long history. Research had shown that settlement in Istanbul dates back to the Neolithic Period (7000-1700 BCE) and the city was controlled by different civilizations including Roman and Ottoman Empires from that period (Barnes, 1981; Ferah, 2009; History.com, 2017).

During its nearly a 1,000-year role as the Byzantine capital, the city was known as Constantinople and was enriched with numerous significant architectural works (Ferah, 2009; Kaçar, 2003; Labatt, 2004).

After the conquer of the city by the Ottoman Empire in 1453, the city remained the capital for nearly 500 years and was extensively rebuilt during this period, with the construction of numerous palaces, religious structures, and educational institutions (Ferah, 2009).

Following the collapse of the Ottoman Empire and with the proclamation of the Republic of Türkiye, Istanbul maintained its economic and social prominence. Accordingly, the population increased and urbanization-related challenges emerged. While some of the city's historical buildings continued to be utilized, some were demolished and new structures were erected in their place with the goal of constructing a modern city. According to 2023 TÜİK data, Istanbul's population is 15,655,924 people. This figure is more than the population of 131 countries in the world (TÜİK, 2024).

The city suffered destruction for various reasons, has been rebuilt, expanded and adopted different types of construction techniques. All of these historical processes have had a lasting impact on the seismic resilience and earthquake risk of Istanbul.

However, one of the most important considerations when assessing a city's earthquake behaviour is the historical record of past earthquakes. Information about the location, intensity, and associated events of previous earthquakes provides valuable data for predicting future seismic events.

According to historical sources, Istanbul was affected by 24 earthquakes during the Byzantine period, between 121 and 1453 AD. The earthquakes that occurred in 447, 478, 557, 989 and 1354 were quite severe and caused great damage. Different sources mention that the dome of Hagia Sophia, which was damaged in the 557 earthquake, collapsed in 558, and it is added that tsunamis occurred after the earthquakes in 557 and 989 (Angell, 2015; Ürekli, 2010).



During the Ottoman period, from 1453 to 1923, 24 earthquakes were recorded in Istanbul and its vicinity. Of these earthquakes, those that occurred in 1509, 1712, 1719, 1754, 1766, 1894 and 1912 were quite severe. The 1509 earthquake, referred to as the *"Kıyamet-i Suğra (Small Apocalypse)"*, reportedly resulted in the deaths of 4,000 to 5,000 people. The earthquake that occurred in 1766 and caused the loss of approximately 5,000 people has been compared to the 1755 Lisbon earthquake. It is stated that after this earthquake, building construction techniques were revised to reduce the risk of fire, and masonry structures began to be preferred instead of hybrid structures such as half-timbered and lath-and-plaster. The earthquake that occurred in 1894 affected a very wide area and caused great destruction. Following this event, Sultan Abdulhamid II initiated seismic research efforts. The 1912 Hendek earthquake, with a magnitude of 7.3, did not cause significant damage to the city as it did not occur close to Istanbul (Angell, 2015; Ürekli, 2010).

In the Republican era, although there were four of the five recorded severe earthquakes, they did not cause significant damage to Istanbul as they were not close to the centre. However, the 1999 Gölcük earthquake, which had a magnitude of 7.4, caused extensive destruction, especially in İzmit and its surroundings, and also caused damage and casualties in western Istanbul (Angell, 2015).

When the earthquakes that occurred in Istanbul and its vicinity are examined chronologically, it is seen that the region has similarities in terms of seismic activity and many earthquakes occurred between the 3rd-6th and 14th-17th centuries. Between the 7th and 13th centuries, the city's seismic activity was weak, especially in terms of severe earthquakes. From the 17th century until the end of the 20th century, the city's seismic behaviour was unusually weak. The 1999 Gölcük earthquake at the end of the 20th century caused great destruction in Kocaeli and its surroundings. In this earthquake, Istanbul was also severely shaken, and destruction occurred in its western parts. Figure 8 illustrates the extent of damage from the August 17, 1999 earthquake (Ambraseys & Finkel, 1991).

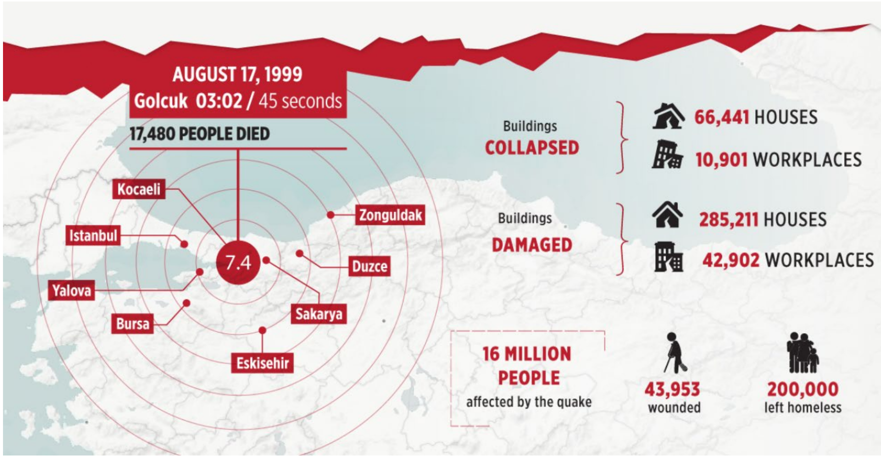



**Figure 8** The destruction on August 17, 1999 earthquake in numbers (Anadolu Ajansı, 2018)

Following the 1999 earthquake, a new Earthquake Regulation was issued, and all structures constructed since that day have been subject to this regulation. Additionally, urban transformation projects have been developed in certain regions of the city, leading to the renovation of old buildings in these regions. Despite these efforts, historic areas of the city still have a high density of old buildings. Furthermore, the buildings which were constructed before the earthquake regulations have low construction quality. The current seismic resistance of these structures remains uncertain.

### *3.2. Evaluating the Earthquake Resilience of Istanbul in Case of a Potential Earthquake*

Vulnerability is a widely used concept in evaluating the risk of urban spaces and developing risk mitigation strategies at different scales. Although evaluating vulnerability is crucial, it is also difficult as vulnerability related issues are usually human induced. Particularly, the earthquake vulnerability of urban spaces is not easy to evaluate as it is mostly affected by human behaviour. The most important factors that affect the earthquake vulnerability are urbanization, population growth, and uncontrolled settlements. Construction and social related features are also important as they affect the quality of disaster management strategies. In short, the earthquake vulnerability is affected by the physical, environmental, social and economic conditions of the city (Alizadeh et al., 2021).



As the city is a living organism which responds as a whole during a disaster, the earthquake vulnerability of Istanbul is evaluated by considering the above-mentioned features. These features affect the urban design strategies and construction practices of Istanbul which collectively shape the city's seismic response. Nevertheless, different configurations of these features alter the level of earthquake risk.

These topics have also been stated and discussed in the recent studies about Istanbul. Firstly, according to the results of two comprehensive surveys which were conducted in 2008 and 2013 there is a rising earthquake awareness in all segments of the community which may support the improvement strategies (Kundak, 2017). However, some of these studies emphasize that, the intensive work carried out on neighbourhood regeneration and the dense construction that occurred as a result of this, increased the city's building and population density and therefore also increased its earthquake vulnerability (Arslan & Kayaalp, 2018; Güney, 2024; Kayaalp, 2024).

Another research highlights urban transformation areas where previously middle-income and low-income groups live become unaffordable for these income groups. This results with a tendency towards illegal housing (Gibson & Gökşin, 2016).

### *3.3. Research Method*

This study aims to identify the potential challenges of the city and to put forward a serviceable strategic approach which takes into consideration all participants of the city in order to improve the seismic resilience. Within this scope, a SWOT analysis is conducted to delineate Istanbul's current characteristics in the context of a potential earthquake. SWOT analysis is a useful approach in the evaluation of internal and external environment of a certain problem to develop an appropriate action in strategic decisions. In an earthquake prone region, it may help local administrators to prioritize interventions or establish future urban planning strategies.

The evaluation criteria which were chosen for SWOT based on the physical, environmental, social and economic conditions of the city. Accordingly; urban planning, economic conditions, social conditions, tourism and technological developments are determined as the evaluation criteria. *Urban planning* is selected as the intersection point of physical and environmental conditions of Istanbul. *Economic and social conditions* of Istanbul are the other two important features affective on earthquake resilience. *Tourism* is also taken as another important feature that affect the city in case of an earthquake as it creates a significant pressure on population. Finally, as *technological developments* help to improve the vulnerability of urban settlements it was also taken as a feature in SWOT analysis.

### *3.4. Findings and Discussion*

The strengths and weaknesses of the city and the threats and opportunities affecting it are revealed. In strategic planning efforts, strengths and weaknesses are controllable internal factors that assist in goal setting, while threats and opportunities are factors that cannot be directly controlled. Recognizing the threats and opportunities that impact the city and taking them into consideration in planning efforts can help to mitigate negative outcomes. Integrating the strengths with opportunities will help to strengthen the earthquake resilience of the settlement. Based on this evaluation methodology the current characteristics of Istanbul can be summarized as follows:

**Table 1** Energy Performance Table for Case Building Across Locations and Different Climate Scenarios

| Feature | Strengths | Weaknesses | Opportunities | Threats |
|---|---|---|---|---|
| **Urban planning** | **S1** Implementation of earthquake regulations<br>**S2** Supports on urban transformation projects<br>**S3** Urban transformation efforts<br>**S4** Infrastructure strengthening efforts<br>**S5** Evaluation and retrofitting of the earthquake resistance in public buildings, hospitals and schools | **W1** Buildings and infrastructure components built before the earthquake regulations<br>**W2** High population density<br>**W3** High construction density<br>**W4** High-rise buildings<br>**W5** Illegal construction<br>**W6** Excessive interventions on existing buildings<br>**W7** Narrow streets<br>**W8** Lack of assembly areas<br>**W9** Construction over or near known active fault lines<br>**W10** Low structural and detail quality<br>**W11** Traffic generated in the city centre<br>**W12** Frequent preference of reinforced concrete in construction | **O1** Growth and development efforts in the housing industry to meet increasing demand<br>**02** Expansion of active transportation network | **T1** Upper scale plans which include high rise buildings |
| **Social structure** | **S6** Collective memory | **W13** Low earthquake awareness of residents | **O3** Growing trends in the world towards sustainable living and disaster protection | **T2** Decline risk in earthquake awareness due to demographic change in some parts of the city |
| **Economy** | **S7** The value of historical cultural assets in the city | **W14** The possibility of low income groups to tend to old buildings or illegal housing | **O4** Incentives given to private companies, especially in housing investments | **T3** Risk of economic crisis, inflation and financial irregularities slowing down urban transformation works<br>**T4** Risk of increasing material costs affecting construction quality |
| **Tourism** | **S8** Prioritization of the seismic retrofitting efforts on historic structures due to their heritage value | **W15** A significant number of historical artifacts and heritage buildings are located in areas with soft soil | **O5** Opportunity to benefit from a sustainable tourism approach | **T5** Excessive burden of mass tourism in the city (Overtourism) |
| **Technology** | **S9** Increased inventory studies on earthquake preparedness<br>**S10** Increased scientific studies on earthquakes<br>**S11** Earthquake early warning system<br>**S12** Tsunami early warning system | | **O6** Technological developments for earthquake resistant building production<br>**O7** Increasing research and development studies to reduce the effects of disasters | |

In the construction of an earthquake resilient settlement, the main aim is to improve the life quality of all its users, ensuring a healthy and safe environment. It is also important to preserve the collective memory of the community and maintain a sustainable urban framework.

While planning the efforts to increase the city's earthquake resilience, various improvement proposals should be put forward within the scope of the previously mentioned topics. These proposals should be evaluated together and integrated into comprehensive plans. Accordingly, the strategies planned for development can be formulated with the goals outlined in Table 2.



**Table 2** Strategic Goals for Increasing the Earthquake Resistance of the City

| ***Feature*** | ***Strategy*** |
|---|---|
| ***Urban planning*** | - To prevent construction near fault lines and on soft soils<br>- To develop urban transformation projects for regions which consist illegal housing and unplanned urbanization<br>- To use alternative construction systems such as steel for high-rise buildings and wooden frame for low-rise residential buildings (taking inspiration from traditional construction techniques of Istanbul)<br>- To retrofit existing reinforced concrete buildings by using external or internal trusses, earthquake bolts, etc.<br>- To increase the amount of green space in densely constructed regions by implementing new urban plans which include transformation by demolishing the old building stock<br>- To take measures to reduce population in densely populated regions. A new urban planning policy that divides the city into several centres could be adopted for this purpose.<br>- To inspect the earthquake resistance of excessively intervened existing buildings. If necessary to oblige retrofit applications, to control and to support them.<br>- To encourage construction firms serving different income groups to develop earthquake-resistant projects, to provide incentives to enable these groups to purchase housing.<br>- To elevate the construction inspection standards and to ensure earthquake resistance in all buildings<br>- To construct multi-functional buildings in order to enhance pedestrian use. |
| ***Social structure*** | - To evaluate the earthquake awareness in regions with high immigration rates and to conduct information and education programmes in regions with low earthquake awareness<br>- To conduct training programmes to increase earthquake awareness among different professional groups involved in the construction industry<br>- To ensure that all income groups benefit equally from earthquake-resistant housing investments |
| ***Economy*** | - To support the local community of low-income group economically in urban transformation projects<br>- To develop projects to find international funds for various artefacts, monuments and structures with historical and touristic value. |
| ***Tourism*** | - To promote sustainable tourism practices in order to mitigate the impact of mass tourism on population density and traffic |
| ***Technology*** | - To design alternative modern technology projects for new development areas that focus on sustainable living and disaster protection |

According to above-mentioned strategic goals, it can be stated that the most important priority of Istanbul is to develop projects that are suitable for the economic conditions of different income groups by improving the social structure of the city and utilizing technological opportunities. However, the most important problem of the city in recent years is the increase in the prices of all old and new housing and the problems that arise from this. While this situation makes earthquake resistance of some regions uncertain, it also leads to the deterioration of the social structure and decrease the security. Different strategies are being developed to eliminate this problem experienced in many important cities of the world. The methods frequently used for this purpose can be mentioned as follows;

- Providing land tenure security in low-income areas, expanding microloan opportunities, supporting low-cost earthquake-resistant housing initiatives
- Increasing governments' economic commitments to develop earthquake resistant housing investments with reasonable payment terms
- Developing infrastructure and reducing building density in several pilot areas that are at the highest risk
- Developing renovation projects undertaken by local governments together with private companies, especially for low-income groups

- Municipalities creating more accessible micro-credit opportunities for low-income groups
- Municipalities purchasing old buildings and renovating them to build earthquake-resistant structures in high-risk areas, selling and renting them to low-income families at affordable prices
- Establishing public, private and public organizations to produce solutions for earthquake-resistant affordable housing
- Developing more efficient methods to construct earthquake resistant buildings with innovative methods, materials and technologies
- Developing earthquake-resistant mass housing projects on public transportation lines to reduce traffic pressure in the city and produce affordable housing
- Evaluating public lands through joint ventures instead of offering them to the market

Following the development of strategic goals for the city, urban planning proposals compatible with these goals need to be developed and implemented. Determining the priorities among the targeted strategies and establishing a timeline for the process are crucial steps in planning a city with high earthquake resilience. When determining priorities, the interests of the local community should be kept at the forefront, and the planning should be both sustainable and achievable.

After identifying the priorities and establishing the timeline, stakeholders who will play role within the scope of different targets should be identified. It is not possible for central and local governments to carry out all the implementations in the process of planning a city with high earthquake resistance. Therefore, external stakeholders will also be necessary for various issues. Key stakeholders include universities, private sector organizations, foundations, social organizations, NGOs, professionals, and local community. In the next part of the process, the strategic objectives should be monitored and evaluated.

## 4. Conclusion

Istanbul is Turkey's most populous city and the locomotive of the Turkish economy. The city has a high tourist intensity due to its historical importance and the immigration rates of the city is also high for economic and social reasons. Some of the most important problems of Istanbul can be mentioned as; uncontrolled population growth, development activities carried out to accommodate the high population, and the problems arising from dense population and intense construction activities.

In addition to all these important features, Istanbul also has a high earthquake risk. The Main Marmara Fault is an active fault line that poses a serious threat to Istanbul. The devastating earthquake series along the East Anatolian Fault in February 2023 have once again highlighted the urgency of taking necessary precautions and preparations for the anticipated Marmara earthquake. Therefore, planning, renewal and construction activities carried out in Istanbul must be compatible with earthquake-resistant urban development strategies.

Following the 1999 Kocaeli/Gölcük earthquake, central and local governments began carrying out various initiatives at Istanbul to increase the city's earthquake resilience. Urban transformation and infrastructure reinforcement efforts supported by the government, along with improvements in the seismic resistance of public buildings likely to be used post-earthquake, are highly valuable in this context. However, as the faulty urban planning practices that have been carried out in Istanbul since the past weaken the city today and as there is a large number of residential buildings constructed before the earthquake regulation, there is a massive urban transformation in many parts of the city.

The urban transformation interventions which continue in different parts of Istanbul, are carried out without considering the economic conditions of the income groups living in the region. These applications often create conditions that the residents of the region will not be happy with or cause the original owners to relocate as they cannot afford the costs. In order to eliminate such problems and create a more equitable environment for all parties, a strategic plan should be put forward in which all stakeholders have a say and take an active role in the decisions to be taken for the development of the city.

The first step in constructing an earthquake-resilient city is to determine the current situation of the city. While doing that, the most important goal should be increasing the life quality of all users. There are many stakeholders in crowded cities like Istanbul. Therefore, in urban design studies that focus to improve earthquake resistance the needs of all stakeholders should be taken into consideration.



This study aims to identify the potential challenges of the city and to put forward a serviceable strategic approach that takes into consideration all participants to improve the seismic resilience. A SWOT analysis is conducted within this scope by focusing on the current physical, environmental, social and economic conditions of the city. Tourism and technological developments were also taken into consideration due to their importance in today's world and hence for the city.

After the determination of the obstacles that affect the city's earthquake resilience, prior goals of an earthquake resilient urban planning strategy are put forward. According to this evaluation; using alternative construction systems, retrofitting reinforced concrete buildings, increasing the percentage of green spaces, developing urban transformation projects for underdeveloped regions, ensuring all income groups benefit equally from earthquake-resistant housing investments can be stated as the most important goals.

The potential long-term effects that improve the urban environment and residents' life quality, by using these strategic applications, can be summarized as follows:

- Ensuring the perception of the city's unique topography by constructing high-rise buildings in certain regions
- Increasing the involvement of public authorities in order to protect the local community while constructing earthquake resistant buildings
- Developing a transport-oriented urban planning in order to connect homes, offices and districts efficiently
- Establishing more economical solutions for low-income groups
- Increasing earthquake awareness of the public
- Reducing public anxiety about earthquakes with information and education programmes
- Reducing building construction practices that compete with or supress natural environment
- Reducing irregularly urbanized regions with the spread of projects that target different income groups
- Reducing problems stemming from economic inequality with projects targeting different income groups

These suggestions can be considered as the first stage of a strategic plan that needs to be carried out in order for different stakeholders to have a say in improving the earthquake resistance of the city. In this context, developing new suggestions by focusing on light, flexible, recyclable and affordable construction systems.

## References

Alizadeh, M., Zabihi, H., Rezaie, F., Asadzadeh, A., Wolf, I. D., Langat, P. K., Khosravi, I., Pour, A. B., Nataj, M. M., & Pradhan, B. (2021). Earthquake vulnerability assessment for urban areas using an ANN and hybrid SWOT-QSPM model. *Remote Sensing*, *13*(22), 4519.

Ambraseys, N. N., & Finkel, C. F. (1991). Long-term seismicity of Istanbul and of the Marmara Sea region. *Terra* Nova, *3*(5), 527-539.

Anadolu Ajansı. (2018, August, 17). *Turkey marks 19th anniversary of Marmara Quake.* AA https://www.aa.com.tr/en/info/infographic/11211

Angell, E. (2015). A seismic cityscape: Earthquakes in Istanbul's history. *History of Istanbul*. https://istanbultarihi.ist/396-a-seismic-cityscape-earthquakes-in-istanbuls-history

Arslan, O., & Kayaalp, E. (2018) *Belirsizliğin bilimi: Beklenen İstanbul Depremi ve uzmanlar antropolojisi [The science of uncertainty: The expected Istanbul earthquake and an anthropology of experts]*. Toplum ve Bilim, 144. Available from: https://iletisim.com.tr/dergiler/toplum-vebilim/3/sayi-144-2018-bilim-teknoloji-toplum/10013 [Accessed 10th September 2021].

Arya, A. S., Boen, T., & Ishiyama, Y. (2014). *Guidelines for earthquake resistant non-engineered construction*. UNESCO.

Balyemez, S., & Berköz L. (2005). Hasar görebilirlik ve kentsel deprem davranışı. *İTÜ Dergisi/a, Mimarlık, Planlama, Tasarım*, *4*(1), 3-14.

Barnes, T. D. (1981). *Constantine and Eusebius*. Cambridge: Harvard University Press. https://archive.org/details/constantineeuseb0000barn

Correia, M., Dipasquale, L., & Mecca, S. (2014). *Versus: Heritage for tomorrow: Vernacular knowledge for sustainable architecture* (p. 288). Firenze University Press.

Erdik, M. (2005). Earthquake risk, earthquake rapid response system, and early warning system in Istanbul. *Macalester International*, *15*(1), 99-124.

Erdik, M., & Durukal, E. (2008). Earthquake risk and its mitigation in Istanbul. *Natural Hazards*, *44*, 181-197.

Ferah, F. E. (2009). 1755 *Lisbon earthquake and protection of cultural heritage from future earthquakes / With a comparative study about earthquake and risk preparedness in Istanbul*. (Master's thesis, Universitat Politècnica de Catalunya).

Gayatri, S. (2023, May, 11). *Turkey's 300-year-old "eco-mansions"*. British Broadcasting Corporation (BBC) https://www.bbc.com/travel/article/20230510-turkeys-300-year-old-eco-mansions

Gibson, M., & Gökşin, Z. A. (2016). Neighbourhood regeneration in Istanbul–from earthquake mitigation to planned displacement and gentrification. *International Planning History Society Proceedings*, *17*(2).

Güçhan, N. Ş. (2007). Observations on earthquake resistance of traditional timber-framed houses in Turkey. *Building and Environment*, *42*(2), 840-851.

Güçhan, N. Ş. (2018). History and characteristics of construction techniques used in traditional timber Ottoman houses. *International Journal of Architectural Heritage*, *12*(1), 1-20.

Günay, R. (2017). *İstanbul'un kaybolan ahşap konutları*. Yem Yayın.

Güney, K. M. (2024). Earthquake, disaster capitalism and massive urban transformation in Istanbul. *The Geographical Journal*, *190*, e12496. Available from: https://doi.org/10.1111/geoj.12496

History.com Editors. (2017, December 6), *Constantinople*, History. https://www.history.com/articles/constantinople

Kaçar, T. (2003, May, 23-25). *Üsküdar Savaşı ve Bizans'ın Temelleri* [Conference session]. *I. Uskudar Symposium,* Istanbul, Türkiye. https://www.uskudar.bel.tr/userfiles/files/1.sempozyum_cilt_1.pdf

Kadıköy Akademi. (2020, June, 24). *Kentsel yoğunluk ve Kadıköy*. Kadıköy Belediyesi Akademi. https://www.kadikoyakademi.org/prof-dr-murat-guvenc-ile-kentsel-yogunluk-ve-kadikoy-uzerine-soylesi/

Kandilli Rasathanesi ve Deprem Araştırmaları Enstitüsü (KOERI). (2019). *İstanbul İli Olası Deprem Kayıp Tahminlerinin Güncellenmesi Projesi (Updating the Earthquake Loss Estimation for Istanbul)*. Istanbul Metropolitan Municipality (IMM).

Kandilli Rasathanesi ve Deprem Araştırmaları Enstitüsü (KOERI). (2021). *İstanbul deprem hızlı müdahale ve erken uyarı sistemi raporu*. Boğaziçi Üniversitesi Kandilli Rasathanesi ve Deprem Araştırma Enstitüsü Deprem Mühendisliği Ana Bilim Dalı. https://8luvomezzzsk.merlincdn.net/wpcontent/uploads/2021/12/IERREWS-Rapor.pdf

Kayaalp, E. (2024). Engineering, law, and the anticipated İstanbul earthquake. *New Perspectives on Turkey*, 1-17.

Kuban, D. (2017). *Türk ahşap konut mimarisi: 17.-19. yüzyıllar.* Türkiye İş Bankası Kültür Yayınları.

Kundak, S. (2017). Enhance household resilience in Istanbul. *International Journal of Disaster Resilience in the Built Environment*, *8*(1), 40-57.

Labatt, A. (2004, October). Constantinople after 1261. *The Heilbrunn Timeline of Art History*. http://www.metmuseum.org/toah/hd/cnst/hd_cnst.htm

Langenbach, R. (2010, July 4-7). Rescuing the baby from the bathwater: Traditional masonry as earthquake-resistant construction [Conference session]. *8th International Masonry Conference*. Dresden, Germany.

Sarıbıyık, M., Mansur, S., Fırat, S., & Aydın, F. (2003, December 18-20). Investigation of concrete quality of collapsed heavily damaged structures during the Marmara Earthquake [Conference session]. *8th International Conference on Inspection*, Appraisal, Repairs, and Maintenance of Structures, Singapore.

Şengör, A. C., & Kındap, T. (2019). The geology and geomorphology of Istanbul. In: Kuzucuoğlu, C., Çiner, A., Kazancı, N. (eds). *Landscapes and landforms of Turkey*, (pp. 249-263). Springer. Cham. https://doi.org/10.1007/978-3-030-03515-0_10

Şengör, A. C., & Zabcı, C. (2019). The north Anatolian fault and the north Anatolian shear zone. In: Kuzucuoğlu, C., Çiner, A., Kazancı, N. (eds). *Landscapes and landforms of Turkey*, (pp. 481-494). Springer. Cham. https://doi.org/10.1007/978-3-030-03515-0_27

TUIK (Türkiye İstatistik Kurumu). (2024, February, 6). *Adrese dayalı nüfus kayıt sistemi sonuçları, 2023*. TUIK. https://data.tuik.gov.tr/Bulten/Index?p=Adrese-Dayali-Nufus-Kayit-Sistemi-Sonuclari-2023-49684

Türkiye İmar Kadastro. (2014). *İl ve ilçe yüzölçümleri.* https://www.imarkadastro.com/userfiles/file/Dokuman/il_ilce_alanlari.pdf

Ündül, Ö., & Tuğrul, A. (2006, September, 6-10). The engineering geology of Istanbul, Turkey [Conference session]. *Proceedings of International Association for Engineering Geology and the Environment (IAEG)*, Nottingham, United Kingdom.

Ürekli, F. (2010). Osmanlı döneminde İstanbul'da meydana gelen afetlere ilişkin literatür. *Türkiye Araştırmaları Literatür Dergisi*, (16), 101-130.



## Resume

*Assoc. Prof. Gülru Koca received her BSc in Architecture from ITU in 2000, MSc and PhD from the same institution in 2004 and 2010. She is currently working at Işık University, Department of Interior Architecture and Environmental Design. Her main research interests are evaluation of building materials, timber building materials, traditional building techniques, non-destructive testing, and sustainability in materials.*

JOURNAL OF DESIGN FOR RESILIENCE
IN ARCHITECTURE & PLANNING

*Research Article*
*Online:* www.drarch.org
*Volume 6, Issue 1 (57-70), 2025*
*DOI: 10.47818/DRArch.2025.v6i1157*

# Assessment of resilience in rural areas: The case of Bağlıköy, Cyprus

Mümüne Selen Abbasoğlu*
Fatma Bıldır**

## Abstract

Recent developments have significantly impacted both urban and rural areas, leading to increased migration from rural to urban regions and considerable challenges in rural areas. Rural activities have decreased due to the reduction in population and the labour force, affecting economic, environmental, social, and demographic structures. These natural and artificial changes constitute potential threats to rural resilience. Consequently, rural resilience analysis has become essential to ensuring the sustainability and well-being of rural communities in the face of economic, environmental, and social challenges. Rural resilience is defined as the ability to adjust, transform and cope with change in response to ever-changing regional dynamics. There are four key components of rural resilience: economic resilience, social resilience, environmental resilience, and cultural resilience. Robust infrastructure, including transportation, communication, and healthcare systems, maintains connectivity and access to essential services during adverse events. The research focuses on the cultural, economic, environmental, and social factors influencing the resilience of rural area. Besides, this study hypothesizes that the resilience of rural areas is significantly influenced by vulnerabilities resulting from regional transformations, and both natural and artificial impacts. Bağlıköy village was selected as the case study area to examine this hypothesis. A SWOT analysis of Bağlıköy's rural resilience helps identify internal strengths and weaknesses, as well as external opportunities and threats that influence its ability to withstand and recover from challenges. The assessment of the vulnerability of rural areas to natural and artificial effects experienced with regional transformations linked to resilience factors. In conclusion, the study evaluates the rural area's resilience and provides recommendations to enhance its sustainability and adaptive capacity.

*Keywords:* resilience, rural area, rural resilience, SWOT analysis, Bağlıköy

## 1. Introduction

Cultural, economic, environmental, social, and demographic systems within urban areas are dynamic and directly related to each other (Cheng et al., 2023). Increasing economic, social, and technological developments in cities contribute to the degradation of both artificial and natural environments. The effects of economic, social, and cultural changes, along with natural disasters, are observable in rural areas. In rural regions, numerous changes are observed in the cultural, environmental and demographic structure in terms of the social and political relationships of users. Linked to the development of urban areas, rural populations continuously migrate to cities, resulting in a decline in rural populations. In this context, the study by Tepecik (2023) raised awareness about the impact of migration on rural resilience. Uncontrolled migration from rural to urban areas has negative effects on production and the economy; they emphasized the increasing threat to creating healthier, more sustainable, economically strong and resilient rural areas. The outcomes of relative effects occurring due to this reduction are larger in rural areas. Understanding the structure of rural areas is particularly crucial, as the context and capacities for managing threats differ significantly between urban and rural environments (Cutter et al., 2016).

**(Corresponding author), Assist. Prof. Dr., European University of Lefke, Turkish Republic of Northern Cyprus*
*sabbasoglu@eul.edu.tr* ***M.Arch, European University of Lefke, Turkish Republic of Northern Cyprus*
*fatmabildir23@gmail.com* *Article history: Received 11 February 2025, Accepted 05 April 2025, Published 30 April 2025*

On a regional scale, the concept of resilience concerns how systems respond to factors of change. The resilience concept is the ability of a system to resist the effect of variables that change and transform (Muntele et al., 2021). The most significant variables to which the system is exposed include migration and ownership problems. It is a necessity to deal with these variables, alongside the performance of cities faced with climate change and potential risks, using a resilience-based approach and include them in planning through quantitative methods (Dincer & Ercoşkun, 2021). Moving from this point, it is crucial to examine rural areas and consider them in terms of resilience. There are numerous studies regarding resilience, especially focused on urban areas, among regional-scale studies (Li, 2023; Jorge-Ortiz et al., 2023; Shukla et al., 2023; Salvia & Quaranta, 2017). Studies related to resilience in cities assessed the potential to cope with unexpected shocks like policies, strategies, cultural, social and environmental change and natural disasters. However, the literature review observed that studies on rural resilience are limited.

Rural areas are regions located distant from city centers and with limited relationship to cities. These areas have limited economic opportunities, low income levels, and generally livelihoods involve agriculture and livestock. With the growth of urbanization, the reduction in the rural population is unavoidable and this situation has contributed to large migrations from rural areas to urban areas. This situation is linked to urban-rural differences in living standards (Li, 2023). Despite these challenges, rural areas are rich regions in terms of culture and cultural heritage elements. At this point, investigation of the resilience of rural areas is a necessity in terms of being able to maintain the continuity of culture and preserving cultural heritage elements. It is essential to research the resilience of rural regions, that encompass the cultural, traditional and environmental values of a society, against artificial and natural threats and protect from vulnerabilities that arise when confronted with sudden shocks in the future. Resilience indicates a system's ability to handle these shocks (Lanlan et al., 2024). In this context, minimizing the vulnerability of rural areas is important in terms of increasing the resilience of the system and their capacity to withstand shocks (Tepecik, 2023). The resilience of a system is considered in the economic, cultural, social and environmental dimensions. In conclusion, rural areas are just as important as urban regions, revealing the necessity and importance of investigating the resilience of the system in terms of unexpected risks and transformations that could have negative impacts.

Holling's (1973) definition of resilience is the ability of systems to absorb change when exposed to change and negative effects, the impact on the system in any situation, and the capacity and stability to return to equilibrium after disruption. The resilience concept focuses on the reaction given by a system at a flexibility threshold when faced with all these changes (Eraydin, 2016). The resilience concept, with various sources, has broad areas of effect. In this context, it has become a new topic attracting much interest in several different disciplines like ecology, economy, planning and design (Lizarralde et al., 2015). Consequently, the resilience approach has expanded into diverse fields, from ecology to psychology and from architecture to economics (Heijman et al., 2019). For these reasons, the wealth of approaches developed for measuring resilience have contributed to the development of resilience approaches in nowadays.

Challenges in urban regions display differences compared to rural regions. This situation means that an effect that does not involve resilience in urban regions can be effective in terms of resilience in rural areas (Cutter et al., 2016). At this point, the concept of rural resilience has come to the agenda, with important debates in the last twenty years linked to the disadvantageous situation of rural areas compared to cities (Karakayacı & Keser, 2021). Rural resilience is defined as the capacity of a rural region to adjust to external conditions linked to varying living standards, and the degree to which it can tolerate change before reorganizing around a new set of structures and processes. At the same time, it may explain how the ecosystem, economic and cultural functions of the rural area equilibrate simultaneously. Economic, human and social development have significant and complex relationships with environmental sustainability (Singh et al., 2019) and also the resilience (Wang et al., 2024). Rural resilience is based on mutual relationships of other resilience types, like ecological resilience and cultural resilience (Karakayacı & Keser, 2021; Heijman et al., 2019).

Migrations experienced in rural areas increase the impact of economic factors, economic losses due to climate change and natural disasters, reduce population and increase vulnerability of cultural heritage elements. Factors such as population reduction, migration, spatial transformation, increased employment outside of agriculture, and decline in agricultural income contribute to reduced resilience. As a result, it is important to develop strategies for vulnerability to increase the resilience of societies and cultural heritage in rural areas.

Accordingly, the objectives of the study were to assess the resilience concept based on vulnerabilities of rural areas resulting from regional transformations and both natural and artificial impacts. The factors affecting resilience in rural areas are considered within the social, economic, cultural, and environmental contexts (Cutter et al., 2008; Bruneau et al., 2003), as indicated by the literature review. As a study area, the transforming Bağlıköy rural area, located in the west of the Turkish Republic of Northern Cyprus. Bağlıköy is an example of an Ecovillage-Cittaslow region. In this direction, while rural resilience is shaped by the variables mentioned above in rural areas such as Bağlıköy, the interaction of these factors with each other positively or negatively affects the resilience in rural areas. As a result of the interrelationships among these factors, the resilience and adaptation capacities of the region are formed. In this context, the analysis of the existing social structure, cultural potential, economic activities and environmental dynamics for rural areas, particularly Bağlıköy, enables the development of rural resilience. At the point of evaluating the results of the analyses, while the existing opportunities for regional development become visible, it enables prioritized action plans for threats. From this point of view, the conceptual framework of the study was analyzed through a literature review on resilience and rural resilience. Following this, resilience indicators were developed at the point of rural resilience according to the literature review. The developed indicators were shaped in accordance with the resilience analysis of Bağlıköy Rural and applied to the participants with a written-interview model. The data obtained were analyzed with SWOT analysis. In the final phase, resilience was analyzed for the chosen rural area, which is rich in cultural heritage and potential tourism activities, and recommendations were developed against possible shocks that may be encountered in the context of resilience.

### *1.1. Resilience*

The resilience concept, expressing the ability of a system to absorb sudden shocks and disruptions while sustaining basic functions (Walker & Pearson, 2007), began to be used to understand ecological change and equilibrium at the end of the 1970s. From the middle of the 1990s, reducing disaster risk was included in studies. After the 2000s, along with adjustment to climate change, it became a concept used against natural disaster risks (Akbaş, 2023). The resilience concept, with increasing research fields within the last twenty years, is currently used in several different study areas (Windle, 2011). The source of the word comes from the Latin root resilire, meaning to spring back (Moloney & Doyon, 2021). Terminologically, it may be explained as the ability to resist pressure and stress. According to Walker and Salt (2006), resilience was defined as the capacity of a system to absorb disorder, and preserve basic functioning and structures. According to the UNISDR (2009) definition, resilience is “the ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic buildings and functions”. At the same time, resilience has variable features according to time and location (Ainuddin & Routray, 2012). In this context, it is an approach that can be tested in several different disciplines at levels involving systems, persons, society, assets and values.

Measuring resilience in the architecture discipline involves assessment of both the physical and sociocultural dimensions of the built environment. In architecture, resilience encompasses the capacity to resist, adjust to and overcome degradations, while preserving the functionality and viability of urban systems and the built environment (Holling, 1973). In this context, resilience is an integrated approach about converting and managing the built environment sensitive to adaptable, robust and variable conditions. Additionally, sociotechnical resilience approaches emphasize the importance of interdependence between physical infrastructure, sociocultural systems and governance mechanisms in developing resilience in the urban context (Pickett et al., 2013).



Currently, the resilience concept may be confused with the sustainability concept. Resilience emerging after the sustainability concept is not sustainability. Resilience is not new sustainability, but there are important overlaps between the two concepts. The system approaches in sustainability and resilience paradigms are sometimes different to each other; in fact, they may contradict. However, in a general sense, efforts made to ensure sustainability bring positive results in terms of resilience (Ercoskun, 2012; Lizarralde et al., 2015). Resilience to naturally derived disasters is explained as society being prepared in every area and returning to previous experiences with minimum harm if this disaster occurs (Inal Onal et al., 2021). If human-derived, it is assessed as analyzing the relationship between the built environment and society and is a concept that can be used for a built environment that can transfer social quality of life to future generations (Ciftcioglu & Sunalp, 2019). For disasters not to result in destruction, resilience aims to make people, communities and systems more prepared for destructive events in both natural- and human-derived risk situations (Gökalp Yılmaz & Şikar, 2023). At the point of evaluation, the resilience concept is investigated in social, economic, cultural and environmental terms linked to the social and physical components of cities (Bruneauet al., 2003; Cutter et al., 2008). Moving from this point, it is a known reality that cities and rural areas will continue to display variation and development. This development process will involve several predictable and unpredictable risk factors. Assessing the resilience of a system against risks is a necessity in terms of being able to transfer the available resources of rural areas, which have limited natural resources, to future generations.

### *1.2. Rural Resilience*

Urban resilience involves continuity, variation and restructuring of the system; in other words, the adaptation/transformation process (Ersavaş Kavanoz, 2020). Like urban resilience, rural resilience is defined as adjustment to varying external environments for continuity of the current system in the internal environment and the capacity to cope with vulnerabilities (Heijman et al., 2007). In other words, rural resilience is similar to urban resilience, and may be defined as the capacity of a rural region to adjust to variable external conditions in a way that sustains present living standards (Heijman et al., 2019). Determining risks that threaten resilience in rural areas and that may create fragility is required to preserve resources and be able to transfer them to future generations. Rural areas, involving differences from social, economic, environmental and cultural aspects, has a multicomponent structure with the potential for large agricultural fields, distance from urban crowding and low population density (Özlü et al., 2021). It is possible to investigate the system dynamics emerging from rural settlements under several different demographic-social, economic, physical and legal-administrative components. At the same time, resilience studies are important for investment and development while preparing rural areas better for shock situations in the future (Altıntaş & Hovardaoğlu, 2023).

As a result of the effects of increasing urbanization activities in the present day, rural areas are faced with the migration factor. This factor causes differentiation of demographic and social structures in rural settlements, involving an aging rural population and changes to family structure, which alters the contribution to agricultural activities of individuals working in the agricultural sector. According to Tepecik (2023), these factors are important in terms of the resilience of the system in rural settlements. From this perspective, the presence of population and the age distribution in rural settlements are important in terms of resilience of the system. Inclusion of the young population in the rural development process will ensure positive development of the social structure, along with the economic structure (Kan et al., 2020). Rural resilience appears to be a social process explaining the reactions of society to external forces like theoretical and economic regressions, natural disasters or other threats to sustainability. Rural dynamics in rural settlements are known to protect the rural population, and improve the quality of life of residents and environmental sustainability.

Development dynamics appear to be successful in reducing problems in rural areas and strengthening social, economic and environmental systems (Salvia & Quaranta, 2017). From another perspective, as defenseless regions, rural settlements not having resilience in economic, social, cultural and environmental terms contributes to the emergence of living standards at present. Social resilience, especially, has central importance in reshaping the role and function of rural areas. Linked to this, the resilience of the system is negatively affected as a result of factors that will increase fragility in these regions. Vulnerabilities include reduced population, the majority of the population comprising the elderly, low numbers or lack of young population, low educational level and limited access to these services, gaps in labor for agricultural production and lack of production tools among producers, lack of disaster experience, lack of planning of settlements, existence of infrastructure problems (water, sewage, communication, etc.), lack of health facilities, use of fossil fuels or coal for heating, weak connections with cooperatives, and lack of transport services. Factors which increase resilience include production in different sectors as additional income for retirees, supports given for agricultural activities and availability of social insurance.

## 2. Methodology

This study aims to analyse resilience and the ability to adapt to economic, social, cultural and environmental dynamics and processes associated with regional transformations in rural areas. Rural resilience was formed in line with the interaction of the dynamics that are effective in rural areas. The analysis of these factors determines the vulnerability of rural areas and identifies regional sustainability and adaptation capacities.

From this perspective, this study includes an assessment of resilience in rural areas. The study data was based on a qualitative data collection method. In this context, in order to analyse the resilience of rural areas, resilience assessment indicators were determined from the literature review. Afterwards, by taking into account the local texture and characteristics of rural areas in general and Bağlıköy, the study area, in particular, were analyzed (Table 1).

**Table 1** Energy Performance Table for Retrofitted and New Buildings in 2090

| Resilience | Resilience indicators |
|---|---|
| Cultural resilience | • Are there positive and/or negative inputs for the village from cultural tourism?<br>• Do you think the cultural tourism activities within the village are sufficient?<br>• Is the traditional cultural texture of the village able to sustain cultural tourism activities sufficiently?<br>• What are your thoughts about the ecovillage and ecotourism models?<br>• Do you think preservation activities for neighborhoods with integrity of traditional texture are sufficient? |
| Environmental resilience | • Are land use activities appropriate to the traditional texture of the village?<br>• Are there prevention plans for disaster hazards?<br>• What is your assessment of infrastructure activities within the village?<br>• What are the effects on the ecological balance of construction in all areas within the village boundaries?<br>• Which disaster hazards have impacted the village? (earthquake, landslide, flood, etc.) |
| Economic resilience | • What is the main source of income in the village?<br>• Do cultural tourism activities sufficiently contribute to the village?<br>• Are rural development activities supported by the local people?<br>• Are ecovillage activities sufficient as an economic resource for the village?<br>• Are economic supports from local government sufficient for development of the village? |
| Social resilience | • Are local government policies for rural villages sufficient to preserve the historical and cultural texture?<br>• Are local government policies for rural villages sufficient to preserve the environmental texture?<br>• Are local government policies for rural villages sufficient to preserve economic activities?<br>• Are there organizational activities about local culture, preserving tradition, revitalization, etc. within the rural area? Are they sufficient?<br>• Are there changes related to the demographic structure with migration occurring in rural areas? |

Then, the written interview method questions were prepared according to the determined indicators. A total of 20 questions regarding the variables related to the resilience levels specific to Bağlıköy rural area were prepared and used to obtain data on these variables. Within the scope of the study, the total population of the village was accepted as 200 based on the 2011 census of the State Planning Organisation (Lefke Municipality, 2024). The prepared questionnaire was applied to 55 users. The written notes obtained were reported and summarised within the scope of the study.

A SWOT analysis was conducted based on the primary data obtained from the participants and the data obtained by on-site observation. With the SWOT analysis method, the strengths and weaknesses of the current situation in the region and the opportunities and threats that may develop in the region were investigated. Analyses have been made for the threats and risks that the Bağlıköy rural area may face, and suggestions have been developed in line with these.

## 3. Bağlıköy Rural Area

Bağlıköy rural area is located in the west of the island (Figure 1) and is a town village linked to Lefke county since Lefke gained the status of 6th county within the scope of the Civil Administration and Divisions (Amendment) Act numbered 2/2017 (Çeliksoy, 2021). Based on the 2011 population census by the State Planning Organization (DPO), the total population was 200, with total number of residences reported to be 79.

**Figure 1** Location of Bağlıköy (Googleearth, 2024)

Bağlıköy, where the traditional village culture of Cyprus still exists, is an important region in the context of rural features due to its location. Council of Ministers Decision Number 152-2013 declared Bağlıköy a Tourism Area in Need of Protection. In this context, it was identified to be a Historical, Cultural and Traditional Life Center in the National Physical Plan. For Bağlıköy rural area, the aim is to develop the settlement within the framework of the ecovillage concept while preserving the original village texture, and to attract tourism investments suitable to the character and scale of the region. Additionally, it is included within the area of the Cittaslow-Slow City and Plan encompassing the whole of Lefke county in the Lefke Zoning Plan Draft Report (LIP). In this context, the region was identified to be a historical, cultural and traditional living center. Additionally, attention was drawn to both spatial and economic policies appropriate for the stated roles within the scope of planning (Town Planning Department (TPD), 2024).

The Cittaslow (slow city) movement is an "international network of cities emphasizing quality of life" (Topal et al., 2016). It is a development model based on local lifestyles and values applied to small cities and aiming to increase quality of life. This model emerged in Italy in 1999. It contributes to sustainable development within the specific values of the region and local economic development. At the same time, it supports livable development models in settlements where the local character comes to the fore by preserving the natural environmental, historical and cultural texture (Öztürk et al., 2023). The Cittaslow movement encourages preservation and development of the green texture by taking precautions against environmental, air, water, noise and light pollution in settlements. It has popularized awareness of livability by ensuring the continuity of local, unique architecture and urban planning in a cultural context, development of the social infrastructure and preservation of demographic texture socially (Özmen & Can 2018). The Cittaslow approach comes to the fore with appropriate, local and unique features in social, economic, cultural and environmental dimensions. The Bağlıköy rural area is a member of the Cittaslow movement, while also being a town village associated with Lefke municipality, one of the top 5 municipalities within the borders of the Turkish Republic of Northern Cyprus (KKTC).



In summary, the reasons for selecting of Bağlıköy as a study area included its historical and cultural neighborhood texture and adobe-dominated traditional building stock, its potential to provide opportunities for crucial economic activities for rural development such as being an eco-village and developing eco-tourism in addition to agriculture and animal husbandry. Moreover, Bağlıköy has significant rural identity with its geographical features and environmental texture, and the fact that it is a member of the Cittaslow (slow village) network, which embraces a development model based on local lifestyles and values.

### 3.1. Bağlıköy Rural Area Resilience Analysis

The concept of resilience for the Bağlıköy rural area was addressed by examining cultural, environmental, economic and social indicators. Data were obtained from primary sources through case study conducted in the Bağlıköy rural area. Written notes collected during written-interview studies were evaluated in conjunction with data obtained from literature review. In this context, assessments along with user opinions were important for analysis of region-focused resilience.

#### 3.1.1. Cultural Resilience Analysis

Preservation of the architectural texture with traditional qualities existing in Bağlıköy and being able to transfer this to future generations were considered crucial. In this context, high rates of users' answers in the written-interview results found that cultural values provided meaningful returns for the village. According to the general opinion of the users “The ecovillage and ecotourism models involve elements like preserving natural resources, supporting local cultures and communities, and creating environmental education and awareness. These models may each be important tools for a sustainable future.”

Additionally, it was thought that the ecovillage and ecotourism models brought positive returns for rural areas in general and for development of Bağlıköy rural area specifically. The ecovillage and ecotourism models were positive approaches in terms of revitalizing social culture and the potential to contribute to the income of people in the region. At this point, studies about including historical values in the tourism sector will create positive effects on cultural sustainability. At the same time, they will play an important role in tourism-focused diversification of economic activities in the rural area and in this context, economic resilience.

The general user opinion also highlighted the importance of supporting local production and contributes to the local economy. However, it was pointed out that when ecovillage or ecotourism is mentioned, festivals held once a year come to everyone’s mind. The definition and aims are not sufficiently explained. This feedback emphasised the need for clearer communication regarding the aims and scope of these models.

However, at the point of contributing a positive approach, additionally, continuous repetition of festivals, important in rural areas both to enliven the culture and for rural development, creates a threat in terms of the originality of local values. Additionally, input about the necessity to ensure more information is given to local people and more active roles be played by experts was obtained at this point. More inclusion of local people in the process was generally emphasized to be important for local development.

Regarding the adequacy of preservation activities for neighbourhoods with integrity of unique traditional village texture in historical, cultural and traditional terms, studies were not found to be adequate and concerns within the scope of cultural heritage preservation were outputs obtained in our field study. In this context, within the scope of analysis and preservation activities for the existing building stock, dominantly adobe structures, there was consensus about the importance of performing this work by observing the existing identity and characteristic features.

#### 3.1.2. Economic Resilience Analysis

The main income sources for the village are provided by animal husbandry and agricultural activities. Pension accommodation centers reflecting the traditional culture and restaurants selling food produced within the village are located within the village boundaries. In this context, the inadequacy of accommodation possibilities in Bağlıköy rural area, with rural tourism potential in terms of rural development, was evaluated as a potential fragility.

Based on the collective opinions of the users, while Ecotourism festivals are held in the village. Along with being important for rural development, I think these activities need to be increased and developed. They are not sufficiently developed or promotion is not performed.

There are festivals organized in relation to ecovillage and ecotourism concepts. The majority of users did not think these activities sufficiently contributed to the village in terms of cultural tourism. They emphasized the development of potential tourism resources and more active participation by non-governmental organizations for labor cooperation in relation to the continuity of rural development. At this point, the importance of sufficient participation by the public was a focus.

In order to ensure the continuity of local culture and increase production activities, users highlighted the need for opportunities like grant-support models be provided. In this context, increases in the contributions from local and regional administrations were emphasized at a high rate.

#### 3.1.3. Environmental Resilience Analysis

The geographical location of Bağlıköy has its own unique environmental texture. However, it was identified that interventions resulting in destruction of sensitive regions in ecological terms had intensified with unplanned development of the region. Buildings in new settlement areas, especially, created inconsistencies with the traditional texture of the village. In this context, it was thought that there were negative impacts that may occur in the ecological balance with increased buildings within the village boundaries.

In this context, the general opinion of those interviewed that Instead of buildings reflecting the environmental and cultural texture, like adobe homes found in Bağlıköy and surroundings, construction of high-rise buildings negatively impact the traditional texture.

At the same time, climate change and landscape hazards due to geographical features comprise threats. In this context, an output in the study area was that services were expected from local and regional administrations in relation to action-prevention plans against natural disaster threats within the village.

#### 3.1.4. Social Resilience Analysis

One of the most important assets in the village is the neighbourhood texture with traditional quality and adobe homes. However, in light of data obtained within the scope of field studies it was revealed that these assets were not sufficiently protected in the context of current policies in the present day.

In this context, the general opinion of those interviewed highlighted that the young population within the village is very low. The feeling of belonging to the village of the young population should be researched and developed.

In conclusion, it was determined the current demographic structure within the village does not comprise a young and dynamic population. In this context, it is necessary to take steps to enhance the feeling of belonging to the village among the young population and to create opportunities to develop employment.

### 3.2. Findings Related to Cultural, Economic, Environmental and Social Resilience Levels of Bağlıköy Rural Area

The cultural, economic, environmental, and social resilience variables were investigated for the Bağlıköy rural area. After these investigations were finalized, the results were combined into separate tables. Then, in this part of the research, the results of the analysis were discussed.



The cultural elements within the boundaries of Bağlıköy rural area have high cultural potential. In this stage of the research, According to the  collected data were formed into the Cultural Resilience Assessment Matrix (Table 2) . Then, while the rural village environment where intangible and cultural heritage can still be experienced increases cultural resilience, the lack or incompleteness of protective activities to be able to transfer these values to future generations was negatively assessed in terms of this resilience. In written-interview studies performed with users about evaluating cultural elements, the local people had positive approaches to ecovillage and ecotourism concepts, which was positively assessed for resilience in this area. However, the inadequacy of these activities in focusing on rural development, inadequate information given to village users and insufficient support from the relevant administrative organs affected resilience in a negative sense.

**Table 2** Cultural Resilience Assessment Matrix

| | | |
|---|---|---|
| **Cultural Resilience** | **Strength** | **Weakness** |
| | • Continuity of existing culture<br>• Has tangible cultural heritage with traditional qualities<br>• A variety of festival interventions to promote the culture | • Inadequate accommodation facilities in areas with rural tourism potential<br>• Inadequate promotion and advertising work for potential rural tourism visitors<br>• Lack of sufficient development of rural tourism awareness<br>• Inadequacy of various festival interventions to promote the culture<br>• Possibility of destruction of intangible cultural heritage over time |
| | **Opportunities** | **Threats** |
| | • High potential for the ecovillage approach due to tangible and intangible cultural heritage<br>• Membership of the Cittaslow movement<br>• Presence of university and relevant departments and potential for cooperation | • Impact on continuity of tangible cultural heritage within the scope of ownership problems<br>• Lack of a legal protection approach for rural areas within the scope of preserving tangible-intangible cultural heritage<br>• Low young population due to the migration factor and inability to continue cultural transfer<br>• Lack of study, like reporting or inventories, for tangible cultural values (neighborhoods with traditional quality, traditional adobe homes, etc.)<br>• Not following practices preserving traditional texture in new construction areas |

Economic activities intensively comprised agriculture and livestock, as valid for rural settlements generally. Bağlıköy rural area is within this generally valid group. However, additionally, the sociocultural potential and tourism activities were accepted an important development in terms of economic income for the rural area—the present study combined economic resilience data collected into the Economic Resilience Assessment Matrix (Table 3). Resilience was negatively affected by inability to sufficiently benefit from institutions/organizations providing grants and funds to support economic activities in the region.

**Table 3** Economic Resilience Assessment Matrix

| | Strength | Weakness |
|---|---|---|
| ***Economic resilience*** | • High potential for ecovillage approach<br>• Potential for agricultural production from the geographical structure of the region<br>• Presence of tourism potential | • Inadequate promotion and advertising wo<br>potential rural tourism visitors<br>• Lack of existing structure to market rural t<br>and structures<br>• Inadequate cooperation to develop touris<br>non-governmental organizations and publi<br>institutions within the scope of rural devel<br>• Inadequate accommodation facilities in ar<br>rural tourism potential<br>• Infrastructure problems and deficiencies i<br>areas |
| | **Opportunities** | **Threats** |
| | • Support for economic development while preserving forgotten cultural and traditional values<br>• Membership of the Cittaslow movement<br>• Presence of university and relevant departments and potential for cooperation | • Culture festivals not adequate for develop<br>• Lack of an area to sell products produced in<br>area |

In this stage of the research, the environmental resilience was evaluated. Firstly were formed the Environmental Resilience. Assessment Matrix (Table 4). connected to the collected data Then, according to the matrix, the environmental resilience was interpreted. Rural settlements have a less degraded natural environment compared to urban settlements. The lack of destruction of Bağlıköy rural area had positive effects in terms of environmental and potential resilience. However, forest fires are among the shocks experienced in rural settlements. The natural environment in rural areas is defenseless against forest fire risks. This situation causes a reduction in resilience. At this point, the importance of preparing a natural disaster management plan can be clearly seen.

**Table 4** Environmental Resilience Assessment Matrix

| | Strength | Weakness |
|---|---|---|
| ***Environmental Resilience*** | • Undegraded environment in the region | • Irregular construction in settlements in rural areas<br>• Inadequate planning-auditing-control mechanisms for new construction |
| | **Opportunities** | **Threats** |
| | • Low threats to natural wealth of the region due to low population density and lack of development of industrial activities<br>• Expected potential for assessment of agricultural resources<br>• Presence of university and relevant departments and potential for cooperation | • Lack of cooperation between local administrations and relevant institutions<br>• Lack of qualified personnel that will occur linked to the increase in rural tourism potential<br>• Threat to natural assets linked to uncontrolled visitor demands<br>• Risk of forest fires and hazards to the vulnerable natural environment<br>• Lack of protection plans for the unique structure of the region |

Rural areas are regions with unique identities in terms of regional architecture and social characteristics. In this part of the study, the Social Resilience Assessment Matrix (Table 5) was formed according to the collected information. Then, social resilience was interpreted as related to the social resilience assessment matrix. The high number of traditional adobe buildings in Bağlıköy rural area increases resilience in social and cultural terms. However, protection of the existing building stock was shown as a weakness at this point. Additionally, the inadequate zoning-audit-control mechanisms for new construction activities in the region negatively affected resilience.

Moving from this point, the still-incomplete legal processes for zoning-protection plans in the region and lack of implementation negatively impacts resilience levels, led by social and environmental resilience, but also from cultural and economic perspectives.

**Table 5** Social Resilience Assessment Matrix



<table>
<tr><td rowspan="4">Social Resilience</td><td>Strength</td><td>Weakness</td></tr>
<tr><td>• Distance from urbanization and industrialization activities<br>• Lack of uncontrolled internal migration</td><td>• Unbalanced ratio between young population and elderly population<br>• Lack of sufficient cooperation between non-governmental organizations and public institutions to develop rural tourism<br>• Protection-zoning plans still not legalized and not implemented<br>• Preservation-focused status detection analyses and inventory studies still not completed</td></tr>
<tr><td>Opportunities</td><td>Threats</td></tr>
<tr><td>• Existence of traditional village texture</td><td>• Negative impact of excess elderly population on dynamicity of rural settlements<br>• Inadequate auditing mechanisms for construction and development within the region</td></tr>
</table>

## 4. Conclusion

Currently, resilience studies have come to the forefront due to shocks with increasing frequency and impact in rural areas. Rural areas have become dependent on cities in the face of changing external conditions and have a fragile structure (Li, 2023). As a result, increasing rural resilience is important in terms of adjusting to newly-developing situations. Resilience is simultaneously a necessity for sustainable rural development. Rural resilience is known as an integrated concept playing an important role in optimizing negative trends resulting from risks faced in rural areas and for sustainable rural development that can resist these risks. The basic aim of sustainable rural development is for rural areas to obtain resilience in their specific social, environmental, economic, institutional or cultural fields. At this point, determining indicators is crucial to understand the formation of the rural area.

In this study, hypothesizes that the resilience of rural areas is significantly influenced by vulnerabilities resulting from regional transformations, and both natural and artificial impacts. As a connected to the hypothesis, the indicators affecting resilience for Bağlıköy rural area were dealt with in cultural, economic, environmental and social contexts. Within the framework of the resilience approach, what problems may induce vulnerability in rural areas were investigated. Additionally, preparation capacity was assessed with tangible approaches to shocks that will have high impact on systems in rural areas. Data were obtained with field studies completed within the scope of the research and written-interview studies in focus groups. In this context, the obtained data were evaluated with the SWOT analysis method.

One of the important vulnerabilities emerging in findings related to social resilience within the scope of Bağlıköy rural area in the research is the case of migration and resulting degradation in the demographic structure. Migration and aging of the existing settled population negatively affects the dynamicity of the rural area. Additionally, it comprises a serious hazard in terms of resilience for transfer of intangible cultural heritage from generation to generation. This factor is connected to more than one area, and affects resilience in the economic, environmental and social areas as well as cultural area. At this point, recording and archive studies about intangible cultural heritage are important. Additionally, another result of migration affects rural development in terms of ensuring continuity of agricultural production by an aging population and this creates economic and also environmental vulnerability. At this point, it is important to protect local culture to be able to reduce the migration pressure from rural areas to towns and to organize grant resources about increasing production. Additionally, it should not be forgotten that the Cittaslow membership of Bağlıköy and its ecotourism potential are strong factors at this point.

Transfer of tangible cultural heritage to future generations, continuous from past to the present, comprises vulnerability in the context of cultural resilience. Most of the existing building stock in Bağlıköy rural area comprises adobe. It is important to be able to transfer this adobe building group to future generations to ensure continuity of the culture. At this point, firstly it is mandatory to define a protection area in the region and to prepare region-focused preservation plans. Additionally, it is necessary to begin relief and inventory studies to analyze the existing building stock immediately. After analysis of the existing building stock, restoration and refunctioning work will contribute to resilience in a cultural sense.



Another of the most important problems experienced in rural areas was clearly revealed in written-interviews in terms of economic resilience. In this context, the need to evaluate the importance of support for local production and economy within the bounds of rural development principles was mentioned. At the same time, the analysis performed for Bağlıköy rural area determined that expectations were not sufficiently met by services like accessibility of local administrations and infrastructure.

The distance of rural areas from local administration centers emerged as a factor causing vulnerability. Additionally, distance to local administrations increased vulnerability in terms of environmental and social resilience. The inadequacy of auditing and control mechanisms affected resilience at this point. To be able to resist shocks that will be experienced in rural areas with increasing natural disaster events, there were expectations from local administrations in terms of disaster prevention and preparation work. Within this framework, this led to the need for more resilience and more robust policies to increase support for agriculture and tourism-focused economic activities, especially, and to overcome interrelated challenges in social, economic, environmental and cultural contexts.

In conclusion, analysis of the impact of any situation causing change, transformation or systemic shocks in rural areas, adjustment to new conditions and how to increase rural capacity is important. As a result of the study, it was observed that indicators of cultural, economic, environmental and social resilience interact with each other. At this point, the results of analyses that will be performed should involve an integrative approach. An integrative resilience analysis approach and how to identify it will be the research focus for future studies to increase the resilience of rural areas and maintain sustainable development capacity.

## References

Ainuddin, S., & Routray, J. K. (2012). Earthquake hazards and community resilience in Baluchistan. *Natural Hazards*, *63*, 909-937. https://doi.org/10.1007/s11069-012-0201-x

Akbaş, İ. (2023). Dirençlilik ve dirençli kent yaklaşiminda yeni eğilimler: Bibliyometrik bir analizi. *Nevşehir Hacı Bektaş Veli University SBE Journal*, *13*(3), 1866-1889. https://doi.org/10.30783/nevsosbilen.1302930

Altıntaş, G., & Hovardaoğlu, O. (2023). Kırsal kırılganlık ve dayanıklı kırsal planlama. *Sketch: Journal of City and Regional Planning*, *04*(01-02), 24-52. https://doi.org/10.5281/zenodo.8068248

Bruneau, M., Chang, S. E., Eguchi, R. T., Lee, G. C., O'Rourke, T. D., Reinhorn, A. M., Shinozuka, M., Tierney, K., Wallace, W. A., & Von Winterfeldt, D. (2003). A framework to quantitatively assess and enhance the seismic resilience of communities. *Earthquake Spectra*, *19*(4), pp 733 752. https://doi.org/10.1193/1.1623497

Cheng, Y., Kang, Q., Liu, K., Cui, P., Zhao, K., Li, J., Ma, X., & Ni, Q. (2023). Impact of urbanization on ecosystem service value from the perspective of spatio-temporal heterogeneity: A case study from the Yellow River Basin. *Land*, *12*(7), 1301. https://doi.org/10.3390/land12071301

Ciftcioglu, G.C., & Sunalp, C. (2019). Exploring the linkages between the building, home garden and human system resilience in Lefke Region of North Cyprus. *Landscape Research*, *44*(6), 716-730. https://doi.org/10.1080/01426397.2018.1498469

Cutter, S. L., Ash, K. D., & Emrich, C. T. (2016). Urban–rural differences in disaster resilience. *Annals of the American Association of Geographers*, *106*(6), pp 1236 125. https://doi.org/10.1080/24694452.2016.1194740

Cutter, S. L., Barnes, L., Berry, M., Burton, C., Evans, E., Tate, E., & Webb, J. (2008). A place-based model for understanding community resilience to natural disasters. *Global Environmental Change*, *18*(4), 598-606. https://doi.org/10.1016/j.gloenvcha.2008.07.013

Çeliksoy, E. (2021). Kuzey Kıbrıs Türk Cumhuriyeti merkezi idare ve yerel yönetim teşkilatı. *21. Yüzyılda Eğitim ve Toplum*, *10*(30), 579-592.

Dincer, Ş. E., & Ercoşkun, Ö. Y. (2021). Kent planlamada yeni bir yöntem önerisi: kentsel dirençlilik endeksi. *Resilience*, *5*(2), pp 159-172. https://doi.org/10.32569/resilience.811875

Eraydin, A. (2016). Attributes and characteristics of regional resilience: Defining and measuring the resilience of Turkish regions. *Regional Studies*, *50*(4), 600-614. https://doi.org/10.1080/00343404.2015.1034672

Ercoskun, O. Y. (2012). A paradigm shift towards urban resilience. *In Green and Ecological Technologies for Urban Planning: Creating Smart Cities*, *IGI Global*, pp. 1-16. https://doi.org/10.4018/978-1-61350-453-6.ch001

Ersavaş Kavanoz, S. (2020). Kentsel direnç kavramı üzerine. *Journal of Urban and Environmental Research,* *2*(1), 5-24.

Gökalp Yılmaz, G., & Şikar, A. (2023). Afetlerin etkilerinin zorunlu göç bağlamında incelenmesi: 2023 Kahramanmaraş Depremi. *Journal of Disaster and Risk*, *6*(4), 1247 1268. https://doi.org/10.35341/afet.1290767

Heijman, W., Hagelaar, G., & Heide, M. (2007). Rural resilience as a new development concept. *Development of Agriculture and Rural Areas in Central and Eastern Europe', 100th seminar of the EAAE*, Novi Sad, Serbia, 21-23 June 2007, 383-396.

Heijman, W., Hagelaar, G., & Van Der Heide, M. (2019). Rural resilience as a new development concept. *EU Bioeconomy Economics and Policies*: Volume *II*, 195-211. https://doi.org/10.1007/978-3-030-28642-2_11

Holling, C. S. (1973). Resilience and stability of ecological systems. *Annual Review of Ecology and Systematics*, *4*(1), 1–23. https://doi.org/10.1146/annurev.es.04.110173.000245

Inal Onal, E., Tekeli Yeşil, S., & Okay, N. (2022). The use of Twitter by official ınstitutions in disaster risk communication and resilience: A case study from Turkey. *Journal of Emergency Management and Disaster Communications*, *3*(01), 25-40. https://doi.org/10.1142/S2689980922500087

Jorge-Ortiz, A., Braulio-Gonzalo, M., & Bovea, M. D. (2023). Assessing urban sustainability: A proposal for indicators, metrics and scoring-a case study in Colombia. *Environment, Development and Sustainability*, *25*(10), pp 11789-11822. https://doi.org/10.1007/s10668-022-02554-6

Kan, M., Kan, A., Nizam. D., Perkin, A. D., Everest B., & Taşçıoğlu, Y. (2020). Dünyada ve Türkiye'de kırsal kalkınma uygulamalarındaki mevcut durum ve gelecek. *Proceedings of the IXth Technical Congress of Turkish Agricultural Engineering-1*.

Karakayacı, Ö., & Keser, F. (2021). Rural areas as resilience spaces in new regional development paradigms: A research in case of rural areas of Beysehir in Konya. *Journal of Geography*, (43): pp 217-233. https://doi.org/10.26650/JGEOG2021-913711

Lanlan, J., Sarker, M. N. I., Ali, I., Firdaus, R. R., & Hossin, M. A. (2024). Vulnerability and resilience in the context of natural hazards: A critical conceptual analysis. *Environment, Development and Sustainability*, *26*(8), pp 19069-19092. https://doi.org/10.1007/s10668-023-03440-5

Lefke Municipality. (2024). Yeşil Lefke: Sakinlik onun doğasında var! Access Address: 12.12.2024. https://www.lefkebelediyesi.com/

Li, Y. (2023). A systematic review of rural resilience. *China Agricultural Economic Review*, *15*(1), pp 66-77. https://doi.org/10.1108/caer-03-2022-0048

Lizarralde, G., Chmutina, K., Bosher, L., & Dainty, A. (2015). Sustainability and resilience in the built environ ment: The challenges of establishing a turquoise agenda in the UK. *Sustainable Cities and Society*, *15*, 96-104. https://doi.org/10.1016/j.scs.2014.12.004

Moloney, S., & Doyon, A. (2021). The resilient Melbourne experiment: Analyzing the conditions for transformative urban resilience implementation. *Cities*, *110*, 103017. https://doi.org/10.1016/j.cities.2020.103017

Muntele, I., Istrate, M., Horea-Șerban, R. I., & Banica, A. (2021). Demographic resilience in the rural area of Romania. A statistical-territorial approach of the last hundred years. *Sustainability*, *13*(19), 10902. https://doi.org/10.3390/su131910902

Özlü, S., Dedeoğlu Özkan, S., & Beyazlı, D. (2021). Kırsallığın seçilmiş sosyo-demografik değişkenler yardımıyla kümelenmesi ve zamana bağlı değişimi. *Planlama*, *31*(1), 31 46. https://doi.org/10.14744/planlama.2020.13540

Özmen, A., & Can, M. C. (2018). Cittaslow Hareketi'ne eleştirel bir bakış. *Planlama*, *28*(2), 91-101. https://doi.org/10.14744/planlama.2018.95967

Öztürk, A., İpek, F., & Kayacan, B. (2023). Cittaslow (sakin şehir) yaklaşımının sürdürülebilir yerel kalkınmaya etkisi: Şavşat örneği. *MANAS Journal of Social Research*, *12*(1), 187-208. https://doi.org/10.33206/mjss.1143649

Pickett, S. T., Cadenasso, M. L., & McGrath, B. (Eds.). (2013). Resilience in ecology and urban design: Linking theory and practice for sustainable cities. (Vol. 3). *Springer Science and Business Media.*

Salvia, R., & Quaranta, G. (2017). Place-based rural development and resilience: A lesson from a small community. *Sustainability*, *9*(6), 889. https://doi.org/ 10.3390/su9060889

Shukla, N., Das, A., & Mazumder, T. (2023). Assessment of urban form resilience: A review of literature in the context of the Global South. *Environment, Development and Sustainability*, pp 1-37. https://doi.org/10.1007/s10668-023-04058-3

Singh, A. K., Issac, J., & Narayanan, K. (2019). Measurement of environmental sustainability index and its association with socio-economic indicators in selected Asian Economies: An empirical investigation. *International Journal of Environment and Sustainable Development*, Vol. *18*, No. 1, pp.57–100. DOI: https://doi.org/10.1504/IJESD.2019.10019989

Tepecik, A. (2023). Kırsal alanlarda dirençlilik meselesi üzerinde bir inceleme. *5th International Congress on Disaster and Resilience*, 11-13 October 2023, pp. 405-414.

Topal, T. Ü., Korkut, T., & Kiper, T. (2016). Yerel kimliğin kent ile buluşması: Cittaslow Yavaş Şehirler. *İdil*, *5* (25), 1413-1430. https://doi.org/10.7816/idil-05-25-06

Town Planning Department (TPD) TRNC. (2024). *Lefke development plan draft report*.

UNISDR. (2009). *Terminology on disaster risk reduction, united nations ınternational strategy for disaster risk reduction, Geneva, Switzerland*.

Walker, B. H., & Pearson, L. (2007). A resilience perspective of the SEE. *Ecological Economics*, *61*(4), 708-715. https://doi.org/10.1016/j.ecolecon.2006.04.010

Walker, H. B., & Salt, D. (2006). Resilience thinking: Sustaining ecosystems and people in a changing world. *Island Press*.

Wang, C., Hao, Y., & Yao, J. (2024). Precise pollution control in new urban development areas: A case study from China. *International Journal of Environment and Sustainable Development*, *23*(1), 1-20. https://doi.org/10.1504/IJESD.2024.135633

Windle, G. (2011). What is resilience? A review and concept analysis. *Reviews İn Clinical Gerontology*, *21*(2), 152-169. https://doi.org/10.1017/S0959259810000420

## Resume

*M. Selen Abbasoğlu completed her undergraduate studies in the Department of Architecture at Eastern Mediterranean University (EMU) in 2001. She received her master's degree in 2003 and her PhD in 2016 from the same university. Since 2011, she has been serving as a faculty member at the European University of Lefke. Her research interests encompass interior architecture and architectural education, design methods, visual perception, subjective well-being, vernacular housing, rural and urban resilience, public spaces, shape grammar, semiotics, cultural identity, children's spaces, and interior design. She actively contributes to interior architecture design studios at her university. Dr. Abbasoğlu has participated in numerous international conferences on topics such as urban quality of life, space syntax, sustainability, resilience, and both architectural and interior architectural education. She has also focused on the theoretical foundations of architectural and interior architectural education, as well as urban and rural resilience, urban conservation, and urban planning. She has contributed articles to national and international publications on these subjects.*

*Fatma Bıldır graduated from the Faculty of Architecture and Design at the European University of Lefke and completed her Master's degree there in 2024. Since 2020, she has been actively involved in both the design and implementation phases of conservation and restoration projects related to cultural heritage. Throughout her career, she has undertaken restoration and preservation work on architectural heritage elements from various historical periods. Her interests lie in the conservation of cultural and environmental heritage, with a focus on ensuring their preservation for future generations and enhancing their accessibility through digitalization. She continuously works to expand her expertise in these areas. In addition, she has participated in both national and international conferences, addressing topics such as urban and rural resilience, urban conservation, and urban planning.*

JOURNAL OF DESIGN FOR RESILIENCE IN ARCHITECTURE & PLANNING

*Research Article*
*Online:* www.drarch.org
*Volume 6, Issue 1 (71-101), 2025*
*DOI: 10.47818/DRArch.2025.v6i1158*

# The importance of water-sensitive planning and design approaches for resilience to flood disaster risk in Istanbul: Evaluation of examples in Çatalca and Beykoz districts

Hale Mamunlu Kocabaş*

## Abstract

Nowadays, climatic changes are coming to the forefront of the global agenda due to their significant impact. Effects can be seen on rainfall and the hydraulic cycle, the number of disasters such as landslides, floods, and flash floods, which are especially increasing in cities. In recent times, flood and flash flood events have adversely affected many settlement areas in Istanbul. Istanbul, which is the main agglomeration of the country, has expanded spatially towards the urban peripheries due to population growth. The study focuses on the innovative basic principles of water-sensitive planning and design approaches for flood risk reduction, which have gained importance in light of international debates. In this context, the study examines the conditions for developing water-sensitive planning and design approaches in Istanbul and makes recommendations. For this purpose, a comprehensive and detailed literature review was conducted and scientific documents such as articles, international-national conventions, institutional research reports and national legislation were utilized. The study aims to determine the current situation in the areas where flood disasters occur in Istanbul, to identify the causes of the disasters, to question whether the land use decisions and urban planning approaches in the existing legal-administrative structure consider the risk factors for reducing flood disasters. Çatalca district, which is located on the urban periphery of the European side of the city, is very rich in water resources and is where the highest loss of life and material damage occurred in the flood disaster of 2009, was selected as the sample area in the study. Beykoz district, which is located on the periphery of the Anatolian side of Istanbul and very rich in water resources, was selected as another sample area. Within the scope of the study, data were obtained through interviews with relevant local institutions and organizations. Previous studies and existing data on the sample areas have been compiled and evaluated. When the practices of the institutions in the sample locations are examined, it is understood that the method of protection distances determined by legislation for the prevention of flood risk in stream beds is insufficient. In areas where flood risk is experienced, it is tried to be prevented by rehabilitation of streams. There is no holistic approach with planning decisions at the basin scale. As the population, settlement area and impervious surfaces increase in the basins where stream rehabilitation is carried out at high costs, these projects will be insufficient to prevent flood risk. Water-sensitive urban planning and design approaches with participatory and collaborative processes in basin scale should be start for resilience to flood disaster risk in Istanbul.

*Keywords:* flood disaster risk, integrated water basin management, resilience, risk-oriented planning, water-sensitive planning and design

## 1. Introduction

Today, one of the leading global problems is the pressure created by human activities on the natural environment and its negative effects. Especially with the increase in impervious areas, the quality and quantity of water are changing as seen in the characteristics of water absorption by soil and drainage of water flowing over the soil. Construction conditions incompatible with nature such as paving roads with asphalt, lead to an increase in the volume and speed of water flowing over the soil; hence, the risk of flooding increases simultaneously. Due to the significant effects of climate change on precipitation and the hydraulic cycle, the number of natural disasters such as sudden

*(Corresponding author), Assist. Prof. Dr., Mimar Sinan Fine Arts University, Türkiye hale.kocabas@msgsu.edu.tr
*Article history: Received 08 December 2024, Accepted 18 April 2025, Published 30 April 2025*

precipitation, flooding, landslides, etc. are increasing all over the world, and their effects are felt much more in urban areas.

In 1992, the UN organized the International Conference on Water and Environment in Dublin. The principles agreed upon at the end of this conference were adopted at the United Nations Conference on Environment and Development held in Rio de Janeiro in 1992 and named as "Dublin-Rio Principles" (GWP, n.d.). Thus, the necessity of integrated management of water resources, which are the basic source of life for all living things, at the basin level with a holistic approach has been recognized on an international scale.

It was at this summit where the United Nations Framework Convention on Climate Change and the Convention on Biological Diversity were opened for signature, while the negotiation of the United Nations Convention to Combat Desertification was called for in the summit outcome - Agenda 21. These three sister conventions later collectively became known as "the Rio Conventions". The biggest overlap in the work of all three Rio Conventions is in the field of "nature-based solutions" (UN-Climate Change, n.d.). In this context, the United Nations Conference on Environment and Development in 1992 in Rio de Janeiro constitutes the cornerstone of acting together against global environmental problems.

A disaster related to either a weather, climate or water hazard occurred every day on average over the last 50 years – killing 115 people and causing US $202 million in losses daily (WMO, 2021, p.16). In 2023, the Emergency Events Database recorded 399 disasters related to natural hazards. These events resulted in 86,473 fatalities and affected 93.1 million people (Delforge et al., 2024). Climate change is primarily a water crisis, and its impact is felt through worsening floods, rising sea levels, shrinking ice fields, wildfires, and droughts. Flooding and rising sea levels can contaminate land and water resources with saltwater and cause damage to water and sanitation infrastructure, such as waterpoints, wells, toilets, and wastewater treatment facilities. However, water can fight climate change. Sustainable water management is central to building the resilience of societies and ecosystems and to reducing carbon emissions. Everyone has a role to play at the individual and household levels, and these actions are vital (UN, n.d.). Mayors and local governments are both key targets and key drivers in building urban resilience. (UNDDR, n.d.).

Flooding is very common and a devastating disaster all over the world, as well as in Türkiye. Urban areas in Türkiye face increasing flood risks due to urbanization and the climate change impacts on water resources, which lead to irregularities in flow regime. Among all natural hazards in Türkiye, flooding is the most common, and accounts for the second largest number of casualties and the highest economic damage (Republic of Türkiye Ministry of Agriculture and Forestry, n.d.). The year 2022 has been the year with the highest number of extreme events, with 1030 extreme events reported. There is an increasing trend in the number of extreme events, especially in the last two decades (see Figure 1). The extreme events recorded in 2022 were heavy rain-floods (33.6%), windstorms (21.4%), hail (18.5%), snow (11.7%), lightning (4.1%), forest fire (0.9%), frost (2.5%), landslide (2.7%), avalanche (2.1%), dust storm (0.2%) and fog (0.3%) (Republic of Türkiye Ministry of Environment, Urbanization and Climate Change, 2023, p.16).

In recent years, the rates of heavy rainfall and flooding in Istanbul have been gradually increasing. Istanbul's climatic characteristics and rugged natural structure can provide favorable environments for the occurrence of flood and inundation risks. In addition to the natural structure of the province, it shows an increasing trend due to the adverse conditions created by the built environment and impermeable surfaces formed by rapid urban development processes. The starting point of this study was a major flood disaster in Istanbul in 2009, which caused serious losses and damage, especially in Silivri, Çatalca and Büyükçekmece districts. Since then, floods have been experienced throughout the province due to sudden and heavy rainfall.

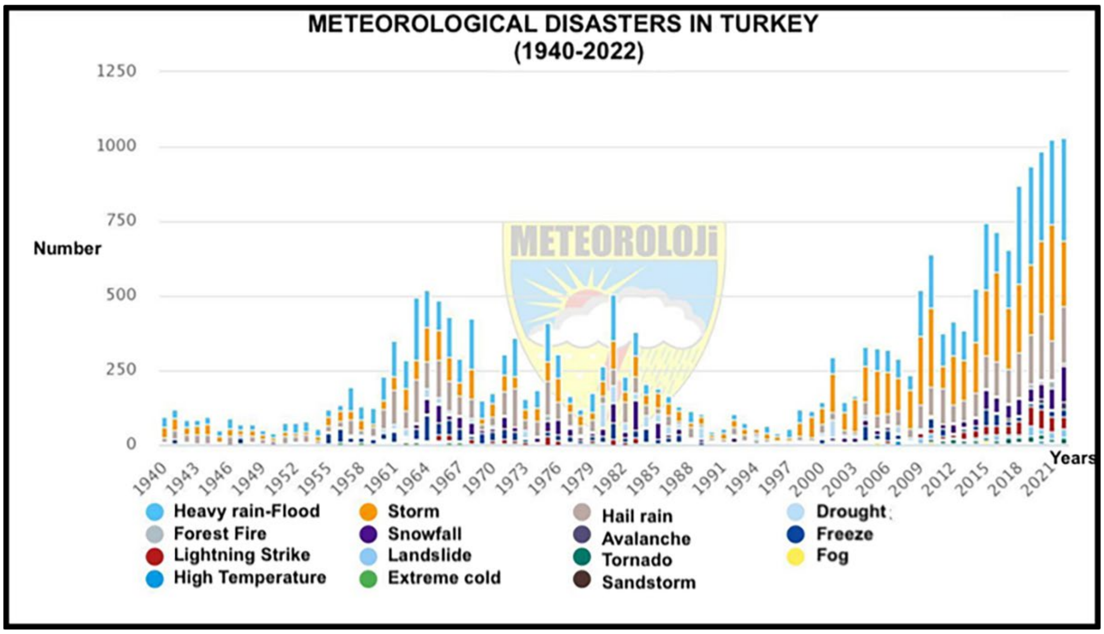



**Figure 1** Annual distribution of meteorological disasters observed in Türkiye (1940-2022) (Republic of Türkiye Ministry of Environment, Urbanization and Climate Change, 2023, p.16)

In recent years, the rates of heavy rainfall and flooding in Istanbul have been gradually increasing. Istanbul's climatic characteristics and rugged natural structure can provide favorable environments for the occurrence of flood and inundation risks. In addition to the natural structure of the province, it shows an increasing trend due to the adverse conditions created by the built environment and impermeable surfaces formed by rapid urban development processes. The starting point of this study was a major flood disaster in Istanbul in 2009, which caused serious losses and damage, especially in Silivri, Çatalca and Büyükçekmece districts. Since then, floods have been experienced throughout the province due to sudden and heavy rainfall.

The floods occurring in Istanbul are the consequences of the urban development of the city. It is clearly seen by surface hydrographic analyses that the natural flow directions and natural flow accumulation characteristics are not taken into consideration in the projects implemented for urban development, and it is possible to define them as urban floods. The increase in the frequency and severity of floods occurring in Istanbul is parallel with the increased possibility of humans intervening more in natural environment features, thanks to developing technological opportunities (Istanbul Governorship of the Republic of Türkiye, n.d).

Istanbul Water and Sewerage Administration-ISKI is preparing stream improvement projects for the streams within the city, but there is no holistic approach at the basin scale. On the other hand, the spatial development of the city continues to spread rapidly towards areas with high flood risk through planning decisions. Today, the Northern Marmara Motorway Project, the 3rd Airport, the 3rd Bosphorus Bridge connections, and the Canal Istanbul Project threaten the topography, hydrological cycles, and ecosystem balance. This situation also increases the risk of flooding in these areas. By the Decision of the President of the Republic of Türkiye No. 8650 (2024) some areas in four provinces, including Istanbul (mostly in Beykoz district), were taken out of the forest border, a decision that makes it difficult to protect the Northern Forests and water sources, and will increase the pressure on flood risk areas.

In order to draw attention to this problem, the study focuses on the districts of Çatalca and Beykoz, located on the urban peripheries of Istanbul. Both districts are located in the north of Istanbul, have significant water resources, and have areas of high flood risk. These districts experience flooding events due to the high slope of the topography, the predominantly impermeable and semi-permeable soils, the development of the built environment due to the development dynamics of the city and inadequate technical infrastructure in these areas located in the north of the city.

### *1.1. Purpose and Method of the Study*



The main aim of this study is to demonstrate the need for new approaches to flood resilience in Istanbul through theory. The study focuses on the innovative basic principles of water-sensitive planning and design approaches for flood risk reduction, which have gained importance in light of international debates. For this purpose, a comprehensive and detailed literature review was conducted and scientific documents such as articles, international-national conventions, institutional research reports, national legislation, and spatial plans were utilized.

The topography and flood risk areas for Beykoz and Çatalca districts, which were selected as sample areas under flood risk in Istanbul, were visualized using GIS - Geographic Information Systems. By compiling previous studies and existing data on these areas, it was evaluated whether land use decisions and spatial planning approaches in these areas include the "flood disaster risk phenomenon". It has been investigated whether there is integration and cooperation between the work carried out by different institutions within the framework of flood risk management and planning approaches to reduce the flood risk faced by Istanbul. In addition, field visits, observations, and interviews with local actors were conducted. In light of these examples, the concluding section assesses the potential and challenges for the application of water-sensitive planning and design principles for flood risk reduction in Istanbul.

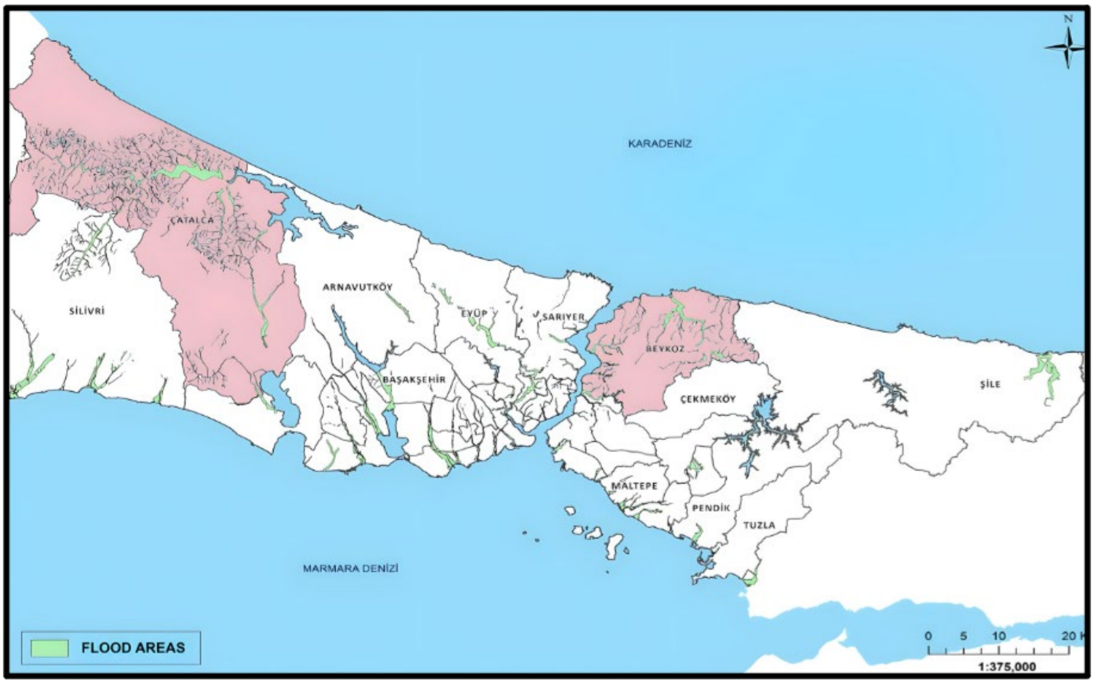



**Figure 2** Flood risk areas and sample areas in Istanbul (IMM, 2017, p.32)

Çatalca district, which is located on the urban periphery of the European side of the city and is very rich in water resources and is where the most loss of life and material damage occurred in the flood disaster in 2009, was selected as the sample area in the study. The main reason for choosing this area is to understand the causes of the flood disaster, to reveal the approaches used, and to learn from these negative experiences. In this context, information was obtained through interviews with local actors. In line with the information obtained, a survey was conducted in the Akalan neighborhood, which suffered the most damage from the flood, with people living in households in the area where the flood spread.

Beykoz district, located on the periphery of the city on the Anatolian side, was selected as another sample area in Istanbul. The rapid urban development of the district due to the second and third bridges and connection roads increases the flood risk in the region. For this reason, Beykoz was selected as another prominent example area in terms of flood risk in the province. Previous studies and existing data on the sample areas were compiled and evaluated. In addition to the general assessments on the flood risk situation of Beykoz district, the flood risk situation of Göksu stream and its surroundings has been revealed.



## 2. Literature Review

### *2.1. Major International Approaches to Reduce Flood Disaster Risk*

According to UN resolutions, 1990-2000 (IDNDR) was declared to be the decade of reducing the effects of natural disasters. In this period, new strategies and principles were determined with the Yokohama Conference in 1994 and the ISDR (International Strategy for Disaster Reduction) was defined as a new organ of the UN in 2000 to implement this strategy. The ISDR organized the Kobe Conference in 2005, and with the decisions taken there, a new decade of activity (2005-2015) the "Hyogo Framework for Action" was envisaged. The focal point of the new policy is the concept of "risk". As the importance of the new policies is realized in Türkiye, it should be expected that some terms such as "mitigation" and "risk reduction" will become more prevalent. Depending on the context in which the concept of risk is used, different terms can be applied. In this context, terms such as "risk", "risk management" and "mitigation plans" have entered the spatial planning literature as new concepts in protection from natural disasters and taking precautions (Balamir, 2007). Disaster risk management is the implementation of disaster mitigation policies and strategies to prevent new disaster risk, reduce existing disaster risk and manage the remaining risk, contribute to strengthening resilience and reducing disaster losses (UN-Water, n.d.).

The Sendai Framework for Disaster Risk Reduction (2015-2030) is the first major agreement of the post-2015 development agenda and provides member states with concrete actions to project development gains from the risk of disaster. The Sendai Framework works hand in hand with other 2030 agenda agreements, including the Paris Agreement on Climate Change, the Addis Ababa Action Agenda on Financing for Development, the New Urban Agenda, and ultimately the Sustainable Development Goals. The Sendai Framework is the successor instrument to the Hyogo Framework for Action (2005-2015): Building the Resilience of Nations and Communities to Disasters (UNDDR, n.d.).

The Sendai Framework for Disaster Risk Reduction 2015-2030 (Sendai Framework) is the roadmap for how we make our communities safer and more resilient. Considering the experience gained through the implementation of the Hyogo Framework for Action, and in pursuance of the expected outcome and goal, there is a need for focused action within and across sectors by states at local, national, regional and global levels in the following four priority areas:

- Priority 1: Understanding disaster risk
- Priority 2: Strengthening disaster risk governance to manage disaster risk
- Priority 3: Investing in disaster risk reduction for resilience
- Priority 4: Enhancing disaster preparedness for effective response and to "build back better" in recovery, rehabilitation and reconstruction (UNDDR, n.d.-a).

In the 2019 United Nations Water Report, it is noted that water is the common and intersecting point of the Sustainable Development Goals (Agenda 2030), Climate Change (Paris Agreement), and Disaster Risk Reduction (Sendai Framework) (UNESCO, 2020, p.44). Integrated planning and management of water resources has become extremely important. While the European Union previously focused on studies to prevent water and environmental pollution, since 1995, it has been seeking a holistic law that collects many scattered laws regarding the management of water resources. Such a law, the Water Framework Directive, was prepared on the water resources of the European Union in 2000. According to the information published on its official website (EU-Water, n.d.), the purpose of the EU Water Framework Directive is potable water protection and sustainable use of surface waters, transitional waters, coastal waters and groundwater, ensuring development.

In the EU directive 2000/60/EC, approved on 23 October 2000, creating "river basin management plans" to ensure sustainable development is required and ensuring its integration with land use decisions is key. Improving the content of the EU Water Framework Directive over time and in line with basin management plans, it includes the preparation of "flood risk management plans". On 6 November 2007, the "Flood "Risk Directive" was entered into force.

Green infrastructure is a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services. It incorporates green spaces (or blue if aquatic ecosystems are concerned) and other physical features in terrestrial (including coastal) and marine areas in the EU. Green infrastructure solutions that boost disaster resilience are also an integral part of EU policy on disaster risk management (European Commission, 2011).

### *2.2. The Importance of Water-Sensitive Planning and Design Approaches for Flood Resilience*

The "New Urban Agenda" was discussed at the HABITAT III-United Nations Conference on Housing and Sustainable Urban Development, which was first held in Vancouver in 1976, secondly in Istanbul in 1996, and thirdly in Quito, Ecuador in 2016. Being the first UN conference to be held after the 2015 Sustainable Development Goals, the Paris Climate Talks COP21 and the Sendai Disaster Risk Reduction Framework, Habitat III, held in 2016, is important in terms of bringing these issues to the new urban agenda and opening their impacts on urban areas to discussion (UN-Habitat, 2017). As sustainability thresholds are increasingly challenged around the world and the negative effects of climate change are felt, emphasis has begun to be placed on nature-based solutions. While climate change varies according to geographical characteristics, many problems such as increasing urban heat island effects, the drying up of water resources, increasing flood risk, rising sea levels, etc., can come to the fore, especially in urban areas. "Water-sensitive approaches" have gained importance at the basin scale for nature-based solutions to the increasing problems with climate change.

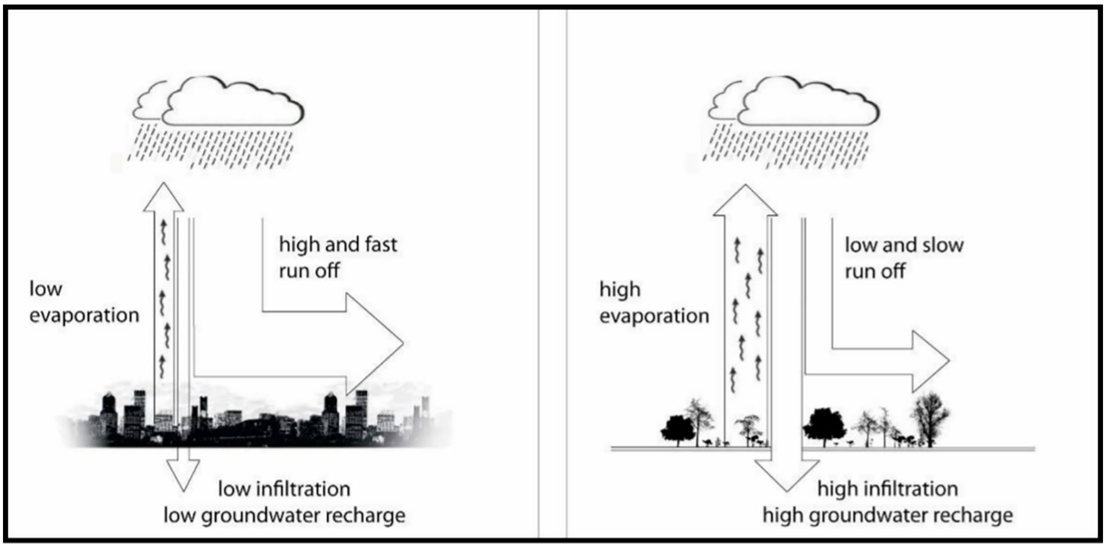



**Figure 3** Rainwater cycling in urban and rural areas (Hoyer, Dickhaut, Kronawitter, Weber, 2011, p.8)

Hoyer, Dickhaut, Kronawitter, Weber (2011) visualized the movement of rainwater in urban and natural areas (see Figure 3). According to this figure, changes in topography due to anthropogenic reasons cause changes in the hydrological cycle, such as low evaporation, etc., affecting the quality and quantity of groundwater and surface water. At the same time, due to the increase in impervious surfaces in urban areas, the drainage properties of rainwater that cannot mix with groundwater change with the effect of the surface, increasing the risk of flooding.

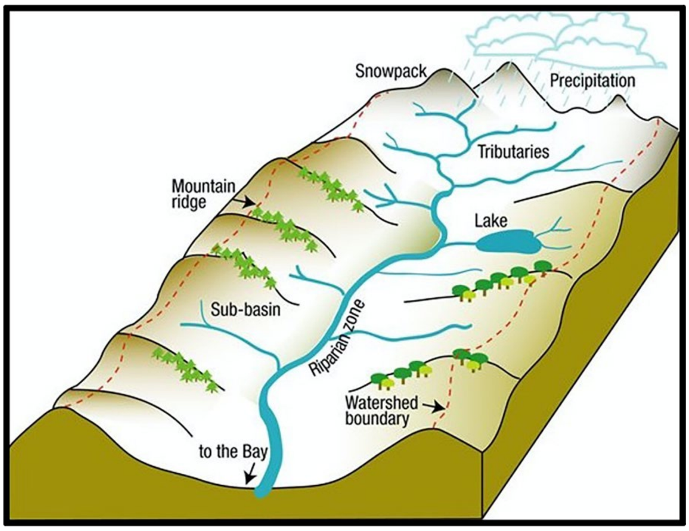



**Figure 4** Water catchment (EPA, 2024)

To understand the causes of flooding, it is necessary to interpret the hydrological cycle and its factors regionally and holistically at the water basin scale. A water basin can be defined as an area, a hydrological topographical unit that sends the precipitation waters falling on it to a certain river section and which is separated from the neighboring basins by a water separation line (topographical boundary) passing through the ridges (Özhan, 2004, p.2). There is a flood-overflow-erosion relationship in the flood basin. A flood is a large mass of water coming from the side streams after rainfall and containing a large amount of solid and coarse material; a flood is the overflow of water along the valley when the water from the side streams reaches the mainstream. Erosion is not only soil erosion-transportation, but also a chain of harmful events with its share in floods, sedimentation, landslides, avalanches, etc. (Boztaş, 2016). For water, a catchment is simply defined as an area of land that drains into a river, lake, or other body of water (EPA, 2024) (see Figure 4).

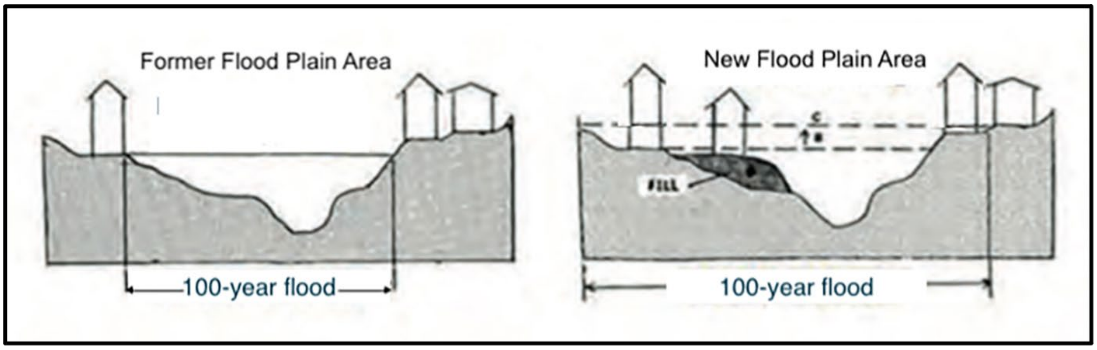



**Figure 5** Changes in floodplain (Kadıoğlu, 2012, p.85)

Buildings that are exempt from flood risk according to the former floodplain are in danger together with the buildings constructed on the riverside without the necessary examination and research. No activity that will change the 100-year flood level in the basins should be allowed. For all these reasons, it is no longer possible to state flood disasters are solely due to meteorological occurrences. In particular, the diversity and intensity of human activities in various parts of the river basins disrupt the hydrological balance in the whole basin, and as a result, flood disasters which cause great loss of life and property are observed. The land structure changes with the settlements growing in the river basins, newly-opened roads, and new facilities, and under these conditions, flood disasters are gradually becoming larger and more frequent (Kadıoğlu, 2012, p. 85) (see Figure 5). With the sudden and heavy rainfall due to climate change, it is recommended to calculate a 500-year (Q 500) floodplain in developed countries.

Current trends of different driving forces and new challenges show that conventional approaches to urban water management no longer work sufficiently. The handling of wastewater, flood control, rain, and surface run-off waters should be approached with integrated solutions that consider the various uses and intrinsic value of water. Cities must transition from relying solely on engineered urban water systems to adopting integrated, adaptive, and climate-resilient water systems (EU, 2024,p). Brown, Keath, and Wong in 2008 reveals that as cities develop, urban water managers are being confronted with increasingly complex and multi-faceted challenges as societal expectations grow and natural resources reach the limits of sustainable exploitation. Given the significant climate change and population growth challenges facing cities, there is a critical need for strategic investment in solutions that will deliver long-term sustainable outcomes. The proposed urban water transitions framework is offered as a tool for assisting urban water strategists with the challenging task of identifying the attributes of more sustainable city states and the capacity development and institutional reform required to deliver Sustainable Urban Water Management (see Figure 6).



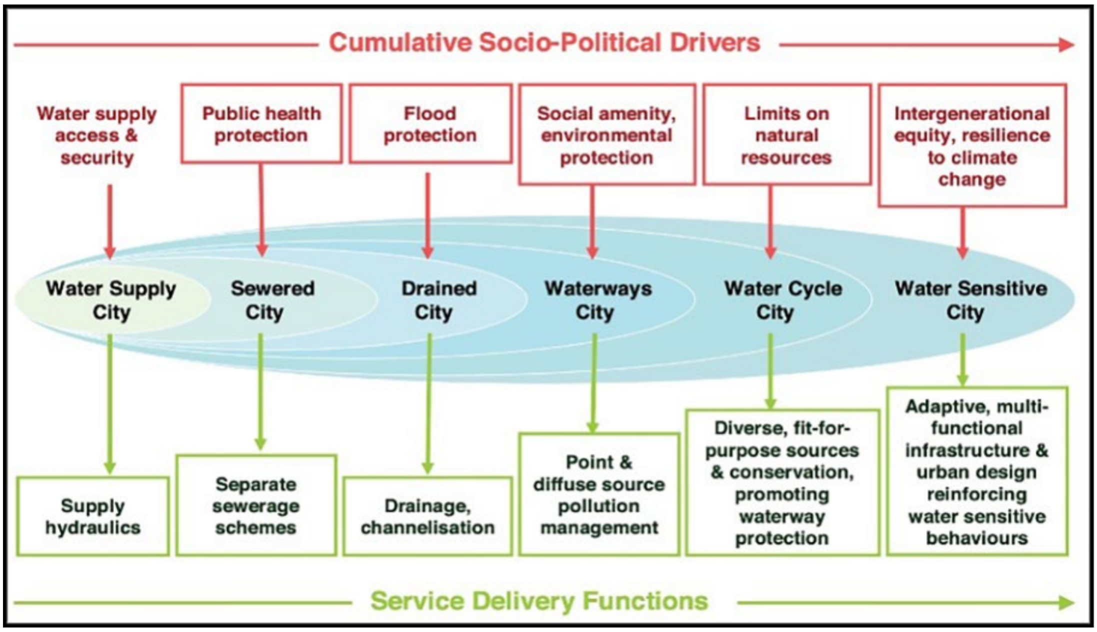



**Figure 6** Urban water management transition framework (Brown, Keath, and Wong, 2008,p.5)

Today, with the discourses of resilience to climate change, water-sensitive cities have gained importance in urban water management. The Cooperative Research Centre for Water-Sensitive Cities in Australia, which develops and implements water-sensitive planning and design approaches in Australia, is a research-practice partnership supporting innovation in urban water management. The Water-Sensitive Cities goals are:

- provide water security, which is essential for economic prosperity, through the efficient use of a range of available resources
- restore and protect the health of waterways and wetlands, surrounding river basins and coasts and bays
- reduce flood risk and damage
- create public spaces that collect, clean, and recycle water (see Figure 7).

A selection of innovative interventions at a catchment scale were investigated for implementation. Interventions that acted to reduce runoff and downstream flood risk included permeable pavements, rain garden tree pits, and stormwater harvesting using large tank storage. Green roofs were also explored as a method of reducing stormwater runoff. The initiatives included in the plan are relevant and transferable to other urban areas with high imperviousness in the upper catchment and downstream flood risk (see Figure 8) (Cooperative Research Centre for Water-Sensitive Cities, 2021).


| Solutions: | Benefits | Enabling Structures |
|---|---|---|
| Green roofs and green walls | Urban heat island mitigation | Governance and policy |
| Water sensitive homes and buildings | Alternative Water supplies | Leadership and influence |
| Rainwater and stormwater harvesting | Amenity and urban greening | Community engagement |
| Wastewater management and recycling | Water literacy and behaviour change | |
| Water sensitive parks and open spaces | Flood resilience | |
| Stormwater treatment | Ecosystems health | |
| Waterway naturalisation | | |
| Water sensitive streets and carparks | | |
| Water sensitive precincts | | |

**Figure 7** Case studies on features in a water-sensitive city (Prepared from Cooperative Research Centre for Water-Sensitive Cities, 2021)

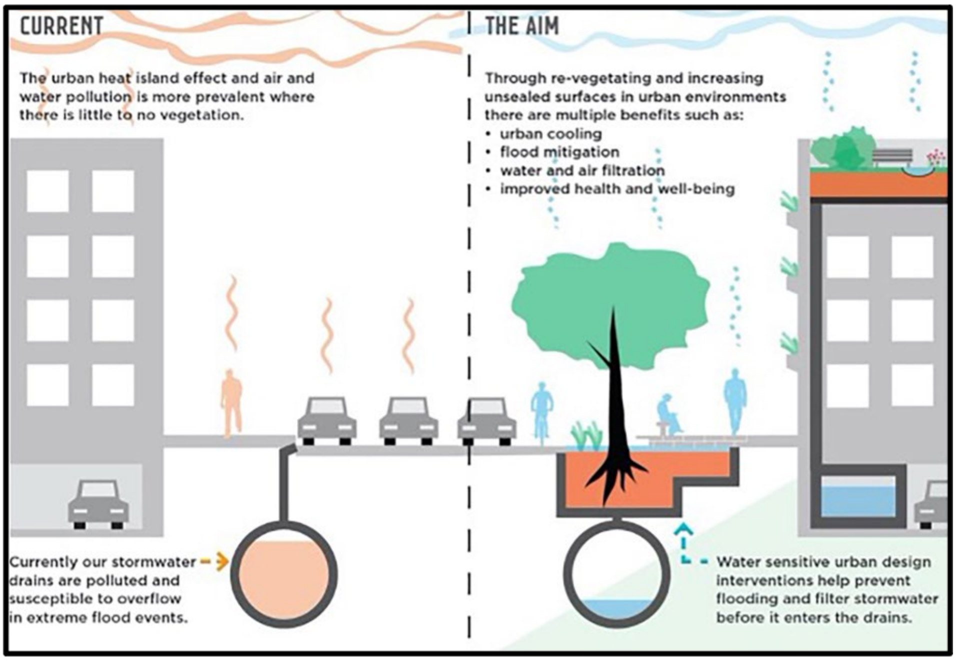



**Figure 8** Elizabeth Street Catchment Integrated Water Cycle Management Plan (Cooperative Research Centre for Water-Sensitive Cities, 2021)

Floods present a growing problem in China. According to a 2021 World Bank Report, 641 of China's 654 largest cities face regular flooding. This has partly been attributed to rapid urban development, which has created sprawl that encases floodplains in impermeable concrete. Varied in form and scale, the projects create new parks, restore wetlands and install rain gardens and permeable pavements, among other measures. In Wuhan, where more than 380 sponge projects-including urban gardens, parks and green spaces- absorb and divert rainwater to artificial lakes, local air quality and biodiversity were found to have improved since they were constructed. Lower temperatures were also recorded at the city's Yangtze River Beach Park, where 45,000 trees and other vegetation utilize an estimated 724 tonnes of carbon per year (Choi, 2024).

**Figure 9** The Dong'an Wetland Park in Sanya (Choi, 2024)

In recent years, the Drainage Department in Hong Kong has actively incorporated "Blue-Green Infrastructure" services into various projects. While continuing to prevent floods, it protects the ecological value of the surrounding environment, promotes biodiversity and water-friendly culture. It has incorporated the "Following Nature with Flexibility" "Sponge City" method into a series of projects to channel rainwater through natural means such as infiltration, and flood storage and retention to reduce large drainage (Drainage Services Department of Hong Kong, 2017). Today, sponge city practices are becoming increasingly common in China (see Figure 9).

## 3. Main Legal-Administrative Structure to Reducing Flood Disaster Risk in Türkiye

In Türkiye, Law No. 4373 on the Protection Against Flood Waters and Inundation (1943) has been in effect since 1943. However, various institutions have been commissioned regarding floods by several laws and regulations. In practice, efforts to reduce the flood risk have been carried out predominantly by the General Directorate of State Hydraulic Works (DSI), which is in 1954 with the Law No. 6200 established. According to the Metropolitan Municipality Law No. 5216 in metropolitan cities: Protecting water basins, providing drinking water, collecting, purifying, and removing wastewater and stream rehabilitation are the responsibility of municipalities.

Within the scope of the harmonization process with the European Union, the Regulation on the Protection of Water Basins and Preparation of Basin Management Plans (2012) entered into force in Türkiye and the Water Management Coordination Board was established. The Regulation on the Preparation, Implementation and Monitoring of Flood Management Plans was published in the Official Gazette on 12 May 2016 and entered into force and The Ministry of Agriculture and Forestry has been preparing Flood Management Plans for water basins in Türkiye.

The Regulation on the Basin Management Central Board, Basin Management Committees and Provincial Water Management Communiqué on the Establishment, Duties, Working Procedures and Principles of the Coordination Boards, and Basin and Provincial Level(2019) entered into force in Türkiye and basin and provincial scale institutional structuring were established. The National Water Plan (2019-2023) was prepared in 2019. The Presidential Decree on the Establishment of the

National Water Board entered into force upon publication in the Official Gazette Dated 20.11.2023 and numbered 32384.

The Ministry of Environment, Urbanization and Climate Change has made important regulations on stormwater management. In this context, the Regulation on Stormwater Collection, Storage and Discharge Systems was published in the Official Gazette dated June 23, 2017, and numbered 30105 to ensure water efficiency by collecting and reusing stormwater without mixing it with other wastewater. In 2017, the Ministry amended the Planned Areas Zoning Regulation regarding rainwater harvesting. Article 57, Paragraph 7 of the "Planned Areas Zoning Regulation" published in the Official Gazette on July 3, 2017 was amended as follows: "In buildings to be constructed on parcels larger than 2000 m2, a rainwater harvesting system project shall be added to the mechanical installation project in order to collect the rainwater on the roof surface in the rainwater collection tank to be installed under the natural ground and to filter and reuse it when necessary. The relevant administrations may also impose an obligation for smaller parcels."

Article (e) of the Decree Law No. 644 on the Organization and Duties of the Ministry of Environment and Urbanization (2011) states: "to determine and monitor the rules for the preparation and approval of risk management and avoidance plans, to conduct, have conducted and approve geological and geotechnical surveys based on the plan". The Regulation on Spatial Plans Construction (2014), which prepared in accordance with Decree Law No. 644 (2011), requires that all studies related to "natural disasters" and in this context flood risk analyses, risk management and mitigation plans, if any, be integrated into zoning plans. Law No. 6306 on the Transformation of Areas under Disaster Risk (2012) is also one of the important legal bases for the transformation of risky areas. The legal-administrative infrastructure has begun to be built in Türkiye, which is a positive step in this regard.

### *3.1. Flood Disaster Risk in Istanbul*

According to TUIK's data in 2024, Istanbul is the province with the highest population in Türkiye with a population size of 15,701,602 people. With a surface area of 5,313 km2, the population density of the province is 3,013 people per km2, which is much more than Türkiye's average of 111 people per km2. The population of Istanbul has increased approximately 11-fold since the foundation of the Republic. Spatially expanding due to population growth, Istanbul is the main agglomeration area of the country. With rapid population growth, urban growth and climate change impact, flash floods and flood disasters have become more frequent in Istanbul in recent years due to changes in land use.

With the mechanization of agriculture in the country since the 1950s, population movement from rural to urban areas started. Istanbul received migration in the 1950s with the presence of industrial areas, and the urban population, which was 983,041 people in 1950, reached 1,466,535 people in the 1960s. In the 1970s, with the completion of the Bosphorus Bridge and the related ring roads and the increase in accessibility, it started to spread towards Küçükçekmece on the eastern axis and Kartal on the western axis. With the construction of the second bridge (Fatih Sultan Mehmet bridge) and connecting roads in the 1990s, the urban areas merged with neighboring provinces in the east and west. In the earthquake on 17 August 1999, Istanbul experienced rather significant material and immaterial losses particularly in areas located in the southeast, which lacked appropriate conditions for construction. This drew focus to the rural areas, forests, and drinking water basins located in the north, the bases of which are more resistant against earthquakes. The legal change that shaped the recent urban development was the approval of Law No. 6360 in 2012. With the establishment of metropolitan municipalities in fourteen provinces and twenty-seven districts based on Law No. 6360, the number of metropolitan municipalities in Türkiye was increased to 30, special provincial administrations were abolished in these areas, and villages were transformed into neighborhoods as in Istanbul.

Today, despite the fact that they were not included in the decisions of the 1/100,000 scale Istanbul Environmental Plan (2009a), and despite all the objections made by non-governmental organizations (NGOs), various professional chambers, academics and citizens, the construction of the new Istanbul airport, the 3rd bridge, and the Northern Marmara Motorway (O7) have been completed in a short period (see Figure 10). The construction of the Northern Marmara Motorway constitutes the 3rd bridge and connecting roads, and destroys the Northern Forests, which are highly sensitive ecosystems. However, in 2020, the 1/100,000 scale Istanbul Environmental Plan (2009a) was revised and amended to include the Canal Istanbul Project. These projects threaten the hydrological structure and ecosystem balance and increase the pressure on flood risk areas.

Istanbul's land value, which was measured at 9.4 trillion liras in 2018, had increased by 149 percent as of the end of 2020. The districts with intense land trade in Istanbul were Silivri, Çatalca, Arnavutköy, Şile, Büyükçekmece, Beykoz, Tuzla, Ümraniye, Beylikdüzü, and Pendik. It was noteworthy that Esenler and Güngören, where construction has been completed, have almost no vacant land. The increase in demand, especially for rural and agricultural land and fields, due to the pandemic, was reflected in prices. This situation stood out as the most important factor triggering the upward movement of real estate, especially in the land category (Independent Newspaper, 2021).


**Figure 10** Aerial photograph of Istanbul and connection roads of 3rd bridge (07) (Google Earth Maps, n.d.-a)

With a surface area of 534,300 hectares, the drinking water basin areas (see Figure 11) in Istanbul are under pressure from urban development. Urban development and construction create serious negative changes in topography and hydrological cycles. Established by Law No. 2560 for Istanbul Water and Sewerage Administration General Directorate Establishment and Duties (1981) under the supervision of the Governorship of Istanbul, Istanbul Water and Sewerage Administration (ISKI) was incorporated into Istanbul Metropolitan Municipality (IMM) in 1984. With Law No. 5216 on Metropolitan Municipality (2004) ISKI's area of responsibility was expanded to include the provincial borders of Istanbul. During the preparation stages of the 1/100,000 scale Istanbul Environmental Plan approved in 2009, the ISKI regulation was revised. For the first time in this plan, "areas to be rehabilitated within the basin" were decided to protect drinking water basins in Istanbul.

Akbulut and Güzel (2022) studied the absolute protection area and the short distance protection area of seven catchment areas (Darlık, Ömerli, Sazlıdere, Elmalı, Büyükçekmece, Alibeyköy, Terkos) within the borders of Istanbul province and analyzed the existing building stock within these areas (see Table 1).

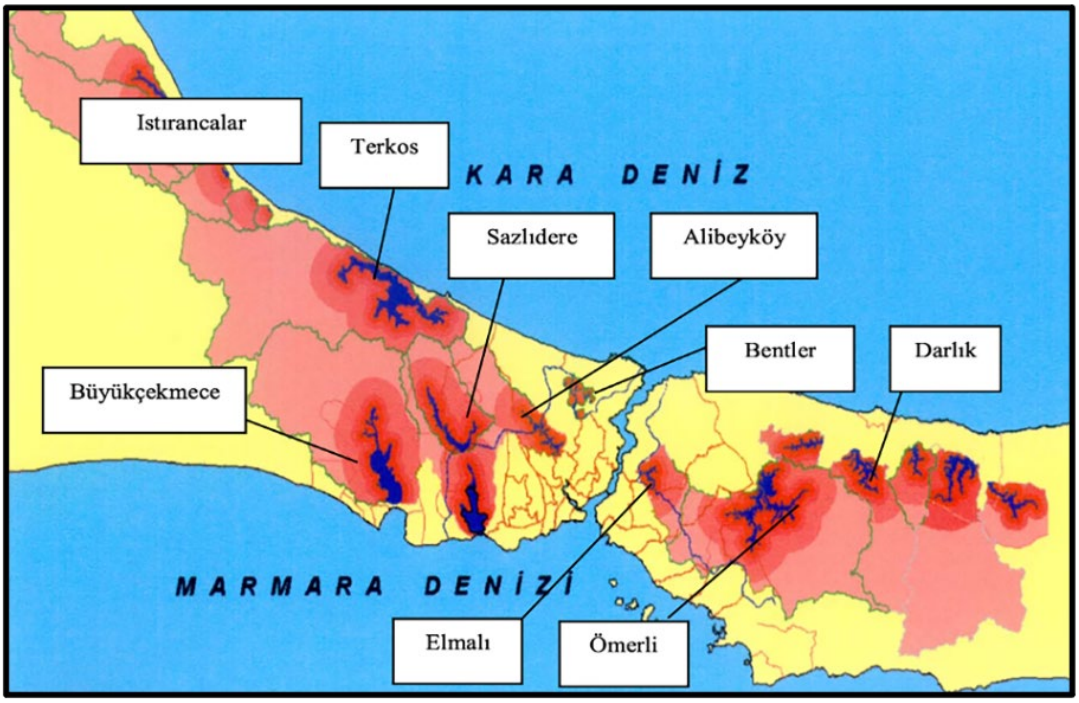



**Figure 11** Drinking water basins in Istanbul (IMM, 2009, p.150)

**Table 1** Percentages of Structures in the Absolute Protection Area and Short Distance Protection Area of Seven Drinking Water Basin Areas within the Borders of Istanbul Province (Akbulut & Güzel, 2022)

| Protection Area | Absolute Protection Area | | Short Distance Protection Area | |
|---|---|---|---|---|
| Basin | Number | Percentage (%) | Number | Percentage (%) |
| Darlık | 3 | 0.07 | 0 | 0 |
| Ömerli | 178 | 4.31 | 1,362 | 9.23 |
| Sazlıdere | 468 | 11.34 | 1,783 | 12.1 |
| Elmalı | 584 | 14.15 | 2,105 | 14.27 |
| Büyükçekmece | 965 | 23.39 | 2,864 | 19.42 |
| Alibeyköy | 638 | 15.46 | 2,999 | 20.33 |
| Terkos | 1,291 | 31.28 | 3,635 | 24.65 |
| Total | 4,127 | 100 | 14,748 | 100 |

ISKI General Directorate Drinking Water Basins Regulation (2011) was amended on 16.01.2013 and stated that "In the drinking water basins, in the parts of the streams named in Annex-1, except for forest areas and areas to be protected in terms of agricultural quality; in accordance with the improvement project, on both sides of the improvement section of these streams; zoning for the purpose of cleaning, maintenance and repairs. At least 10 meters of "stream operation band" is allocated in the plans. The stream rehabilitation area and stream operation bands are expropriated by the administration".

In many districts of Istanbul, floods occur with every heavy rainfall, flooding houses, workplaces, and roads and causing material and mortal damage. Kasımpasa, Alibeyköy, Küçükköy, Maltepe, Kartal, Bağcılar (Otocenter Region), Esenler Çinçin Stream, Bayrampaşa, Zeytinburnu, Sarıyer Tarabya, Beşiktas Ihlamur Region, Bahçelievler (Tavukçu stream), Silivri, Selimpaşa and Çatalca regions are flood zones affected by heavy rains. After the droughts in Istanbul in 2007, Tavukcu stream in October 2007, floods were experienced across the city, for instance, on the Anatolian side of Istanbul in September 2008, Silivri, Selimpaşa, and Çatalca regions, and Ayamama stream in received excessive rainfall September 2009 (Demir, 2013). 85% of Istanbul streams have lost their natural structure due to pollution, occupation, and false land use decisions. The upper surface of the streams, enclosed in a closed section, are used as highways. These streams are Rumeli Kavağı, Kalender, Büyük Bebek-Küçük Bebek, Ortaköy, Ihlamur, Ambarlı, Islambey, 10. Yıl streams on the European side and Turşucu, Istavroz streams on the Asian side (Dinc & Bolen, 2014). Istanbul's climatic characteristics and rugged natural structure can provide favorable environments for the occurrence of floods. The adverse effects of the built environment created by rapid spatial development processes are showing an increasing trend.



According to Turoğlu (2011): the roughly north-south oriented flow directions of surface waters in Istanbul and its immediate surroundings are due to the natural slope characteristics of the region. The E80 and D100 Highways in the east-west direction cross these valleys and drainage systems, while the valley floors are generally preferred for their connection roads. Highways crossing river valleys play a role in preventing surface runoff and increasing the amount of water flowing (as in the Silivri-Selimpaşa in 2009 example). On the other hand, connecting roads that use valley floors in the downstream direction act as drainage channels during extraordinary rainfall.

In 2009, the flood disasters in Istanbul increased the need for stream rehabilitation projects. In this context, a protocol was signed in 2009 between General Directorate of State Hydraulic Works (DSI), IMM and ISKI for the improvement of streams. Although streams have been identified in the division of responsibilities; streams located in rural areas and flowing into Büyükçekmece Lake and to the north are under the responsibility of (DSI) and streams located in the urban and flowing to the south are under the responsibility of ISKI. The main problem areas for stream reclamation in flood-prone areas are expropriation, which requires compromise and high costs.

The rivers of Istanbul flow into the Black Sea, Bosphorus and Marmara Sea. The total length of Istanbul's streams is 2,540,688 km. Of the streams flowing into the Marmara Sea in Istanbul, 297,245 km have been rehabilitated and 651,660 km have not been rehabilitated. In the Büyükçekmece basin, 4,334 km has been rehabilitated and 363,040 km have not been rehabilitated. In the Terkos basin, 658 m was rehabilitated, and 372,813 km was not rehabilitated. In Ömerli basin, 43,562 km was rehabilitated, 154,092 km was not rehabilitated. Of the streams flowing into the Bosphorus, 805 km were rehabilitated and 40,810 km were not rehabilitated. Of the streams flowing into the Black Sea, 5,228 km were rehabilitated, and 925,977 km were not rehabilitated (Istanbul Governorship of the Republic of Türkiye, n.d, p.39).

The Marmara Basin Flood Management Plan for the Marmara Basin, which includes Istanbul, was most recently approved in the Official Gazette on January 17, 2025. In the study covering the years 2023-2027, flood risk analysis was conducted for all streams of Istanbul, and necessary interventions and responsible organizations were identified. In this context, while IMM is the responsible organization under Law No. 5216, IMM and DSI are defined as the relevant organizations under Law No. 6200.

### *3.1.1. Flood Disaster Risk in Çatalca District*

According to the land use data of IMM Urban Planning Directorate (IMM, n.d.), which is the most recent study, Çatalca district has the largest surface area of Istanbul at 111,513 hectares and is in the Thrace sub-region of the Marmara region. Forest areas within the borders of the district total 72,191 hectares, which corresponds to 65% of the district, agricultural areas total 32,765 ha., which corresponds to 29% of the district, and residential areas in the district total 4,302 km2, which corresponds to 9% of the district (see Figure 12). The population of the district, which has the lowest population and density in Istanbul, increased from 62,001 persons in 2010 to 80,399 persons in 2024 (TUIK, 2024). Demand for second houses is rising along with land prices in the district due to its increased accessibility. In terms of environmental sustainability, it is also considered critical. Although Çatalca district has extremely fertile agricultural lands in general, the number of residences, especially summer houses, has started to increase throughout the district with the accessibility of III. Bridge connection roads.

In the northern part of Çatalca on the Black Sea coast, there are elevations covered with forests, which are the continuation of the Yıldız Mountains. In the south of these, fertile plains begin. 97% of Çatalca district is within the basin boundaries. The district is within the Büyükçekmece and Terkos basin borders. The 3% of the district that is not within these basin boundaries is in the Küçükçekmece water basin area, which is removed from the basin boundaries. 90% of Çatalca's surface area is within the ISKI protection basins. Most of Istanbul's drinking water is supplied from Durusu Lake and Büyükçekmece reservoir, which are located near the district borders. There are many large and small streams that carry water to other dams (IMM, 2010, p.II).

The Istranca Mountains and streams, where Istanbul's water has been supplied from since ancient times, are the site of historic waterways. In the 1/100,000 scale Istanbul Environmental Plan Decisions (2009a), it is proposed to create areas in Çatalca district (Muratbey, Izzettin, and the north of Çatalca Center) whose natural and rural character will be preserved. In the plan, recreation areas are proposed in Çatalca to meet the recreation needs of the urban dwellers for daily use in and around the urban areas, especially the need for green areas. Ecological tourism areas are proposed in the north of Çatalca. For the first time in this plan, "areas to be rehabilitated within the basin" were decided to protect drinking water basins in Istanbul. In this context, Çatalca district is also within the scope of the area to be rehabilitated within the basin.

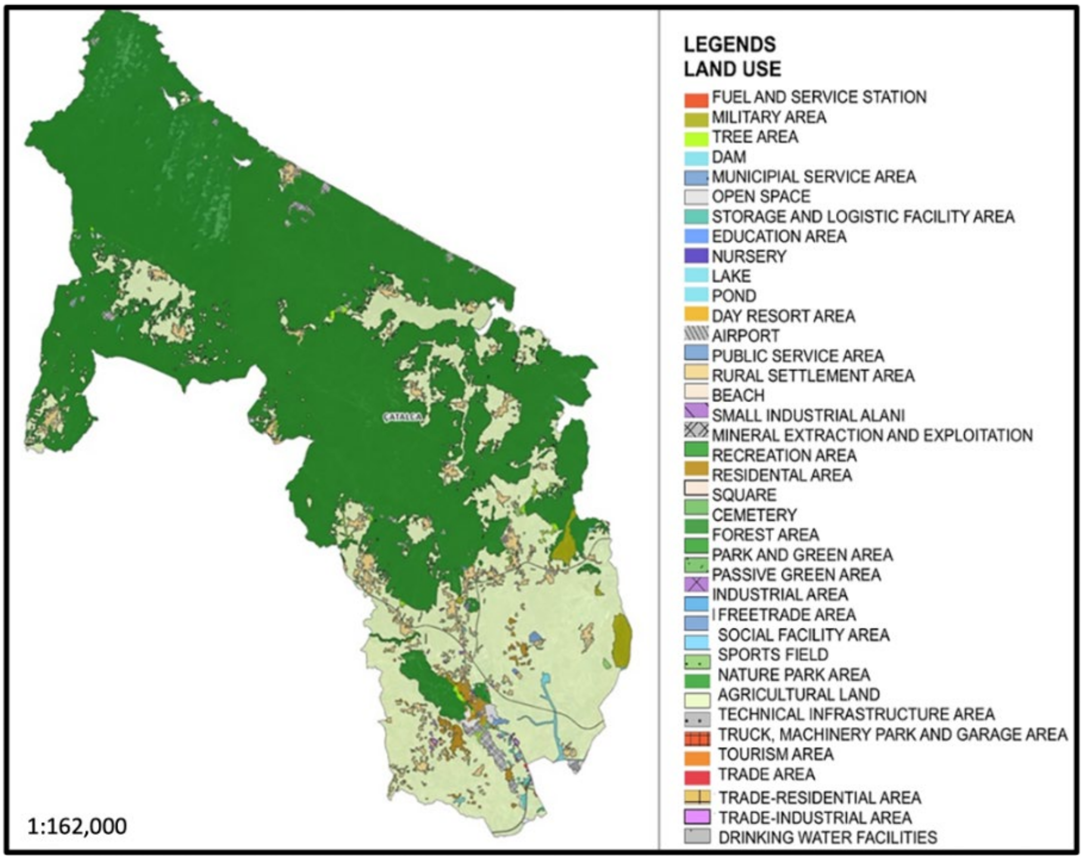



**Figure 12** Land use in Çatalca District (IMM,n.d)

Çatalca Center has a topography that is partially suitable for settlement in terms of slope. The average slope in the built-up area of Kaleiçi and Ferhatpaşa neighborhoods is between 2-10%. The slope increases towards the west from the built-up area and rises to 40% (IMM, 2010, p.II). In terms of the morphological structure of the district, there are areas with flood risk in Çatalca district, which has a sloping structure reaching up to 40% in places, in the Black Sea and Marmara climate transition zone and is rich in water resources and contains (high flow) rivers (see Figure 13).

In the flood disaster on September 8-10, 2009, as a result of the general inspection, it was observed that most of the bridges connecting the surrounding villages to Çatalca were destroyed and the houses in front of the narrow and high sloping valleys were flooded. In addition to the flooding in a wide area, waterways were formed from fields and forested ridges. It can be said that the greatest disaster impact was in the valley beds flowing into Çatalca and Büyükçekmece (IMM, 2009b, p.43) (see Figure 14).

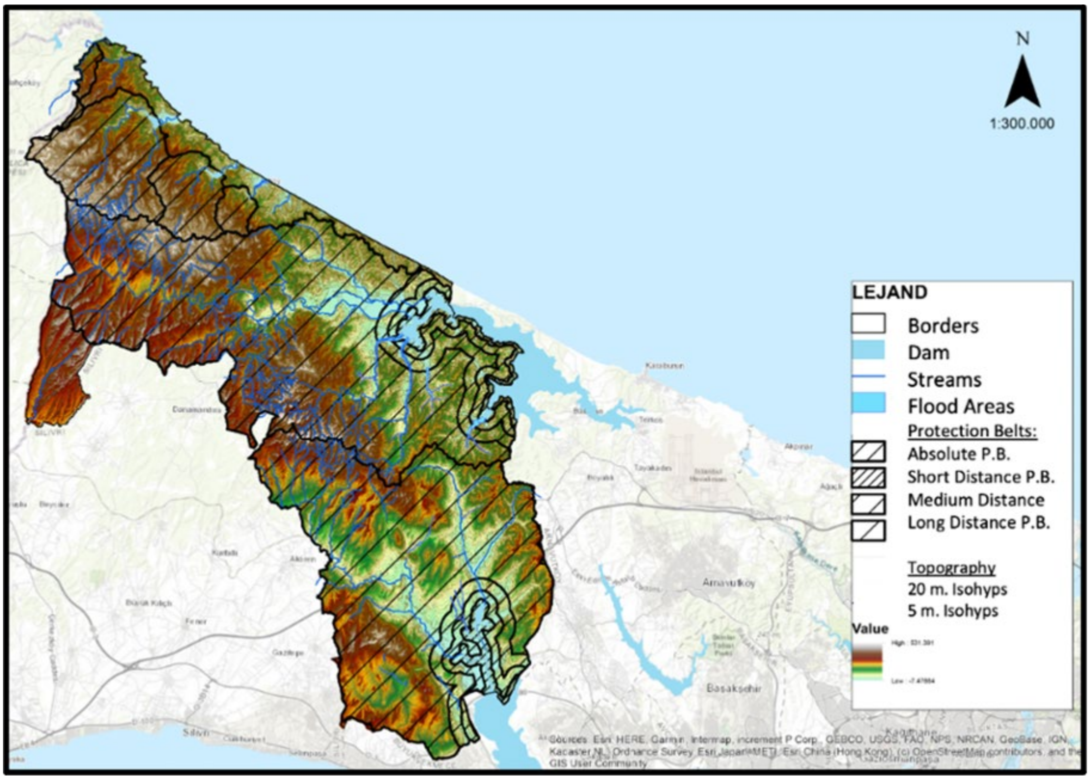



**Figure 13** Topography and flood areas of Çatalca district. Prepared for this study with data of IMM (n.d.) and ISKI (2024)

According to the information obtained from Çatalca Municipality, in the 2009 flood disaster, seven people lost their lives, 298 houses and 113 workplaces were damaged. Ferhatpaşa Bayırı, where the flood disaster occurred in the city center, is 40-50 meters high, extending southwestward from the intersection of the gently sloping Ferhatpaşa and Kaleiçi neighborhoods in the center. There were squatter settlements in an area with a 25-40% slope between two hills close to each other.

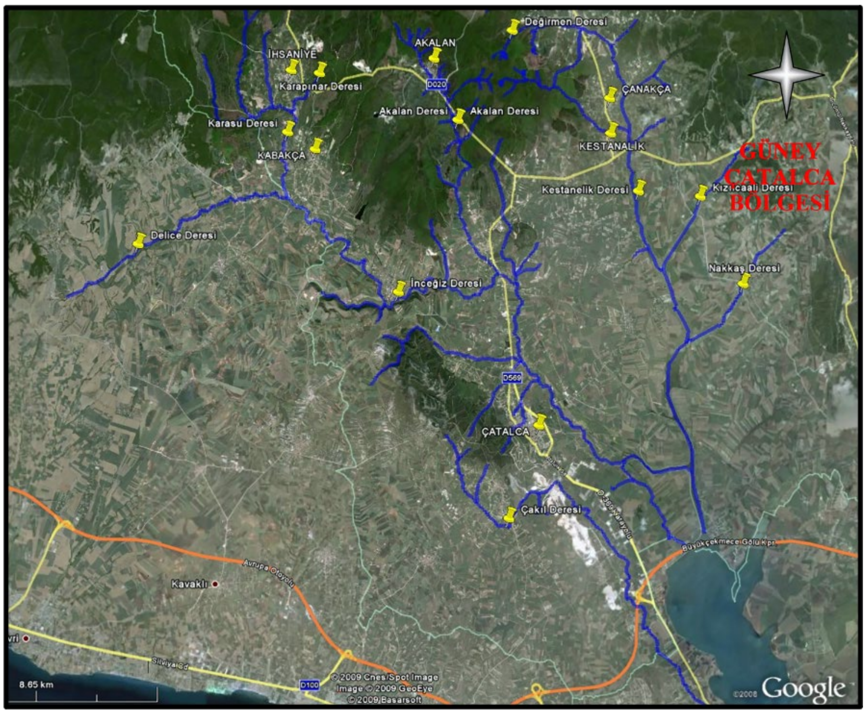



**Figure 14** Flood areas in the southern part of Çatalca district in 2009 (IMM, 2009b, p.10)

75 families affected by the flood disaster were placed in temporary prefabricated containers on the initiative of Çatalca Municipality (Milliyet Newspaper, 2013). The area where the houses were located in Ferhatpaşa Bayırı was declared a Slum Prevention Zone. The Housing Development Administration (TOKI) and Çatalca Municipality signed a protocol in 2009. On September 1, 2016, the houses built for the victims of the 2009 flood disaster were inaugurated. Çatalca district is still experiencing floods and meteorological disasters. In the Marmara Basin Flood Management Plan (2024), which was approved and entered into force on January 17, 2025, and establishes the rules to be implemented under the responsibility of (DSI and IMM) between (2023-2027) regarding streams at risk of flooding, flood hazard maps were prepared for all streams in Çatalca (see Figure 15).

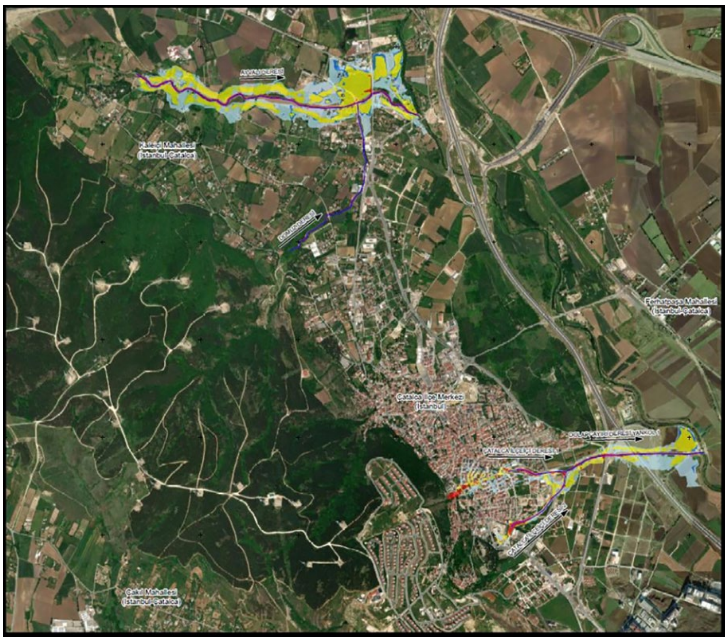


**Figure 15** Flood hazard map for Çatalca central district (Q500) (Republic of Türkiye Ministry of Agriculture and Forestry, 2024, p.321)

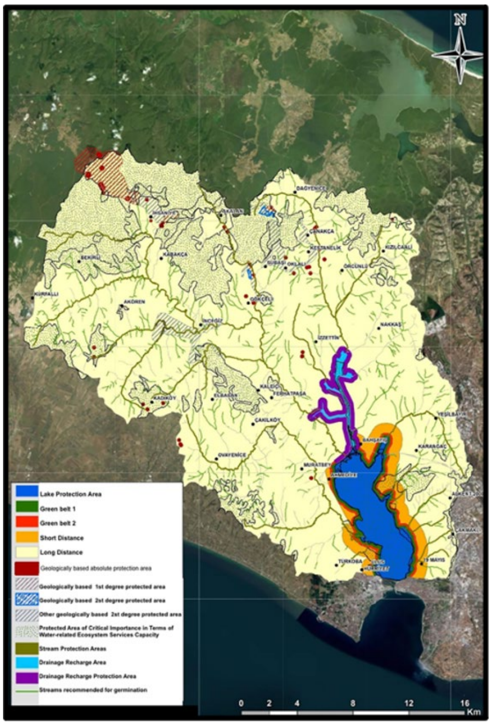



**Figure 16** Büyükçekmece Basin Protection Plan (Republic of Türkiye Ministry of Agriculture and Forestry, 2019)

The Büyükçekmece Basin Protection Plan prepared by the General Directorate of Water Management of the Ministry of Agriculture and Forestry in Istanbul entered into force on March 20, 2019 (see Figure 16). This plan was prepared within the scope of the Regulation on the Protection of Drinking and Potable Water Basins (2017) and is important in that it specifies that geologically permeable surfaces and the drainage supply areas should be protected.

*3.1.1.1. Example of Flood Disaster Risk in Akalan Neighborhood*

The population of Akalan was 981 persons in 1985 and in 2017 there were 1,085 persons, with a population density of 29 persons/hectare. The number of inhabitants in 2024 was 1,169 persons (TUIK, 2024). In the 1/100,000 scale Istanbul Environmental Plan (2009a), Akalan settlement is in the long-distance protection area in the water basin of Büyükçekmece Dam. When the historical development process of Akalan settlement is analyzed, it is found to have been established in 1924 by the Muhajirs who came from Thessaloniki. Akalan Stream is a tributary of Karasu Stream and is within the Büyükçekmece drinking water basin boundary. Although there are no industrial or other production or polluting facilities in the Akalan neighborhood, most of the predominantly residential area falls within the 200-meter stream approach boundary set by ISKI. Akalan settlement (see Figure 17), where there are approximately 450 households today, is predominantly on fertile agricultural class soils.


**Figure 17** Akalan neighborhood (Google Earth Maps, n.d.-b)

According to the information obtained from Çatalca Municipality, in the disaster in Akalan Neighborhood on September 8, 2009, 53 households were damaged, but there were no casualties. In the flood disaster on September 8-10, 2009, many houses in the village center were flooded, and some agricultural lands were damaged as a result of the overflow of the Akalan Stream. In addition, the culverts on the stabilized roads on the stream and the bridge on the former Istanbul-Edirne highway were also destroyed because of the flood. The sewage line passing through the village was also damaged. Due to the high slope in the upper basin and low slope in the lower basin, the water velocity increases in the lower basin during flooding and flood damages increase. The reclamation project based on Q500 calculations prepared by DSI for the Akalan stream started to be implemented in September 2013 with public funding (see Figure 18).

In Akalan, the survey was conducted within the flood extent area in the center of the settlement in 2016. Of the 32 buildings in this area, 26 are residences, one is a barn, and the others are not in use. 20 of the buildings have one storey, seven have two storeys and two have three storeys. According to the results of the survey, it was learned that 83% of the people interviewed in the households in the flood-prone area where the survey was conducted did not have flood insurance when the disaster occurred in 2009, 11% had flood insurance, 6% had disaster-related insurance and the insurance did not cover the cost because it did not cover the flood disaster. 78% of the people surveyed did not previously know that they lived in a flood risk area.

**Figure 18** Rehabilitation Project of Akalan Stream (Author's own Archive, 2016)

In the 1/5,000 scale Master Plan of Akalan, which was prepared in line with the decisions of the 1/100,000 scale Istanbul Environmental Plan (2009a) and approved on 25.06.2009, Precautionary Areas-1, Precautionary Areas-2 and Areas Requiring Detailed Geotechnical Investigation were defined according to the settlement suitability assessment map and soil survey report. The 1/1,000 scale Implementation Plan of Akalan was prepared in 2014. It includes the decisions of the 1/5,000 Master Development Plan, and in line with the opinion of DSI after the flood disaster in 2009, the details “Approach Boundary of Stream Structure with Flood Risk and Precautionary Area-3: Areas where precautions should be taken in terms of flood risk” were added (Çatalca Municipality, 2014) (see Figure 19).

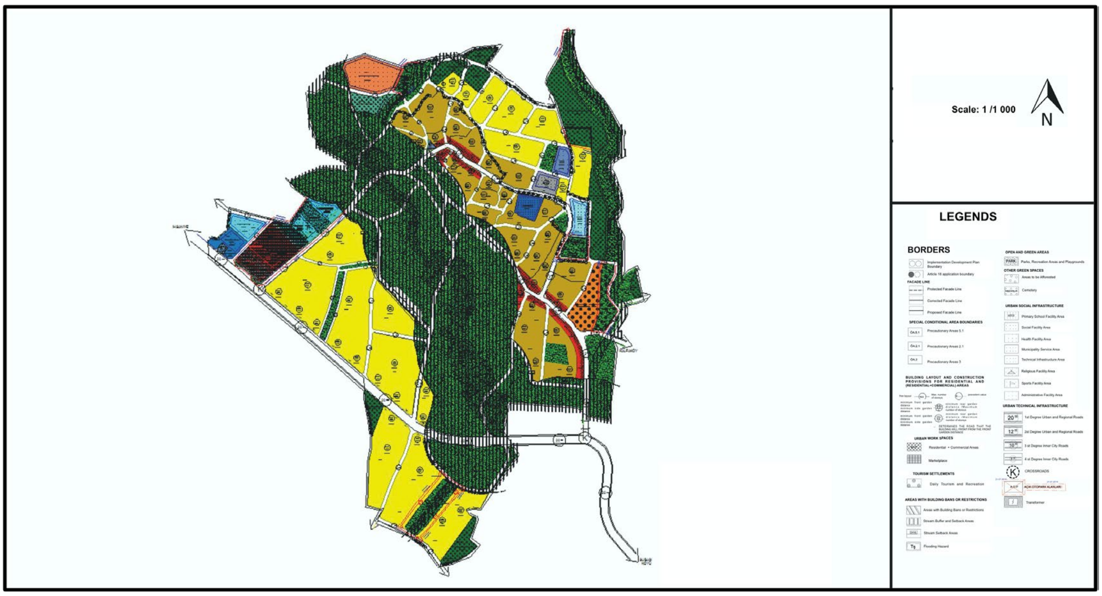



**Figure 19** 1/1,000 Akalan Implementation Plan (2014) (Çatalca Municipality, 2014)

### *3.1.2. Flood Disaster Risk in Beykoz District*

According to TUIK’s data, the population of Beykoz district was 58,317 persons in 1960, 58,317 persons in 1990 and 245,440 persons in 2024. 10% of the population lives in rural areas. Kavacık neighborhood, which developed after the 1990s, is the neighborhood with the fastest growing and highest population in the district, with 22,138 persons in 2024. According to the land use data of

IMM Urban Planning Directorate (IMM, n.d.-a), which is the most recent study, forest areas within the borders of the district total 22,109 ha., which corresponds to 71.2 % of the district, agricultural areas total 1,817 ha., which corresponds to 5.9 % of the district, and residential areas in the district total 5,110 ha., which corresponds to 16.5 % of the district (see Figure 20)

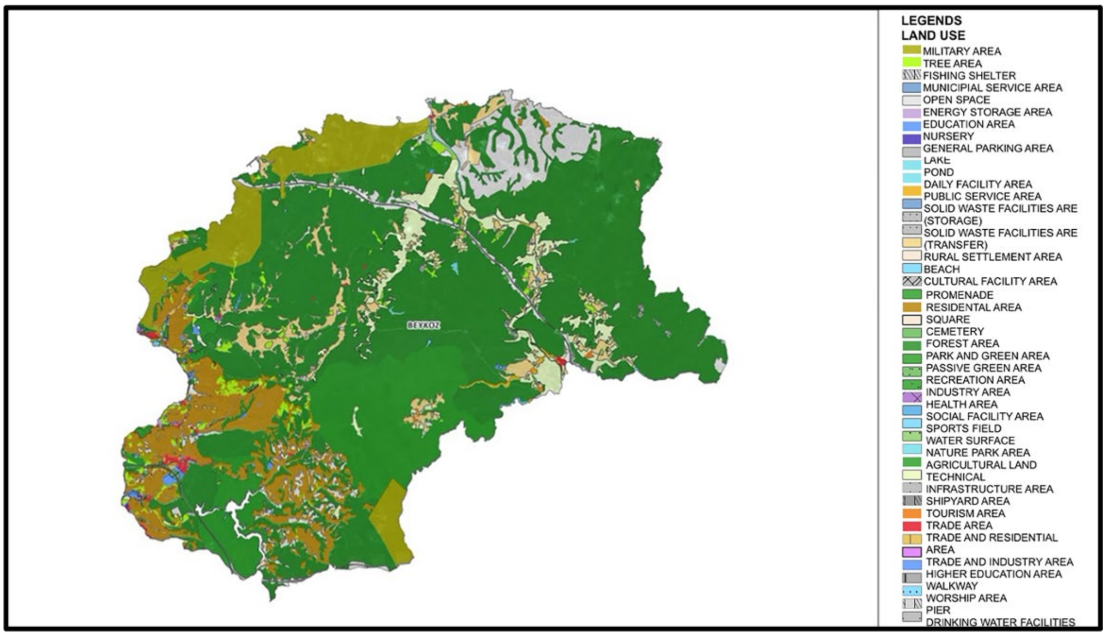



**Figure 20** Land use in Beykoz district (IMM, n.d.-a)

The district, which was known to have been used mostly as a hunting and recreation area due to the presence of Riva, Küçüksu and Göksu streams during the Ottoman period, carries the traces of the industrial city with now-closed industrial premises (Paşabahçe Glass, Beykoz Sümerbank, Shoe Factory, and Tekel Factory) in the Early Republican Period. Beykoz District, where nature parks and natural sites such as Polenezköy and civil architecture works subject to cultural heritage and natural beach areas such as Riva are intertwined, developed the Kavacık center with the 2nd Bosphorus crossing (F. Sultan Mehmet Bridge) in the 1990s. New residential areas have emerged in Kavacık and Göksu (Hisar Evleri, Göksu Evleri etc.). Very close to Kavacık on the Riva Road examples of gated communities (Acarkent, Beykoz Konakları) have developed. In 2017, with the 3rd Bosphorus Highway crossing (Yavuz Sultan Bridge), the settlement in Beykoz district expanded north and northeast towards natural and rural areas.

The entire Beykoz district is a protected area. There are 56 natural and natural-historical protected areas covering an area of 31,301 hectares in Beykoz district. 89% of the protected areas are "natural protected areas" registered with the decision dated 15.11.1995 and numbered 7,755, and 11% of the protected areas are "natural-historical protected areas" consisting of the Bosphorus foresight and outlook zones registered with the decision dated 14.12.1974 and numbered 8,172 (Dinçer, Enlil, Evren, 2009). The 1980s were the years when the urban development dynamics of Istanbul gained momentum in the most striking way. Since then, the process of urban development and sprawl has accelerated. In this development process, to prevent the destruction of natural, cultural, and historical assets in urban areas and to protect its original structure, Law No. 2960, the Bosphorus Law (1983), which covers the settlements in the Bosphorus, entered into force. This is an important and positive law in preventing the Bosphorus, with its unique location and values, from being negatively affected by the uncontrolled development of the urban area. Beykoz district has a topography that is partially suitable for settlement in terms of slope and flood areas (see Figure 21).

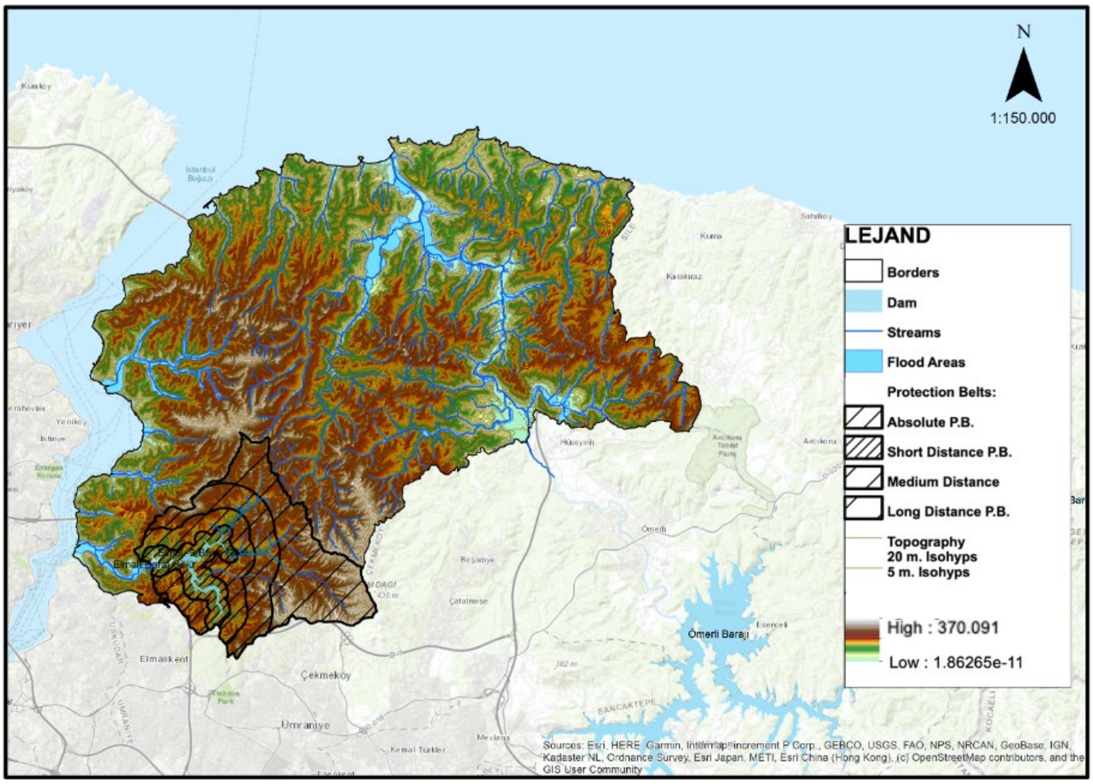



**Figure 21** Topography and flood areas of Beykoz district. Prepared for this study with data from IMM (2017 (n.d.-a) and ISKI (2024)

In 2014, the Ministry of Environment, Urbanization and Climate Change started to prepare an Ecologically Based Scientific Research Report (ETBAR) for 506 natural protected areas in Istanbul, including Beykoz. Beykoz district in Istanbul has a sloping topography and is one of the largest districts (31,036 ha.) in Istanbul. The priority issues of the planning agenda for Beykoz are title deed problems and unplanned construction, destruction, and danger of loss of protected areas such as forest areas, streams, agricultural areas, and Elmalı Water Basin, and the protection of the Bosphorus Region. The 1/25,000 scale Conservation Master Development Plan was completed by the Istanbul Metropolitan Municipality Urban Planning Directorate in January 2023. With the Assembly Decision dated September 12, 2024, it was returned to Directorate for the opinion of Beykoz Municipality (IMM, n.d.-a).

The Elmalı Basin Protection Plan, prepared by the General Directorate of Water Management of the Ministry of Agriculture and Forestry in Istanbul entered into force on March 20, 2019. It is important that the Ministry of Agriculture and Forestry has prepared the Elmalı Basin Protection Plan (2019) and the Marmara Basin Flood Risk Management Plan (2024); according to these plans, land use decisions need to be revised in Beykoz.

#### *3.1.2.1. Flood Disaster Risk of Göksu Stream in Beykoz District*

Within the scope of Preparation of Microzonation Reports and Maps for Anatolian Side "Flood Hazard" has been investigated, analyzes have been made to select the areas subject to flooding that may occur as a result of the realization of three main hazards: excessive precipitation, dam damage caused by earthquake, and tsunami effects, and a Flooding Hazard Map has been prepared (IMM, 2009). In this project, the area where the Göksu stream flows into the Bosphorus is identified as the riskiest area in the case of a possible flood due to the damage to Elmalı Dam II in Istanbul (see Figure 22). The impacts that will occur because of the failure of Elmalı Dam II due to a possible earthquake were analyzed, and the results of the analysis were shown with the maximum depth map, maximum flow velocity map, and arrival time map. The water flow's arrival time due to dam damage will be about 10 minutes under the highway bridge (TEM Molla Gürani Viaduct) and about

40 minutes at the seaside (where Göksu stream joins the Bosphorus). In the case of flooding due to dam damage, the worst-case scenario is assumed, but the probability of occurrence is very low. In this study, the boundaries of the risky area in the Preparation of Microzonation Reports and Maps for the South of the Anatolian Side of Istanbul" (IMM, 2009) and the 1/5,000 scale Master Plan for Natural and Historical Values of the Bosphorus (1983) are overlapped (see Figure 22).



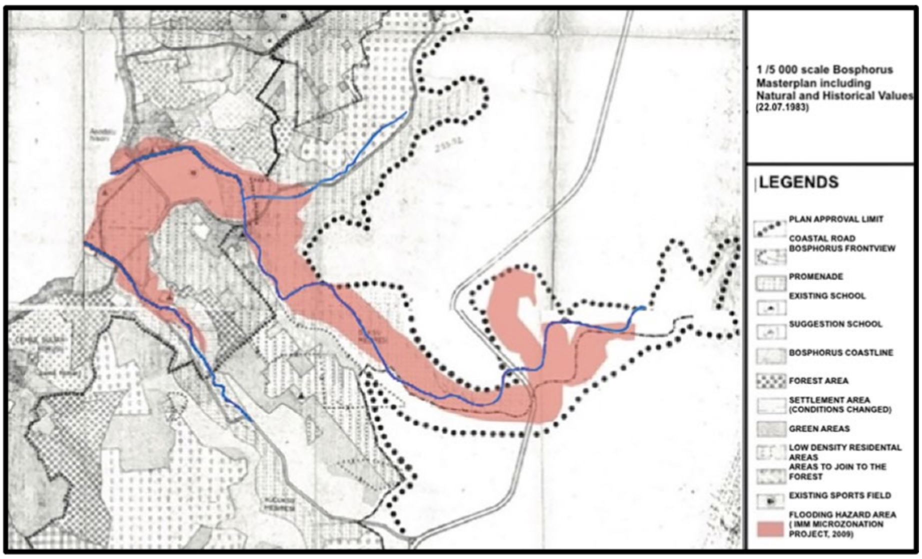



**Figure 22** Flood hazard area. Flood hazard area in IMM (2009) overlapped with 1/5,000 scale Bosphorus Natural and Historical Values Master Plan (1983)

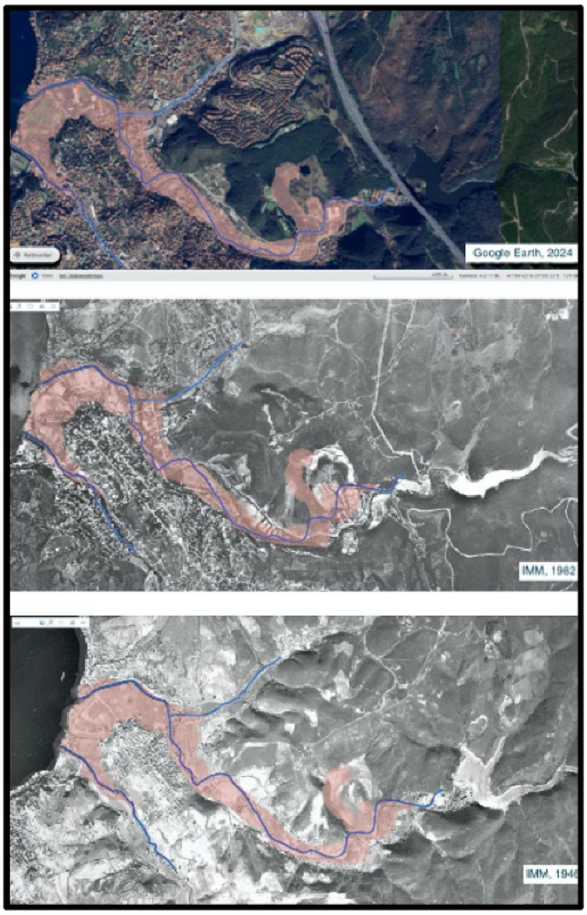



**Figure 23** Flood hazard area in 1946, 1982 and 2024. Flood hazard area in IMM (2009) overlapped with satellite images

In recent years, population and construction have been increasing in the Kavacık, Yenimahalle and Göztepe neighborhoods, which are new settlement areas outside the foreground zone according to Bosphorus Law No. 2960 (1983). After the 1990s, Hisar Evleri, Göksu Evleri, etc. mass housing projects and Medipol University campus can be given as the main examples of the built-up area in the upper basin of Göksu stream (see Figure 24 and Figure 25).

**Figure 24** View from the tributary of Göksu Stream towards Medipol University in Kavacık (Authors Archive,2025)


**Figure 25** New settlements in the upper basin of the tributary of Göksu Stream (Authors Archive, 2025)

According to TUIK's data, in 2024, the population of Kavacık was 22,138 persons, the population of Yenimahalle was 19,200 persons and population of Göztepe was 9,388 persons. The Hekimbaşı neighborhood of Ümraniye district, located in the upper basin of the Göksu stream, has 7,411 inhabitants. The population of Göksu neighborhood, which is predominantly a coastal settlement within the scope of Bosphorus protection, is 2,320 persons. Urban development with population growth will lead to high imperviousness in the upper basin and increase flood risk in the lower basin. Reclamation works in the Göksu and Küçüksu streams are carried out by ISKI in a process where compromise is difficult and public costs are high. However, allowing new settlements to develop in the upper basin throughout the region will still increase the flood disaster risk. Nowadays, flood events are increasing in the region (see Figure 26).


**Figure 26** Satellite image (3D) of the flood hazard area and its surroundings (Google Earth Maps, n.d.-c)

In the Marmara Basin Flood Management Plan (2024), which was approved and entered into force on January 17, 2025, and establishes the rules to be implemented under the responsibility of DSI and IMM between (2023-2027); regarding streams at risk of flooding, flood hazard maps were prepared for all streams in Beykoz. Intervention methods for Göksu stream, which is among the streams at risk of flooding in Beykoz, and decisions for strengthening Elmalı Dam are shown in Figure 27.


**Figure 27** Decisions for Göksu Stream and Elmalı Dam in the Marmara Flood Management Plan (2024)

## 4. Results and Conclusions

Istanbul, which has a significant weight in the Turkish economy, is the main urban agglomeration area of the country. Due to the rapid population growth in Istanbul, the urban macroform has expanded, encroaching on forests and watersheds, and destroying rural settlements. In this urbanization process of Istanbul, sensitive ecosystems and stream basins have been opened for settlement due to the lack of a holistic planning and management approach, lack of coordination, and confusion over authority. It is imperative to preserve the natural and rural qualities on the periphery of the city. In Istanbul, water basins are not protected by protection belts according to certain distances determined by ISKI legislation.

When the flood risk problems experienced in the sample areas in Çatalca and Beykoz are examined, it is understood that there are legal or illegal constructions that have chosen a location in areas with flood risk without being aware of the risk. The protection distances determined by ISKI legislation for Istanbul's streams are insufficient to prevent flood risk. When the practices of the institutions for the prevention of flood risk are examined, it is understood that the prevention of flood risk is attempted by the rehabilitation of the streams occurring in the area where the built environment is located. There is no holistic approach at the basin scale.

As examined in the sample locations, in sloping areas, due to the high slope in the upper basin and low slope in the lower basin, the water velocity increases in the lower basin during flood times, and flood damage may increase. Highways crossing river valleys also play a role in preventing surface runoff and increasing the amount of water flowing. Further, connection roads that use valley floors in the downstream direction act as drainage channels during extraordinary rainfall. As long as construction and population increase continue in the basins where stream rehabilitation is carried out at high costs, these projects will be insufficient to prevent flood risk. With developing technological possibilities, the predictability of floods will decrease as human beings intervene more in natural environmental features. Due to its close location, the Canal Istanbul Project is a particular threat to the Çatalca area. With the 3rd Bridge and its connection roads, it is necessary to increase resilience against flood risk against the increasing urban development pressure.

Today, water-sensitive urban planning and design approaches that support integrated watershed management studies have become extremely important in order to adapt to climate change on a global scale, protect and increase the efficiency of water resources, and reduce flood disaster risk. Adopting this approach would also be in line with the key principles of the Sendai Framework for Disaster Risk Reduction (2015-2030) on how to make our societies safer and more resilient (understanding disaster risk, strengthening disaster risk governance to manage disaster risk, investing in disaster risk reduction for resilience and enhancing disaster preparedness for effective response, and "building back better" in recovery, rehabilitation and reconstruction) also overlap with focused actions at local, national, regional, and global levels and across governments and sectors.

When examples from the developed world are examined, it is important to produce nature-based solutions such as the creation of green infrastructure, stormwater management, sustainable urban drainage systems, landscape planning and design within the scope of stream improvement projects proposed for settlements and to integrate them with spatial planning and design decisions, and these will provide long-term permanent and cost benefit solutions. By increasing permeable surfaces, rainwater harvesting, and the selection of appropriate landscape elements, it is possible to slow down the flow of water in urban areas and prevent its spread to the environment. In this context, for example, in China, the importance of producing nature-based solutions has been emphasized with "sponge-city" concept projects that include rainwater harvesting and rainwater management to protect water basins, improve water quality, and reduce flood disaster risk.

The Turkish Republic Ministry of Agriculture and Forestry works on flood management plans in line with the development of water basin management plans for reducing flood risk. The Marmara Basin Flood Management Plan for the Marmara Basin, which includes Istanbul, was most recently approved in the Official Gazette on January 17, 2025. In the study covering the years 2023-2027, flood risk analysis was conducted for all of Istanbul's streams, and necessary interventions and responsible organizations were identified. These interventions are generally annual cleaning and flood rehabilitation of the streams. In this context, while IMM is the responsible organization under Law No. 5216, IMM and DSI are defined as the relevant organizations under Law No. 6200.



Preparation of flood hazard maps, flood risk maps, and evacuation plans within the scope of the Marmara Basin Flood Management Plan is valuable. These studies should be developed with multiple risk analyses that take into account other risk factors, especially the earthquake risk in Istanbul. The Ministry of Agriculture and Forestry should guide spatial planning approaches for local actors by combining the Elmalı Basin Protection Plan (2019), Büyükçekmece Basin Protection Plan (2019), and the Marmara Basin Flood Risk Management Plan (2024) prepared for drinking water basins in the sample area. Protection plans prepared for drinking water basins should also be prepared for groundwater and surface water basins that do not have drinking water quality.

In this context, spatial planning studies and land use decisions at all scales should be revised and implemented in a participatory manner with water-sensitive planning and design principles in line with flood hazard maps, flood risk maps, and flood management plans in the light of scientific data for Istanbul's water basins. More detailed and comprehensive studies should be carried out by shifting from macro scale to micro scale and using locally specific analyses (climate, topography, hydrology [the natural flow directions and natural flow accumulations], the hydrogeology, soil structure and permeability, etc.). The process of water-sensitive planning and design should be a collaborative effort of all stakeholders (planners, architects, engineers, technical experts, practitioners, environmental groups, NGOs, etc.) and local communities. This process should also be supported by a flood disaster risk management process that includes the awareness and participation of all actors on risk issues.

## Acknowledgements

*In this study, the preliminary findings of Çatalca and Beykoz case studies of the Scientific Research Project titled "The Relationship of Flood Risk with Planning: The Case of Istanbul Province" supported by Mimar Sinan Fine Arts University are presented. The study has been theoretically developed and updated.*

## References

Akbulut, B., & Güzel, A. İ. (2022). Watershed areas under urbanization pressure: The case of Istanbul. *Journal of Environmental and Natural Studies*, *4*(3), (pp.207–224). https://doi.org/10.53472/jenas.1148604 (Date of Access: 01.09.2023).

Balamir, M. (2007). Afet politikası, risk ve planlama. *TMMOB Afet Sempozyumu*, (pp.31 43). http://www.imo.org.tr/resimler/ekutuphane/pdf/3887.pdf (Date of Access: 01.06.2014).

Boztaş, İ. (2016). Yukarı Havza Sel Kontrolü Eylem Planı ve Uygulamaları. *4. Ulusal Taşkın Sempozyumu Panel Sunuları ve Tebliğler Kitabı* (23 25 Kasım 2016). https://cdniys.tarimorman.gov.tr/api/File/GetFile/425/KonuIcerik/745/1093/DosyaGaleri/4-ulusal-ta%C5%9Fk%C4%B1n--sempozyumu-sonuc-bildirgesi-ve-tebligler.rar.rar (Date of Access: 01.06.2017)

Brown, R., Keath,N., and Wong,T. (2008).Transitioning to Water Sensitive Cities:Historical, Current and Future Transition States. *Proceedings of the 11th International Conference on Urban Drainage,* 2008, Edinburgh, Scotland, UK. https://collaboration.worldbank.org/content/usergenerated/asi/cloud/attachments/sites/collaboration-for-development/en/groups/tdlc-technical-deep-dive/groups/iuwm-south-south-knowledge-exchange/documents/_jcr_content/content/primary/blog/general_iuwm-WqPt/7.%20Transitioning%20to%20Water%20Sensitive%20Cities%20(Rebekah%20Brown,%20Nina%20Keath%20and%20Tony%20Wong,%202008).pdf (Date of Access: 14.04.2025).

Choi, C. (2024). Why turning cities into ‘sponges’ could help fight flooding? *CNN Style.* https://edition.cnn.com/2024/08/13/style/china-sponge-cities-kongjian-yu-hnk-intl/index.html (Date of Access: 11.04.2025).

Cooperative Research Centre for WaterSensitive Cities. (2021). *Case Studies*. https://watersensitivecities.org.au/solutions/case-studies/ (Date of Access: 10.04.2025).

Çatalca Municipality. (2014). *1/1,000 Akalan Implementation Plan Report*. Çatalca Municipality. Istanbul.

Decision of the President of the Republic of Türkiye No.157, Official Gazette no: 32384 on 29.11.2023. (2023). https://www.resmigazete.gov.tr/eskiler/2023/11/20231129-17.pdf (Date of Access: 04.04.2024).

Decision of the President of the Republic of Türkiye No. 8650, Official Gazette no: 32566 on 28.06.2024. (2024). https://www.resmigazete.gov.tr/eskiler/2024/06/20240628-2.pdf (Date of Access: 04.07.2024).

Decision of the President of the Republic of Türkiye No. 9419, Official Gazette no: 32785 on 17.01.2025. (2025). https://www.resmigazete.gov.tr/eskiler/2025/01/20250117-10.pdf (Date of Access: 04.04.2025).

Decree No. 644 on the Organization and Duties of the Ministry of Environment and Urbanization, Official Gazette on 04.07.2011. (2011). http://www.resmigazete.gov.tr/eskiler/2011/07/20110704M1-1.htm (Date of Access: 04.07.2020).

Delforge, D., Below, R., Speybroeck, N., & Van Loenhout., J. A. F. (2024). Disaster year in review 2023. *EM-DAT_The CRED/UCLouvain International Disaster Database*, Issue 74. https://files.emdat.be/2024/04/CredCrunch74.pdf (Date of Access: 19.06.2024).

Demir, A. (2013). İstanbul'da yaşanan taşkınlar ve taşkın önleme çalışmaları. *3. Ulusal Taşkın Sempozyumu* (29-30 Nisan 2013). http://www.dsi.gov.tr/faaliyetler/sempozyum-ve-sergiler/3-ulusal-taskin-sempozyumusunulari (Date of Access: 07.07.2016).

Dinç, H., & Bölen, F. (2014). İstanbul derelerinin fiziki yapısı. *Journal of Planning*, *24*(2), (pp.107–120). https://doi.org/10.5505/planlama.2014.97269 (Date of Access: 04.07.2020).

Dinçer, İ., Enlil, Z., & Evren, Y. (2009). İstanbul'un koruma alanlarının değerlendirilmesi. *Megaron*, *4*(1), (pp. 5–15). https://megaronjournal.com/jvi.aspx?pdir=megaron&plng=eng&un=MEGARON-42275&look4= (Date of Access: 19.06.2024).

Drainage Services Department of Hong Kong. (2017). *Sustainability Report 2016-2017*. https://www.dsd.gov.hk/Documents/SustainabilityReports/1617/en/director_statement.html (Date of Access: 10.04.2025).

EPA-United States Environmental Protection Agency. (2024). *Watershed-Based Plans in New England. What is a Watershed?* https://www.epa.gov/tmdl/watershed-based-plans-new-england (Date of Access: 01.045.2025).

EU Directive 2000/06/EC, Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000. (2000). *Official Journal of the Communities on 22.12.2000*. https://eur-lex.europa.eu/resource (Date of Access: 01.05.2020).

EU Directive 2007/60/EC, Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks (text with EEA relevance). (2007). *Official Journal of the European Union.* https://eur-lex.europa.eu/eli/dir/2007/60/oj/eng (Date of Access: 01.05.2020).

European Commission. (2011). *Green infrastructure.* https://environment.ec.europa.eu/topics/nature-and-biodiversity/green-infrastructure_en (Date of Access: 01.11.2024).

EU-European Union-Water. (n.d). *Water Framework Directive.* Directorate-General for Environment. https://environment.ec.europa.eu/topics/water/water-framework-directive_en (Date of Access: 01.06. 2024)

EU-European Union (2024). *Water Sensitive City. Ex-ante assessment of the "Water Sensitive City" thematic area under the Urban Agenda for the EU. Final Report.* https://www.urbanagenda.urban-initiative.eu/sites/default/files/2024-08/EAA_Water%20Sensitive%20City_FINAL.pdf (Date of Access: 14.04.2025).

Google Earth Maps. (n.d._a). [Istanbul Aerial Photograph]. https://earth.google.com/web/search/istanbul/@41.21134426,28.77253132,107.62993. (Date of Access: 01.07. 2024)

Google Earth Maps. (n.d._b) [Akalan settlement]. https://earth.google.com/web/search/Akalan,+%c3%87atalca%2f%c4%b0stanbul/@41.25566998,28.41522081,155.39043459a,3800.30636425d,35y,0h,0t,0r/data=CigiJgokCfQKmGEOm0RAEYIzsmYMm0RAGQiZqzLJxTxAIVde4BDAxTxA (Date of Access: 01.07. 2024)

Google Earth Maps. (n.d._c) [The Satellite image (3D)]. https://earth.google.com/web/search/g%c3%b6ksu+deresi/@41.0753107,29.07787756,2.32447224a,3195.40958848d,35y,77.06652078h,59.96723495t,-0r/data=CigiJgokCWp34UkpokRAEfTH9htKn0RAGb7eVqnscDxAIWREGCmrYzxA (Date of Access: 01.07. 2024)

GWP_Global Water Partnership. (n.d). *Dublin_Rio Principles.* https://www.gwp.org/contentassets/05190d0c938f47d1b254d6606ec6bb04/dublin-rio- principles.pdf (Date of Access: 01.06. 2024)

Hoyer, J. D, Dickhaut, W., Kronawitter, L., Weber, B. (2011). *Water Sensitive Urban Design-Principles and Inspiration for Sustainable Stormwater Management in the City of the Future.* Projectreport.018530-SWITCH Sustainable Water Management in the City of the Future- Integrated Project Global Change and Ecosystems. https://www.hcu_hamburg.de/fileadmin/documents/Research/Forschungsgruppen/REAP

/WD_Publikationen /Hoyer_Dickhaut_Kronawitter_Weber_Manual_WSUD_2011.pdf (Date of Access: 04.06.2024)

IMM-Istanbul Metropolitan Municipality. (2009). *Anadolu Yakası Mikrobölgeleme Rapor ve Haritalarının Yapılması İşi.* Earthquake and Ground Investigation Department. https://depremzemin.ibb.istanbul/calismalarimiz/tamamlanmis_calismalar/istanbul_ili_mikrobolgeleme_projeleri/ (Date of Access: 04.07.2020).

IMM-Istanbul Metropolitan Municipality. (2009a). *1/100,000 scale Istanbul Environmental Plan Revision*. Urban Planning Department. https://sehirplanlama.ibb.istanbul/ust-olcekli-planlar/ (Date of Access: 04.07.2024).

IMM-Istanbul Metropolitan Municipality. (2009b). *Istanbul European Side (Silivri-Selimpasa-Çatalca-K.Çekmece-Kilyos) September 2009 Flood Disaster Investigation Report.* Earthquake Risk Management and Urban Renovation Directorate, Earthquake and Ground Investigation Department. https://depremzemin.ibb.istanbul/wp-content/uploads/2020/04/Sel-Felaketi-Rapor.pdf (Date of Access: 06.06.2024).

IMM-Istanbul Metropolitan Municipality. (2010). *1/5,000 Çatalca Urban Center and Environment Revision Plan Report.* Urban Planning Department. Istanbul.

IMM-Istanbul Metropolitan Municipality. (n.d). *Land use in Çatalca*. Urban Planning Department. https://sehirplanlama.ibb.istanbul/catalca-ilcesi/ (Date of Access: 10.06.2024).

IMM-Istanbul Metropolitan Municipality. (n.d.-a). *Land use in Beykoz*. Urban Planning Department. https://sehirplanlama.ibb.istanbul/beykoz-ilcesi/ (Date of Access: 10.06.2024).

IMM-Istanbul Metropolitan Municipality. (2017). *1/25, 000 Scale Geological Survey Report for Land use.* Earthquake Risk Management and Urban Renovation Directorate, Earthquake and Ground Investigation Department. https://depremzemin.ibb.istanbul/wp-content/uploads/2020/04/iSTANBUL-iLi-1-25000-oLcEKLi-ARAZi-KULLANIMINA-ESAS-JEOLOJiK-ETuD-RAPORU.pdf (Date of Access: 20.06.2024).

Independent Newspaper. (2021). İstanbul’un arsa değeri yüzde 149 arttı: İşte en değerli ilçeler. https://www.indyturk.com/node/372306/ekonomi%CC%87/i%CC%87stanbulun-arsa-de%C4%9Feri-y%C3%BCzde-149-artt%C4%B1-i%CC%87%C5%9Fte-en-de%C4%9Ferli-il%C3%A7eler (Date of Access: 15.05.2024).

ISKI- Istanbul Water and Sewerage Administration General Directorate (2011), Drinking Water Basins Regulation, https://www.iski.gov.tr/web/assets/SayfalarDocs/Mevzuat%20ve%20Y%C3%B6netmelikler/ISKI-ICMESUYU-HAVZALARI-YONETMELIGI-29092017.pdf (Date of Access: 10.08.24)

ISKI-Istanbul Water and Sewerage Administration. (2024). *Streams and Flood Areas.* Digital Data. Unpublished.

Istanbul Governorship of the Republic of Türkiye. (n.d). *Istanbul Provincial Disaster Risk Reduction Plan Report.* Provincial Disaster and Emergency Directorate. https://istanbul.afad.gov.tr/kurumlar/istanbul.afad/PDF-Dosyalar/irap_istanbul.pdf (Date of Access: 04.07.2020).

Kadıoğlu, M. (2012). Climate Change Risk Management in Türkiye. *Paper for the Project of Preparation of 2nd National Declaration on Climate Change of Türkiye* (ISBN:978_605_52912_0). https://www.researchgate.net/profile/Mikdat_Kadioglu/publication/258108645_Turkiye%27de_Iklim_Degisikligi_Risk_Yonetimi/links/02e7e526fa28021a95000000/Tuerkiyede-Iklim-Degisikligi-Risk-Yoenetimi.pdf (Date of Access: 17.06.2024).

Law No. 4373 on the Protection Against Flood and Inundation (1943). Official Gazette of the Republic of Türkiye. No:5310 on 14.01.1943. Retrieved from http://www.mevzuat.gov.tr/MevzuatMetin/1.3.4373.pdf (Date of Access: 17.06.2024).

Law No. 2560 for Istanbul Water and Sewerage Administration General Directorate Establishment and Duties, Official Gazette no:17523 on 23.11.1981. (1981). https://www.mevzuat.gov.tr/mevzuat?MevzuatNo=2560&MevzuatTur=1&MevzuatTertip=5 (Date of Access: 17.06.2024).

Law No. 2960 for Bosphorus. Official Gazette no:18229 on 18.11.1983. (1983). https://mevzuat.gov.tr/mevzuat?MevzuatNo=2960&MevzuatTur=1&MevzuatTertip=5 (Date of Access: 17.06.2024).

Law No. 5216 on Metropolitan Municipality. Official Gazette no:18229 on 18.11.1983. (2004). http://www.mevzuat.gov.tr/MevzuatMe tin/1.5.5216.pdf (Date of Access: 17.06.2024).

Law No. 6200 on Organization and Duties of the General Directorate of State Hydraulic Works (1953). Official Gazette no:8592 on 25.12.1953. http://www.mevzuat.gov.tr/MevzuatMetin/1.3.6200.pdf (Date of Access: 05.01.2024).

Law No. 6306 on Transformation of Areas at Risk of Natural Disaster (2012). Official Gazette no:28309 on16.05.2012. http://www.mevzuat.gov.tr/MevzuatMetin /1.5.6306.pdf (Date of Access: 05.01.2024).

Law No. 6360 on the Establishment of Metropolitan Municipalities and Twenty-seven Districts in Fourteen Provinces and Amendments to Certain Laws and Decree Laws, Official Gazette no:28489 on

12.11.2012.(2012). https://www.mevzuat.gov.tr/mevzuat?MevzuatNo=6360&MevzuatTur=1&MevzuatTertip=5 (Date of Access: 05.05.2024).

Milliyet Newspaper. (2013). Bu kış da efkarlıyız. https://www.milliyet.com.tr/gundem/bu-kis-da-efk-rliyiz-1770330 (Date of Access: 01.06.2024).

Özhan, S. (2004). *Havza Amenajmanı.* İstanbul Üniversitesi Rektörlük Yayını, No: 4510, Or. Fak. Yay. No:481.

Prime Ministry Circular No. 2010/5 on Rehabilitation of Streams and Creek Beds, Official Gazette no: 28444 on 17.10.2012. (2012). http://www.resmigazete.gov.tr/eskiler/2010/02/20100220-17.htm (Date of Access: 04.07.2024).

Republic of Türkiye Ministry of Agriculture and Forestry. (2019, March 20). Büyükçekmece Basin Protection Plans. https://www.tarimorman.gov.tr/SYGM/Belgeler/%C4%B0%C3%87ME%20SUYU%20KORUMA%20PLANLARI%2028.12.2022/B%C3%BCy%C3%BCk%C3%A7ekmece%20Baraj%20G%C3%B6l%C3%BC%20%C3%96zel%20H%C3%BCk%C3%BCmleri.pdf (Date of Access: 01.07.2024).

Republic of Türkiye Ministry of Agriculture and Forestry. (2019). *National Water Plan.* https://www.tarimorman.gov.tr/SYGM/Belgeler/NHYP%20DEN%C4%B0Z/ULUSAL%20SU%20PLANI.pdf (Date of Access: 07.08.2024).

Republic of Turkiye Ministry of Agriculture and Foresty. (n.d.). Flood issues in the basin. *In Technical Assistance to Prepare Flood Risk Management Plan for Meriç-Ergene River Basin (TR2018 ESOP MI A1.17/SER/28) Project*. https://floodmerg.tarimorman.gov.tr/en/flood-issues-in-the-basin (Date of Access: 04.04.2024).

Republic of Türkiye Ministry of Environment, Urbanization and Climate Change. (2023). *Meteorological Characteristic Disaster Evaluation Report for 2022.* General Directorate of Meteorology. https://www.mgm.gov.tr/FILES/genel/raporlar/2022afet.pdf (Date of Access: 04.07.2020).

Republic of Türkiye Ministry of Agriculture and Forestry. (2024). *Marmara Waterbasin Flood Management Plan.* Ankara. https://www.tarimorman.gov.tr/SYGM/Belgeler/Ta%C5%9Fk%C4%B1n%20Y%C3%B6netim%20Planlar%C4%B1%2026.12.2022/MARMARA%20HAVZASI%20TASKIN%20YONETIM%20PLANI.pdf (Date of Access: 10.04.2025).

The Regulation on Protection of Water Basins and Preparation of Management Plans (2012), Official Gazette no:28444 on 17.09.2012. http://www.resmigazete.gov.tr/eskiler/2012/10/20121017-2.htm (Date of Access: 05.05.2024).

The Regulation Spatial Plans Construction (2014), Official Gazette no:29030 on 14.06.2014. (2014). http://www.resmigazete.gov.tr/eskiler/2014/06/20140614-2.htm (Date of Access: 05.05.2024).

The Regulation on the Preparation, Implementation and Monitoring of Flood Management Plans (2016), Official Gazette no: 29710 on 12.05.2016. (2016). https://www.resmigazete.gov.tr/eskiler/2016/05/20160512-6.htm (Date of Access: 05.05.2024).

The Regulation on Stormwater Collection, Storage and Discharge Systems (2017) , Official Gazette no:30105 on on 23.06.2017. https://www.resmigazete.gov.tr/eskiler/2017/06/20170623-8.htm. Date of Access: 16.04.2024).

The Regulation on Planned Areas Zoning (2017), Official Gazette no: 30113 on 03.04.2017. https://www.mevzuat.gov.tr/mevzuat?MevzuatNo=23722&MevzuatTur=7&MevzuatTertip=5 (Date of Access: 06.07.2024)

The Regulation on the Protection of Drinking and Potable Water Basins (2017), Official Gazette no:30224 on 28.10.2017. (2017). https://www.mevzuat.gov.tr/mevzuat?MevzuatNo=24036&MevzuatTur=7&MevzuatTertip=5 (Date of Access: 01.06.2024).

The Regulation on the Basin Management Central Board, Basin Management Committees and Provincial Water Management Communiqué on the Establishment, Duties, Working Procedures and Principles of the Coordination Boards, and Basin and Provincial Level (2019), Official Gazette no:30659 on 18.01.2019. https://istanbul.tarimorman.gov.tr/Belgeler/SolMenu/RESMI%20GAZETE2019-2019/TEBLIGLER/HavzaYonetimiTebligi2019.pdf (Date of Access: 01.05.2024).

TUIK-Turkish Statistical Institute. (2024). *Adress-Based Population Registration System Results.* https://data.tuik.gov.tr/Bulten/Index?p=Adrese-Dayali-Nufus-Kayit-Sistemi-Sonuclari-2024-53783 (Date of Access: 04.04.2025).

Turoğlu, H. (2011). İstanbul'da meydana gelen sel ve taşkınlar. *Fiziki coğrafya araştırmaları; sistematik ve bölgesel*, (pp. 411–430). Babil Basım. https://avesis.istanbul.edu.tr/yayin/69c8eec2-3fc3-4727-8da5-352728868778/istanbulda-meydana-gelen-sel-ve-taskinlar (Date of Access: 01.04.2019).

UN-Habitat (2017). *New Urban Agenda. HABITAT III- United Nations Conference on Housing and Sustainable Urban Development Report.* https://habitat3.org/wp-content/uploads/NUA- English.pdf (Date of Access: 10.06. 2024)

UN-United Nations Water. (n.d.). *UN Water and Climate Change.* https://www.unwater.org/water-facts/water-and-climate-change (Date of Access: 01.06.2024).

UNDDR-United Nations Office for Disaster Risk Reduction. (n.d.). *MCR 2030 Making Cities Resilience*. https://mcr2030.undrr.org/join (Date of Access: 01.07.2024).

UNDDR-United Nations Office for Disaster Risk Reduction. (n.d.-a). *Implementing the Sendai Framework.* https://www.undrr.org/implementing-sendai-framework/what-sendai-framework#priorities (Date of Access: 10.04.2025).

UNESCO-United Nations Educational, Scientific and Cultural Organization. (2020). *The United Nations World Water Development Report 2020: Water and Climate Change.* In United Nations Educational, Scientific and Cultural Organization Digital Library. https://unesdoc.unesco.org/ark:/48223/pf0000372985.locale=en (Date of Access: 02.07.2024).

WMO-World Meteorological Organization (2021). *Atlas of Mortality and Economic Losses from Weather, Climate and Water Extremes (1970–2019) WMO-No. 1267.* (No. 978-92-63-11267–5). https://library.wmo.int/viewer/57564/download?file=1267_Atlas_of_Mortality_en.pdf&type=pdf&navigator=1 (Date of Access: 01.06.2024).



## Resume

*Hale Mamunlu Kocabaş received her BSc (1998), MSc (2001), and PhD (2009) degrees from Mimar Sinan Fine Arts University (MSFAU), Faculty of Architecture and Department of Urban and Regional Planning. She studied at ETH Zurich-Swiss Federal Institute of Technology Zurich, Department of Civil, Environment and Geomatic Engineering, in 2002-2003 (with Swiss Government Excellence Scholarships). She conducted her research studies under Prof. Dr. Willy Schmid's supervision for her dissertation and attended educational programmes at ETHZ, Institute for Spatial and Landscape Development, during her stay between 2003-2004. She was a member of the Turkish National Delegation of ISOCARP- International Society of City and Regional Planners-from 2006-2009. She has been working as a lecturer at Mimar Sinan Fine Arts University (MSFAU), Faculty of Architecture and Department of Urban and Regional Planning since 2000. Between 2000 and 2010, she worked as a Research Assistant at MSFAU, and since 2010 she has been working as an Assistant Professor. She currently gives courses at the undergraduate and graduate level at MSFAU. Her main fields of interest and research are: ecological planning, environmental management, water basin planning and management, flood risk management, and rural planning. As Representative of MSFAU of UN SDSN-Sustainable Development Solutions Network Türkiye and Water Efficiency Coordinator since 2023, and Sustainable Green Campus Coordinator since 2024 at Mimar Sinan Fine Arts University, she has been working to raise awareness by providing various trainings, organizing events and workshops on environmental sustainability issues.*

JOURNAL OF DESIGN FOR RESILIENCE
IN ARCHITECTURE & PLANNING

*Research Article*
*Online:* www.drarch.org
*Volume 6, Issue 1 (102-123), 2025*
*DOI: 10.47818/DRArch.2025.v6i1159*

# The CODASC database for analyzing the impact of morpho-climatic characteristics of canyon streets on air pollutant concentrations

Loubna Khellaf*
Meriem Naimi Ait-Aoudia**
Farid Rahal***

## Abstract

Canyon-type urban streets are one of the urban forms in which critical and harmful situations for health and the urban environment are emerging today, such as urban heat islands, areas of poor ventilation, and retention zones for pollutants emitted by road traffic, heating, and industrial activities. The higher pollution levels are due to inappropriate relationships between morphological and microclimatic parameters specific to urban street canyons. Previous studies have highlighted the most common factors, namely the aspect ratio (H/W), the orientation of the street to the prevailing winds, and vegetation. In the city of Algiers, the urban street canyon is particularly noticeable in two dominant urban fabrics: the medieval organic fabric and the colonial fabric dating back to the French occupation. This paper aims to explain the effect of different factors specific to urban canyons in Algiers on the concentration trends of air pollutants by adopting the CODASC database, which contains data on normalized average air pollutant concentrations (C+) related to different street canyon models, according to aspect ratios H/W values, wind flow direction (α), tree stand density (ρs), and tree crown porosity (PVol). In order to validate the developed methodology, measurements of particle pollution concentrations were carried out at several points on the studied streets, using an analyzer equipped with the GP2Y1010AU0F microsensor. Based on the collected data, a statistical model was developed to assist in the reconfiguration of canyon-type streets in order to increase the dispersion of pollutants and consequently, reduce their concentrations. The results showed that Larbi Ben M'Hidi Street is more polluted than Mohammed Azzouzi Street due to the impact of the maximum values of the aspect ratio and tree density on wind behavior. The study's findings could provide a strategic guide for pollution mitigation, to be used by urban planners in the design and implementation phases of sustainable urban development projects in Algiers.

*Keywords:* air pollutant concentrations, canyon streets, city of Algiers, CODASC database, morpho-climatic parameters

## 1. Introduction

Air quality continues to deteriorate in large urban cities, particularly in developing countries. This is due to a combination of various urban factors, such as construction, manufacturing, and transportation (Tao et al., 2020; Wu, Li et al., 2021). As the effects of rapid urbanization and human activities on the urban microclimate change and their impact on public health continue to intensify, urban pollution has become a global environmental issue, particularly with regard to human health in cities (OECD, 2014; Hankey & Marshall, 2017; Boppana et al., 2019; WHO, 2021; Cevik Degerli & Cetin, 2023; Zeren Cetin, Varol et al., 2023; Zeren Cetin, Varol, Ozel et al., 2023; Uslu et al., 2024). Previous studies have addressed urban air pollution, proposing various mitigation techniques, such as the establishment of low-emission zones, tree planting, and the adoption of electric vehicles or sustainable transportation options (Yuan et al., 2014; Hong et al., 2017; Yang et al., 2020; Huang et

*(Corresponding author), PhD Student, University Saad Dahlab Blida 1, Algeria architectekhellaf@gmail.com
**Conference Lecturer, University Saad Dahlab Blida 1, Algeria naimiaitaoudia.meriem@univ-blida.dz
***Prof. Dr., University of Science and Technology of Oran-Mohammed Boudiaf, Algeria farid.rahal@univ-usto.dz
*Article history: Received 31 December 2024, Accepted 12 March 2025, Published 30 April 2025*

al., 2021; Voordeckers, Lauriks et al., 2021; da Silva et al., 2022; Cetin, Cebi Kilicoglu et al., 2023; Cebi Kilicoglu & Zeren Cetin, 2024; Zeren Cetin, 2024a).



The issue of air quality can be addressed at various scales, including that of the urban canopy (Vardoulakis et al., 2003). At this scale, one of the predominant urban forms is the canyon street, where air quality is particularly sensitive due to the combined effects of morphological and microclimatic parameters (Peng et al., 2019; Miao et al., 2020; Buccolieri et al., 2022; Miao et al., 2023). Some of these parameters play a crucial role in local climatic conditions and bio-comfort zones. Consequently, Cetin, Sevik et al., (2023), Cetin, Adiguzel et al., (2023), and Zeren Cetin (2024b) have emphasized that taking such factors into account when managing urban environmental effects is an optimal approach for making strategic decisions in urban and landscape planning. For instance, understanding the spatial and temporal variations of environmental parameters, particularly the phenomenon of pollutant concentrations in urban zones, is essential for effective landscape and urban planning aimed at mitigating air pollution and, consequently, optimizing overall air quality (Zeren Cetin, 2024c).

In Algeria, and more specifically in Algiers, the capital, urban air pollution has been a growing concern since independence from French colonial rule in 1962, largely due to significant economic, demographic, and urban development (Belamri et al., 2017; Nejjari et al., 2003). These developments are closely linked to four major factors: road traffic, industry, construction, and waste generation (Rahal et al., 2014; Benselhoub et al., 2015; Oucher et al., 2015). Among these factors, road traffic is a major source of air pollutant emissions in Algiers, particularly the substantial emission of fine particles (PM2.5 and PM10). In this context, relevant studies by (Ali-Khodja et al., 2008; Belhout et al., 2018; Boughedaoui et al., 2004; Kerbachi et al., 1998, 2006; Oucher & Kerbachi, 2012; Talbi et al., 2018) have shown that PM10 and PM2.5 levels in the city are extreme, exceeding both international (WHO, 2016) and national standards (Journal Officiel de la République Algérienne Démocratique et Populaire N°10, 2006). This constitutes a significant threat and negatively impacts human health in urban areas of Algiers (Kerchich & Kerbachi, 2012; Terniche et al., 2018).

The study of air pollutant concentration under the urban canopy, particularly at the canyon street scale, has been the subject of several studies worldwide (Vardoulakis et al., 2003). This issue has been extensively investigated using CFD fluid dynamics simulations, which rely on a variety of numerical parameters, such as computational domain size, grid type, grid resolution, mesh refinement, boundary conditions, turbulence model, algorithm resolution, time step, and convergence criteria (Neofytou et al., 2006; Sabatino et al., 2008; Vranckx et al., 2015; Abhijith et al., 2017; Wu, Hang et al., 2021; da Silva et al., 2022; Zheng et al., 2022; Wang et al., 2022; Hang et al., 2022). The primary focus of these studies is on developing models for pollutant dispersion and concentration, as well as turbulence and wind flow within canyons with different morpho-climatic characteristics.

At the national level, specifically in the urban center of Algiers, few studies have addressed the issue of air quality (Rahal et al., 2014). Most of these studies have focused on establishing an inventory of air pollutant emissions, their sources, origins, impacts on health and the environment, as well as their types and sizes, using conventional measurement and monitoring techniques (Oucher et al., 2015; Abderrahim et al., 2016; Talbi et al., 2018; Belhout et al., 2021; Ibrir et al., 2021). Particulate matter concentrations are not continuously assessed in Algeria, specifically in Algiers, by air quality monitoring networks. To address this shortcoming, analyzers based on micro-sensor technology have been developed. Indeed, this technology allows for the creation of low-cost, low-power, and miniaturized electronic assemblies (Rahal, 2020; Rahal et al., 2020; Rahal, Benabadji et al., 2021; Rahal, Rezak et al., 2021; Benabadji et al., 2024). These sensors have demonstrated their usefulness for static and mobile deployments (Rai et al., 2017; Baron & Saffell, 2017; Maag et al., 2018). Furthermore, this type of air pollution sensor has been successfully integrated into various deployments to provide detailed air pollution information for quantitative studies (Yi et al., 2015). Additionally, to date, no studies have investigated the concentration of pollutants and its relationship with the morpho-climatic parameters of the urban area of Algiers, particularly at the canopy scale, where the urban fabric is characterized by a specific geometry of canyon streets that varies depending on the nature of the urban fabric in each of the two cities: the medieval city (Casbah) and the 19th-20th century city (French city). The objective of this analysis is to assess the effect of the interaction between key indices determining canyon geometry, such as H/W, L/H, W, and those of the urban microclimate, including wind (direction, speed, and orientation relative to the prevailing wind). Secondary parameters, such as the vehicle fleet, the typology of building facades facing canyon streets, the configuration and density of the immediate environment surrounding the canyon, and tree establishment (shape, type, and density), are also considered. These factors influence wind trajectories, dispersion, and pollutant concentration within the canyon streets, shaping specific patterns. Therefore, the present study aims to analyze and interpret the dispersion/concentration models of pollutants in selected canyons in the city center of Algiers. To achieve this purpose, we adopt a method based on the pollutant concentration measurement data provided by the CODASC database from the university of Karlsruhe in Germany (CODASC, 2022). This database contains data on the concentration of traffic-related pollutants for different urban canyon configurations, considering aspects such as aspect ratio, wind direction, and tree planting. In addition, these were obtained from wind tunnel experiments (Gromke, 2013). We have carefully selected canyon streets in Algiers city that exhibit similarities to those in the CODASC database, taking into account the morphological parameters, including canyon aspect ratio, wind direction, and street plantings. Therefore, in order to validate the results obtained from the CODASC database, we recorded measurements of the concentrations of fine particles, temperature, and humidity using an APOMOS analyzer equipped with a micro-sensor. These measurements were taken at different points on walls A and B of the studied streets. Additionally, we collected other data, such as hourly traffic volume, number of trees per linear meter (Nb_tree), aspect ratios (H/W), and wind speed (using an anemometer). Based on the collected data, a statistical model was developed to assist in the reconfiguration of canyon-type streets in order to increase the dispersion of pollutants and consequently, reduce their concentrations. The results of this study could provide guidelines for urban planning and development projects in Algiers, helping to mitigate urban pollution and enhance scientific understanding and data on Algiers, particularly in terms of air quality assessment, prediction, and improvement.

## 2. Methodology

### 2.1. *Case Study*

#### 2.1.1. *Geographic Location of the Studied Canyon Streets*

The city of Algiers is a significant urban area due to its strategic geographic location, substantial urban and economic development, and rapid population growth, which reached nearly 3.6 million inhabitants in 2019 (Boubezari, 2021). Additionally, transportation, construction, and industry are the primary factors that simultaneously affect air quality in urban areas of Algiers through the emission of air pollutants (Belamri et al., 2017; Belhout et al., 2018, 2021; Rahal et al., 2014; Talbi et al., 2018). Road traffic in Algiers is frequently congested due to several specific factors, including increasing motor vehicle usage, rugged topography, centralized urban organization, narrow and inadequate roads, and the presence of the port (Tabti-Talamali & Baouni, 2018). As a result, many researchers have identified road traffic as the main source responsible for the deterioration of air quality in Algiers (Oucher & Kerbachi, 2012; Talbi et al., 2018). The scope of this study is highly localized, focusing on Canyon Streets. The urban center of Algiers is predominantly characterized by this type of street. Therefore, we have selected Mohammed Azzouzi Street and Larbi Ben M'Hidi Street, which are located in two dominant urban fabrics: the medieval organic fabric and the colonial fabric. Figure 1 below shows the location of the selected urban canyons.

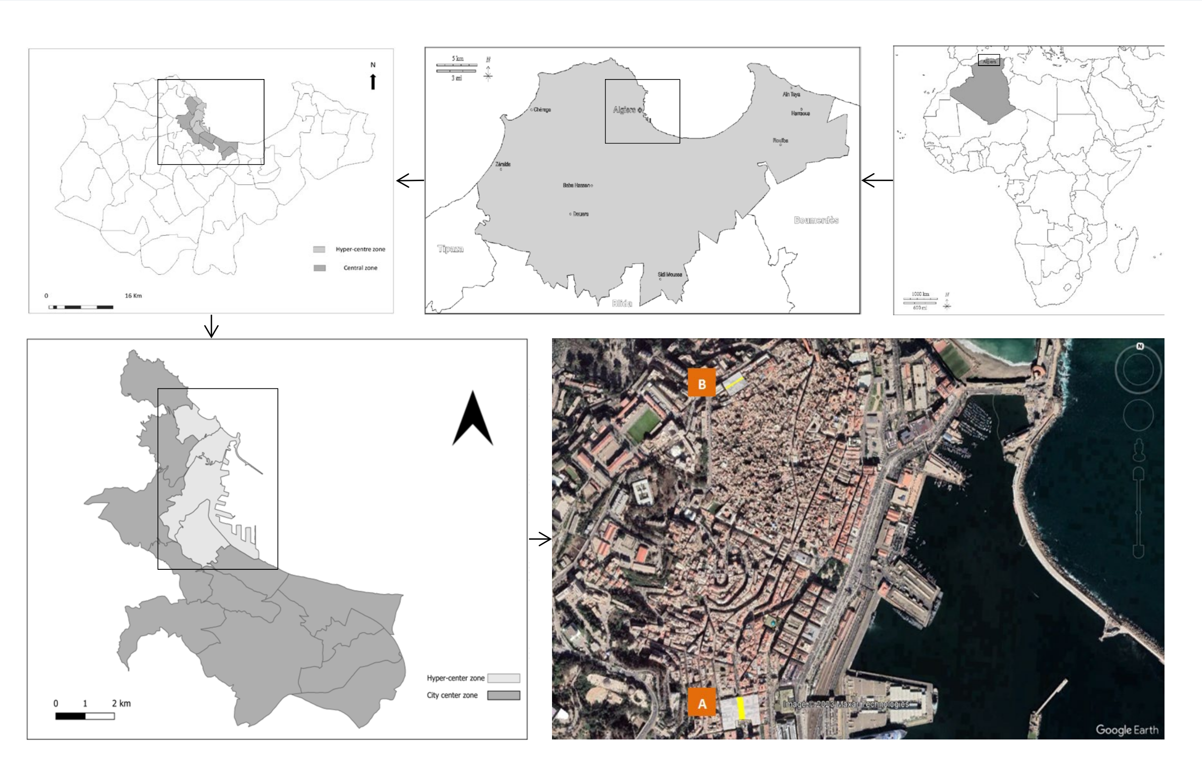
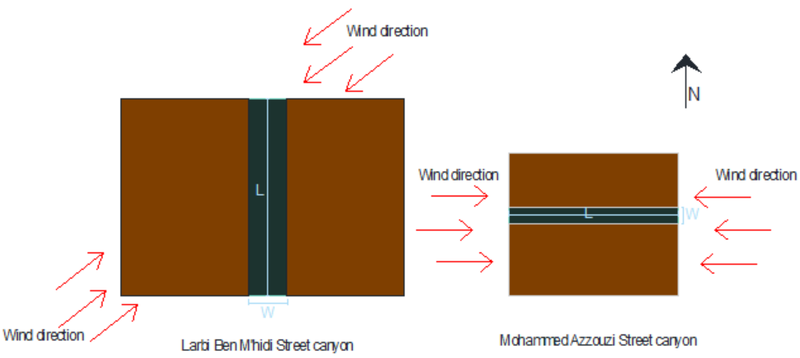



**Figure 1** The location of the selected canyon streets in the hyper-central zone of Algiers: (A) Larbi Ben M'Hidi Street; (B) Mohammed Azzouzi Street

### *2.1.2. Criteria for Selecting Canyon Streets*

This work focuses on two canyon street configurations located in two distinct urban fabrics that characterize the city center of Algiers: Mohammed Azzouzi Street and Larbi Ben M'Hidi Street, located in the medieval organic fabric (the Medina) and the colonial fabric, respectively (see Figure 1).

The selection criteria for these two canyon streets are based on those of the CODASC database developed by the University of Karlsruhe in Germany (see Sections 2.2 and 2.3). The characteristics of the climatic and geometric parameters defining the two selected canyons, which share similarities with those in the CODASC database, include the canyon aspect ratio (AR= 1 and AR= 2), wind direction penetrating the street (α= 0° and α= 45°), and trees along streets (zero trees and low vegetation density i.e. stand density loose ρs = 0,5 and crown porosity PVol = 96.0% [λ = 200m-1]). The advantage of using the CODASC database is that it is not specific to a particular climate, since it was created from simulations carried out in a wind tunnel by varying several parameters (Gromke, 2013; CODASC, 2022). Consequently, the morpho-climatic characteristics of the streets chosen in Algiers are thus adapted to the criteria of the CODASC database. The 2D and 3D plans of the selected canyons are shown in Figure 2.



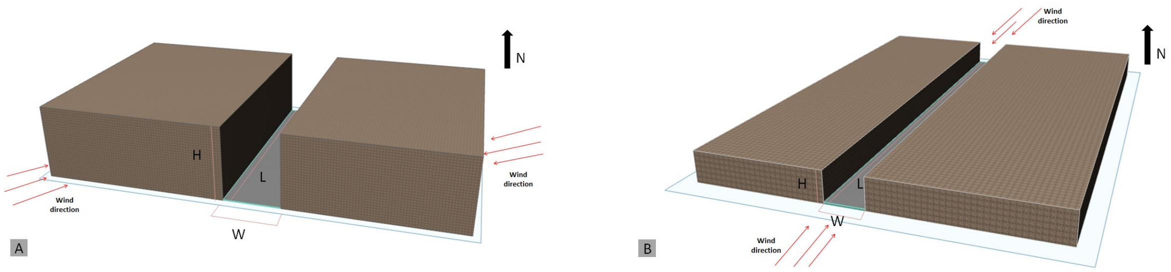



**Figure 2** 2D and 3D plans of the selected canyon streets with the prevailing wind direction (A) Larbi Ben M'Hidi Street with an aspect ratio (AR=2) and inclined wind (α=45°) (B) Mohamed Azzouz Street with an aspect ratio (AR=1) and parallel wind (α=0°) (Source: Authors)

### *2.2. Theoretical Framework*

To achieve the objective outlined above, the concentration patterns of pollutants within Larbi Ben M'Hidi and Mohammed Azzouzi streets are analyzed, taking into account the specific morphological and microclimatic parameters of the canyons. The approach of this study is primarily based on the CODASC database, which provides statistical data and simulated parametric models related to pollutant concentrations in various canyon street configurations derived from wind tunnel studies (See details at the following link: https://www.umweltaerodynamik.de/bilder-originale/CODA/CODASC.html). After selecting streets with characteristics similar to those in the CODASC database, we can extract pollutant concentration patterns for these two canyon streets. In this case, areas of higher or lower pollutant concentrations, both polluted and clean, can be identified. Canyon geometry and urban microclimate variables will be used as explanatory factors for air pollutant concentration profiles in urban canyons, alongside relevant previous studies. Figure 3 outlines the procedures adopted to achieve the objective described above.

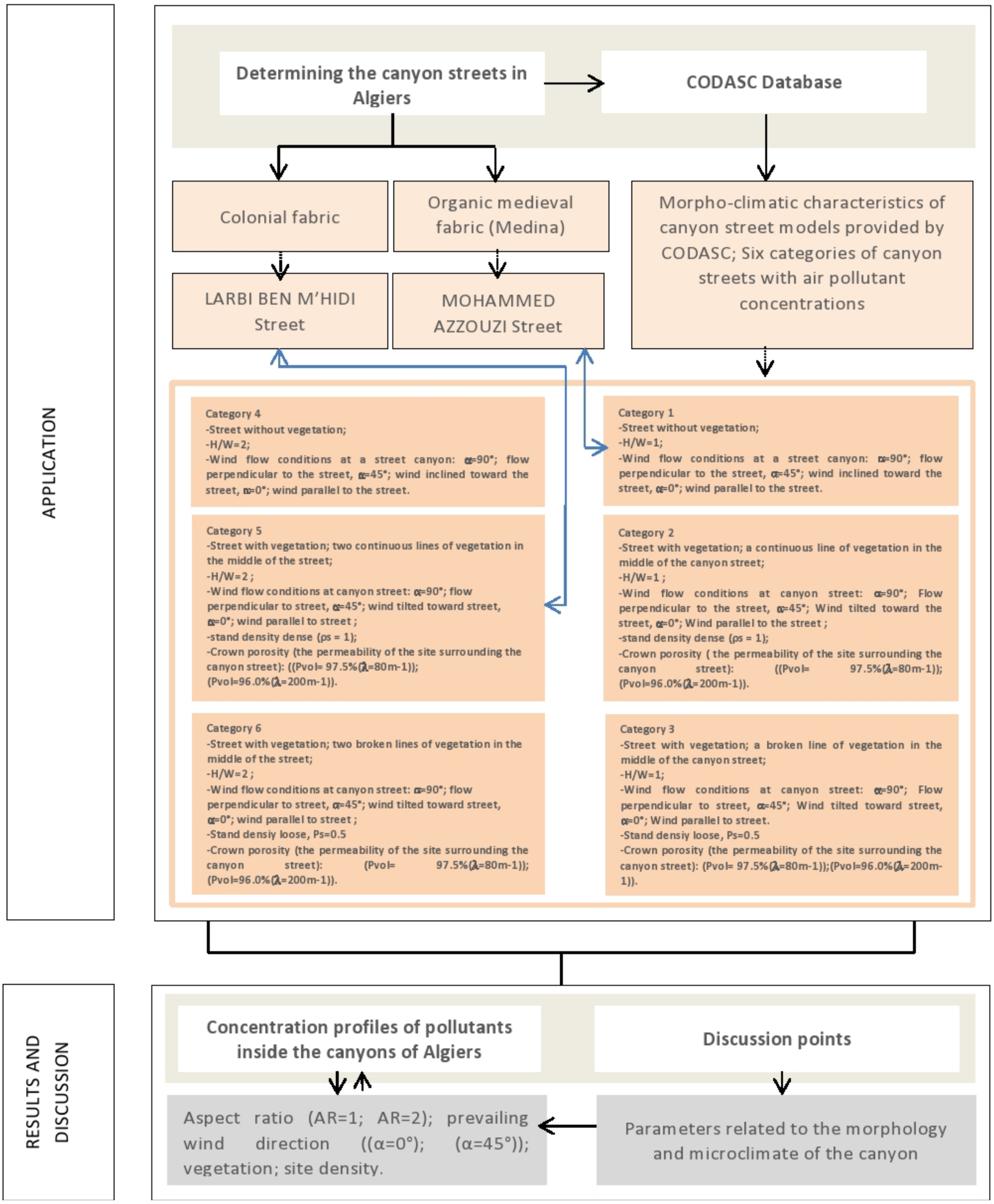



**Figure 3** Method design diagram (Source: Authors, using the CODASC database)

### *2.3. Morpho-Climatic Characteristics of Canyon Streets from the CODASC Database with Similarities to Those Selected in Algiers*

The two tables below present the characteristics of the parameters related to the morphology and microclimate of the two selected canyon streets in the city of Algiers, as well as those from the CODASC database.

**Table 1** Morphological and Climatic Parameters of the Canyon Streets in the City of Algiers

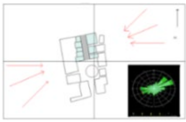
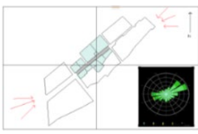
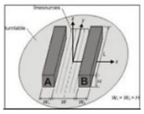
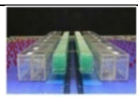
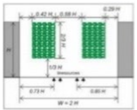
| **Larbi Ben M'Hidi Street** | | | | | |
|---|---|---|---|---|---|
| ***2D and 3D canyon plans*** | **Morpho-climatic characteristics** | | | | |
| | **Aspect ratio (AR)** | **Prevailing winds in Algiers** | **Dominant wind direction of the street** | **Vegetation density** | **Density of the area surrounding the street** |
|   | AR=2 |  The wind blows from the southwest (SW) to the northeast (NE) |  Wind inclination towards the street at an angle of α= 45° | Vegetated street | Impermeable site with high density |
| **Mohammed Azzouzi Street** | | | | | |
| **2D and 3D canyon plans** | **Morpho-climatic characteristics** | | | | |
| | **Aspect ratio (AR)** | **Prevailing winds in Algiers** | **Dominant wind direction of the street** | **Vegetation density** | **Density of the area surrounding the street** |
|   | AR=1 |  The wind blows from the southwest (SW) to the northeast (NE) |  Wind parallel to the street at α= 0° | Street without vegetation | Impermeable site with high density |

**Table 2** Morphological and Climatic Parameters of the Canyon Streets Provided by the CODASC Database

| Canyon streets from the CODASC database | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Category 1: Corresponding to Mohammed Azzouzi street** | | | | **Category 5: Corresponding to Larbi Ben M'Hidi street** | | | |
| **Canyon plans** | **Aspect ratio (H/W)** | **Wind flow entering the canyon street** | **Tree planting** | **Canyon plans** | **Aspect ratio (H/W)** | **Wind flow entering the canyon street** | **Tree planting** |
|   | H/W= 1 | Wind parallel to the street (α= 0°) | Without Trees : Pvol=100% |    | H/W= 2 | Wind inclined towards the street (α=45°) | With trees : Low vegetation density, i.e. stand density loose (ps = 0,5) and crown porosity (PVol = 96.0% [λ = 200m-1]). |

## 2.4. Validation Methods

In situ measurements and multiple linear regression statistical analysis were conducted in the selected canyons to validate the direct application of the CODASC database in terms of pollutant concentration variations across different canyon-type street configurations, compared to those in the city of Algiers with similar morpho-climatic characteristics. In situ measurements of pollutant concentrations and microclimatic parameters were taken at various points within the studied canyons during the evening rush hour at 3 points at wall A and at 3 other points at wall B of Larbi Ben M’hidi street and the same approach was adopted for Mohammed Azzouzi Street on a summer working day, July 31, 2022, using an APOMOS (Air Pollution Monitoring System) fine particle analyzer. The locations of the measurements points within the studied canyons are shown in Figures 4 and 5 below.

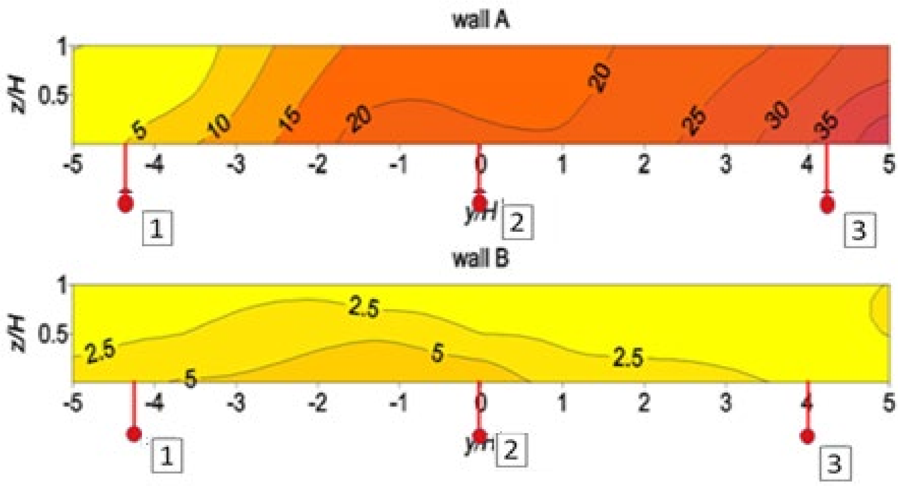



**Figure 4** Position of the fine particle concentration measurement points at Larbi Ben Mhidi Street (Source: Authors, using the CODASC database)

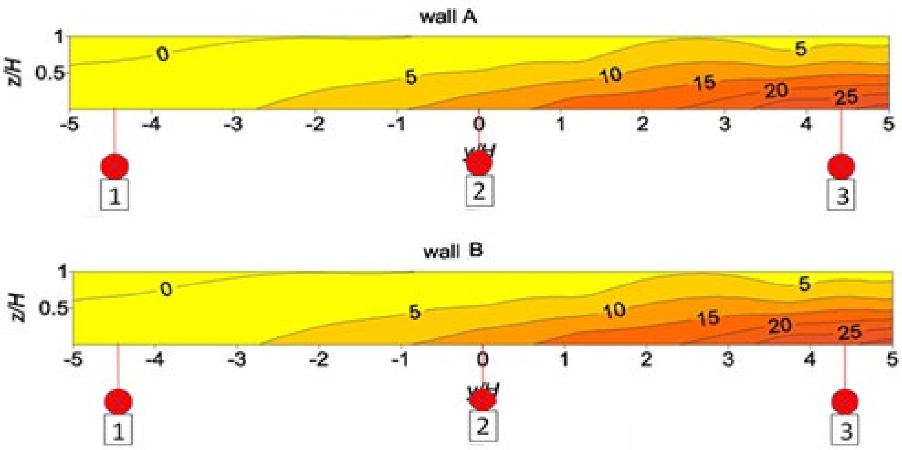



**Figure 5** Location of the fine particle concentration measurement points on Mohammed Azzouzi Street (Source: Authors, using the CODASC database)

### 2.5. The APOMOS Analyzer

The APOMOS analyzer used in this study is equipped with the GP2Y1010AU0F particle sensor and the DHT22 temperature and humidity sensor. These components are controlled by the PIC16F1825 microcontroller.

The GP2Y1010AU0F sensor is equipped with an infrared emitting diode and a phototransistor arranged diagonally. Thus, it detects light reflected from dust in the air. It is particularly effective for detecting fine particles (Tasić et al., 2016). The low cost of the APOMOS system components allows for the production of multiple units to assess particle pollution. This solution is attractive for developing countries that lack air quality measurement networks and the budgets required to purchase conventional analyzers. Figure 6 shows two units of the APOMOS system for assessing particle pollution.


**Figure 6** Particle analyzers equipped with the GP2Y1010AU0F micro-sensor

The APOMOS analyzer was calibrated with a conventional analyzer of the Ethera Nemo type which is shown in Figure 7.


**Figure 7** Classic Ethera Nemo type analyzer

## 3. Results and Discussion

### *3.1. Concentration of Pollutants in the Selected Canyon Streets*

The results of the topology of the normalized average pollutants concentration within the selected canyon streets, corresponding to those in the CODASC database, are displayed in the urban canyon model. The model shows AR= 2, PS= 0.5, and PVol= 96.0% for Larbi Ben M'Hidi canyon street, and AR= 1, PS= 0, and PVol= 100% for Mohammed Azzouzi canyon street. Regarding the wind flow, it is inclined toward the street with α= 45° in the first case and parallel to the street with α= 0° in the second case (Figure 8, 9, 10).

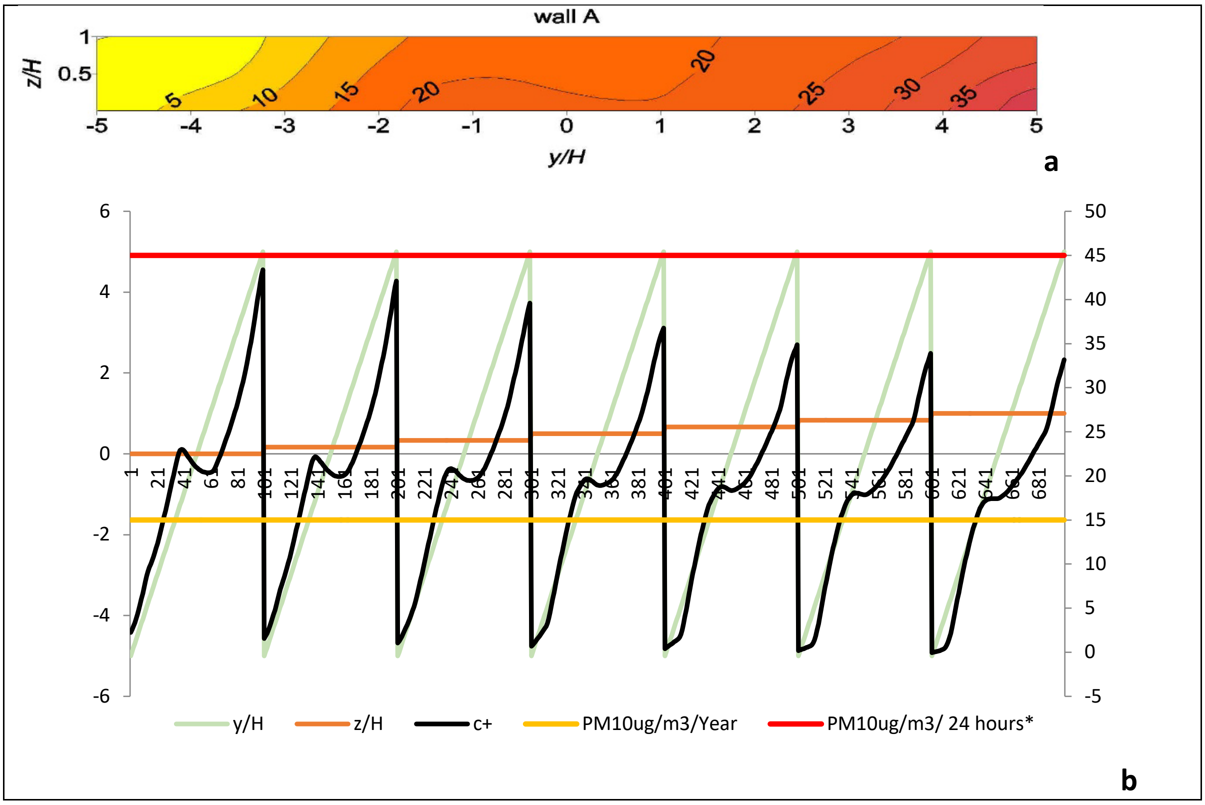



**Figure 8** (a): Model of the average standardized pollutant concentrations (C+) characterizing Larbi Ben M'Hidi Canyon Street (b): Profiles of normalized average pollutant concentrations (C+) compared to the Y/H and Z/H axes on wall A of Larbi Ben M'Hidi Canyon Street, with profiles defining the air quality standards for fine particulate matter (PM10) recommended by the WHO in 2021

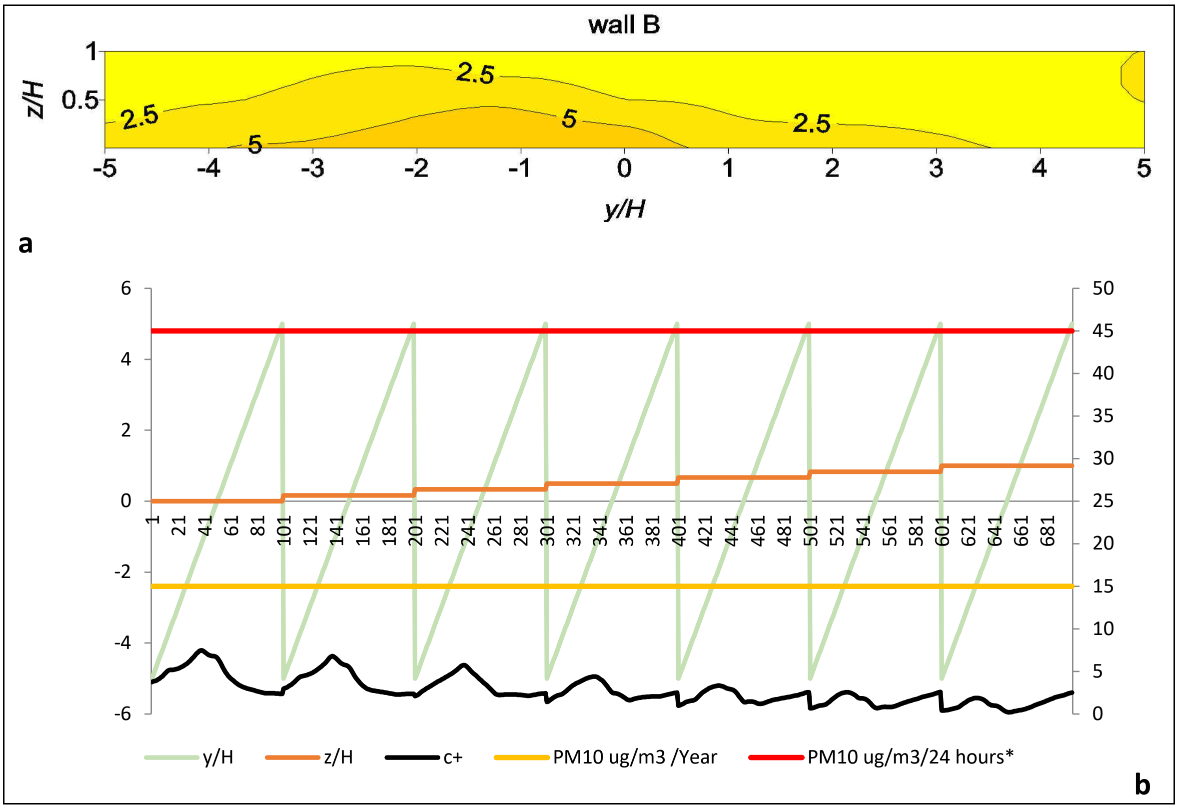



**Figure 9** (a): Model of the average standardized pollutant concentrations (C+) characterizing Larbi Ben M'Hidi Canyon Street (b): Profiles of normalized average pollutant concentrations (C+) compared to the Y/H and Z/H axes on wall B of

Larbi Ben M'Hidi Canyon Street, with profiles defining the air quality standards for fine particulate matter (PM10) recommended by the WHO in 2021

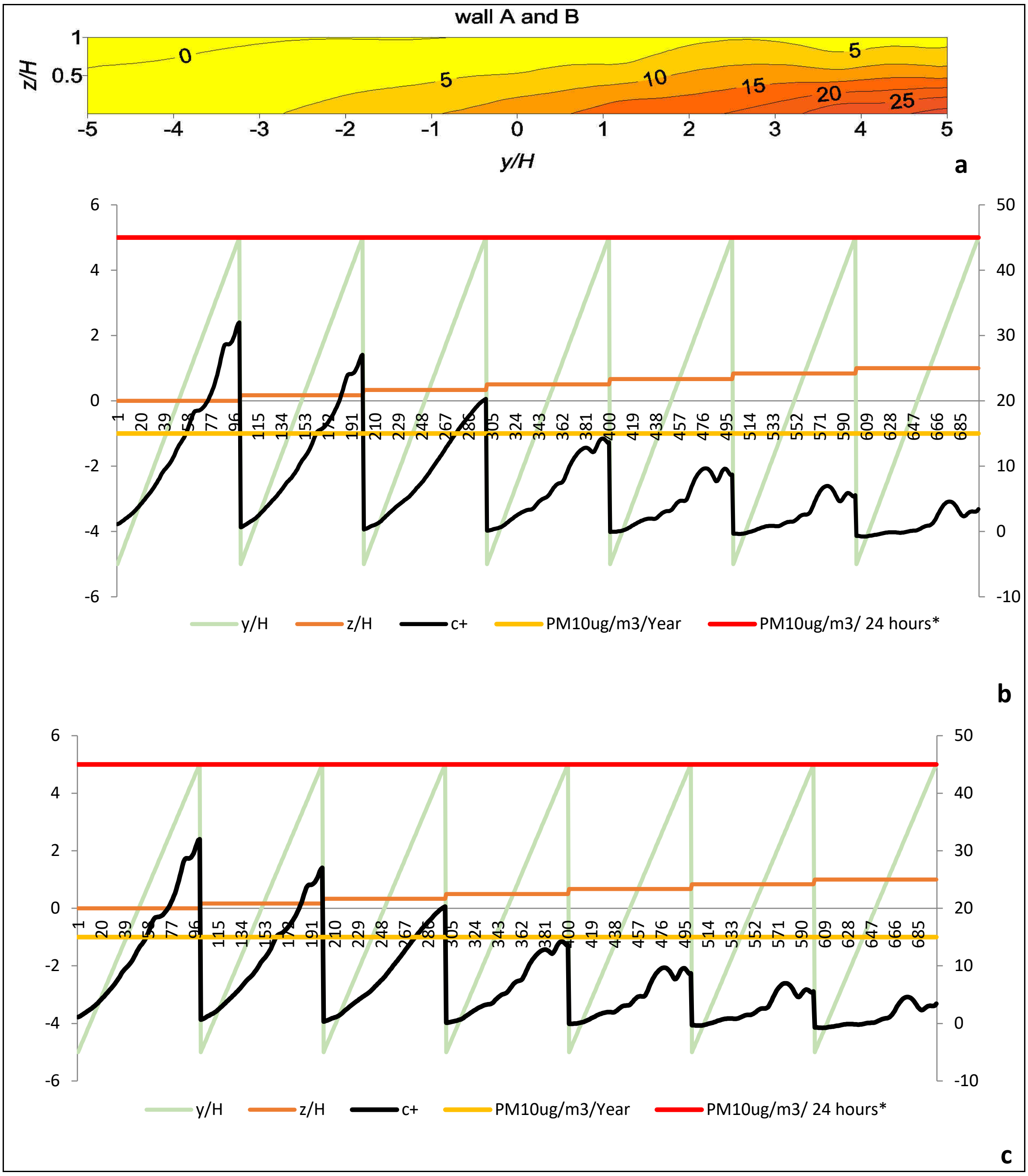



**Figure 10** (a): Model of the average standardized pollutant concentrations (C+) characterizing Mohammed Azzouzi Canyon Street (b) and (c): Profiles of normalized average pollutant concentrations (C+) compared to the Y/H and Z/H axes on walls A and B of Mohammed Azzouzi Canyon Street, with profiles defining the air quality standards for fine particulate matter (PM10) recommended by the WHO in 2021

### *3.2. Validation Results*

#### *3.2.1. Comparison of Measured Pollutant Concentration Profiles with Those Presented by CODASC Database*

Figure 11 shows measurements taken on Sunday, July 31, 2022, which is a weekday in Algiers. Vehicle traffic on the selected streets was estimated at 971 UVP during the evening rush hour for Larbi Ben M'hidi Street, a major traffic route, and 0 UVP on Mohammed Azzouzi Street, a pedestrian street.

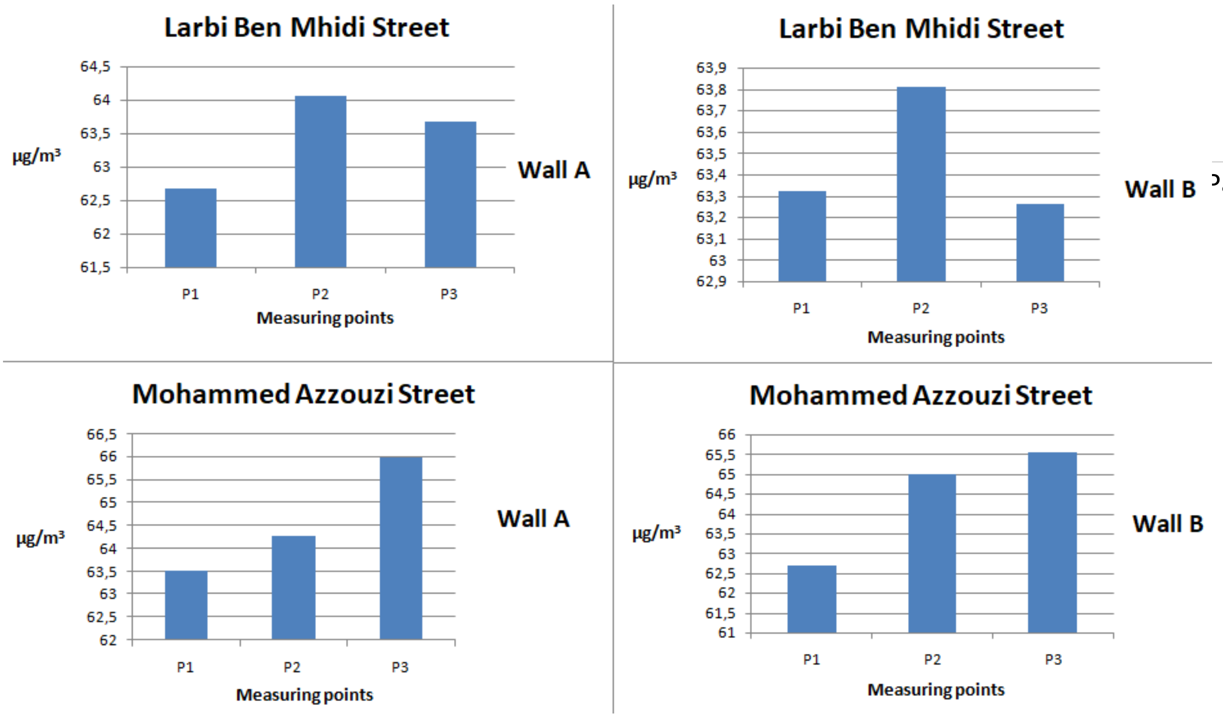



**Figure 11** Concentration of Fine Particle Pollution Collected by the APOMOS Analyzer on Larbi Ben Mhidi and Mohammed Azzouzi Streets on Sunday, July 31, 2022

The measurement results show that the variations in concentrations in the selected streets largely correspond to the variations shown by the CODASC database.

### *3.2.2. Multiple Linear Regression Statistical Analysis Model*

The statistical model developed is based on all the data measured within the selected urban canyons, with a simulation of these data using a multiple linear regression test. The result of this simulation reveals significant correlations between the measured particulate concentrations and the street characterization data, CODASC data, and meteorological data, as shown in the correlation matrix presented in Figure 12.

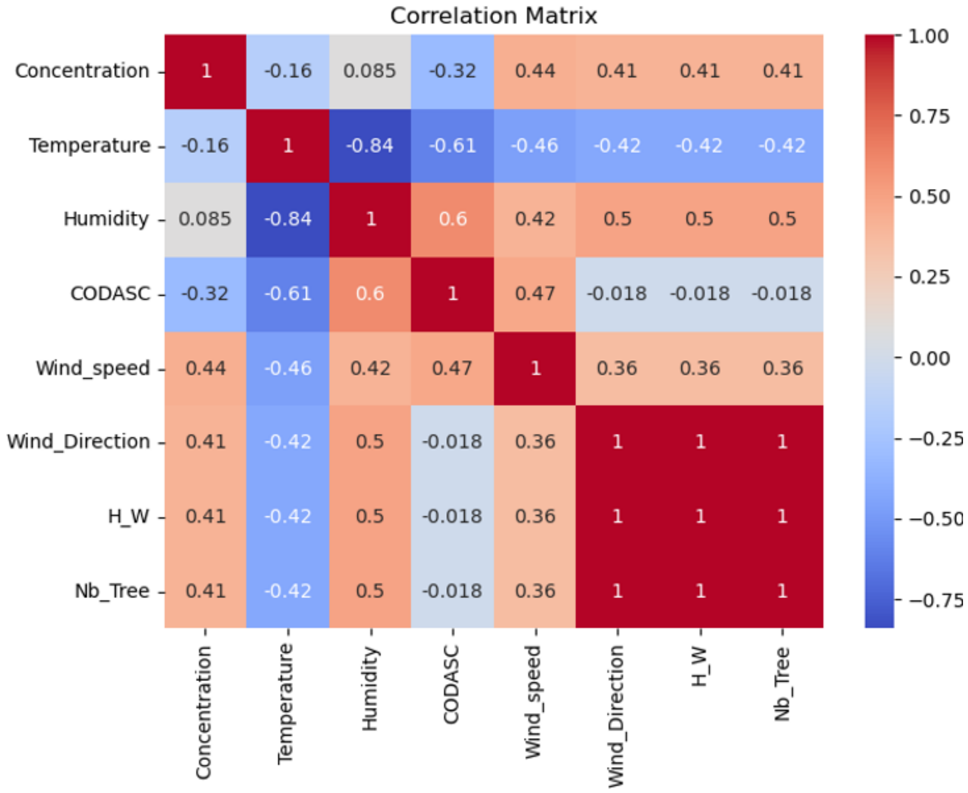



**Figure 12** Correlation matrix between the parameters influencing the concentration of particulate pollution in the streets studied

A multiple linear regression was performed to simulate particulate pollution concentration values using data from the CODASC database, street characteristics, and meteorological data. Comparison between recorded and simulated values showed a coefficient of determination of 99.80%, as shown in Figure 13.

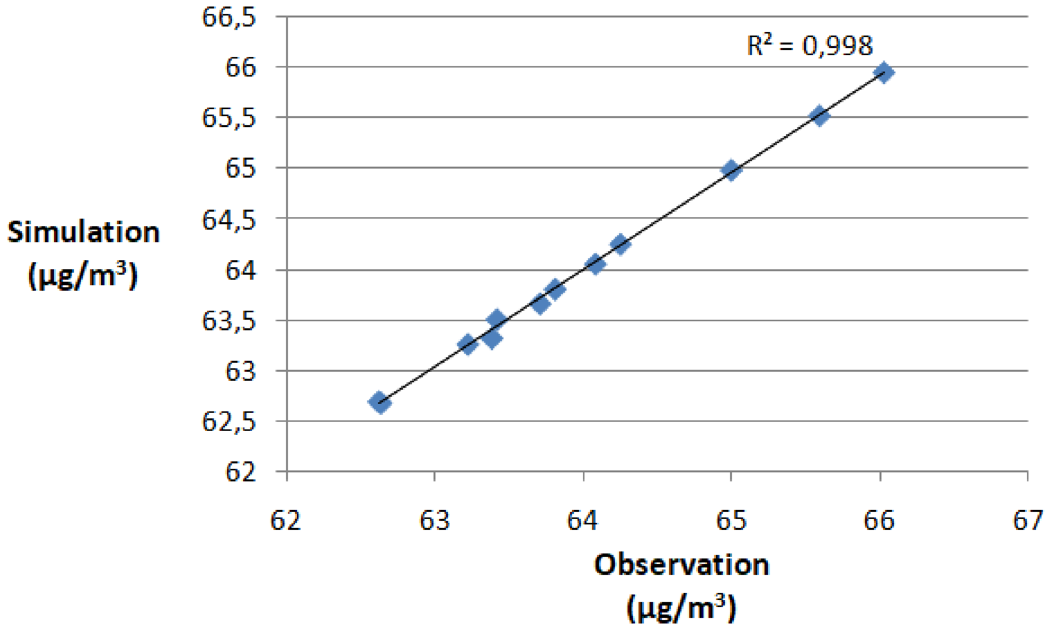



**Figure 13** Scatter plot comparison between observed and simulated particle pollution concentrations in the streets studied

### 3.3. Confrontation of Pollutant Concentrations and Morpho-Climatic Characteristics

#### 3.3.1. Aspect Ratio (AR) =H/W = 1 and 2

The concept of aspect ratio (AR) is one of the morphological parameters specific to Canyon Streets. It is related to the height of the building (H) and the width of the street (W), and the equation that expresses it is AR=H/W (Hassan et al., 2022). A very deep Canyon Street corresponds to an H/W value greater than 2, a semi-deep Canyon to an H/W value equal to 1, and a wide Canyon to an H/W value less than 1 (Fouzia & Bourbia, 2011; Athamena, 2012). A long Canyon Street corresponds to a ratio of L/H<7, a medium Canyon Street corresponds to L/H=5, and a short Canyon Street corresponds to L/H<3, where L is the length of the canyon and H is the height of the Canyon (He et al., 2019; Muniz-Gäal et al., 2020). These ratios significantly impact airflow and pollutant concentrations inside Canyon Streets (da Silva et al., 2022; He et al., 2019; Li et al., 2020; Voordeckers, Meysman et al., 2021).

It should be noted that the two street cases chosen for this study have two common characteristics: both are short canyons, with an L/H ratio of less than 3, and their immediate environment is dense. Therefore, in the interpretation of the results, the elements to be discussed are the direction of the wind entering the street, the aspect ratio (AR), vegetation, and their impacts on the pollutant concentrations.

PM10 is generally considered a primary indicator of fine particle pollution from road traffic at the local level (Ladji et al., 2009; Talbi et al., 2018; Belarbi et al., 2020). Considering this pollutant, Figures 8, 9, and 10 show the variation in average normalized concentrations (C+) of pollutants on both sides of Larbi Ben M'Hidi and Mohamed Azzouzi canyons Streets. By analyzing the pollutant concentration values displayed in the graphs above, we observe that the peak pollutant concentration values in Larbi Ben M'Hidi Canyon Street are higher than those in Mohamed Azzouzi Canyon Street. Indeed, the maximum normalized average concentration values of pollutants (C+) for Larbi Ben M'Hidi Canyon Street reached 41.95 and 7.27 for walls A and B, respectively (see graphs 8 and 9), whereas in Mohamed Azzouzi Canyon Street, this concentration value (C+) reached 31.33 for both walls A and B (see graphs 10). Moreover, when comparing the peak (C+) values of the two canyons with the PM10 values recommended by the World Health Organization (WHO, 2021), we notice that these values exceed the admissible annual standards of 15ug/m3, contrary to the daily standard of 45ug/m3, in most walls of both canyons, except for wall B of Larbi Ben M'Hidi (See Figures 8, 9, 10). However, it can be said that the population frequenting Larbi Ben M'Hidi Canyon Street, especially near wall A, is more vulnerable to the effects of daily PM10 concentration values than those frequenting Mohammed Azzouzi Canyon Street near both walls A and B (See graph b in Figure 8 and graph b in Figure 10). These higher pollutant levels related to road traffic are likely due to the higher aspect ratio of Larbi Ben M'Hidi Street (H/W=2; deep street canyon), which is greater than that of Mohammed Azzouzi Street (H/W=1; shallow street canyon). This is consistent with the results of previous studies, which have shown that a deeper aspect ratio (AR) plays a key role in increasing pollutant concentration levels (Gromke & Ruck, 2012; Di Bernardino et al., 2018; Voordeckers, Meysman et al., 2021). Furthermore, (Baik & Kim, 1999; Tan et al., 2019; Zhang et al., 2020) demonstrated in their studies that deep canyons largely favor the trapping of pollutants near the walls due to the greater buildings height and the narrow width of the street. This creates a very confined space that prevents air circulation and favors the accumulation of pollutants. In contrast, shallow canyons allow pollutants to be more freely distributed, through the availability of space for air circulation, which provides better ventilation conditions due to the lower building height and the wider width of the canyon. This ultimately leads to a reduction in the concentration levels of pollutants near the ground.

#### 3.3.2. Prevailing Wind Direction in the Canyon Street

When Larbi Ben M'Hidi street is subjected to an oblique wind direction (α = 45°), the normalized average pollutant concentrations (C+) are higher on wall A than on wall B (see Figures 8 and 9). This is due to wall A being on the leeward side, while wall B is on the windward side, where concentrations are lower (Gromke & Ruck, 2008). Consequently, a flow regime is established in this context, specifically a corkscrew flow regime that promotes the accumulation of pollutants in the leeward parts of the canyon (Gromke & Ruck, 2012; He et al., 2019). Additionally, the wind flow inclined towards the canyon, may first impact wall B and then move towards wall A, influenced by obstacles in the middle of the street, such as vehicles and vegetation, which affect the wind direction within the canyon (Buccolieri et al., 2011; Makar et al., 2021). As a result, under these conditions, particularly when vegetation density is very high, traffic is dense, and buildings are closely spaced, vortices are generated. These vortices can alter the wind direction and contribute to the accumulation of pollutants near the ground in the canyon street. This is especially evident on wall A, located on the leeward side, where pollutant concentrations are much higher compared to wall B, located on the windward side, which experiences lower concentrations (see Figure 9) (Zhang et al., 2020).

In the case where Mohammed Azzouzi Street is subjected to a parallel wind direction ($\alpha = 0°$), the normalized average pollutant concentrations (C+) are the same and parallel for both walls A and B (See Figure 10). As shown in Figure 10, due to the channeling flow formed inside the canyon, pollutants accumulate in the final part of the canyon (Gromke & Ruck, 2012; He et al., 2019; Voordeckers, Meysman et al., 2021). This type of airflow creates a direct relationship with the concentration of pollutants. Specifically, when the wind blows straight down the street, it indicates that there are no obstacles, such as trees and cars, which would otherwise reduce the vertical exchange of air with the atmosphere above. As a result, pollutants tend to accumulate towards the end of the street, where the wind direction concludes. On the other hand, ventilation in the part of the canyon exposed to the wind, particularly at the beginning of the street, remains more effective, and pollutant concentrations are lower, as shown in Figure 10 (Huang et al., 2019).

### *3.3.3. Tree Planting in Canyon Street*

Larbi Ben M'Hidi canyon street is characterized by the presence of trees along both sides of the street, which are associated with low stand density ($\rho ts = 0.5$) and low crown porosity (PVol = 96.0%; $\lambda$ = 200m-1), where $\lambda$ is the pressure loss coefficient of the tree crown. In contrast, Mohammed Azzouzi Street has no trees, i.e. zero stand density ($\rho ts = 0$) and (PVol= 100%). Previous studies have shown that the presence of trees in a street affects wind behavior, including its direction and speed, as well as pollutant concentration levels (Buccolieri et al., 2011; Gromke & Ruck, 2012; Karttunen et al., 2020). Higher pollutant concentration values were observed in Larbi Ben M'Hidi Street, unlike those in Mohammed Azzouzi Street (see Figures 8, 9, 10). This can be explained by the presence of trees, even at low stand density ($\rho ts = 0.5$) and low crown porosity (PVol = 96.0%; $\lambda$ = 200m-1). The low stand density means that pollutants are captured by direct deposition to a limited extent in Larbi Ben M'Hidi Street. At the same time, the low crown porosity means that the trees are dense, with little space for air to pass through. This prevents air from circulating beneath the trees, reducing both vertical and lateral dispersion of air, and thus increasing the accumulation of pollutants at the street level (Gromke et al., 2008; Salmond et al., 2013; Vos et al., 2013; Abhijith et al., 2017).

## 4. Conclusion and Recommendation

This study aims to explore the theoretical use of the CODASC database to interpret the heterogeneity of air pollutant concentration patterns in two types of urban canyons.

We propose a methodology for this work, which is primarily based on selecting canyon streets from different urban fabrics in Algiers, specifically the medieval organic fabric and the colonial fabric. These canyons were chosen because they share similarities with those in the CODASC database in terms of aspect ratio (H/W), direction of the prevailing wind ($\alpha$), and tree planting ($\rho ts$ and PVol). Consequently, the selected canyons are Larbi Ben M'Hidi Canyon Street in the colonial fabric and Mohammed Azzouzi Canyon Street in the medieval organic fabric.

The typologies and normalized average air pollutant concentration profiles (C+) representing the canyon models studied demonstrate that the highest pollutant concentration levels are clearly associated with canyon depth, which is strongly influenced by the aspect ratio (H/W), determining whether the canyon is deep or shallow. In addition, the perpendicular wind (α=45°) results in higher pollutant concentrations on the leeward wall compared to the windward wall, while the parallel wind (α=0°) shows lower concentrations along both sides of the walls, except at the extreme ends of the canyon. Furthermore, the presence of trees negatively affects pollutant concentration levels due to their unsuitable morphology on Larbi Ben M'Hidi Street, in contrast to Mohammed Azzouzi Street, which has no trees, leading to lower pollutant concentrations.

The statistical model developed in this study allows for simulations and scenario studies aimed at mitigating particulate pollution in canyon-type streets by adjusting appropriate parameters. However, to gain a better understanding of the methodology developed, it is necessary to analyze additional streets and rely on continuous air quality measurements. This will increase the data volume and allow it to be processed and analyzed by machine learning algorithms to develop even more powerful models.

The study of the impact of geometric and microclimatic parameters of canyons on air quality using CFD numerical simulations should be considered during the design phase of future sustainable urban development projects in Algiers. This could include, for example, the grouping of morpho-climatic parameters that favor the prevention of pollutant accumulation as a mitigation strategy for urban pollution. Key factors include: an aspect ratio that is either shallow or wide; surrounding areas of canyon streets that should be permeable to facilitate air exchange; wind direction, which should preferably be parallel to the canyon axis; and trees, which should be planted on the walls and roofs of buildings bordering the urban canyon to avoid disrupting air flow in the street. For future research, the use of the CODASC database should evolve from theoretical to practical by incorporating new configurations of canyon streets. Furthermore, urban planners and policymakers should take advantage of the presence of dilapidated buildings to carry out urban restructuring that involves creating openings parallel to prevailing winds, removing obstacles to winds, reinforcing vegetation cover, and reducing aspect ratios in new urban fabrics or through heightening in preserved fabrics.

## Acknowledgement

*The Directorate General for Scientific Research and Technological Development (DGRSDT) of the Algerian Ministry of Scientific Research, the Laboratory of Environment and Technology for Architecture and Heritage (ETAP) at the University of Saad Dahlab Blida 1, the Laboratory of Sciences, Technology and Process Engineering at the University of Sciences and Technology of Oran, Mohamed Boudiaf, and the Image Ville et Environnement Laboratory at the University of Strasbourg in France for providing us with the Ethera Nemo analyzer, which enabled us to calibrate the APOMOS analyzer used in this study, are gratefully acknowledged.*

## References

Abderrahim, H., Chellali, M. R., & Hamou, A. (2016). Forecasting PM10 in Algiers: Efficacy of multilayer perceptron networks. *Environmental Science and Pollution Research*, *23*(2), 1634–1641. https://doi.org/10.1007/s11356-015-5406-6

Abhijith, K. V., Kumar, P., Gallagher, J., McNabola, A., Baldauf, R., Pilla, F., Broderick, B., Di Sabatino, S., & Pulvirenti, B. (2017). Air pollution abatement performances of green infrastructure in open road and built-up street canyon environments – A review. *Atmospheric Environment*, *162*(8), 71–86. https://doi.org/10.1016/j.atmosenv.2017.05.014

Ali-Khodja, H., Belaala, A., Demmane-Debbih, W., Habbas, B., & Boumagoura, N. (2008). Air quality and deposition of trace elements in Didouche Mourad, Algeria. *Environmental Monitoring and Assessment*, *138*(1–3), 219–231. https://doi.org/10.1007/s10661-007-9792-1

Athamena, K. (2012). *Modélisation et simulation des microclimats urbains : Etude de l'impact de la morphologie urbaine sur le confort dans les espaces extérieurs*. Cas des Eco-Quartiers (Doctoral dissertation, Ecole Centrale de Nantes (ECN). https://theses.hal.science/tel-00811583/

Baik, J. J., & Kim, J. J. (1999). A numerical study of thermal effects on flow and pollutant dispersion in urban street canyons. *Journal of Applied Meteorology*, *38*(11), 1576_1589. https://doi.org/https://doi.org/10.1175/1520-0450(1999)038<1576:ANSOFA>2.0.CO;2

Baron, R., & Saffell, J. (2017). Amperometric gas sensors as a low cost emerging technology platform for air quality monitoring applications: A review. *ACS Sensors*, *2*(11), 1553–1566. https://doi.org/10.1021/ACSSENSORS.7B00620/ASSET/IMAGES/MEDIUM/SE-2017-00620N_0018.GIF

Belamri, M., Bounemia, L., Azbouche, A., Boukeffoussa, K., & Chaouch, C. L. (2017). Assessment of air pollution by heavy metals in the urban center of Algiers. *Australian Journal of Basic and Applied Sciences*, *11*(5), 35_44. https://d1wqtxts1xzle7.cloudfront.net/76615102/35_44_libre.pdf?1639772578=&response_content_disposition=inline%3B+filename%3DAssessment_of_air_pollution_by_heavy_met.pdf&Expires=1725183994&Signature=R~DItKGlWTqmbty57k5PXtqoliS8xea4jsf1FMC8KdUFkQILo-UAYYtw

Belarbi, N., Belamri, M., Dahmani, B., & Benamar, M. A. (2020). Road traffic and PM10, PM2.5 emission at an urban area in Algeria: Identification and statistical analysis. *Pollution*, *6*(3), 651–660. https://doi.org/10.22059/POLL.2020.294710.730

Belhout, D., Kerbachi, R., Relvas, H., & Miranda, A. I. (2018). Air quality assessment in Algiers city. *Air Quality, Atmosphere and Health*, *11*(8), 897–906. https://doi.org/10.1007/s11869-018-0589-x

Belhout, D., Relvas, H., Haddad, B., Kerbachi, R., & Miranda, A. I. (2021). Impact of energy efficiency policies on the air quality of a North African urban area: Emission scenarios by the horizon 2030. *Energy Efficiency*, *14*(8), 1–14. https://doi.org/10.1007/s12053-021-09986-5

Benabadji, N., Rahal, F., & Menakh, I. N. (2024). Datalogger prototyping for NH3 ground concentrations measures and comparison with NH3-IASI generated datamaps. *AIUB Journal of Science and Engineering (AJSE)*, *23*(2), 177–185. https://doi.org/10.53799/AJSE.V23I2.826

Benselhoub, A. M., Kharytonov, M. M., Zaichenko, A. O., & Stankevich, S. A. (2015). Environmental risks of man-made air pollution in Grand Algiers. *Journal of the Georgian Geophysical Society*, *18*(19), 43–51. https://ggs.openjournals.ge/index.php/GGS/article/view/1748

Boppana, V. B. L., Wise, D. J., Ooi, C. C., Zhmayev, E., & Poh, H. J. (2019). CFD assessment on particulate matter filters performance in urban areas. *Sustainable Cities and Society*, *46*(January), 101376. https://doi.org/10.1016/j.scs.2018.12.004

Boubezari, M. (2021). Which urban development for Algiers far from oil dependency? Towards TOD solution. *56th ISOCARP World Planning Congress in Doha, Qatar International Society of City and Regional Planners*. https://doi.org/10.47472/jxdr4596

Boughedaoui, M., Kerbachi, R., Kessali, D., & Joumard, R. (2004). Mesure de la pollution plombifère dans l'air ambiant d'Alger. *Pollution Atmospherique*, *46*(181), 105–112. https://doi.org/10.4267/pollution-atmospherique.1602

Buccolieri, R., Carlo, O. S., Rivas, E., Santiago, J. L., Salizzoni, P., & Siddiqui, M. S. (2022). Obstacles influence on existing urban canyon ventilation and air pollutant concentration: A review of potential measures. *Building and Environment*, *214*(2), 108905. https://doi.org/10.1016/j.buildenv.2022.108905

Buccolieri, R., Salim, S. M., Leo, L. S., Di Sabatino, S., Chan, A., Ielpo, P., de Gennaro, G., & Gromke, C. (2011). Analysis of local scale tree-atmosphere interaction on pollutant concentration in idealized street canyons and application to a real urban junction. *Atmospheric Environment*, *45*(9), 1702–1713. https://doi.org/10.1016/j.atmosenv.2010.12.058

Cebi Kilicoglu, M., & Zeren Cetin, I. (2024). Determination of the suitable biomonitors to be used in monitoring the change for reducing the concentration of v in areas with high-level of air pollution. *Bulletin of Environmental Contamination and Toxicology*, *113*(6), 63. https://doi.org/10.1007/S00128-024-03966-Y/METRICS

Cetin, M., Adiguzel, F., & Zeren Cetin, I. (2023). Determination of the effect of urban forests and other green areas on surface temperature in Antalya. In Concepts and Applications of Remote Sensing in Forestry (pp. 319–336). *Springer*, Singapore. https://doi.org/10.1007/978-981-19-4200-6_16

Cetin, M., Cebi Kilicoglu, M., & Kocan, N. (2023). Usability of biomonitors in monitoring the change of tin concentration in the air. *Environmental Science and Pollution Research*, *30*(52), 112357–112367. https://doi.org/10.1007/S11356-023-30277-2/METRICS

Cetin, M., Sevik, H., Koc, I., & Zeren Cetin, I. (2023). The change in biocomfort zones in the area of Muğla province in near future due to the global climate change scenarios. *Journal of Thermal Biology*, *112*, 103434. https://doi.org/10.1016/J.JTHERBIO.2022.103434

Cevik Degerli, B., & Cetin, M. (2023). Evaluation of UTFVI index effect on climate change in terms of urbanization. *Environmental Science and Pollution Research*, *30*(30), 75273–75280. https://doi.org/10.1007/S11356-023-27613-X/METRICS

CODASC. (2022). *Laboratory of building and Karlsruhe Institute of Technology KIT*. Accessed on 19 December 2022. https://www.umweltaerodynamik.de/bilder-originale/CODA/CODASC.html

da Silva, F. T., Reis Jr, N. C., Santos, J. M., Goulart, E. V., & de Alvarez, C. E. (2022). Influence of urban form on air quality: The combined effect of block typology and urban planning indices on city breathability. *Science of the Total Environment*, *814*(3), 152670. https://doi.org/10.1016/j.scitotenv.2021.152670

Di Bernardino, A., Monti, P., Leuzzi, G., & Querzoli, G. (2018). Pollutant fluxes in two-dimensional street canyons. *Urban Climate*, *24*(7), 80–93. https://doi.org/10.1016/j.uclim.2018.02.002

Fouzia, B., & Bourbia, F. (2011). Impact de la geometrie des canyons urbains sur le confort thermique exterieur dans un climat semi aride,cas du coudiat de constantine. *The Egyptian Journal Of Environmental Change*, *3*(1), 62_67. https://www.researchgate.net/publication/322527419_Impact_de_la_geometrie_des_canyons_urbains_sur_le_confort_thermique_exterieur_dans_un_climat_semi_aride-cas_du_coudiat_de_constantine

Gromke, C. B. (2013). CODASC: A database for the validation of street canyon dispersion models. *In Proceedings of the 15th International Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes (HARMO)*, May 6-9, Madrid, Spain.

Gromke, C., Buccolieri, R., Di Sabatino, S., & Ruck, B. (2008). Dispersion study in a street canyon with tree planting by means of wind tunnel and numerical investigations - Evaluation of CFD data with experimental data. *Atmospheric Environment*, *42*(37), 8640_8650. https://doi.org/10.1016/j.atmosenv.2008.08.019

Gromke, C., & Ruck, B. (2008). Aerodynamic modelling of trees for small-scale wind tunnel studies. *Forestry*, *81*(3), 243–258. https://doi.org/10.1093/forestry/cpn027

Gromke, C., & Ruck, B. (2012). Pollutant concentrations in street canyons of different aspect ratio with avenues of trees for various wind directions. *Boundary-Layer Meteorology*, *144*(1), 41–64. https://doi.org/10.1007/s10546-012-9703-z

Hang, J., Liang, J., Wang, X., Zhang, X., Wu, L., & Shao, M. (2022). Investigation of O3–NOx–VOCs chemistry and pollutant dispersion in street canyons with various aspect ratios by CFD simulations. *Building and Environment*, *226*(12), 109667. https://doi.org/10.1016/j.buildenv.2022.109667

Hankey, S., & Marshall, J. D. (2017). Urban form, air pollution, and health. *Current Environmental Health Reports*, *4*(4), 491–503. https://doi.org/10.1007/s40572-017-0167-7

Hassan, S., Akter, U. H., Nag, P., Molla, M. M., Khan, A., & Hasan, M. F. (2022). Large-eddy simulation of airflow and pollutant dispersion in a model street canyon intersection of Dhaka city. *Atmosphere*, *13*(7), 1028. https://doi.org/10.3390/atmos13071028

He, B. J., Ding, L., & Prasad, D. (2019). Enhancing urban ventilation performance through the development of precinct ventilation zones: A case study based on the Greater Sydney, Australia. *Sustainable Cities and Society*, *47*(5), 101472. https://doi.org/10.1016/j.scs.2019.101472

Hong, B., Lin, B., & Qin, H. (2017). Numerical investigation on the effect of avenue trees on PM2.5 dispersion in urban street canyons. *Atmosphere*, *8*(7), 129. https://doi.org/10.3390/atmos8070129

Huang, Y. D., Hou, R. W., Liu, Z. Y., Song, Y., Cui, P. Y., & Kim, C. N. (2019). Effects of wind direction on the airflow and pollutant dispersion inside a long street canyon. *Aerosol and Air Quality Research*, *19*(5), 1152–1171. https://doi.org/10.4209/aaqr.2018.09.0344

Huang, Y., Lei, C., Liu, C. H., Perez, P., Forehead, H., Kong, S., & Zhou, J. L. (2021). A review of strategies for mitigating roadside air pollution in urban street canyons. *Environmental Pollution*, *280*(7), 116971. https://doi.org/10.1016/j.envpol.2021.116971

Ibrir, A., Kerchich, Y., Hadidi, N., Merabet, H., & Hentabli, M. (2021). Prediction of the concentrations of PM1, PM2.5, PM4, and PM10 by using the hybrid dragonfly-SVM algorithm. *Air Quality, Atmosphere and Health*, *14*(3), 313–323. https://doi.org/10.1007/s11869-020-00936-1

Journal Officiel de la République Algérienne Démocratique et Populaire N°10. (2006). Conventions et accords internationaux – Lois et décrets arrêtés, décisions, avis, communications et annonces. https://www.joradp.dz/FTP/jo-francais/2006/F2006010.pdf

Karttunen, S., Kurppa, M., Auvinen, M., Hellsten, A., & Järvi, L. (2020). Large-eddy simulation of the optimal street-tree layout for pedestrian-level aerosol particle concentrations – A case study from a city-boulevard. *Atmospheric Environment: X*, *6*(12), 100073. https://doi.org/10.1016/j.aeaoa.2020.100073

Kerbachi, R., Boughedaoui, M., Bounoua, L., & Keddam, M. (2006). Ambient air pollution by aromatic hydrocarbons in Algiers. *Atmospheric Environment*, *40*(21), 3995_4003. https://doi.org/10.1016/j.atmosenv.2006.02.033

Kerbachi, R., Boughedaoui, M., Koutai, N., & Lakki, T. (1998). La pollution par les oxydes d'azote et l'ozone a Alger. *Pollution Atmospherique*, *158*, 89–101. https://doi.org/10.4267/pollution-atmospherique.3520

Kerchich, Y., & Kerbachi, R. (2012). Measurement of BTEX (benzene, toluene, ethybenzene, and xylene) levels at urban and semirural areas of Algiers City using passive air samplers. *Journal of the Air and Waste Management Association*, *62*(12), 1370–1379. https://doi.org/10.1080/10962247.2012.712606

Ladji, R., Yassaa, N., Balducci, C., Cecinato, A., & Meklati, B. Y. (2009). Annual variation of particulate organic compounds in PM10 in the urban atmosphere of Algiers. *Atmospheric Research*, *92*(2), 258–269. https://doi.org/10.1016/j.atmosres.2008.12.002

Li, Z., Shi, T., Wu, Y., Zhang, H., Juan, Y. H., Ming, T., & Zhou, N. (2020). Effect of traffic tidal flow on pollutant dispersion in various street canyons and corresponding mitigation strategies. *Energy and Built Environment*, *1*(3), 242–253. https://doi.org/10.1016/j.enbenv.2020.02.002

Maag, B., Zhou, Z., & Thiele, L. (2018). A survey on sensor calibration in air pollution monitoring deployments. *IEEE Internet of Things Journal*, *5*(6), 4857–4870. https://doi.org/10.1109/JIOT.2018.2853660

Makar, P. A., Stroud, C., Akingunola, A., Zhang, J., Ren, S., Cheung, P., & Zheng, Q. (2021). Vehicle-induced turbulence and atmospheric pollution. *Atmospheric Chemistry and Physics*, *21*(16), 12291–12316. https://doi.org/10.5194/acp-21-12291-2021

Miao, C., Yu, S., Hu, Y., Bu, R., Qi, L., He, X., & Chen, W. (2020). How the morphology of urban street canyons affects suspended particulate matter concentration at the pedestrian level: An in-situ investigation. *Sustainable Cities and Society*, *55*(4), 102042. https://doi.org/10.1016/j.scs.2020.102042

Miao, C., Yu, S., Zhang, Y., Hu, Y., He, X., & Chen, W. (2023). Assessing outdoor air quality vertically in an urban street canyon and its response to microclimatic factors. *Journal of Environmental Sciences*, *124*(2), 923–932. https://doi.org/10.1016/j.jes.2022.02.021

Muniz-Gäal, L. P., Pezzuto, C. C., Carvalho, M. F. H. de, & Mota, L. T. M. (2020). Urban geometry and the microclimate of street canyons in tropical climate. *Building and Environment*, *169*(2), 106547. https://doi.org/10.1016/j.buildenv.2019.106547

Nejjari, C., Filleul, L., Zidouni, N., Laid, Y., Atek, M., Meziane, A. El, & Tessier, J. F. (2003). La pollution atmosphérique, un nouveau risque respiratoire pour les villes du sud. *Int J Tuberc Lung Dis*, *7*(3), 223–231. https://d1wqtxts1xzle7.cloudfront.net/33638229/Article_IJTLD_2003_libre.pdf?1399356743=&response_content_disposition=inline%3B+filename%3DINT_J_TUBERC_LUNG_DIS_7_3_223_231_2003_I.pdf&Expires=1725182427&Signature=M5jSqJyxG5WSb3AC6VFXMJTk-VD8cnA7vIkPaOE9VDc

Neofytou, P., Venetsanos, A. G., Rafailidis, S., & Bartzis, J. G. (2006). Numerical investigation of the pollution dispersion in an urban street canyon. *Environmental Modelling and Software*, *21*(4), 525–531. https://doi.org/10.1016/j.envsoft.2004.08.012

OECD. (2014). *The cost of air pollution: Health impacts of road transport*, OECD Publishing. http://dx.doi.org/10.1787/9789264210448-en

Oucher, N., & Kerbachi, R. (2012). Evaluation of air pollution by aerosol particles due to road traffic: A case study from Algeria. *Procedia Engineering*, *33*(2009), 415_423. https://doi.org/10.1016/j.proeng.2012.01.1221

Oucher, N., Kerbachi, R., Ghezloun, A., & Merabet, H. (2015). Magnitude of air pollution by heavy metals associated with aerosols particles in Algiers. *Energy Procedia*, *74*(8), 51_58. https://doi.org/10.1016/j.egypro.2015.07.520

Peng, Y., Gao, Z., Buccolieri, R., & Ding, W. (2019). An investigation of the quantitative correlation between urban morphology parameters and outdoor ventilation efficiency indices. *Atmosphere*, *10*(1). https://doi.org/10.3390/atmos10010033

Rahal, F. (2020). Low-cost sensors, an interesting alternative for air quality monitoring in Africa. *Clean Air Journal*, *30*(2), 1–2. https://doi.org/10.17159/CAJ/2020/30/2.9223

Rahal, F., Benabadji, N., Bencherif, M., & Bencherif, M. M. (2021). Development of a low-cost outdoor carbon monoxyde analyser applied to the city of Oran, Algeria. *Journal of Fundamental and Applied Sciences*, *13*(3), 1495–1510. https://doi.org/10.4314/jfas.v13i3.22

Rahal, F., Benharrats, N., Blond, N., Clappier, A., & Ponche, J. L. (2014). Modelling of air pollution in the area of Algiers city, Algeria. *International Journal of Environment and Pollution*, *54*(1), 32–58. https://doi.org/10.1504/IJEP.2014.064049

Rahal, F., Rezak, S., & Benabadji, N. (2020). Evaluation of the impact of the COVID-19 pandemic on photochemical pollution in urban areas. *Environmental Health Engineering and Management Journal*, *7*(4), 237–243. https://doi.org/10.34172/EHEM.2020.28

Rahal, F., Rezak, S., & Benabadji, N. (2021). Influence de la pandémie du COVID-19 sur la pollution par le dioxyde d'azote dans la ville d'Oran, Algérie. *Algerian Journal of Health Sciences*, *3*(2), 52–57. https://doi.org/10.5281/zenodo.4657587

Rai, A. C., Kumar, P., Pilla, F., Skouloudis, A. N., Di Sabatino, S., Ratti, C., Yasar, A., & Rickerby, D. (2017). End-user perspective of low-cost sensors for outdoor air pollution monitoring. *Science of The Total Environment*, *607–608*, 691–705. https://doi.org/10.1016/J.SCITOTENV.2017.06.266

Sabatino, S. Di, Buccolieri, R., Pulvirenti, B., & Britter, R. E. (2008). Flow and pollutant dispersion in street canyons using FLUENT and ADMS-urban. *Environmental Modeling and Assessment*, *13*(3), 369–381. https://doi.org/10.1007/s10666-007-9106-6

Salmond, J. A., Williams, D. E., Laing, G., Kingham, S., Dirks, K., Longley, I., & Henshaw, G. S. (2013). The influence of vegetation on the horizontal and vertical distribution of pollutants in a street canyon. *Science of the Total Environment*, *443*(1), 287–298. https://doi.org/10.1016/j.scitotenv.2012.10.101

Tabti-Talamali, A., & Baouni, T. (2018). Public transportation in Algiers: Towards a new governance approach. *Case Studies on Transport Policy*, *6*(4), 706–715. https://doi.org/10.1016/j.cstp.2018.08.009

Talbi, A., Kerchich, Y., Kerbachi, R., & Boughedaoui, M. (2018). Assessment of annual air pollution levels with PM1, PM2.5, PM10 and associated heavy metals in Algiers, Algeria. *Environmental Pollution*, *232*(1), 252–263. https://doi.org/10.1016/j.envpol.2017.09.041

Tan, W., Li, C., Wang, K., Zhu, G., & Liu, L. (2019). Geometric effect of buildings on the dispersion of carbon dioxide cloud in idealized urban street canyons. *Process Safety and Environmental Protection*, *122*(2), 271–280. https://doi.org/10.1016/j.psep.2018.12.020

Tao, Y., Zhang, Z., Ou, W., Guo, J., & Pueppke, S. G. (2020). How does urban form influence PM2.5 concentrations: Insights from 350 different-sized cities in the rapidly urbanizing Yangtze River Delta region of China, 1998–2015. *Cities*, *98*(10), 102581. https://doi.org/10.1016/j.cities.2019.102581

Tasić, V., Jovašević-Stojanović, M. Topalović, D., & Davidović, M. (2016). Measurement of PM 2 . 5 concentrations in indoor air using low-cost sensors and Arduino platforms. *In Proceedings of the 6 Th Scientific Meeting EuNetAir*, *10*, 69–72. https://doi.org/10.5162/6EuNetAir2016/18

Terniche, M., Laid, Y., Guerinik, M., & Taright, S. (2018). Symptômes respiratoires et pollution de l'air par les PM10 à Alger : Problèmes et perspectives. *Revue Des Maladies Respiratoires*, *35*(1), A231–A232. https://doi.org/https://doi.org/10.1016/j.rmr.2017.10.537

Uslu, D. Y., Almansouri, H. M. S., Elahsadi, A. H. M., &, & Çetin, M. (2024). Towards sustainable cities : Evaluating the distribution and functionality of green spaces in Atakum. *Journal of Design for Resilience in Architecture and Planning*, *5*(3), 461_476. https://doi.org/https://doi.org/10.47818/DRArch.2024.v5i3143

Vardoulakis, S., Fisher, B. E. A., Pericleous, K., & Gonzalez-Flesca, N. (2003). Modelling air quality in street canyons: A review. *Atmospheric Environment*, *37*(2), 155–182. https://doi.org/10.1016/S1352-2310(02)00857-9

Voordeckers, D., Lauriks, T., Denys, S., Billen, P., Tytgat, T., & Van Acker, M. (2021). Guidelines for passive control of traffic-related air pollution in street canyons: An overview for urban planning. *Landscape and Urban Planning*, *207*(6), 103980. https://doi.org/10.1016/j.landurbplan.2020.103980

Voordeckers, D., Meysman, F. J. R., Billen, P., Tytgat, T., & Van Acker, M. (2021). The impact of street canyon morphology and traffic volume on NO2 values in the street canyons of Antwerp. *Building and Environment*, *197*(2), 107825. https://doi.org/10.1016/j.buildenv.2021.107825

Vos, P. E. J., Maiheu, B., Vankerkom, J., & Janssen, S. (2013). Improving local air quality in cities: To tree or not to tree? *Environmental Pollution*, *183*(12), 113–122. https://doi.org/10.1016/j.envpol.2012.10.021

Vranckx, S., Vos, P., Maiheu, B., & Janssen, S. (2015). Impact of trees on pollutant dispersion in street canyons: A numerical study of the annual average effects in Antwerp, Belgium. *Science of the Total Environment*, *532*(11), 474–483. https://doi.org/10.1016/j.scitotenv.2015.06.032

Wang, L., Tian, W. X., Zhao, X. Y., & Huang, C. Q. (2022). Numerical simulation of the effects of canopy properties on airflow and pollutant dispersion in street canyons. *Indoor and Built Environment*, *31*(2), 466–478. https://doi.org/10.1177/1420326X211005174

World Health Organization (WHO). (2016). *Ambient air pollution: A global assessment of exposure and burden of disease*. https://iris.who.int/bitstream/handle/10665/250141/?sequence=1

World Health Organization (WHO). (2021). *WHO global air quality guidelines: particulate matter (PM2. 5 and PM10), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide*. World Health Organization. https://iris.who.int/bitstream/handle/10665/345329/9789240034228-eng.pdf?sequence=1&

Wu, L., Hang, J., Wang, X., Shao, M., & Gong, C. (2021). APFoam 1.0: Integrated computational fluid dynamics simulation of O3-NOx-volatile organic compound chemistry and pollutant dispersion in a typical street canyon. *Geoscientific Model Development*, *14*(7), 4655–4681. https://doi.org/10.5194/gmd-14-4655-2021

Wu, W., Li, L., & Li, C. (2021). Seasonal variation in the effects of urban environmental factors on land surface temperature in a winter city. *Journal of Cleaner Production*, *299*(5), 126897. https://doi.org/10.1016/j.jclepro.2021.126897

Yang, J., Shi, B., Zheng, Y., Shi, Y., & Xia, G. (2020). Urban form and air pollution disperse: Key indexes and mitigation strategies. *Sustainable Cities and Society*, *57*(6), 101955. https://doi.org/10.1016/j.scs.2019.101955

Yi, W. Y., Lo, K. M., Mak, T., Leung, K. S., Leung, Y., & Meng, M. L. (2015). A survey of wireless sensor network based air pollution monitoring systems. *Sensors 2015*, Vol. 15, Pages 31392-31427, *15*(12), 31392–31427. https://doi.org/10.3390/S151229859

Yuan, C., Ng, E., & Norford, L. K. (2014). Improving air quality in high-density cities by understanding the relationship between air pollutant dispersion and urban morphologies. *Building and Environment*, *71*(2), 245–258. https://doi.org/10.1016/j.buildenv.2013.10.008

Zeren Cetin, I. (2024a). Optimizing plant biomonitoring for cd pollution. *Water, Air, and Soil Pollution*, *235*(10), 1–8. https://doi.org/10.1007/S11270-024-07466-X/METRICS

Zeren Cetin, I. (2024b). The effects of Sinop province ' s relative humidity values on bioclimatic comfort and urban and landscape planning. *Journal of Design for Resilience in Architecture and Planning*, *5*(3), 401–408. https://doi.org/10.47818/DRArch.2024.v5i3139

Zeren Cetin, I. (2024c). Used in urban area for landscape planning and design spatial and temporal variations in chromium (Cr) concentrations in picea orientalis l. *Turkish Journal of Agriculture - Food Science and Technology*, *12*(10), 1730–1738. https://doi.org/10.24925/TURJAF.V12I10.1730-1738.7093

Zeren Cetin, I., Varol, T., & Ozel, H. B. (2023). A geographic information systems and remote sensing–based approach to assess urban micro-climate change and its impact on human health in Bartin, Turkey. *Environmental Monitoring and Assessment*, *195*(5), 1–14. https://doi.org/10.1007/S10661-023-11105-Z/METRICS

Zeren Cetin, I., Varol, T., Ozel, H. B., & Sevik, H. (2023). The effects of climate on land use/cover: A case study in Turkey by using remote sensing data. *Environmental Science and Pollution Research*, *30*(3), 5688–5699. https://doi.org/10.1007/S11356-022-22566-Z/METRICS

Zhang, Y., Gu, Z., & Yu, C. W. (2020). Impact factors on airflow and pollutant dispersion in urban street canyons and comprehensive simulations: A review. *Current Pollution Reports*, *6*(4), 425_439. https://doi.org/10.1007/s40726-020-00166-0

Zheng, X., Montazeri, H., & Blocken, B. (2022). Impact of building façade geometrical details on pollutant dispersion in street canyons. *Building and Environment*, *212*(10), 108746. https://doi.org/10.1016/j.buildenv.2021.108746

## Resume

*Loubna Khellaf is a doctoral student at Saad Dahlab Blida 1 University, within the Institute of Architecture and Urban Planning (IAU). Her current research is focused on urban pollution and its relationship with the urban microclimate.*

*Meriem Naimi Ait-Aoudia is a conference lecturer at the Institute of Architecture and Urban Planning (Saad Dahlab University - Blida 1) in Algeria. She holds a degree in architecture from the same university and a PhD in architecture and the environment from the Polytechnic School of Architecture and Urban Planning (EPAU) in Algiers. At the university, Meriem Ait-Aoudia supervises workshops on Architecture and Urban Design, and also teaches lecture courses. Her research interests primarily include urban form design, green infrastructure planning, urban carrying capacity assessment, water resource management, and promoting environmental justice. She is currently conducting and managing a research project [PRFU] titled "Environmental Optimization of Urban Form." Additionally, she is a member of the Observatory of City and Architecture for Urban and Spatial Mutations (OVAMUS) Laboratory.*

*Farid Rahal is a professor at the Department of Architecture, University of Science and Technology of Oran Mohamed BOUDIAF in Algeria. His research focuses on air quality modeling, the emission cadastre of gaseous pollutants, urban risks, and environmental modeling.*

JOURNAL OF DESIGN FOR RESILIENCE
IN ARCHITECTURE & PLANNING

*Research Article*
*Online:* www.drarch.org
*Volume 6, Issue 1 (124-142), 2025*
*DOI: 10.47818/DRArch.2025.v6i1160*

# A traditional trace in the urban fabric: Architectural analysis of the Maltepe Mosque

Necdet Bekirhan Soy*
Murat Karademir**

## Abstract

This study aims to present an evaluation of contemporary mosque architecture by addressing the Maltepe Mosque in Ankara, which was built with a traditional approach. In Turkey, modern mosque architecture often adopts design approaches that aim to maintain the traces of the past and remain loyal to the local cultural identity. However, this sometimes causes traditional elements to become an obstacle to innovative architectural approaches. In the study, the architectural features of the Maltepe Mosque, the traditional elements used and the relationship of these elements with modern architecture will be analyzed. In particular, how key architectural elements such as the dome, minaret, mihrab and minbar, which are fundamental to Ottoman and Seljuk architecture, were used in this building and how they were integrated with modern construction techniques will be examined through the plan and structural elements of the mosque. The Maltepe Mosque was selected as a case study in order to question the place of traditional mosque architecture within modern urban life and architectural understanding, to discuss issues of aesthetics, functionality, and originality through architectural elements, and to provide a critical perspective on the future of mosque architecture in Turkey. Whether the design of the Maltepe Mosque, enriched with traditional elements, contributes to the creation of a contemporary structure, its integration with the urban fabric and the degree to which it meets the needs of the users are among the focal points of this study. The limitations imposed by traditionalist approaches in the mosque architecture in the context of modern architecture will be evaluated in terms of aesthetics, functionality and originality. The relationship of the building with its surroundings and the sustainability of traditional mosque forms in a modern city will also be addressed within this framework. Finally, the study aims to offer a unique perspective on the harmony of traditional architecture with modern architecture in Turkey, specifically in the Maltepe Mosque. While the repetition of traditional patterns in mosque architecture can be seen as a factor that limits creativity, it can also be considered as a meaningful step towards preserving collective memory. Therefore, the aim of this study is to critically evaluate this balance between the traditional and the modern and to offer ideas on how mosque architecture in Turkey may evolve in the future.

*Keywords:* Ankara, architectural criticism, Maltepe Mosque, traditional mosque architecture

## 1. Introduction

Although studies on contemporary mosque architecture are limited, existing mosques are generally analyzed in two main groups: "*Traditional Approach*" and "*Modern Approach*" (Serageldin, 1996). The "*Traditional Approach*" refers to buildings that are designed to be close to the plans of historical mosques or as a copy of them but have encountered various problems in practice. While this approach repeats the classical elements of the Ottoman and Seljuk periods, it has a structure that limits its adaptation to today's user needs and contemporary architectural expectations (Soy, 2023).

On the other hand, the "*Modern Approach*" refers to mosques that move away from traditional patterns and are built with modern materials and techniques in their own style and aesthetics. This

*(Corresponding author), Art and Architectural Historian, Türkiye bekirhansoy@hotmail.com
**Assoc. Prof. Dr., Selcuk University, Türkiye karademir22@hotmail.com
*Article history: Received 20 November 2024, Accepted 12 April 2025, Published 30 April 2025*

approach tries to create a unique architectural language outside the classical mosque forms by developing innovative solutions in an effort to be different. The modern approach considers the mosque not only as a place of worship, but also as a social space rich in aesthetics and functionality (Gürsoy, 2013).



This distinction between traditional and modern approaches constitutes an important area of discussion for the future of mosque architecture. Structures that balance the deep-rooted symbols of traditional architecture with the functional and aesthetic innovations of modern architecture can enable mosque architecture to evolve in line with the needs of contemporary society.

Eyüpgiller questions the symbolic significance of the dome and minaret in places of worship considered sacred from a sociocultural perspective, arguing that the earliest mosques were not domed structures and claiming that the functional necessity of the dome ended with the invention of steel and reinforced concrete (Eyüpgiller, 2006). Altınöz, emphasizes that in such approaches, facades are merely replicated and new mosque constructions are reduced to decorative surfaces, thereby diminishing architecture to a superficial façade practice (Bilgin Altınöz, 2010). In imitative mosque architecture, constructing forms specific to older styles and periods using contemporary building technologies does nothing more than applying a historical façade onto a modern structure (Kazmaoğlu & Tanyeli, 1986). Despite all the opposing views in the literature, contemporary mosques continue to be designed in the likeness of historical ones, featuring domes, arched windows, courtyards, and minarets, yet built with reinforced concrete frames (Kaymaz & Şenkal Sezer, 2017).

Modern mosque architecture in Turkey sometimes limits the opportunity to develop original and innovative approaches by frequently resorting to traditional elements in an effort to maintain traces of the past. The overemphasis on traditional forms and decorative elements can prevent the development of innovative architectural solutions in many mosques. This creates an environment, especially in public projects, where the concern for adhering to local identity makes it difficult to develop buildings that are aesthetically and functionally compatible with contemporary norms.

The Maltepe Mosque in Ankara can be considered as an example of this type of building. Although it was built with reference to traditional Ottoman-Turkish architecture, the design of the mosque is a repetition of past architectural elements rather than an original approach. This overshadows the creative potential of modern architecture instead of increasing the aesthetic value of the mosque. While innovative solutions suitable for user needs are expected, the fact that these buildings remain solely dependent on traditional forms creates a controversial area in terms of the architectural evolution of Turkey, which needs more functional buildings that are more compatible with today's urban fabric.

This study adopts a qualitative architectural analysis method to examine the Maltepe Mosque within the context of traditional mosque architecture and its relationship with contemporary architectural approaches. The analysis is structured under key architectural components including site layout, plan organization, section, structural system, mass and façade composition, material usage, and ornamental details. Each of these elements is critically evaluated in terms of their aesthetic, functional, and symbolic roles. The study also compares the architectural language of the mosque with both classical Ottoman-Seljuk examples and selected contemporary mosque designs in Turkey. Visual and spatial analyses are supported by architectural drawings, archival materials, and on-site observations, allowing for a comprehensive understanding of the building's architectural identity.

Within the scope of the study, the architectural features of the Maltepe Mosque, the traditional elements used in its design and their relationship with modern architecture will be discussed. Firstly, the elements that refer to traditional Ottoman Mosque architecture will be analyzed through the plan and structural elements of the mosque. The connection of basic structural and decorative elements such as the dome, minaret, mihrab and minbar with traditional architectural patterns and how these elements are combined with contemporary construction techniques will be evaluated.

Furthermore, the functionality of these traditional elements in meeting the needs of the mosque users will be analyzed under critical headings such as the harmony of the building with the environment and the urban fabric. This analysis will aim to shed light on the extent to which traditional forms make sense in today's urban environment and the limitations that such architectural approaches impose on contemporary architecture. Finally, how the architectural design of the Maltepe Mosque affects the originality and creativity of mosque architecture in modern Turkey will be discussed and the positive and negative aspects of the traditionalist approach of the building will be emphasized.



## 2. The Maltepe Mosque

The Maltepe Mosque is located on Şehit Gönenç Street in the Maltepe district of Çankaya, Ankara, on Block 5553 and parcel number 20, No: 3. The construction of the mosque began on May 16, 1954, and was completed and opened for worship on August 3, 1959. Designed by architect Recai Akçay, the building was constructed entirely using cut stone[1]. In the interior, sections up to 5 meters high were decorated with tile coverings, and marble material was preferred for the mihrab and minbar, preserving the traditional lines. These structural features of the mosque reflect both the architectural approaches of the period and the aesthetic understanding that remains loyal to the traditional Ottoman style.


**Map 1** Aerial view of the Maltepe Mosque

In 1950, the “Association for the Construction of a Mosque in Ankara Maltepe” was founded under the chairmanship of Hasan Balbudak with the participation of the public in order to build a mosque in Ankara Maltepe (Association Archive). This association, whose name was later changed to “Association for the Construction and Preservation of Ankara Maltepe Mosque”, continues its activities under this new name today. The area initially considered for the mosque and allocated by the municipality to the association was the land opposite the current location of the mosque in Maltepe, where the units of Çankaya Municipality are located today. However, a 7019 m² plot of land on block 5553 and parcel 20 in its current location (Map 1), which was deemed more suitable in terms of usage area and the city's layout plan, was allocated to the association by the municipality for 99 years for the construction of the mosque (Association Archive) (Figure 1).

[1] Architect Recai Akçay (1909–1967) studied at the Academy of Fine Arts in Istanbul and worked in the studio of Ernst Egli until 1933. In addition to numerous significant projects, he also participated in the Anıtkabir design competition alongside Hamit Kemali Söylemezoğlu and Kemal Ahmet Arû, receiving an honorable mention (Menderes, 1968; Savaş Okumuş & Kıvılcım Çorakbaş, 2023).

**Figure 1** Image of Maltepe Mosque taken in 1965 (Koç University, Vekam Dijital Library)

The square-planned harim (prayer hall) section of the building is covered with a main dome with a diameter of 20 meters and a height of 30 meters. Corner walls at the four corners support the square baldachin structure of the building (Drawing 1). The dome covering the entire space rests on large back arches connecting these corner walls, and the transition to the dome is provided by pendants. The plan structure is based on the central square baldachin structure as in the Classical Ottoman plan type. The harim floor rises gradually with curtain walls, symbolic weight towers and a central dome, and the copper finial at the top of the main dome has a crescent motif (Figure 2).

**Figure 2** General view of Maltepe Mosque north facade

There are two minarets with a height of 50 meters in the northern corner of the mosque's harim. The minarets have a polygonal prism-based structure sitting on rectangular bases and attract attention with their cylindrical forms (Figure 3). Each minaret has a balcony, the bottom of twhich is decorated with three rows of muqarnas (Figure 4). The railings made with cage technique using marble material give the balconies an aesthetic appearance. The access to the balconies is provided only by stairs, and there are tile plates in the semicircular niches under the cone sections of the minarets. In addition, the cones are completed with lead coating.

**Figure 3** General view of Maltepe Mosque minaret

**Figure 4** A detail from the Maltepe Mosque minaret

The mosque is surrounded by a large courtyard which does not have any portico arrangement (Figure 5). The courtyard, which is slightly higher than the road level, is designed at the same level with the surrounding landscaping. The fountain or pool, which is often seen in the middle of the courtyard in the traditional style, is not included here (Figure 6).

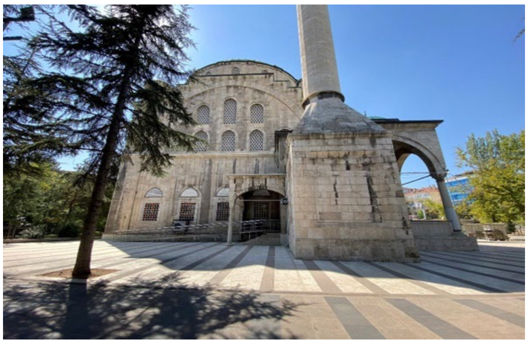


**Figure 5** General view of the Maltepe Mosque east facade

**Figure 6** General view of the Maltepe Mosque West facade

The last congregation area of the building is reached by five steps (Figure 7). Designed in five sections, each section of this area is covered with a dome. In the porticoes in the last congregation place, cylindrical columns are connected to each other with pointed arches, and the columns have two rows of muqarnas capitals and flat bases. Both sides of this section are designed to be open.

There are four large rectangular windows on the wall of the mahfil (gathering-place) on both sides of the door. These windows, with pointed arched pediments, have iron cages on the lower floor. The smaller upper windows are placed symmetrically to the windows below and also have pointed arches. In the center of the lower floor windows, there are mihrabiyas with muqarnas arches and these mihrabiyas and windows are connected to the harim (Figure 9). The inner surfaces of all the domes in the last congregation mahfil have hand-drawn decorations in the center and a single row of muqarnas decorations at the bottom (Figure 8).

**Figure 7** Last congregation place of the Maltepe Mosque

**Figure 8** Decoration of the dome of the last congregation place

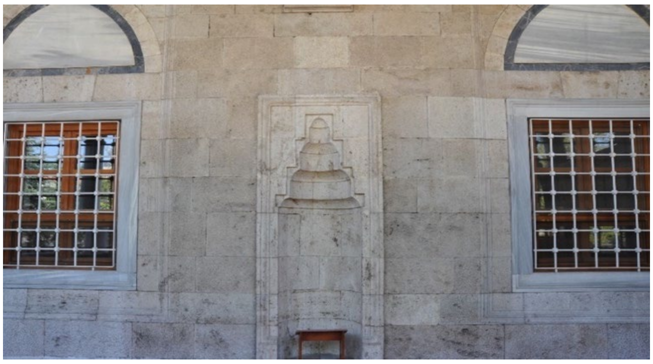


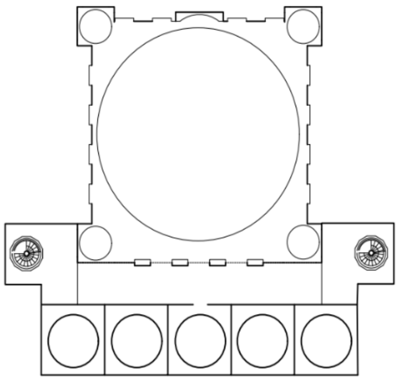
**Figure 9** Mihrabiya of the last congregation place

The entrance to the harim is provided by a marble crown door from the last congregation place. An additional wooden porch-style entrance door was later built in front of this crown door. The door, which is in a large pointed arched niche, opens to both sides with concave and convex moldings (Figure 10). The flat arch of the door was formed using two colored stones interlaced with each other. At the top of the arch, there is an inscription written in celi sülüs calligraphy on marble.

**Figure 10** Crown gate of the Maltepe Mosque

The wooden door wings are divided into three panels with similar decorations. The top panel of the door wings, made using the hammered kundekari technique, is smaller than the others and has a composition consisting of a five-armed star motif around a circle in the center. The large rectangular panel in the middle and the smaller rectangular panels below have an eight-armed star form in the center, surrounded by five-armed star motifs.





**Drawing 1** The plan of the Maltepe Mosque (N. B. Soy, 19.11.2023)

To the north of the harim is the upper floor mahfil, which is protruding in the form of a balcony. At the level of the mahfil, there is a narrow balcony surrounding the building from three sides (Figure 11). The railings of the mahfil are made of marble and formed with cage technique. The rectangular columns are also made of marble and support the mahfil.

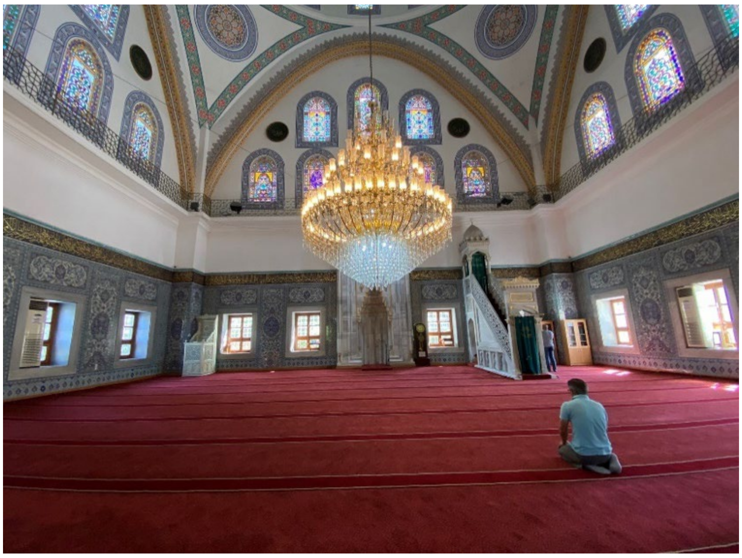


**Figure 11** General view of the Maltepe Mosque harim

The mihrab located on the south wall of the mosque in the qibla direction is on the same axis with the qibla wall (Figure 12). The mihrab made of marble is bordered by large cylindrical columns on both sides. The capitals of the columns are hourglass shaped. The niche of the mihrab, which has six rows of muqarnas kavsara, is polygonal and is surrounded by columns on both sides. The corners of the arch are decorated with small layered rosettes covered with gilding (Figure 13). The 149th verse of the Surah Al-Baqara, “Fevelli vecheke shetral masjidil haram” (فَوَلِّ وَجْهَكَ شَطْرَ الْمَسْجِدِ الْحَرَامِ) is written on the kavsara. The upper part is decorated with a spiral rumi and palmette array, and all the decorative protrusions of the mihrab are covered with gold leaf.

**Figure 12** General view of the Maltepe Mosque mihrab

**Figure 13** Detail from the mihrab of the Maltepe Mosque

The minbar of the building is made of marble. On both sides of the pointed arched entrance, there are two columns with rectangular bodies, the capitals of which have muqarnas (Figure 14). There is a rosette on each side of the arch pediment, and there is an inscription on the pointed arch. The entrance begins with a single row of muqarnas and ends with a crown. The crown is decorated with plant ornaments consisting of spiral rumi and palmette motifs. The perimeter of the side transoms of the minbar is surrounded by a flat molding. The triangular section is left empty. Under the transoms, there are four niches with segmented arches within rectangular panels. The passage section is plain. The square panel above the passage is decorated with geometric ornaments.

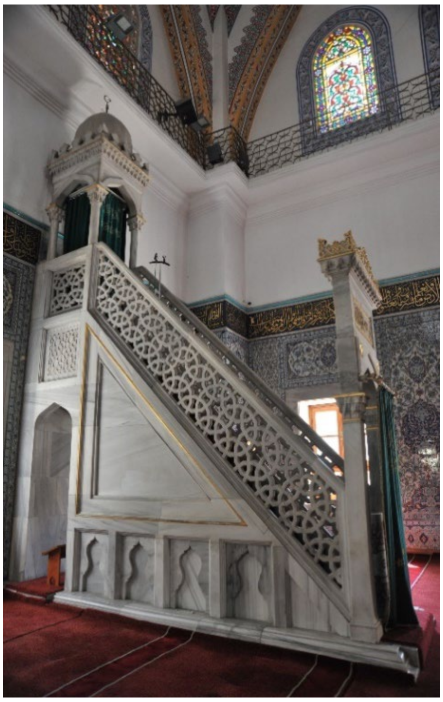


**Figure 14** General view of the Maltepe Mosque minbar

The railing is decorated with geometric patterns using the pierced-work technique. In the center is a six-armed star and around this star is a composition formed by the intersection of twelve-armed star forms. The pavilion section is built on four columns with flat bodies and muqarnas capitals, connected to each other by pointed arches and covered with a flat ceiling. The bottom of the palmette-shaped top of the pavilion is decorated with a single row of muqarnas (Figure 15). The cone part is in the shape of an onion and there is a copper finial with a crescent motif on the top.

**Figure 15** Front view of the Maltepe Mosque minbar

The sermon platform is made of wood, and its lower part consists of segmented arched niches arranged as two panels on each side (Figure 16). The upper part consists of panels decorated entirely with geometric compositions. There is a ten-armed star motif in the center, and the surroundings of this star are enriched with five-armed star motifs. The railing of the platform is made of MDF, and it has a geometric composition derived from a six-armed star in the center. The top is in the form of a palmette and the bottom is decorated with a single row of muqarnas.

**Figure 16** Sermon platform of the Maltepe Mosque

The mosque has many windows around the curtain wall and the dome (Figure 17). The windows at the foot of the dome are small in size and have pointed arches. On the curtain wall, there are five pointed arched windows on the same axis as the lower mahfil floor. The windows on the same level with the upper floor mahfil have also pointed arches. The middle one of these windows is larger than the others, and there are three in total. The windows are made in two layers, interior and exterior, and the cage technique is applied on their exterior surfaces. Colored stained glass is used in the interior parts, giving the mosque a very bright appearance. The windows on the lower floor are in rectangular form and are complemented with pointed arched pediments.

The lighting in the mosque is provided by a pendant chandelier put under the large dome.

**Figure 17** Interior decorations of the Maltepe Mosque dome

The most prominent decorations in the Maltepe Mosque include calligraphy, hand-drawn works and tile decorations. The most striking example of calligraphy is the Surah Fatiha written in gold leaf on a black background in the center of the large dome. On the upper part of the tile panels in the harim, the Surah Tegâbün, written in celi sülüs calligraphy in gold leaf on a black background with the ground carving technique on marble, surrounds the harim walls from three sides. In addition, on both sides of the upper floor windows, there are panels with the names of Allah, Muhammad and the four caliphs. These panels are also carved in celi sülüs calligraphy in gold leaf on a black background.

One of the most magnificent elements of the building is the richness of the hand-drawn decoration. The main dome, pendants and window frames attract attention with hand-drawn ornaments applied on plaster. In the center of the dome, there are sun motifs dominated by yellow and green colors on a claret red background. Inside these sun motifs are flowers, leaves and rumi motifs in hatayi style. At the ends of the sun motifs, palmette motifs decorated with yellow and white on a green background stand out. In the middle, there is a full sun motif dominated by navy blue, white and claret red on a turquoise background. At the foot of the dome, the sun motifs decorated with palmette motifs at their ends are dominated by green (Figure 18).



**Figure 18** Hand-drawn decorations in the Dome Center

The edges of the pendants are surrounded by a border dominated by claret red, navy blue and white on a green background (Figure 19). This border is decorated with palmettes, spiral rumi and hatayi motifs. In the middle of the pendants is a large medallion decorated with palmettes, hatayi leaves and spiral rumi motifs in navy blue, white and claret red on a white background. The outer frame is decorated with penç, hatayi and spiral rumi motifs adorned with white, claret red and navy blue on a turquoise background. The borders that determine the borders of the back arches contain compositions consisting of spiral rumi, hatayi leaves and carnation motifs dominated by claret red and white on a yellow background. The upper floor window edges are also decorated with penç, hatayi and spiral rumi motifs dominated by white, claret red and navy blue on a turquoise background.

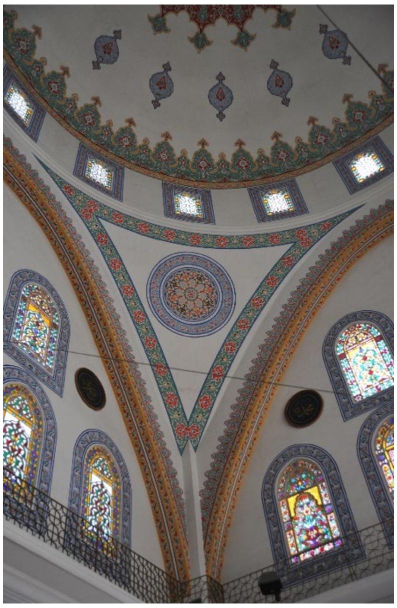


**Figure 19** Hand-drawn decorations on Pendants

The harim section of the mosque is covered with tiles up to 5 meters high, and these tile decorations were arranged by Mahmut Akok. The tile panels on the right and left walls of the mihrab niche of the mosque are surrounded by a border consisting of leaves curled in the form of dagger and penç applied in white on a turquoise background (Figure 20). The corners are decorated with spiral rumi motifs in white on a cobalt blue background. In the center of the panel, there is a sun motif bordered in white, and decorated with spiral rumi motifs on a navy-blue background. Below the motif is a vase motif, also decorated with spiral rumi motifs. The lower sections are decorated with flowers such as tulips, carnations, hyacinths and large curved leaves. The rest of the panel is elaborately filled with large dagger-shaped curved leaves, elegant penç, pomegranate flowers, hatayi motifs and peonies, all in a saz style using blue and green colors on a white background, leaving no empty spaces.

**Figure 20** Detail of tile panel

One of the vertical rectangular tile panels on the side walls is surrounded by a border consisting of white penç and dagger-shaped leaves on a turquoise background. The interior is decorated with a turquoise-colored sliced arch form on the upper section, and the composition of spiral rumi motifs dominated by green and blue on a white background is on the corners of the arches. Inside the panel, there are three sun motifs created with white and turquoise colors on a navy blue background. These forms include large curved dagger-shaped leaves, penç, rumi and hatayi motifs. The panel is generally filled with large green curved leaves, penç and hatayi motifs on a white background. Another tile panel on the north wall of the harim has navy blue sun and hatayi motifs inside curved branches. Spring branches, carnations and penç motifs are placed between the motifs as ornaments (Figure 21).

**Figure 21** Tile panel detail from harim north wall

On the upper part of the lower floor windows, there are transversely rectangular tile panels. In the center of these panels is a sun motif on a dark blue background. The sun is surrounded by large leaves, penç and hatayi motifs dominated by green and dark blue on a white background. In the corners of the panel, there are penç motifs in white and claret red on a navy blue background.

## 3. Evaluation

Maltepe Mosque stands out as a building that bears the traces of Classical Ottoman Mosque architecture with its general architectural design. The mosque reflects the symmetry and centrality of Ottoman mosques with its central dome and square-planned harim. Designed in the square baldachin style, the plan of the building offers a balanced spatial composition with a large main dome and corner walls supporting the dome. The height and diameter of the dome increase the spaciousness of the interior and the splendor of the prayer hall, thus transforming the building from being a mere place of worship to an architectural work that offers an aesthetic experience to its visitors.

Today, Turkey's major cities are experiencing a significant increase in the number of mosques in line with the growing population. These buildings often adopt a style based on the classical Ottoman period, particularly 16th century architecture. In the construction of new mosques, there is a preference for adhering to or establishing a connection with the traditional style rather than original and modern designs. This is due to the effort to preserve the architectural identity of mosques and the society's respect for the past. However, sometimes these preferences lead to the exact copying of the traditional form and limit the development of original designs that will meet contemporary needs.

Classical Ottoman architecture is known for elements such as central planning, domed structures, and fine craftsmanship in ornamentation, and these features are frequently reproduced in contemporary mosques. Elements such as minarets, large domes, interior decorations and arches are reinterpreted by referencing classical period architecture. In this context, although original designs are limited in modern mosque architecture, there are also examples where traditional details are blended with modern building techniques and materials.

However, the tendency to adopt architectural formulas of the past instead of introducing new interpretations through contemporary architecture also reflects the aim of creating a socially and culturally familiar atmosphere. While this approach reinforces the function of mosques as spiritual and cultural centers in society, it also limits the search for original and innovative designs.

Maltepe Mosque has adopted the central square baldachin plan type seen in Classical Ottoman Mosque architecture. This plan structure is supported by the corner walls at the four corners of the building, and the dome covering the entire space is placed on large back arches connecting the corner walls. This structural arrangement is similar to a dome composition that Mimar Sinan frequently used and experimented with in his mosques. Sinan's dome designs have been evaluated as a basic structural and aesthetic element that shapes space and mass, beyond being just a covering element (Necipoğlu, 2005).

The spatial arrangement preferred by Mimar Sinan in mosque architecture and built on a four-legged square baldachin constitutes an important example of the classical Ottoman Mosque typology (Erarslan, 2020). Examples of this arrangement include works such as Edirnekapı Mihrimah Sultan, Eyüp Zal Mahmut Pasha, Lüleburgaz Sokullu Mehmet Pasha and Manisa Muradiye Mosques (Kuban, 2007; Necipoğlu, 2005; Goodwin, 2012). Maltepe Mosque follows this traditional plan scheme, preserving the essence of Ottoman architecture and reinterpreting the spatial aesthetics of the classical period.

Today's construction technology has reached a level where the functional importance of the dome in spanning large spaces has been largely eliminated. Thanks to modern construction materials and engineering techniques, spanning large spaces can now be achieved with more diverse and flexible solutions. However, the dome has a deep historical and social meaning in mosque architecture; therefore, social acceptances cause the dome to maintain this function at a perceptual level (Dural, 2017). Even today, architects prefer the dome as an indispensable element in mosque designs as it continues to play both an aesthetic and spiritual role as the focal point of space in mosque architecture.

There are many factors that shape the design of a mosque. Among these, the identity and specific demands of the person commissioning the mosque, the location and dimensions of the land, the relationship between the building and its surroundings, and the orientation of the land are the key elements. These factors determine the plan scheme and dimensions of the mosque, and different designs emerge in mosques in line with these limitations. For example, the location of the land provides important clues as to whether the mosque should be in harmony with its surroundings, as well as the orientation of the mosque. The special demands of the person or institution financing the building can also have a direct impact on the architectural style and ornamentation of the mosque. Thus, each mosque acquires its own characteristic features.

One of the most prominent features of contemporary mosque design is the positioning of the building on a large area of land. Traditional arcaded courtyards are generally not used in such buildings. While it is common to surround the space with elements that draw a clear boundary in traditional mosque courtyards, such boundary-defining elements are not present in contemporary designs. The courtyard in the building under study is slightly elevated from the road level and is located on the same plane with the surrounding landscaping, creating an organic integrity with the building's surroundings. This allows the mosque to establish a more fluid relationship with its surroundings, blurring the boundaries of the space and offering a more open and inviting space for users.

In mosques designed in recent years, open courtyard arrangements that are not surrounded by sharp boundaries have become increasingly common. The Sancaklar Mosque (2013), one of the most modern examples of this approach, is located on a large land and is completely underground and integrated with nature (Akbulut & Erarslan, 2017). Similarly, the Yeşil Vadi Mosque (2010) rises on a white marble platform surrounded by a shallow pool of water on the south side, and the courtyard is accessed by stairs (Öney, 2019). The Marmara University Faculty of Theology Mosque (2015) is located above the street level and uses natural elevations instead of a wall defining its boundaries (Taşdemir & Erarslan, 2018). In addition, the TBMM Mosque (1989) offers a more fluid courtyard arrangement that is not surrounded by sharp boundaries by taking advantage of the slope of the land like the Sancaklar Mosque. The modern courtyard designs in these mosques make the mosque architecture more organic and in harmony with its surroundings, redefining the mosque as a social meeting point beyond a place of worship.

The Maltepe Mosque does not have a fountain or pool, which are common in traditional mosque courtyards. This deficiency shows that the mosque has adopted a different approach in the courtyard arrangement. While the absence of a fountain makes the overall design of the mosque simpler, it has allowed this area to be planned in an integrated manner with the landscape.

The last congregation place also stands out as an important element in the architecture of the mosque. This area, which has five sections and each section is covered with a dome, adds depth to the front face of the mosque. The muqarnas decorations on the columns and arches and the low arched doors keep the Ottoman aesthetics alive in the details.

The use of an odd number of units in the arcades of the last congregation place and the elevation of one or three units in the middle with wider arches or by keeping the centers above the springing line level is a traditional practice that emphasizes the entrance axis in classical architecture (Özyalvaç, 2020). This design approach gives the building symmetry and balance, emphasizing the direction of entrance for visitors and creating a visual focal point at the same time.

While the minaret of the Maltepe Mosque adheres closely to traditional Ottoman architecture, it does not adequately reflect the search for an original and contemporary design. The cylindrical form and polygonal prismatic base used in the minaret repeats the aesthetic understanding of the classical period, while remaining far from the innovative structural techniques of today's architecture. Although the height of the minaret and the single balcony structure provide a visually conventional symmetry, they do not offer an element that is in harmony with its surroundings or differentiates the user experience.

Mosques such as Çamlıca Mosque, Ataşehir Mimar Sinan Mosque and Arnavutköy Taşoluk Yeşil Mosque are among the buildings that repeat the cylindrical form and balcony minaret designs of the classical Ottoman scheme. In particular, the six-minaret structure of the Çamlıca Mosque carries the aesthetic elements of the Ottoman period to the present day, but instead of presenting an innovative architectural understanding, it is limited to an approach based on reproducing the past (Koçak & Özdemir, 2021). In such buildings, the tendency to reuse the symbols of the classical period makes it difficult for mosques to gain a unique architectural identity.

A similar situation is observed in the Ataşehir Mimar Sinan Mosque. The cylindrical minarets with three balconies on the four corners appear as an exact repetition of traditional forms rather than a contemporary interpretation. This design preference distances the mosque from being an original structure and causes it to remain as a reproduction of a symmetrical form taken from the past.

Although the Yeşil Vadi Mosque is a building designed with a modern architecture, a structure close to the traditional Ottoman form was preferred for the minaret (Akbulut & Erarslan, 2017). The cylindrical form, small windows and balcony design made of stainless steel pipes do not fully comply with the modern character of the mosque. This shows how necessary it is to deal with minarets in an original and innovative way in modern architecture. Adhering to traditional forms is an obstacle to the development of a more innovative and contemporary language in mosque architecture.

Although the harim of the Maltepe Mosque is designed with elements that repeat the classical Ottoman mosque scheme, it does not adequately respond to modern needs and today's aesthetic understanding. While the square-plan baldachin structure covered with a central dome makes the space symmetrical and balanced, it has difficulty in providing a contemporary usage experience.

The load-bearing elements of the building are supported by a central dome resting on large arches at the four corners. This dome system is a frequently preferred form in classical mosque architecture and was able to meet the structural requirements of the period. However, in today's architecture, lighter, more durable and flexible building materials and techniques can be used in order span large spaces and provide spaciousness in the space. In this respect, the dome of the Maltepe Mosque remains a traditional design rather than an innovative upper covering system.

In mosques built with a traditional approach, liturgical elements such as mihrab, minbar, muezzin's mahfil and sermon platform are of great importance. The mihrab, which stands out as a guiding building element in mosque architecture, is at the forefront of these elements. The mihrab schemes of classical Ottoman architecture, which developed under the leadership of Chief Architect Koca Sinan in the 16th century, formed the characteristic examples of monumental Ottoman mihrabs in terms of crown and frame designs. In these mihrabs, a unity of style is noticeable in terms of material selection, decorative features and technical use, which is a distinctive feature of classical practices that continued until the 18th century (Bozkurt, 2007).

Today, however, the repetition of these traditional mihrab designs may prevent the development of an innovative and original architectural language. While more functional and contemporary forms can be created with modern building techniques and materials, the strict repetition of traditional schemes can make the architectural identity of the building become ordinary. The reconstruction of liturgical elements in traditional patterns limits the potential of the space to adapt to modern user experiences, making it difficult for the mosque to gain a unique structural expression.

As a place where Friday and Eid sermons are read and where the state is represented in the mosque, the minbar is considered one of the most important elements of mosque architecture (Apa, 2007). However, the traditional approach to the minbar in Maltepe Mosque could not take the opportunity to give the building a unique character. Although the placement of the minbar to the west of the mihrab is in accordance with Ottoman architecture, a more contemporary interpretation could have been offered with different placement and design alternatives.



Innovative designs that contribute to the aesthetic and spatial experience of the space while preserving the functionality of the minbar may be preferred in modern mosque architecture. Here, however, the construction of the minbar by adhering to classical forms has led to the limitation of the space to traditional patterns and has been insufficient to adapt the building to modern user needs. Although this traditional approach preserves the role of the minbar within the mosque, it is restrictive in terms of giving the mosque a unique character.

The sermon platform in the Maltepe Mosque is made of wood and decorated with classical hatayi and rumi motifs but fails to offer a modern interpretation or innovative design. The panels decorated with traditional ornaments and geometric patterns contribute to the aesthetic details of the mosque, but while the sermon platform in the mosque's architecture could have been reinterpreted in a more contemporary and functional manner, this opportunity has been overlooked.

During the Ottoman period, doors showed a tendency towards simplicity and a decrease in ornamentation. These doors were usually decorated with simple mouldings and muqarnas arches and were bordered by columns with hourglass-shaped capitals at the top and bottom. Two-colored marble was often used in the door arches and these elements added a characteristic elegance to classical Ottoman architecture (Karademir, 2014). However, these traditional door designs can become a limiting factor in the unique identity of mosques.

The last congregation place and courtyard arrangements with porticoes and fountains, which were also applied by Sinan in the Ottoman classical period, created a significant change in the northern facades of mosques. One of the areas where these changes are most visible is the crown gates. However, replicating the traditional crown door design in contemporary buildings may prevent the development of an innovative architectural language. While the functional and aesthetic reinterpretation of crown gates today offers opportunities to create more original solutions in mosque design, the repetition of classical forms and ornaments may limit the integration of the building with modern architecture and block the way for more innovative and bold designs.

Windows play an important role in ensuring the balance of openness and closedness of the structures by removing the walls of the mosque from being merely closed surfaces (Yetkin, 1959). These elements, which are both technically and aesthetically functional, allow the space to receive light and strengthen the interior-exterior relationship. However, in traditional mosque architecture, windows are often used with standardized forms and limited ornamentation, which adds a certain aesthetic to the building but limits originality.

Today, in mosque architecture, a more original and innovative approach to window design can give the space a more dynamic character. Diversifying the use of windows with different sizes, modern stained-glass techniques and variable forms can increase the aesthetic value of the building and give the space a more contemporary atmosphere.

The structural design of traditional mosque architecture is shaped by main load-bearing elements such as continuous load-bearing walls, piers and columns, while it is supported by auxiliary elements such as buttresses, mihrab front or maksure dome, squinch, pendant and Turkish triangle. As covering elements, arches, vaults and domes provide both aesthetic and functional richness to the building. The methods adopted by the designers in order to make the mosque different, permanent, monumental and expressive have revealed an original style in the use of materials and technology, nourished by religious philosophy (Arpacıoğlu, 2013).

Classical materials such as cut stone, marble and wood were preferred in the construction of the Maltepe Mosque, and these choices show that they remained loyal to the Ottoman mosque architecture. For example, the marble mihrab and minbar are similar to those of the classical period in terms of both material selection and detailing. However, these traditional materials do not benefit sufficiently from modern techniques supported by today's lightweight, durable and sustainable building materials.

Technically, the building remains loyal to traditional construction methods. While this maintains the aesthetic and structural values of classical architecture, it limits the building's ability to be a contemporary building. While modern construction techniques have the potential to create spacious and open spaces with wider openings and less material use, Maltepe Mosque ignores these innovations and repeats the traditional construction.



The decorations in the Maltepe Mosque were designed in strict accordance with the traditional Ottoman mosque aesthetics. Calligraphy, hand-drawn works and tile decorations are among the prominent decorative elements and repeat the motifs common in classical Ottoman mosques. In particular, the gold-leaf calligraphy of Surah Fatiha in the center of the dome and Surah Tegâbün surrounding the walls are indicators of adherence to the traditional decorative language. However, the repetition of such classical calligraphy applications has a limited effect in terms of adding originality to the space.

Hexagonal and six-armed star motifs are among the most popular geometric compositions used on the marble minbar railings of the Maltepe Mosque. This motif is a frequently preferred pattern in the Ottoman period and is also seen in important historical buildings such as Bursa Yeşil Mosque, Divriği Ulu Mosque, Edirne Selimiye Mosque and Üç Şerefeli Mosque (Demiriz, 2004). The octagonal and eight-armed star motifs used on the double-leaf door wings of the Maltepe Mosque carry deep symbolic meanings in traditional Islamic art. The eight-armed star is one of the complex geometric compositions formed by the intersection of lines at a certain center and was symbolized as the “heaven tamga” or “heaven gate” by pre-Islamic Turks (Aslan & Duran, 2021; Şaman Doğan, 2002). This motif was called the “Seljuk Star” during the Seljuk period and was frequently used in historical buildings such as Konya Kubadabad Palace, Aksaray Ulu Mosque, Bursa Yeşil Mosque and Bursa Yeşil Tomb (Demiriz, 2004).

Although the tile decorations are enriched with traditional motifs used around the mihrab and on the walls of the harim, they do not include an innovative perspective. Classical plant patterns such as dagger leaves, rumi and hatayi motifs in the saz style increase the general aesthetic value of the mosque, but do not give the building an original character. However, in modern architectural decorations, it is possible to see more creative, dynamic and unique designs with contemporary interpretations of traditional motifs.

Although the reuse of traditional motifs in hand-drawn decorations preserves a certain level of artistic value of the building, it has deprived the architectural character of the mosque of an innovative approach. While the hand-drawn decorations on the dome, pendants and window frames reflect the elements of the classical period, they do not offer a contemporary expression. The excessive repetition of traditional motifs makes the building artistically ordinary and limits the potential of modern users to have a different experience.

From this point of view, the decorations of the Maltepe Mosque, while respecting the classical Ottoman decorative tradition, are far from offering an innovative aesthetics we expect to see in contemporary architecture. This prevents the mosque from gaining artistic originality and condemns the building to a historical repetition.

## 4. Conclusion

In Turkey, mosque construction is carried out by various institutions and organizations, but the architectural form and style of mosques has become an increasing topic of discussion in recent years. The constant repetition of traditional architectural approaches distances the buildings from responding to contemporary needs, and this situation reveals the necessity of innovative solutions in mosque designs. Functional, aesthetic and environmentally compatible designs should be developed in mosque architecture, taking into account the changing social structure and needs.



In mosque projects, geographical and regional conditions should be blended with technological possibilities, and buildings should be transformed into spaces with strong environmental aesthetics, intertwined with the city. Considering the land size and congregation capacity, importance should be given to the solutions of small-scale structures, especially neighborhood masjids. This will allow small and functional masjids to take part in urban life instead of only large and monumental buildings. In addition, considering the costs, high-quality but modest structures that will meet the needs should be designed.

The characteristics of the environment should be taken into account in the exterior space arrangements of mosques, and the dimensions and proportions of the buildings should be adjusted to be compatible with the urban texture. Avoiding the constant repetition of traditional architectural elements, new and original styles should be developed. In this way, a balanced combination of traditional and modern elements in mosque architecture can be achieved, and sustainable, functional and socially compatible buildings can be created in the future. The functionality and functional elements of mosques should be re-evaluated according to today's technology and user needs so that worship areas can be functional and aesthetic.

As a result, the Maltepe Mosque exhibits its commitment to traditional mosque architecture by repeating the decorative and structural elements of classical Ottoman and Seljuk architecture. Although the elements used in the structure such as the minaret, dome, crown gate, mihrab and minbar are decorated with symbols dating back to the Ottoman period, these elements have missed the opportunity to evaluate the innovative design opportunities offered by contemporary architecture. The geometric motifs such as the eight-armed star, hexagon and six- armed star on the door wings have also caused the intensive use of traditional motifs and the aesthetic language of the building to remain closely tied to the past.

The construction of the Maltepe Mosque with this traditional approach condemns the building to a historical repetition by distancing it from being an original work of art and architecture. While it is possible today to interpret traditional motifs in a different way and develop original solutions in terms of functionality and aesthetics with modern building materials, advanced techniques and innovative design approaches, the mosque's preference for classical patterns has made the building ordinary.

As a result, Maltepe Mosque is a building that respects traditional mosque architecture but missed the opportunity to develop a contemporary architectural language. Addressing mosque architecture in the future in a way that is more original, creative and responsive to the aesthetic values of the time will be an important step for the architectural development of this field.

## References


Akbulut, N., & Erarslan, A. (2017). Türkiye'de çağdaş cami mimarisi tasarımında yenilikçi yaklaşımlar. *İstanbul Aydın Üniversitesi Dergisi, 35*, 33-59. https://doi.org/10.17932/IAU.IAUD.13091352.2017.9/35.33-59

Apa, G. (2007). *Osmanlı dönemi selâtin cami minberleri* (Unpublished doctoral thesis). Selçuk University, Konya.

Arpacıoğlu, Ü. (2013). İslam ve cami mimarisinde malzeme, teknoloji ve sanat kullanımının değerlendirilmesi. In *1. Ulusal Cami Mimarisi Sempozyumu: Gelenekten Geleceğe Cami Mimarisinde Çağdaş Tasarım ve Teknolojileri* (pp. 401-410). Ankara: Diyanet İşleri Başkanlığı.

Aslan, Y., & Duran, R. (2021). Türk sanatında cennet damgası ve Türk kültüründe sekize "8" yüklenen anlamlar. *Selçuk Üniversitesi Türkiyat Araştırmaları Dergisi*, *51*, 383-405. https://doi.org/10.21563/sutad.984825

Bilgin Altınöz, A. G. (2010). Tarihi dokuda yeninin inşası. *Ege Mimarlık*, 18_26. http://egemimarlik.org/75/index.php

Bozkurt, T. (2007). *Osmanlı selâtin cami mihrapları* (Unpublished doktoral thesis). Selçuk University, Konya.

Demiriz, Y. (2004). *İslam sanatında geometrik süsleme*. İstanbul: Yorum Sanat ve Yayıncılık.

Dural, M. (2017). *Çağdaş cami mimarisinde kubbe ögesinin algısal etkisinin mimari eğitim seviyesine göre farklılaşması* (Unpublished master thesis). Yıldız Technical University, İstanbul.

Erarslan, A. (2020). Mimar Sinan'ın dörtlü baldaken sistemli tek kubbeli camilerinde görülen farklı mekân kurguları. *Turkish Studies, 15*(2), 944-958. http://dx.doi.org/10.29228/TurkishStudies.41660

Eyüpgiller, K. K. (2006). Türkiye'de 20. Yüzyıl cami mimarisi. *Mimarlık Dergisi, 331*, 1. http://www.mimarlikdergisi.com/index.cfm?sayfa=mimarlik&DergiSayi=48&RecID=1178

Goodwin, G. (2012). *Osmanlı mimarlığı tarihi* (M. Günay). İstanbul: Kabalcı Yayınevi.

Gürsoy, E. (2013). Günümüz cami mimarisinde "ilkesiz yaklaşım". *SDÜ Fen Edebiyat Fakültesi Sosyal Bilimler Dergisi, 28*, 239-253. https://dergipark.org.tr/tr/download/article-file/117811

Karademir, M. (2014). *Mimar Sinan dönemi yapılarında taçkapılar* (Unpublished doktoral thesis). Selçuk University, Konya.

Kaymaz, E., & Şenkal Sezer, F. (2017). User satisfaction assessment of indoor environmental quality in today's mosques: The case of Nilufer, Bursa. *Uluslararası Hakemli Tasarım ve Mimarlık Dergisi*, *12*, 75–97. http://dx.doi.org/10.17365/TMD.2017.3.3

Kazmaoğlu, M., & Tanyeli, U. (1986). 1980'li yılların Türk mimarlık dünyasına bir bakış. *Mimarlık, 24*(2), 31–48. http://dergi.mo.org.tr/dergiler/4/530/7806.pdf

Koçak, N. S., & Özdemir, Ş. (2021). Çamlıca Camii'nin evrensel tasarım kapsamında değerlendirilmesi. *Bartın University International Journal of Natural and Applied Sciences, 4*(2), 133_145. https://dergipark.org.tr/tr/download/article-file/1878676

Kuban, D. (2007). *Osmanlı mimarisi*. İstanbul: Yem Yayınları.

Menderes, A. (1968). Recai Akçay'ın ölümü. *Arkitekt, 329*(1), 32.

Necipoğlu, G. (2005). *The Age of Sinan: Architectural culture in the Ottoman Empire*. Princeton and Oxford: Princeton University Press.

Öney, G. (2019). Gelenekselden çağdaşa özgün bir tasarım: Yeşil Vadi Cami. *Akdeniz Sanat Dergisi, 13*, 371-380. https://dergipark.org.tr/tr/download/article-file/807894

Özyalvaç, A. N. (2020). Konya Sultan Selim (Süleymaniye) Camii biçim özellikleri ve müellif mimar meselesine bir katkı. *Art-Sanat*, *14*, 323-347. https://doi.org/10.26650/artsanat.2020.14.0013

Savaş Okumuş, H., & Kıvılcım Çorakbaş, F. (2023). Understanding, interpreting and presenting heritage sites that lack integrity: the case of the old Arifiye village institute campus (1). *METU JFA*, *40*(1), 175-204. https://jfa.arch.metu.edu.tr/uploads/docs/sayilar/sayi-40-1/metujfa2023108.pdf

Serageldin, I. (1996). A critical methodology for discussing the contemporary mosque. In I. Serageldin & J. Steele (Eds.), *Architecture of the contemporary mosque* (pp. 8–19). London: Academy Editions.

Soy, N. B. (2023). *20 ve 21. yüzyıl cami mimarisinde geleneksel yaklaşımlar: Ankara örneği* (Unpublished master thesis). Selçuk University, Konya.

Şaman Doğan, N. (2002). Anadolu Selçuklu dönemi geometrik süslemelerine (yıldız kompozisyonlarına) yüklenen anlamlar. In *Ortaçağ'da Anadolu, Prof. Dr. Aynur Durukan'a Armağan* (pp. 397-413). Ankara.

Taşdemir, A. S., & Erarslan, A. (2018). Çağdaş cami tasarımında yenilikçi bir yaklaşım: Marmara İlahiyat Camii; Plan ve iç mekân özellikleri. *ABMYO Dergisi*, *52*, 55-70. https://dergipark.org.tr/tr/download/article-file/724391

Yetkin, S. K. (1959). *İslam mimarisi*. Ankara: Ankara Üniversitesi İlahiyat Fakültesi.

## Note

*This article is based on a section of the master's thesis titled "Traditional Approaches in 20th and 21st Century Mosque Architecture: The Case of Ankara" completed in 2022 at Selçuk University.*

## Resume

*Necdet Bekirhan Soy was born in Istanbul in 1993. He received his BA and MA degrees in the departments of art history and architecture at Selçuk University. He graduated from his MA with his thesis project titled "Traditional Approaches in 20th and 21st Century Mosque Architecture: The Case of Ankara". His areas of expertise include architectural history, theory and criticism, and art history. He is the founder of Neoarch Studio.*

*Assoc. Prof. Dr. Murat Karademir is a faculty member at Selçuk University, Faculty of Literature, Department of Art History. His research interests and publications include Turkish water architecture, architectural structures of Mimar Sinan period, and Ottoman tombstones. He teaches courses on "Early Ottoman Architecture", "Medieval Archaeology and Excavation Techniques" and "Ancient Cities of Anatolia".*

JOURNAL OF DESIGN FOR RESILIENCE
IN ARCHITECTURE & PLANNING

*Research Article*
*Online:* www.drarch.org
*Volume 6, Issue 1 (143-162), 2025*
*DOI: 10.47818/DRArch.2025.v6i1161*

# The effects of western housing practices on Turkey's social housing experience

Fatema Alhashemi*
Mehmet Saner**

## Abstract

Social housing emerged as an inevitable yet late response to the changes brought about by industrialization. The sudden population influx caused by mass migration towards expanding old cities and newly developed industrial towns resulted in poor living conditions and the lack of proper accommodation. The evolving response to housing problems paved the way for social housing, which eventually turned into common practices worldwide to provide adequate accommodation to those in need. This paper examines the evolution of Western housing policies and practices, their limitations in the modern social context, and the impact of Western housing practices upon Turkey's social housing experience. |The analysis aims to highlight the adaptability, challenges and opportunities presented by Western housing policies in a distinct cultural and socio-economic environment.

*Keywords:* housing policies, industrialization, social housing, western influence on Turkey

## 1. Introduction

The rise of industrialization during the 19th century led to an increase in urban populations as low-income workers were drawn to industrial cities by economic opportunities. This unprecedented urban growth created a demand for affordable housing, leading to the development of social housing policies (Marcuse, 1995). However, these early initiatives in Western Europe and the United States failed to resolve issues (Lim, 1987). Many of these policies struggled with challenges such as environmental degradation, social upheaval, poverty and crime.

### *1.1. The Problem Definition*

In Turkey, the founding of the Republic intensified the need for housing, primarily in the new capital Ankara, to accommodate bureaucrats and officials (Habib, 1951). Early Turkish housing models heavily influenced by German practices, were generally well received. However, following WWII, mass internal migration triggered a housing crisis, prompting a shift in Turkey's approach to housing policies (Munro, 1974). While Western housing policies introduced standardization and regulations for mass housing, their direct application has led to mixed outcomes in Turkey. In addition, difference in economic structures, social dynamics greatly affected the adaptability and efficiency of some policies.

This paper will examine the evolution of social housing policies in the West, with a primary focus on Germany and the United States. It will examine the strengths and shortcomings of these models, considering their social and economic implications. Building on this analysis, the paper will explore the Western influence on Turkish social housing policies. This paper will compare the advantages and limitations of each model, evaluating their effectiveness in meeting housing needs in different socio-economic contexts.

*M.Arch Student, Ozyegin University, Türkiye fatema.alhashemi@ozu.edu.tr
**(Corresponding author), Assist. Prof. Dr., Ozyegin University, Türkiye mehmet.saner@ozyegin.edu.tr
Article history: Received 06 January 2025, Accepted 24 April 2025, Published 30 April 2025

### *1.2. Hypothesis*

This study hypothesizes that the initial housing needs of Turkey differed greatly from Western countries due to its distinct socio-economic conditions, leading to a unique adaptation of Western housing policies. However, over a period of time, Western and Turkish developments began to prioritize quantity over special quality, with a focus on mass housing production to meet demands. However, this large-scale approach often disregarded the social needs of communities, contributing to discontentment and in some cases, playing a role in the increase of poverty and crime. As a country located between Eastern and Western influences, Turkey has continuously modified Western housing models to align with its distinctive socio-economic environment. Overtime, these evolving policies led to the establishment of TOKI as a central mechanism for mass housing development.

## 2. Literature Review

### *2.1. The Industrial Revolution and the Housing Problem*

The Industrial Revolution, originating in the 18th century in Britain and spreading globally, marked a decisive turning point in history, transforming the economy, transportation, and production methods (Allen, 2011). Factory-based systems and the adoption of new materials replaced many traditionally handcrafted industries (Floud & McCloskey, 1994), introducing the concept of standardized goods, which streamlined production and improved efficiency., and later extended beyond manufacturing to influence housing policies, shaping regulations and the development of social housing projects.

#### *2.1.1. Developments and Urban Changes Brought About by Industrialization*

Industrialization also reshaped the urban landscape by creating a massive demand for labor, prompting widespread migration to industrial cities (Lawton, 1979). Older cities struggled to accommodate the sudden population influx resulting in chaotic slums lacking in essential amenities such as clean water, and basic infrastructure (Polyzos, 2012). Alongside this growth, new industrial towns emerged near factories, mines and trade routes, mirroring the British and German industrial town model (Reeder & Rodger, 2000).

As factories expanded, so did the need for housing and amenities to accommodate the growing workforce, ultimately prompting government intervention. The population of London increased from 900,000 to 4.5 million, while that of Berlin from 190,000 to 2 million, and of New York from 60,000 to 3.4 million in the 19$^{th}$ century (Fishman, 1982). Such rapid increase in population resulted in overcrowding and unsanitary conditions which impacted workers productivity.

In Britain, poor slum conditions became a critical issue in the late Victorian era (Stewart, 2005), as reformers began addressing poverty as a social issue, leading to the development of the 1875 Public Act, which improved sanitation, street lighting and water supplies, with cities like Liverpool leading these efforts (Clarke, 1931). Despite these reforms, lower-income households continued to live in poor conditions.

In the France, early urban developments in the 18$^{th}$ century with building codes in cities like Paris and Marseilles, paved the path for Baron Haussmann's 19$^{th}$ century urban renewal project (Papayanis, 2004). Appointed in 1853, Haussmann sought to modernize Paris by introducing wide boulevards, parks and promenades to replace existing narrow streets and constructing an extensive sewage system improving public health (Chapman, 1953). While these reforms modernized Paris, they failed to address the underlying poverty and housing problem because of Haussmann viewing the issue as a secondary concern.

In Germany, by the 1840s, the housing crisis was increasingly recognized as a part of a broader social crisis threatening "family life, religion, morality, patriotism" (Honhart, 1990). This understanding led to the introduction of "Schwabe's law". This law highlighted the disproportionate burden of rising rent rates on low-income households, often spending a substantial amount of their earning on rent compared to middle- and upper-income households (Brown 1989). During the mid to late 19th century, many companies in Germany provided worker housing, but the financial collapse in 1873, left many companies unable to sustain these efforts (Brown 1989). Berlin's Statistical Office reported declining housing density, yet overcrowded and unsanitary conditions persisted until WWI. To address the housing shortage, *Meitskaserne* as seen in Figure 1 (Epstein et al., 1929) or rental barracks were introduced, however these units typically lacked toilets, and proper ventilation (Kuck, 2010). The project's focus on maximizing profit and cutting costs were evident and indicated "capitalist greed and the rise of proletarian culture" (Rousset, 2021). By 1901, the overcrowding was formulating into a public issue where *Meitskaserne* structures had approximately nine people per unit (Rousset, 2021). The government established guidelines for city expansion, regulating building height and density, and the placement of public infrastructure. However, the specifications for residential units were left to private developers and eventually failed to address housing demands or affordability, resulting in authorities reevaluating housing policies.

**Figure 1** Mietskaserne, Berlin 1929 (Epstein et al., 1929)

In the U.S, social housing policies emerged to address slum formation, population growth, and rising crime. The 1901 tenement law protected tenant rights, ensuring fair rent while allowing landlords 4 – 6% profit margin (Karr, 1992). In 1910, the National Housing Association was founded to address common issues, such as slum conditions, though these early initiatives focusing on affordable housing construction, were targeted the needs of the middle class (Hubka & Kenny, 2006), inevitably widening the income gap. Initially, "most reformers believed that poverty usually resulted from individual depravity" (Karr, 1992), therefore clarifying the initial focus on middle households. This perspective began to weaken later, as the conditions of the slums were recognized as an environment that hindered economic development. During the Great Depression, rising poverty and unrest, including the 1935 black community riots, led to the adoption of the Public Housing Act and housing projects like Harlem River, boosting employment and improving living conditions, albeit minimally (Marcuse, 1995).

### *2.2. Urban Utopias in Relation to Housing Problem from 19th to Early 20th Century*

When industrial developments strained expanding or newly emerging cities, there also emerged utopian responses to overcome the negative aspects of industrialization. Social reformers such as

Robert Owen and Ebenezer Howard promoted sustainable community-oriented living (Dunhill 1964; Edwards, 1913), while architects such as Le Corbusier, Frank Lloyd Wright and Tony Garnier focused on modern, technological-driven cities (Shelton 2011; Wiebenson, 1960).

### *2.2.1. Ebenezer Howard, Garden City*

The Garden City movement introduced by Ebenezer Howard envisioned a utopian city integrating nature with industrialization to reduce social alienation from the natural environment (Blanc 1974; Morris, 1971). Howard proposed self-sufficient green cities for 32,000 residents interconnected by a transportation network (Batchelor, 1969; Eden, 1947) (Fig.2), featuring residential, industrial and commercial zones divided by green spaces, leading to a central garden with essential amenities (Llano, 2020) (Fig.3). Howard (1898) emphasized the importance of public or community land ownership to ensure equitable distribution and uniform living standards. This principle extended into town planning: while Howard (2003) proposed fixed placements for housing, he encouraged individual creativity in the appearance of homes (Osborn, 1946).

However, Garden City faced criticism regarding its economic feasibility and implementation. The residential houses outlined in the plan required high rent, with those located on the outskirts struggling to find tenants. Moreover, the large green spaces reduced community interaction and diminished the sense of community (Edwards, 1913). However, many elements of Howard's vision influenced modern housing solutions in several cities.

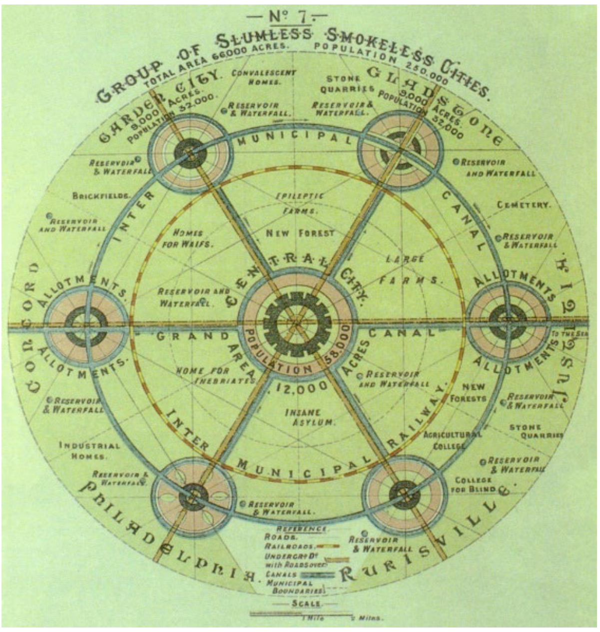



**Figure 2** A layout of the proposed Garden City (Llano, 2020)

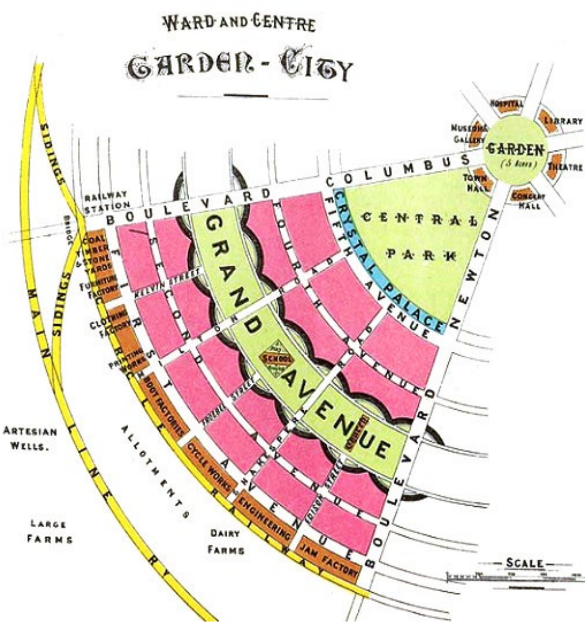



**Figure 3** Garden Cities of Tomorrow diagram (Howard, 1902)

### *2.2.2. Le Corbusier, Radiant City*

Le Corbusier, a key figure in shaping modern European architecture, had a significant influence on urbanism. Amid high population density within industrialized cities, the prevailing approach to solving urban congestion was vertical construction. He proposed high-rise housing blocks for all segments of society, asserting "that all classes were poorly housed" (Marmot, 1981). This perspective contrasted with other urban planners, as Le Corbusier envisioned skyscrapers as revolutionary solutions to urban congestion. In 1922, he introduced the Radiant City (Fig. 4) a utopian plan designed to attain societal and urban harmony for three million residents, aimed to create balance between the environment and its inhabitants, promoting better living (Curtis, 2009). Through this concept, Le Corbusier sought to integrate high density living yet still reserving large greenery by reducing the building blocks' footprint, utilizing modern materials and methods. The model of Radiant City featured a grid pattern with central towers, defining areas for work, home, and leisure (Montavon et al., 2006) (Fig. 4). These structures consisted of 17 stories, a limit Le Corbusier imposed to maintain a connection between family living and vertical circulation (Montavon et al., 2006).



Despite its visionary nature, the Radiant City plan was never realized, primarily due to its sustainability and cost. Critics largely agreed that “psychological, structural and economic difficulties rendered higher apartment buildings quite unfeasible” (Marmot, 1981). Nevertheless, partly by the aid of advances in technology and by the rationale to increase habitable land on multiple floors, high-rise housing blocks have spread all over the world.

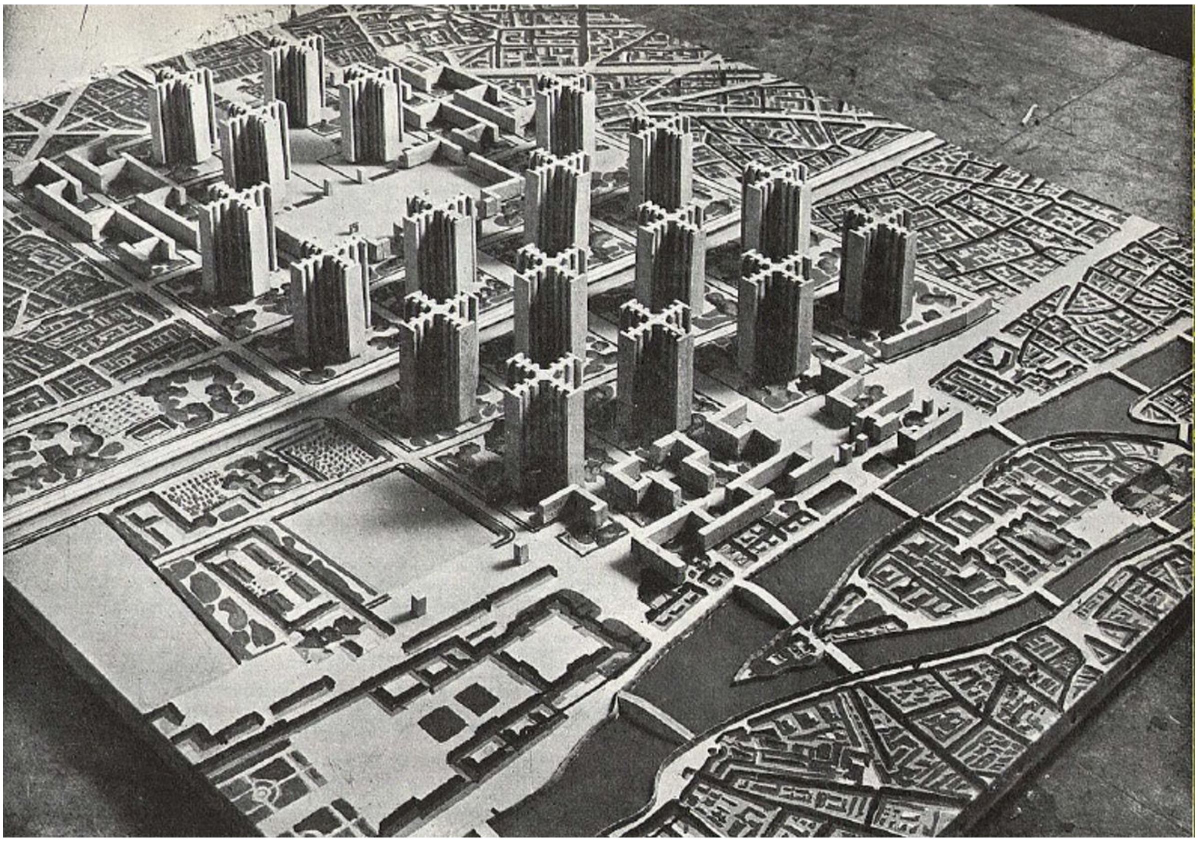


**Figure 4** Radiant City Model, Le Corbusier, 1925 (Musset, 2023)

### *2.3. Policy Based Responses to Need for Housing until WWII*

Urban utopias formulated in the first quarter of the 20$^{th}$ century influenced urban planning greatly, however it was evident that not all housing issues could be solved through idealized visions alone. Governments began to take practical measures to address the increasing housing problem by developing organized social and economically feasible approaches to tackle the issue.

The housing crisis in Britain worsened after WWI. The Housing Act of 1919 aimed to construct 500,000 dwellings in 3 years but failed due to economic decline. The Ministry of Health, established in 1919, linked better housing to improved public health (Stewart, 2005). The 1924 Housing Provision Bill marked a shift towards housing for low-income households, followed by the 1926 Housing Act, which provided financial aid for construction (Engle, 1937). During the 1930s further housing policies were introduced focusing on slum clearance. Despite budgetary constraints, these policies resulted in the construction of 700,000 dwellings and long-term improvements in living conditions (Clarke 1931).

After WWI, Germany faced a severe housing shortage estimated at 1,5 million units due to widespread destruction (Silverman, 1970). The Weimar Republic (1918-1933) pledged reforms to provide housing for all Germans under Article 155 (Clingan, 2000). However, widespread financial hardship limited the funding (Silverman, 1970). A rent tax established in 1921 failed to generate enough funds causing the government to rely on private investments to produce public income. Between 1924 and 1931, only 50% of housing construction was publicly funded (Silverman, 1970). The lack of action from the Weimar Republic aggravated the public leading to uprising as the economy declined further and the housing crisis began to increase.



These conditions fostered a new typology of housing for the working class, called *Seidlung* as introduced by German architect Bruno Taut (Droste & Knorr Siedow, 2014). Taut aimed to reunite Germany by improving urban layouts and housing, inevitably reducing poverty in the process (Ludwig, 2020). Taut's early designs followed a circular pattern segmented into zones such as housing, commercial and industrial (Canniffe, 2015). Most *Seidlung* housing shared similar features such as ensuring the availability of health and educational amenities, to form an ideal community (Kafkoula, 2013). The layouts of the housing projects were constructed in similar formats with each group of apartments or housing forming a neighborhood.

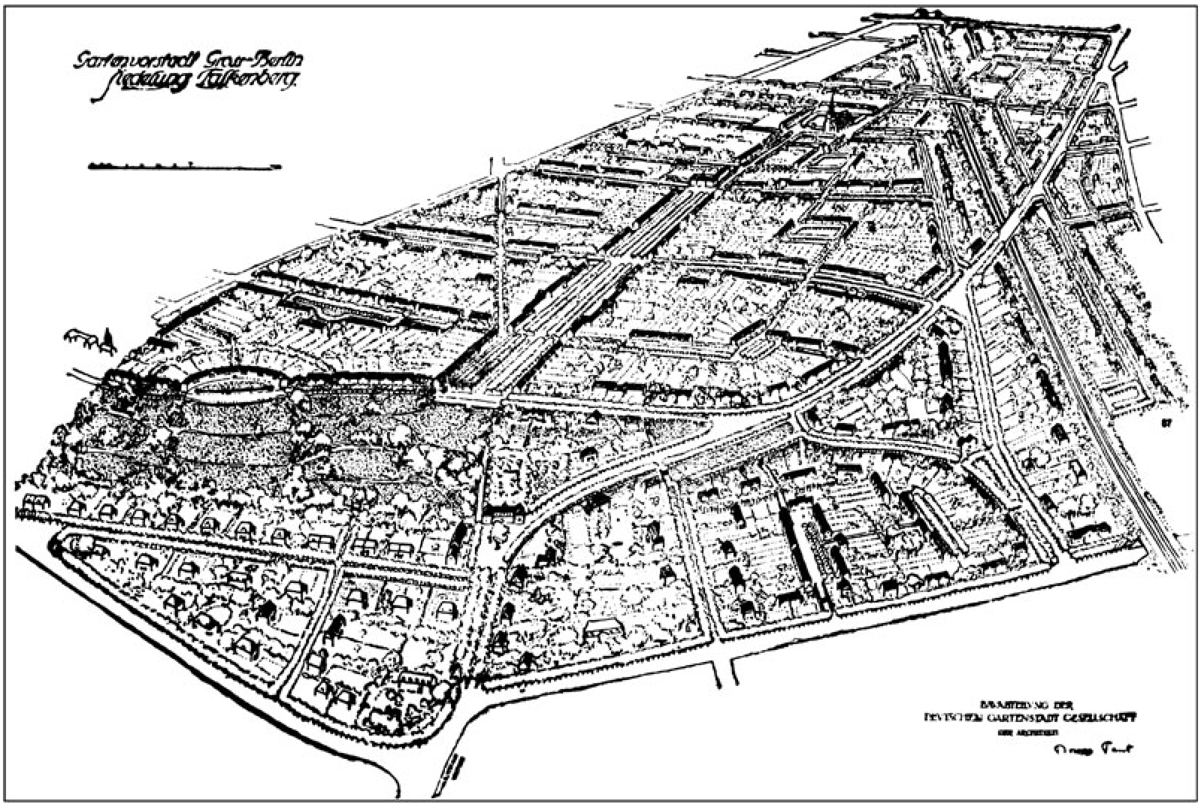


**Figure 5** Gardenstadt Falkenberg Berlin, Master Of Colourful Architecture (Altenmüller & Mindrup, 2009)

As an example of *Seidlung* housing, the Falkenberg Garden City designed by Bruno Taut was completed between 1913-1916, and consisted of 128 housing units, with 80 single family dwellings and 48 apartments spread across 6 buildings. It accommodated approximately 740 individuals. (Fig. 5) The Falkenberg project exhibits many of Bruno Taut's vision along with the influence of the Garden City Movement, with emphasis on organization, control, and community focused development (Drew, 2024; Lucarelli, 2019).

Under the Nazi regime, the focus on housing shifted from public to private ownership, reversing the Weimar Republic's 7:3 public-private balance (Störtkuhl, 2021). By 1937, 315,698 new units were built which aided in reducing the unemployment crisis (Störtkuhl, 2021). However, in late 1936, a four-year plan was introduced by the Nazi regime redirecting national funds toward military endeavors instead.

### *2.4. Post World War II Cases for Social Housing*

After WWII, Germany faced widespread devastation with the division of Germany into East and West. East Germany came under Soviet rule, adopting a communist approach, while West Germany became a democratic state under the United States (Wertheimer, 1958). Housing policies also diverged. The case of West Germany illustrates a clash between an established housing system and the introduction of a foreign standards.

In 1947, The U.S. military invited Walter Gropius, a German American architect and the founder of the Bauhaus, to assess the damage to German cities and provide guidance (Lupfer & Sigel, 2004). Gropius proposed the establishment of small towns with 5,000 – 8,000 residents, allowing people to settle, develop a working environment and economic growth, ultimately generating funds for rebuilding city centers (Krohn, 2019). Gropius's plan aided the framework for federal and local housing policies.



Between 1945-1950 the majority of the population was living in temporary housing or overcrowded conditions (Staub, 2014). In 1950, the government passed the first housing law, setting the criteria for sanitary living conditions (Busch Geertsema & Kofler, 2000). By 1951, the Economic Cooperation Administration (ECA) utilizing the Marshall Plan to provide housing in 15 West German cities (Knapp et al., 1981; Staub, 2014). Compared to housing provided by the Weimar Republic, the ones offered by ECA were relatively small, with enough kitchen space for one person (Staub, 2014). High rise construction was also utilized as a solution to accommodate the middle class and reflecting American influence on Germany's housing landscapes towards single-family dwellings (Einem, 1982). This new standard, aimed to maximize the number of units within a limited space under the Marshall Plan (Knapp et al., 1981).

The same standard put into force by the American rule in West Germany to maximize the number of units in limited spaces and within high-rise blocks seems to be valid also in the United States after World War II. The 1940s and 1950s saw a shift in public housing objectives, with approximately 200,000 units built during this decade. The 1946 Lanham Act focused on housing for war laborers while the 1949 Housing Act aimed to provide quality homes for families, prioritizing displaced families due to urban renewal (McCarty, 2014; von Hoffman, 2000).

The 1960s introduced new public housing legislations, and ending discriminatory housing applicant selection, with section 236 established to serve low-income families and elderly (McCarty, 2014). These laws expanded public housing access to disadvantaged groups and prohibited denial based on race or ethnicity. Yet, the implementation of such principles did not match with the intentions.

Pruitt-Igoe was probably the best case to prove how housing was not just a problem of architecture or urban planning. The complex, designed by Minoru Yamasaki and constructed in the early 1950s in St. Louis, Missouri, consisted of 33 identical 11 story buildings in a linear layout, built on a former slum area as a part of a federally funded post-WWII renewal program (Bolukbas, 2016). Shaped with modernist intentions not just to create a high number of housing units in high rise blocks but also to shape the society via ideal architectural and urban methods, the project stood so short, and blocks began to be demolished in 1972 to reset the social crisis spoken loudly through the architecture of the housing blocks. The demolition was broadcasted live on TV, marking a symbolic moment often described as the "death of modern architecture" (Bristol 1991). Yet even though it was the architecture that was blamed, high-rise point blocks of mass housing spread all over the world as efficient solutions to housing shortages. Even though the modernist aspirations to change society through architecture has faded away, Corbusian housing blocks remained.

## 3. Social Housing in Turkey

The initial cases of mass housing if not social housing in Turkey date back to late Ottoman period where the housing needs of not the overall public but only of some upper classes of the society and mostly of some bureaucrats and tradesmen were met with some housing projects. Even though incomparable in scale and in the number of houses produced with the western cases of the time, the row houses in Beşiktaş Akaretler of the 1870s, Taksim Surp Agop row houses, or Harikzedegân Apartments (also known as Tayyare Apartments) in Laleli dated to 1921 were initial mass housing projects which had differentiated from Ottoman house layout and had been designed to suit a western lifestyle (Tapan, 1999). The reason why mass housing typology had not appeared in Turkey before the foundation of the new Republic was that there had not been mass migration to existing or newly emerging centers and consequently had not risen a need for large number of houses produced in shorter times, as had been witnessed in industrializing west. Yet, such migration cases and subsequently the need for mass houses were experienced in Turkey, initially with the term "low-cost housing", beginning with welcoming nearly 500 thousand immigrants from the Balkans shortly after the end of the War of Independence (Sey, 2005).[1]

### *3.1. Housing in the Early Republican Period*

More or less spontaneously with the relocation of migrants, the new Turkish Republic witnessed another wave of migration, this time upon the designation of Ankara as the new capital city. Before WWI, Ankara was a small town with around 25.000 residents. Its status as the new capital brought about sudden changes in Ankara's social and political landscape, spurred by the relocation of government institutions (Batuman, 2013). Housing for the relocating state officials and also for the masses migrating to the new capital was among the primary problems faced in the first few years of the construction of Ankara.[2] To be able to respond that need for housing and also to ease the construction of the new capital as a modern city, not only first development plans for the city was prepared by Carl Christoph Lörcher for the old city in 1924 and for the new in 1925 (Cengizkan, 2004) (Figure 6), but also 4 million square meters of land was expropriated by the Ankara Municipality in 1925 (Tankut, 1993). However, this expropriated land was not developed by the central government or the local authority to respond to the housing need, most probably because of the economic deficit that the new republic suffered but was purchased in parcels for individual house production.


**Figure 6** Lörcher Plan of Ankara with annotations (Cengizkan, 2024)

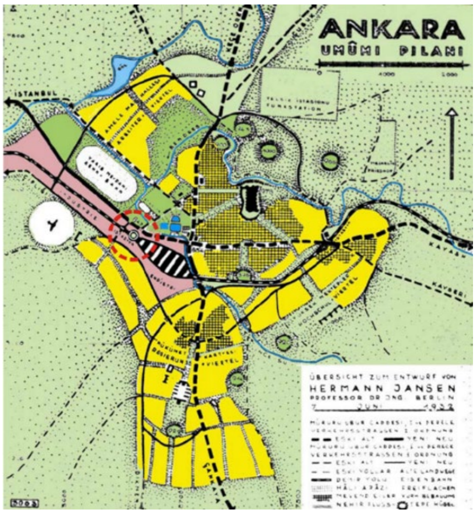



**Figure 7** Jansen Plan (Çalışkan, 2009)

Lörcher's plans for Ankara were implemented maybe not in terms of public funded mass housing projects but still in terms of infrastructure and macroform of the city until the beginning of the 1930s. In the meantime, a competition was held in 1928 to obtain a new development plan for the city, where only three foreign architects were invited. The winning proposal belonged to Hermann Jansen, and it was extensively implemented until the 1940s (Figure 7). In terms of housing, Jansen plan included new zones for this purpose while not erasing what had already been offered by

[1] It should be noted that despite in both western and Turkish cases social housing emerged as a response to the rapid population increase due to migration, the reasons behind the migrations deeply differed. In most western cases it was the outcome of socio-economic factors that moved masses from the rural areas to new industrial centers as workers, whereas in Turkey the reasons behind the mass migration were more socio-political decisions, such as the population exchange after the War of Independence or establishing Ankara as the capital city of the new Republic, at least until the mid-20th century (Munro, 1974).

[2] The rapid increase in the population of Ankara in the first decade of the Republic is revealed in numbers as such: it had risen to 47.727 in 1926, 74.533 in 1927 and to 107.641 in 1928 (Cengizkan, 2004).

Lörcher that had already started to be implemented. In the Republic's early years, one can hardly speak of an overarching policy related to housing. There were initiatives to respond to housing needs though. For instance, the 1930 Municipality Law no. 1580 aimed to promote affordable housing construction but faced setbacks due to budget constraints (Sari et al., 2022). Nevertheless, efforts continued throughout the 1930s, notably with the 1935-1944 cooperative housing movement, where 50 housing cooperatives were erected - 22 in Ankara, 8 in Istanbul and the remainder in other cities (Şahin & Şener, 2021). Among them, one of the best examples to demonstrate the approach to housing problem has been *Bahçelievler* in Ankara.

Designed by Hermann Jansen as an addition to the city plan, *Bahçelievler* was an outstanding housing district on the western outskirts of the proposed development areas (Tümtürk, 2017). (Figure 8) Jansen emphasized integrating residential areas with nature while maintaining proximity with the city (Akcan, 2019). Realized in the mid-1930s, the project embodied Garden City principles, incorporating greenery with communal spaces and reflecting the ideas of the Republic. (Sönmez, 2023). Planned as a low-density neighborhood with row houses and central amenities, it primarily served the bureaucratic class yet failed to address Ankara's growing housing problem (Kılınç, 2012).

Even though Ankara as a city and *Bahçelievler* as a realized housing project based on garden city principles were more apparent in the housing history of Turkey, there had been many other significant projects that showcase the mass housing attempts in the early Republican Period. Among them were "low-cost houses" design by Seyfi Arkan in 1933. These single-storey row houses were designed to be workers' houses as indicated by Jansen on the city plan at the northern outskirts of the city (Akbulut & Akay, 2012). Sey (1998) states that Arkan, not just with design but in his other low-cost houses designs, was heavily influenced by then current architectural movements in Europe, and especially by the Bauhaus principles to promote functionality and mass production in housing to minimize building costs. Another method in mass housing production of the time was the houses specifically produced by a factory (almost always a state factory) for its workers or by a state institution for its employees, such as the ones in Ereğli, Karabük, Hereke, and İzmit (Tapan, 1999). Seyfi Arkan's workers' neighborhood for Zonguldak and Kozlu coal miners and even Saraçoğlu Neighborhood in Ankara designed by Paul Bonatz for upper class state officials fall into this category. The design principles in these projects were again found to be influenced by the similar cases in Europe, and by Bauhaus and/or De Stijl movements that prolonged to that time (Tapan, 1999).

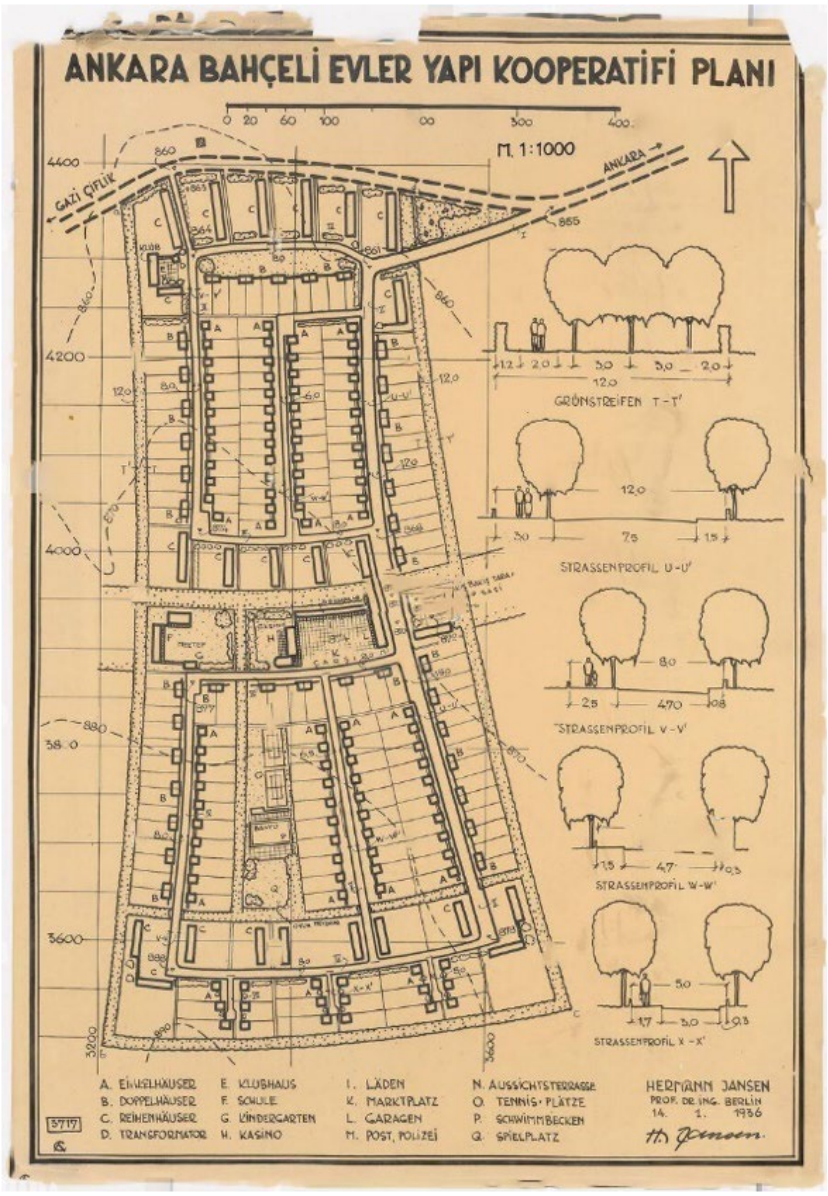



**Figure 8** Ankara Bahcelievler Site Plan, Museum of Architecture at Berlin Institute of Technology (Jansen, 1937)

### *3.2. Housing in the 1950-1980 Period*

The radical and extensive social transformation that had been experienced by the industrialized countries since the 19th century started to be valid for Turkey after the Second World War (Bilgin, 1992). The transformation had been multifaceted. In the postwar period, the United States were emerging as a dominant economic force in the global economy, that was leading to a polarization of the world economy between them and Russia. In the meantime, Turkey was passing from the single party regime to a multi-party democracy, that was going to result with the Democrat Party government between 1950 and 1960. Setting strong relations with the United States politically and economically, the Democrat Party government was aided by Marshall Plan during the 1950s, which led to an economic upturn that was demonstrated in the mechanization of agriculture and flourishing industries. These two factors freed masses from the rural areas and paved the way for mass migration towards big cities like Istanbul, Ankara and İzmir, where industries had also invested in. the rate of population growth that had been 20,1% between 1940 and 1950 jumped to 80,2% between 1950 and 1960 (Sey, 1998). The city became a key destination for migrants seeking jobs in expanding industrial sector (Dinçer, 2011). By being the particular focus of most private sector industrial investments and by being at the center of political preferences, Istanbul, who lost its importance to Ankara after serving as the Ottoman capital for centuries, regained attraction in the

1950s. That is why both housing shortages were at their utmost and also attempts to respond to them were more evident in Istanbul.

The responds to housing shortage should first be classified into two: legal or illegal. Since the state did not take on the role as the chief producer of mass/social houses and since at the same time migration was at its peak, *gecekondu*[3] type of houses spread rapidly in major cities. Despite the first cases of *gecekondu* neighborhoods were seen in Ankara since the 1940s, they turned into a major issue in the post-war period. The estimated number of *gecekondu*s that had been around 25-30 thousand in 1948 increased drastically to 80 thousand in 1953 and even more so to 240 thousand in 1960 (Sey, 1998). Initially, these houses lacked basic infrastructure, including access to electricity, water and sewage, and failed to meet basic sanitary requirements (Erman, 1997). Despite overcrowding and challenging terrain, they provided essential shelter for rural migrants near urban centers. By the 1950s, *gecekondus* began transforming into established neighborhoods (Demirtaş & Şen, 2007). While early urban planning targeted *gecekondus* for urban clearance (Yalçıntan & Erbaş, 2003), their growth eventually forced authorities to recognize their existence and legalize them.

Against such spread of *gecekondus* and increasing shortage of housing, there were some precautions by the central authority to prevent more of them or at least to limit illegal housing and to promote legal housing instead. Among them was providing individual low-rate credits via *Emlak Kredi Bankası* (Real Estate Credit Bank) or *Sosyal Sigortalar Kurumu* (Social Insurance Institution) for the construction of mainly middle-income family houses, which resulted with successful housing projects like Levent (1947-1951) and Koşuyolu (1951) cases (Tapan, 1999). Although there were some other precautions formulated at laws or legislations level, like the establishment of Ministry of Construction and Settlement in 1958, housing standards and credit legislation of the early 1960s, or the five-year development plans that were initiated by 1962. But perhaps none of them were as effective on the housing market as the Condominium Law (*Kat Mülkiyeti Kanunu*) that had been first passed in 1954 and gained its current situation as of 1966. Instead of single land ownership including the house built on, the condominium law allowed shared ownership of land and of separate flats to be built on. It was no coincidence that multi-storey apartment blocks began to rise instead of single-family houses all over major cities of Turkey by the mid-1950s. The case of Levent neighborhood and Ataköy housing projects demonstrated this passage clearly. While the first stage of Levent housing project included single family houses exclusively, as also evidence of prolonging garden city movement influences in the late 1940s, Ataköy housing project designed in 1955 and the fourth stage of Levent neighborhood included multi-storey apartment blocks alongside the low-rise housing units (Tapan, 1999).

The Ataköy housing complex began construction in the 1950s and continues with additions until the 1990s in eleven phases, resulting in a district size neighborhood with 12.000 units in apartment blocks. These projects emphasized quality over quantity, with units being relatively large in size (Balamir, 1996). The governments focused on home ownership with the aim of creating a sustainable source of capital and aimed at attracting a specific demography to newly expanded neighborhoods.

Apart from such comprehensive projects, not the government who had limited financial means as there was no steady source of public housing fund (Öcü, 1988), but the housing market in Turkey produced another alternative for home ownership: build-and-sell. With the availability of flat ownership upon the condominium law but without the sufficient capital both to own the land and to complete the construction, two actors appeared on the market to complete the process: on the one hand, there were multiple owners of a single land who did not have enough financial resources or the technical knowledge to realize the construction, and on the other hand there appeared small scaled contractors, who neither owned the land nor had the enough resources yet had the capacity

[3] *Gecekondu* could be described as the Turkish type of squatter houses. Meaning “landed overnight”, it gives the impression how hastily these houses were built.

to realize constructions. Thus, with an agreement between the two sides in exchange for apartment flats to be produced, this model spontaneously proved itself to be valid for Turkey. The landowners would eventually end up owning houses in apartment blocks without any payment other than what they already had paid to own the land, where the contractor would carry on the construction by selling the incomplete houses beforehand and making his profit by selling the remaining houses after completion of the project. This whole process called build-and-sell has reached its peak in the mid-1960s and lived its golden era during the 1970s and served the housing market until the 1980s. (Işık, 1995).



### *3.3. Housing Between 1980 and Today*

Housing sector in Turkey that was left unsupported and vulnerable after the 1980 coup has negatively been affected by the new economy policies followed that increased the construction costs and that weakened the profitability of investments on housing (Sey, 1998). However, upon realizing the negative effects of a recess in the housing sector on other sectors, new policies were put into force immediately. The Mass Housing Law No.2487 was passed in 1981 and the Mass Housing Administration (Toplu Konut İdaresi – TOKİ) was founded in 1984 to meet the need for social housing in Turkey (Tapan, 1999). TOKI's early policies demonstrated a transition from government regulation towards an active role (Bölen, 2004). Responsibilities for government-funded housing were gradually transferred to TOKI, which adopted a distinct financial model. The Mass Housing Fund, became the primary provider for public housing construction, aiming to provide homes in "current market conditions" (Demirci & Zengel, 2023). Between 1984 and 1989, the fund supported the construction of 584,000 dwellings (Türel & Koç, 2015). Additionally, since it was foreseen with the Mass Housing Law that cooperatives were to be given priority in distribution of funds for housing construction, a number of cooperatives were founded in the early-1980s alongside the already existing ones like the Batıkent, Ankara case that revived and started extensive construction in this period (Sey, 1998). As an overall, 85,7% of 950.00 houses that were supported with credits from mass housing funds were houses produced by cooperatives (Özüekren, 1999).

The passage of TOKI from a more organizing and funds creating role to more builder since the 1990s has not resulted with very optimistic outcomes though. The abolition of the mass housing fund necessitated TOKI's financial restructuring to operate self-sufficiently and generate its own income by direct constructions. In TOKI way of house production, roughly beginning with the 1990s, the core principles were affordability, often utilizing inexpensive, government-owned plots for its projects and employing "a limited set of ready-made architectural plans" (Bican, 2020). This standardization has become a trademark of TOKI's construction but has drawn criticism for neglecting the diverse landscapes and contemporary needs across different regions. However, this uniformity was not a characteristic of TOKI's early years. During the 1990s, the organization produced higher quality projects such as Eryaman in Ankara.

Eryaman housing project was constructed in response to the growing prevalence of informal housing on the outskirts of Ankara (Çalışkan, 2009). "The aim was to provide low-income households without compromising the quality of the built environment" (Bican, 2020). The project began in 1990, divided into four phases, and completed in 1995, with additional buildings included later to accommodate the growing population. This project symbolized collaboration between prominent architects and the government, aiming to create a harmonious housing environment (Bican, 2020). By 1990, 4.064 dwellings were completed, followed by 670 more in 1992, collectively housing 20.000 individuals (Duyar, 1996). Housing units were categorized based on applicant needs: 392 small, one- bedroom apartments, 1670 two-bedrooms apartments, 2713 three-bedroom apartments and 85 four-bedroom apartments (Alkan, 1999).

Eryaman III was designed to balance public and private areas (Çayır, 2022), incorporating both type A single housing and Type B attached blocks. The site plan strategically positioned various blocks to create a sense of community and "a variety of housing types of different heights is mixed to provide architectural diversity" (Albostan, 2009).


**Figure 9** Eryaman III Site Plan (Kavas, 2016)

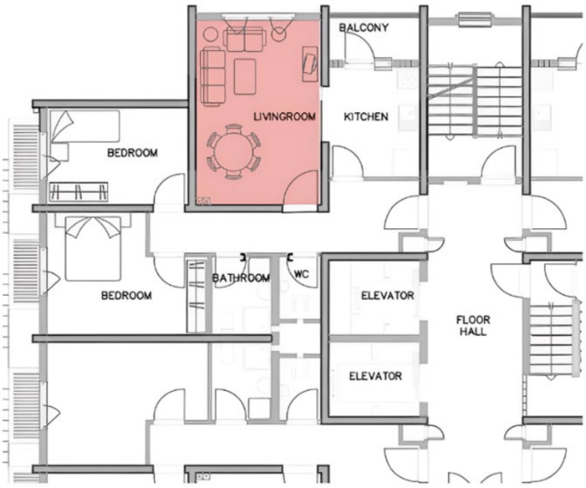



**Figure 10** Partial floor plan 2-bedroom apartment (Eranil & Gurel, 2022)

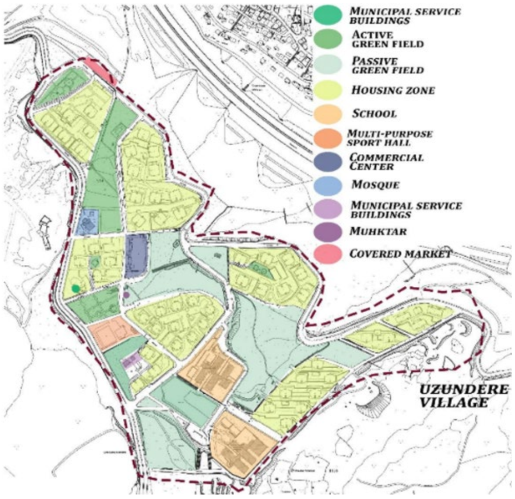



**Figure 11** Site Plan Of Uzundere Project (Bekir, 2022)

However, it is notable that only the early phases of the Eryaman project, as seen in Figure 9 (Kavas, 2016) adhered to its original principles adhered to its original principles (Alkan, 1999). In later stages, TOKI transitioned to constructing uniform single-height apartment buildings, reducing architectural diversity in favor of efficiency and cost-cutting (Yıldırım et al., 2007).

This shift is evident in most of TOKI’s recent approaches, such as the Uzundere project in Izmir in Figure 11 (Bekir, 2022) and Figure 10 (Eranil & Gurel, 2022). In 2003, the Izmir Metropolitan Municipality collaborated with TOKI to relocate residents from hazardous areas to safer housing (Demirtas Milz, 2013). By 2005, 1968 houses were demolished and TOKI constructed new cluster housing in Uzundere for the displaced population (Demirli et al., 2015).

The TOKI Uzundere project was constructed on a 469,425 square meter plot and featured high-rise units measuring 30.80m, with four distinct housing types. In addition to residential units, the project included essential facilities like health centers, schools, multipurpose halls and other amenities to support the community (Bekir, 2022). Despite these efforts, several issues arose, including its distance from the city center, being isolated on the outskirts and housing units that were relatively small for the needs of large immigrant families. These shortcomings led to significant community dissatisfaction (Borsuk & Eroglu, 2020; Eranil & Gürel, 2022).

## 4. Western but the Turkish Way

Turkey's approach to mass or social housing has been heavily influenced by western models from the early Republican period until the post-WWII period and towards the early-90s. However, especially with the inclusion of TOKI as the chief actor in housing sector, the western effects corroded and a new way of mass or social housing started to take over Turkish cities. No longer clearly western, but at the same time not local at all, this model represents the current Turkish way of producing mass housing.

To better understand these housing projects, building density calculations - measuring the number of units or residents per area – will be used to assess the levels of overcrowding. These density figures provide an understanding of the functionality of a housing project, as higher density often associates with strained infrastructure, reduced livability as well as evident social challenges, while moderate density may demonstrate more sustainable living.

The formula for gross residential density is the following:

$$Gross\ Density = \frac{Total\ no.of\ Housing\ Units}{Total\ Land\ Area\ (Hectares)}$$

### *4.1. Performance of Existing Building*

Garden cities were amongst the first housing methods introduced in Turkey after the foundation of the Republic, influenced by the German *Siedlung* example (Akcan, 2012). Projects like *Bahçelievler* adopted a similar approach towards urban and architectural planning, emphasizing organization, functional zoning, and community development (Tümtürk, 2017). A distinct feature was low- density housing, maintaining a connection with nature. Both Taut and Jansen believed this approach improved community health and contributed to the aesthetic appearance (Akcan, 2012; Lucarelli, 2019).

In both *Siedlung* and *Bahçelievler* housing, spatial requirements were prioritized to ensure adequate living standards. The layouts in both contexts emphasized functionality and efficiency in indoor and outdoor spaces, enhancing community satisfaction (Altenmüller, 2013; Tümtürk, 2017). The dwellings demonstrated free plan, well-lit rooms, and large windows overlooking the greenery, cultivating a strong connection with the environment (Lucarelli, 2019) (Fig. 12-13).

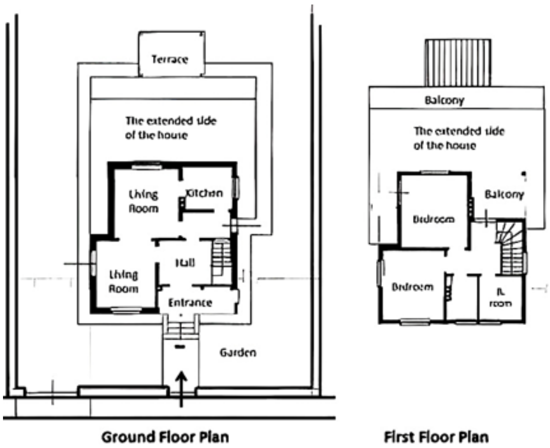



**Figure 12** Bahcelievler B type housing (Gökçe & Chen, 2014)

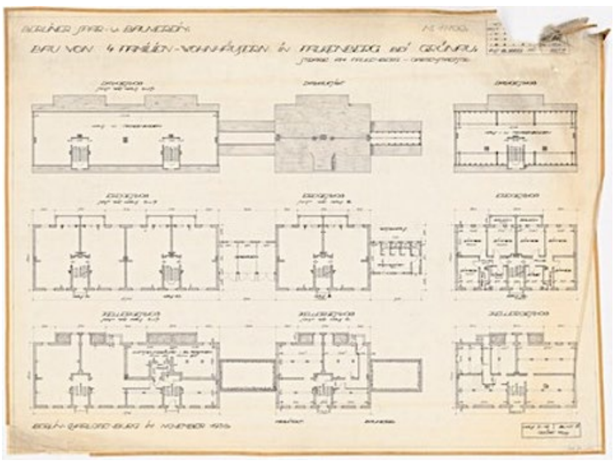


**Figure 13** Falkenberg Housing Plans (Museum of Architecture at Berlin Institute of Technology, n.d.)

*Bahçelievler*'s housing configuration aligns more closely with *Seidlung* housing than traditional Turkish design (Gökçe & Chen, 2014), signifying a departure from traditional styles and marking the beginnings of the modern Republic (Akcan, 2012). The designs integrate European influences, particularly the *Seidlung* model shaped by the Garden City utopia. Features such as large private gardens simplified interior layouts and standardized exterior appearances. The emphasis on "nature-bound planning" became a defining characteristic of the new housing approach (Kılınç, 2012), establishing the *Seidlung* concept as a model for Turkey's new housing developments.

$$29.1\, unit\ per\ hectare = \frac{128}{4.4}$$

When evaluating the building density of Falkenberg utilizing the building density calculation, it is evident that the area is intentionally designed to be low-density. The settlements are spread out on a large plot of land with many gardens between the buildings.

$$12.8\, unit\ per\ hectare = \frac{384}{30}$$

The original plan for Bahçelievler proposed by Herman Jansen is constructed on 30 hectares of land (Sevik & Efeoglu, 2022) with aproximately 384 housing units. This plan provided a spacious layout for residents, however was not sufficient enough to cater to the growing population of Ankara, with later projects containing 830 apartments over 6.3 hectares of land demonstrating a large increase in building density.

Mass housing according to garden city principles was prolonged throughout the Early Republican Period's limited cases. When drastic changes in the political and economic landscape of Turkey were happening during the 1950s, the design approach to mass housing was also altered. Upon the condominium law that allowed shared ownership on single lands and on single blocks, together with the spreading implementation of point blocks in the western countries (Bilgin, 1992), the garden city approach was incrementally replaced with high-rise point blocks approach that could be traced back to Corbusian utopias.

### *4.2. TOKI, High Rise housing and Radiant City*

Even though never realized, Le Corbusier's Radiant City concept served as a utopian blueprint that inspired the development of high-rise housing as a solution to the urban housing crisis, influencing many mass housing projects worldwide (Lathouri, 2005). Le Corbusier anticipated standardization as the future of architecture, emphasizing efficiency and uniformity (Millais, 2018). Envisioning skyscrapers large enough to house 5.000-8.000 residents, such housing blocks were supposed to rise so to allow more space for urban open spaces (Marmot, 1981; Montavon et al., 2006).

Responding to housing shortage in a rational and economical way, such high-rise housing blocks are still being built all around the world today. And Turkey is no different. On the contrary, the implementation of high-rise housing blocks is pushed to the limits, by disregarding the basic principle of open and communal spaces, instead shifting the focus towards maximum resident capacity.

$$88.8\, unit\ per\ hectare = \frac{515}{5.8}$$

Early TOKI projects, such as Eryaman Project prioritize organizing areas into residential, commercial and educational zones with diverse building orientations for better light and ventilation (Kavas, 2016). Eryaman housing project displayed 515 units over 5.8 hectares, however, later additions such as the Eryaman III Social Housing included an additional 2,800 apartment units to cater to the growing demands. Images from various TOKI projects across Turkey reveals a striking uniformity in construction, primarily focusing on maximizing the number of buildings within a plot (Mutlu, 2009). This approach obviously favors quantity over quality, which results in repeating the same or very similar housing block typology. TOKI's objective is to meet 5% to 10% of the Turkish housing demands and to not only increase the number of dwellings but also provide nearby educational and recreational facilities which many western projects neglect.

$$62.7\ unit\ per\ hectare = \frac{2070}{33}$$



Dense construction is also evident in projects like Uzundere, Izmir. In Bezirganbahçe project, Istanbul, 33 hectares of land was covered to host 2,070 units in 700 buildings to accommodate 8,800 residents (Waite, 2019). This uniform approach has become a trademark of TOKI's architectural identity, reflecting its focus on mass housing production.

## 5. Conclusion

The Industrial Revolution was a decisive break in human history. Transforming modes of production, transportation, and consumption, and radically changing urban life. Modern cities, as we call them today, are drastically different from ancient or medieval cities in terms of density, urban sprawl, and networks. Triggered by mass migration from the rural areas to new and/or expanding old centers. In Turkey, the founding of the Republic triggered a need for immediate housing in the new capital, Ankara. Initially influenced by Western – particularly German- housing models, early developments were well received. However, post-WWII internal migration and rapid urbanization triggered a housing crisis, leading to significant shifts in policy approaches. While Western countries had a longer history of managing urban dwelling requirements through standardized, regulated systems, the direct implementation of these models in the Turkish context often produced mixed outcomes due to the unique economic and social environment.

This study hypothesized that that Turkey's initial needs differed greatly from those in the West, resulting in a unique adaptation from those in the West. The research confirms this: early stages demonstrate the direct importation of Western solutions, such as the adoption of architectural styles in areas such as Akaretler, Istanbul and planning expertise in early Ankara. Overtime, Turkey progressed through stages of adaptation- first by inviting Western experts, then by educating local architects in European methods, and eventually by localizing and transforming these approaches. This concluded in the establishment of TOKI, which prioritized large-scale, cost-effective solutions.

However, this shift towards mass housing also aligned Turkey with the global trend – seen in both Western and Turkish contexts – of emphasizing quantity over quality. While high-density developments met the persistent housing demands, it often did at the cost of community cohesion, adequate infrastructure and livability. The hypothesis that such models often contributed to discontentment, and in some case exacerbated rates of poverty and crime, is supported by the analysis of these developments. Nevertheless, the impact of density remains context-dependent, influenced by cultural norms, spatial design and urban policy framework.

Ultimately, this study reinforces the importance of understanding housing policies as a dynamic process shaped by socio-economic context. Turkey's experience reveals how foreign models must be thoughtfully adapted rather than directly applied. This research offers a foundation for further investigation into individual housing projects, both in Turkey and abroad, to deepen our understanding of how global models can be successfully localized to meet diverse urban challenges.

## References

Akbulut, M. R., & Akay, Z. (2012). *Halk için tasarlamak: Seyfi Arkan'ın şehirciliği ve 'ucuz konut' projeleri*, in Modernist Açılımda Bir Öncü: Seyfi Arkan, ed. A. Cengizkan, A.D. İnan, N. M. Cengizkan, 231-248. Ankara: TMMOB Mimarlar Odası.

Akcan, E. (2012). *Architecture in translation: Germany, Turkey, and the modern house*. Duke University Press.

Akcan, E. (2019). Bahçelievleri. *Mekânlar/zamanlar/insanlar: Kimlik, aidiyet ve mimarlik tarihi*. 1. Orta Doğu Teknik Üniversitesi, 1-16.

Albostan, D. (2009). *"Flexibility" in multi-residential housing projects: Three innovative cases from Turkey*. Middle East Technical University.

Alkan, H. F. (1999). *A study on the social environmental analysis of the qualitative values in mass housing areas in suburbs: A case study in Ankara-Eryaman*. Middle East Technical University.

Allen, R. C. (2011). Why the industrial revolution was British: Commerce, induced invention, and the scientific revolution. *The Economic History Review*, *64*(2), 357–384.

Altenmüller, U. (2013). The city crown: An utopianist's vision of a better world by Bruno Taut. *Spaces of Utopia: An Eletronical Journal*, *2*.

Balamir, M. (1996). Making cities of apartment blocks, transformation of the built environment in Turkey by means of reorganizations in property rights. *Housing and Settlement in Anatolia*. Turkiye Ekonomik ve Toplumsal Tarih Vakfi.

Batchelor, P. (1969). The origin of the Garden City concept of urban form. *Journal of the Society of Architectural Historians*, *28*(3), 184–200. https://doi.org/10.2307/988557

Batuman, B. (2013). City profile: Ankara. *Cities*, *31*, 578–590. https://doi.org/10.1016/j.cities.2012.05.016

Bekir, D. (2022). *Tactics of conversion in social housing settlements: Uzundere TOKİ housings* (Master thesis). Izmir Institute of Technology, Turkey.

Bican, N. B. (2020). Public mass housing practices in Turkey: The urgent need for research-based spatial decision_making. *Journal of Housing and the Built Environment*, *35*(2), 461_479. https://doi.org/10.1007/s10901-019-09692-w

Bilgin, İ. (1992) *Konut üretiminin karşılaştırmalı bir analizi*. İstanbul: YÜMFED Yayınları.

Blanc, A. (1974). Emblems of a social conscience. *Built Environment (1972-1975)*, *3*(7), 355–359.

Bolukbas, N. (2016). *Re-reading of the Pruitt-Igoe Housing Project (St. Louis, Missouri, U.S.) ın the context of modernism*, (Master thesis). Middle East Technical University, Turkey.

Borsuk, I., & Eroglu, E. (2020). Displacement and asset transformation from inner-city squatter settlement into peripheral mass housing. *European Urban and Regional Studies*, *27*(2), 142 155. https://doi.org/10.1177/0969776419828794

Bölen, F. (2004). Housing policy and housing systems in Turkey. *A|Z ITU Journal of The Faculty Of Architecture*, *1*(1), Article 1.

Bristol, K. G. (1991). The Pruitt-Igoe myth. *Journal of Architectural Education (1984-)*, *44*(3), 163–171. https://doi.org/10.2307/1425266

Brown, J. C. (1989). Reforming the urban environment: Sanitation, housing, and government intervention in Germany, 1870-1910. *The Journal of Economic History*, *49*(2), 450–452.

Busch Geertsema, V., & Kofler, A. (2000). *Housing policy in Germany*. Bremen: GISS.

Canniffe, E. (2015). *The City Crown by Bruno Taut*. Ashgate Publishing Ltd.

Cengizkan, A. (2004). *Ankara'nın ilk planı: 1924-25 Lörcher Planı*. Ankara: Ankara Enstitüsü Vakfı ve Arkadaş Yayınevi.

Chapman, B. (1953). Baron Haussmann and the planning of Paris. *The Town Planning Review*, *24*(3), 177–192.

Clarke, J. J. (1931). Slums and the housing act, 1930. *The Town Planning Review*, *14*(3), 163–193. JSTOR.

Clingan, C. E. (2000). More construction, more crisis: The housing problem of Weimar Germany. *Journal of Urban History*, *26*(5), 630–644. https://doi.org/10.1177/009614420002600503

Curtis, W. J. R. (2009). Intersections: On re-reading Le Corbusier. *AA Files*, *58*, 50–55.

Çalışkan, O. (2009). Forming a capital: Changing perspectives on the Planning of Ankara (1924-2007) and lessons for a new master-planning approach to developing cities. *Footprint*, *3*(5), 23–53.

Çayır, D. (2022). *An investigation on the social sustainability of a neighbourhood unit: Eryaman Stage III in Ankara* (Master thesis). Middle East Technical University.

Demirci, H., & Zengel, R. (2023). TOKI and Reits: Dominating housing actors in türkiye and their design approaches. *Khulna University Studies*, *20*(2), 315_332. https://doi.org/10.53808/KUS.2023.20.02.ICCAUA372-se

Demirli, M. E., Tuna Ultav, Z. E., & Demirtaş-Milz, N. (2015). A socio-spatial analysis of urban transformation at a neighborhood scale: The case of the relocation of Kadifekale inhabitants to TOKİ Uzundere in İzmir. *Cities*, *48*, 140–159. https://doi.org/10.1016/j.cities.2015.06.013

Demirtaş, N., & Şen, S. (2007). Varoş identity: The redefinition of low income settlements in Turkey. *Middle Eastern Studies*, *43*(1), 87–106. https://doi.org/10.1080/00263200601079732

Demirtas Milz, N. (2013). The regime of informality in neoliberal times in Turkey: The case of the Kadifekale urban transformation project. *International Journal of Urban and Regional Research*, *37*(2), 689–714. https://doi.org/10.1111/1468-2427.12005

Dinçer, İ. (2011). The impact of neoliberal policies on historic urban space: Areas of urban renewal in Istanbul. *International Planning Studies*, *16*(1), 43–60. https://doi.org/10.1080/13563475.2011.552474

Drew, N. (2024). *Between tradition and innovation: balancing architectural and societal heritage through conscious stewardship of Garden Cities since 1903* (Bachelor thesis). University of Chicago, United States https://doi.org/10.6082/uchicago.12710

Droste, C., & Knorr Siedow, T. (2014). Social housing in Germany. *In social housing in Europe* (pp. 183–202). https://doi.org/10.1002/9781118412367.ch11

Dunhill, N. (1964). A pioneer new town: New Lanark. *Ekistics*, *18*(108), 364–366. JSTOR.

Duyar, U. (1996). *Post-occupancy evaluation on environmental quality in new development areas: The case of Eryaman*, (Master thesis), Bilkent Universitesi, Turkey.

Eden, W. A. (1947). Studies in urban theory II: Ebenezer Howard and the Garden City Movement. *The Town Planning Review*, *19*(3/4), 123–143.

Edwards, A. T. (1913). A criticism of the Garden City Movement. *The Town Planning Review*, *4*(2), 150–157.

Einem, E. von. (1982). National urban policy—The case of West Germany. *Journal of the American Planning Association*, *48*(1), 9–23. https://doi.org/10.1080/01944368208976163

Engle, N. H. (1937). The British housing program. *The Annals of the American Academy of Political and Social Science*, *190*, 191–204.

Epstein, H. (1929). *Berlin in bildern bild 3. GEO*. Retrieved from https://www.geo.de/wissen/weltgeschichte/fotoshow---berlin-in-bildern----bild-3_30052918-30165416.html

Eranil, M., & Gürel, M. Ö. (2022). Social housing as paradoxical space: Migrant women's spatial tactics ınside Toki Uzundere blocks. *Home Cultures*, *19*(1), 23-48.

Erman, T. (1997). Squatter (gecekondu) housing versus apartment housing: Turkish rural-to-urban migrant residents' perspectives. *Habitat International*, *21*(1), 91–106. https://doi.org/10.1016/S0197-3975(96)00048-3

Falkenberg Garden City (1913–16). (n.d.). Siedlungen der Berliner moderne. https://world-heritage-estates-berlin.com/falkenberg/

Fishman, R. (1982). *Urban utopias in the twentieth century: Ebenezer Howard, Frank Lloyd Wright, Le Corbusier*. The MIT Press.

Floud, R., & McCloskey, D. N. (1994). *The economic history of Britain since 1700* (Issue v. 1). Cambridge University Press.

Gökçe, D., & Chen, F. (2014). The evolution of House form and the change of culture: A purkish Perspective. *21st International Seminar on Urban Form*, Porto, Portugal.

Güngör, S., & Özcan, U. (2022). Şehir Mimarı Hermann Jansen'in planlama anlayışı ve başkent Ankara'nın imarı. *International Journal of Social and Humanities Sciences (IJSHS)*, *6*(3), 155-172.

Habib, H. (1951). Industrialization in Turkey. *Pakistan Horizon*, *4*(1), 40_51. http://www.jstor.org/stable/41392473

Honhart, M. (1990). Company housing as urban planning in Germany, 1870-1940. *Central European History*, *23*(1), 3–21.

Howard, E. (1902). Garden Cities of To-morrow. *Organization and Environment*, *16*(1), 98–107.

Hubka, T. C., & Kenny, J. T. (2006). Examining the American dream: Housing standards and the emergence of a national housing culture, 1900-1930. *Perspectives in Vernacular Architecture*, *13*(1), 49–69.

Işık, O. (1995). Yapsatçılığın yazılmamış tarihi: Türkiye'de konut kesiminde küçük üreticiliğin varlık koşulları ve gelişimi üzerine gözlemler. *Mimarlık 261*, 43-46.

Jansen, H. (1937). *Gesamtbebauungsplan Ankara siedlung Bahceli Evler Yapi Kooperatifi*. OMNIA. Museum of Architecture at Berlin Institute of Technology Archive.

Kafkoula, K. (2013). On garden-city lines: Looking into social housing estates of interwar Europe. *Planning Perspectives*, *28*. https://doi.org/10.1080/02665433.2013.737708

Karr, R. D. (1992). Shelter the American way: Federal urban housing policy, 1900-1980. *New England Journal of Public Policy*, *8*(1), 13.

Kavas, G. G. (2016). *An alternative housing experiment by the housing administration of Turkey: Ankara, Eryaman stage III*, (Master thesis). Middle East Technical University, Turkey.

Kılınç, K. (2012). Imported but not delivered: The construction of modern domesticity and the spatial politics of mass housing in 1930s' Ankara. *The Journal of Architecture*, *17*(6), 819_846. https://doi.org/10.1080/13602365.2012.746015

Knapp, M., Stolper, W. F., & Hudson, M. (1981). Reconstruction and west-integration: The impact of the Marshall Plan on Germany. *Zeitschrift Für Die Gesamte Staatswissenschaft / Journal of Institutional and Theoretical Economics*, *137*(3), 415–433.

Krohn, C. (2019). *Walter Gropius: Buildings and projects*. Birkhäuser.

Kuck, R. (2010). *Mietskaserne* [Research Paper]. Delft University of Technology. https://preservedstories.com/wp-content/uploads/2013/01/Mietskaserne-1.pdf

Lathouri, M. (2005). Frame and fragment: Visions for the modern city. *AA Files*, *51*, 58–67.
Lawton, R. (1979). Mobility in nineteenth century British cities. *The Geographical Journal*, *145*(2), 206–224. https://doi.org/10.2307/634387
Lim, G. C. (1987). Housing policies for the urban poor in developing countries. *Journal of the American Planning Association*, *53*(2), 176–185.
Llano, S. E. P. (2020). From the urban project to the participative public space project: A historical approach. *Módulo Arquitectura-CUC*, *24*, 67-82.
Lucarelli, F. (2019). *Bruno Taut: The City Crown (1919)*. SOCKS. https://socks-studio.com/2013/09/28/bruno-taut-the-city-crown-1919/
Ludwig, B. (2020). Types of housing estate–German nomenclature and systematics on the example of Wałbrzych agglomeration settlements. *Technical Transactions*, *117*(1).
Lupfer, G., & Sigel, P. (2004). *Walter Gropius, 1883-1969: The promoter of a new form*. Taschen.
Marcuse, P. (1995). Interpreting "Public Housing" history. *Journal of Architectural and Planning Research*, *12*(3), 240–258.
Marmot, A. F. (1981). The legacy of Le Corbusier and high-rise housing. *Built Environment (1978-)*, *7*(2), 82–95.
McCarty, M. (2014). *Introduction to public housing*. Congressional Research Service.
Millais, M. (2018). *Le Corbusier, the dishonest Architect*. Cambridge Scholars Publishing.
Montavon, M., Steemers, K., Cheng, V., & Compagnon, R. (2006). *La Ville Radieuse by Le Corbusier, once again a case study*. PLEA 2006.
Morris, A. E. J. (1971). History of urban form—3: Public health and social reform. *Official Architecture and Planning*, *34*(6), 460–462.
Morris, A. E. J. (1971). History of urban form—5: Origins of Garden City. *Official Architecture and Planning*, *34*(10), 779–781.
Munro, J. M. (1974). Migration in Turkey. *Economic Development and Cultural Change*, *22*(4), 634–653. JSTOR.
Musset, A. (2023). *Equitable society, just city and utopia*. In City, Society, Justice. A Spatial and Cultural Approach (pp. 465_487). Essay, EUDEM. Retrieved from https://www.researchgate.net/publication/369826849_EQUITABLE_SOCIETY_JUST_CITY_AND_UTOPIA
Mutlu, E. (2009). *Criteria for a "good" urban renewal project: The case of Kadifekale urban renewal project (Izmir, Turkey)*, (Master's thesis), Izmir Institute of Technology, Turkey.
Nas, T. F., & Odekon, M. (Eds.). (1992). *Economics and politics of Turkish liberalization*. Lehigh University Press.
Osborn, F. J. (1946). The Garden City Movement: Reaffirmation of the validity of Ebenezer Howard's idea. *Landscape Architecture*, *36*(2), 43–54.
Öcü, A. (1988). The politics of the urban land market in Turkey: 1950–1980. *International Journal of Urban and Regional Research*, *12*(1), 38–64.
Özüekren, A.Ş. (1999). *Cooperatives and housing production, in housing and settlement in Anatolia: A historical perspective*, ed. Y. Sey, 355-365. İstanbul: Türkiye Ekonomik ve Toplumsal Tarih Vakfı.
Papayanis, N. (2004). *Planning Paris before Haussmann*. Johns Hopkins University Press.
Polyzos, S. (2012). *Urban development*. IntechOpen.
Reeder, D., & Rodger, R. (2000). Industrialization and the city economy. *The Cambridge Urban History of Britain*, *3*, 1840–1950. Cambridge University Press.
Sari, Ö. B. Ö., Khurami, E. A., & Uzun, N. (2022). *Housing in Turkey: Policy, planning, practice*. Taylor & Francis.
Sevik, E., & Efeoglu, H. E. (2022). The effect of urban form on functional organization of space: A critical perspective on the role of configuration in urban planning by comparing three districts in Ankara, Turkey.
Sey, Y. (1998). *Cumhuriyet Döneminde konut, in 75 yılda değişen kent ve mimarlık*, ed. Y. Sey, 273-300. İstanbul: Tarih Vakfı ve İş Bankası.
Sey, Y. (2005). *To house the new citizens: Housing policies and mass housing, in modern Turkish architecture*, ed. R. Holod, A. Evin, S. Özkan, 159-181. Ankara: TMMOB Mimarlar Odası. (First published by University of Pennsylvania Press, 1984).
Shelton, T. (2011). Automobile utopias and traditional urban infrastructure: Visions of the coming conflict, 1925—1940. *Traditional Dwellings and Settlements Review*, *22*(2), 63–76.
Silverman, D. P. (1970). A pledge unredeemed: The housing crisis in Weimar Germany. *Central European History*, *3*(1/2), 112–139.
Sönmez, F. (2023). Garden houses design: Sugar factory laborers housing cooperatives, Kayseri. *Online Journal of Art and Design*, *11*(4).

Staub, A. (2014). The road to upward mobility: Urbanity and the creation of a new middle class in postwar West Germany. *Journal of Urban History*, *40*(3), 563–584. https://doi.org/10.1177/0096144213516081

Stewart, J. (2005). A review of UK housing policy: Ideology and public health. *Public Health*, *119*(6), 525–534. https://doi.org/10.1016/j.puhe.2004.07.006

Störtkuhl, B. (2021). Practices in building housing and settlements in the Nazi era. Case study: Breslau. *Architectus*, *3*(67), 25–34.

Şahin, P., & Şener, S. M. (2021). A review on changing housing approaches and media contents in Turkey: 1930-1980 period. *A|Z ITU Journal of The Faculty of Architecture*, *18*(2), Article 2. https://doi.org/10.5505/itujfa.2021.38243



Tankut, G. (1993). *Bir başkentin imarı: Ankara 1929-1939*. Ankara: Anahtar Kitaplar.

Tapan, M. (1999). *Mass housing and its development in Turkey, in housing and settlement in Anatolia: A historical perspective*, ed. Y. Sey, 366-378. İstanbul: Türkiye Ekonomik ve Toplumsal Tarih Vakfı.

Tümtürk, O. (2017). Collective form and space: A comparative case of Bahçelievler and German Siedlungen. *Designing Urban Design: Towards a Holistic Perspective. Ankara: Middle East Technical University Sympossium 2016*, 20.

Türel, A., & Koç, H. (2015). Housing production under less-regulated market conditions in Turkey. *Journal of Housing and the Built Environment*, *30*(1), 53–68.

von Hoffman, A. (2000). A study in contradictions: The origins and legacy of the housing act of 1949. *Housing Policy Debate*, *11*(2), 299–326. https://doi.org/10.1080/10511482.2000.9521370

Waite, İ. A. (2019). Policy recommendations for the planning of multi-level redevelopment and social housing practices. *ICONARP International Journal of Architecture and Planning*, *7*(2), 540-567.

Wertheimer, R. G. (1958). The miracle of German housing in the postwar period. *Land Economics*, *34*(4), 338–345. https://doi.org/10.2307/3144545

Wiebenson, D. (1960). Utopian aspects of tony garnier's cité industrielle. *Journal of the Society of Architectural Historians*, *19*(1), 16–24. https://doi.org/10.2307/987962

Yalçıntan, M. C., & Erbaş, A. E. (2003). Impacts of gecekondu on the electoral geography of Istanbul. *International Labor and Working_Class History*, *64*, 91_111. https://doi.org/10.1017/S0147547903000218

## Resume

*Fatema Alhashemi is a master's Student with a focus on the study of the Western impact on social housing in Turkey. She holds a BSc. In Architecture from Ozyegin University.*

*Dr. Mehmet Saner obtained his B.Arch. and M. Arch from Middle East Technical University (METU), Department of Architecture in 2001 and 2004 respectively, and Ph.D. in City and Regional Planning from METU in 2014. He visited TU Dortmund and carried on his researches for two years on a research grant from DAAD during his doctoral studies. Along with his expertise on urban voids, he is interested in conservation and re-use of old industrial buildings and areas in urban and regional scales.*

JOURNAL OF DESIGN FOR RESILIENCE IN ARCHITECTURE & PLANNING

*Research Article*
*Online:* www.drarch.org
*Volume 6, Issue 1 (163-181), 2025*
*DOI: 10.47818/DRArch.2025.v6i1162*

# Analysing morphogenetic design approaches in the context of hypothetical housing examples

Anday Türkmen*

## Abstract

Conceptual approaches that systematically integrate ecological reasoning with algorithmic design processes have gained increasing attention in theoretical discussions on architectural practice. However, a significant gap remains in terms of their application, particularly within the context of housing architecture. In response to this theoretical gap, this study aims to evaluate the algorithmic orientations of designers who transform their spatial inquiries into an ecological organization through hypothetical housing examples. This evaluation is framed through the concept of morphogenetic design—a biologically informed architectural approach in which form and space evolve not through predetermined templates but through generative, adaptive, and systemic processes. Accordingly, the study addresses two main research questions: 'The potential impact of morphogenetic design on residential buildings' and 'Integration of morphogenetic design into housing construction processes'. The study employed a qualitative research design and the literature review method to answer the research questions. The research sample consists of four hypothetical housing projects: Embryological House, Multistory Apartment Building, Molecular Engineered House, and The Fab Tree Hab. These projects were developed using morphogenetic design approaches in 2000 and beyond. In order to collect data from the main mass in an easy and fast way, Homogeneous sampling method, one of the purposeful sampling types, was preferred. In this context, the 'descriptive content analysis method' was preferred to analyse the data obtained in the research and the data was analysed in two stages. In the first stage, descriptive analysis was carried out and the general trend was determined by examining the qualitative studies that could answer the research questions. In the second stage, content analysis was carried out and the data obtained were organised and interpreted according to the parameters set by the researcher. The analysis indicates that morphogenetic design has the capacity to substantially transform the formal, functional and ecological dimensions of future residential buildings. Digital design methods, biologically inspired production techniques and user-participatory design strategies have rendered it feasible for buildings to self-renew, establish symbiotic relationships with their environment and adapt to various living scenarios. This process is characterised by the integration of sustainability and user experience across multiple stages, ranging from design to construction.

*Keywords:* embryological house, fab tree hab, molecular house, morphogenetic design, multistory apartment

## 1. Introduction

Housing is a phenomenon that reflects social values and is a crucial element of architectural practice and thought discussions. It establishes the built environment as an effective spatial value (Şensoy & Özaslan, 2020, p. 281). In this context, housing meets the need for shelter, which is the most irreducible element of daily life, and thus shows the quality of being a basic component of the built environment (Riley, 1999, p. 9). The content of housing has been influenced by changes in people's understanding of life based on the prevailing knowledge of the time. The production and spatial organisation of housing can be discussed through hypothetical propositions. The act of sheltering is the most important aspect of living possibilities and is the common content of new design approaches emerging for the current situation. The negative consequences of industrialisation, such as uncontrolled population growth, excessive urbanisation, and reduction of

*(Corresponding author), Assist. Prof. Dr., Istanbul Gedik University, Türkiye andayturkmen@gmail.com
*Article history: Received 24 December 2024, Accepted 28 April 2025, Published 30 April 2025*

natural areas, have led to a search for solutions. This has resulted in the proposal of many designs that aim to address the problems caused by industrialisation in social life and the physical environment. Nature has been a guiding, informative, and inspiring source throughout the evolutionary process of the human species on earth. Understanding nature has directly or indirectly influenced the accumulation of knowledge produced by humans. This is because nature is inherent in all activities resulting from human physical or mental activity. On the other hand, various factors significantly impact the relationship between our understanding of nature and architectural design theories. These factors include religious beliefs, scientific advancements, technology, and human subjective experiences. These parameters establish the theoretical background of the relationship between natural philosophy, science, and architectural discipline, shaping the logical framework of architectural design methodologies. This research evaluates morphogenetic design approaches within the context of housing problems. These approaches reflect technological and scientific developments of the period. The potential of these approaches to solve housing problems has not yet been sufficiently researched.



### 1.1. Problem

The main problem of this research is to explore the impact of morphogenetic design approaches on housing production processes and to demonstrate these effects through hypothetical designs. The study analyses the applicability, aesthetic values, and sustainability factors of morphogenetic design in housing production using specific examples. Furthermore, the potential contributions of this design approach to the housing industry are evaluated.

### 1.2. Purpose

The objective of this research is to establish a dialogue between the morphogenetic design approach, which is one of the current manifestos in the discipline of architecture, and housing production. The theoretical underpinnings of the morphogenetic approach will be analysed through interdisciplinary relationships. Additionally, the algorithmic orientations of designers who transform their spatial searches into an ecological organization through hypothetical housing examples are comparatively evaluated.

### 1.3. Questions

The study aimed to answer the following two research questions (RQ1 and RQ2) based on the identified problems:

RQ1: What is the potential impact of morphogenetic design on future residential buildings?

RQ2: How is morphogenetic design integrated into housing construction processes?

### 1.4. Importance

This study explores the ecological framework established within residential buildings for architectural experimentation, highlighting the location and implementation of morphogenetic design approaches in housing production, predicting the interaction between biology and architecture, and synthesising the wealth of research information currently available to contribute to the existing literature.

### 1.5. Limitations

The study's limitations are discussed in terms of theoretical and methodological aspects, as well as the internal and external validity of the research. Although a comprehensive literature review was conducted on the research topic, the limited number of scientific studies aiming to establish a dialogue between morphogenetic design approaches and housing production is considered a theoretical limitation of this research. It is important to note that the research was conducted on hypothetical designs rather than implemented projects, which weakened the internal validity of the study. It is also possible that housing production may be affected by other factors beyond the parameters included in the research. The study assessed the impact of factors that were controllable or known. However, it had methodological limitations. The data was collected only from four housing projects developed in 2000 and after, which limits the generalisability of the findings. The study's external validity was negatively affected by the limited sample area.

### 1.6. Literature Review



While there is a shortage of research directed at forming a connection between morphogenetic design approaches and residential buildings, there are significant studies that explore the topic in its own context and scrutinize comparable issues. This section provides a short summary of the compiled national and international literature on the notion of morphogenetics.

Kolarevic's (2000) study examines how digital morphogenesis is used as a generative tool for deriving and transforming form rather than solely as a representational tool for visualisation. In Hensel et al.'s (2004) research, they discuss morphogenetic design approaches as a development that will affect not only the construction of buildings but also the composition of new materials. In the study carried out by Akyol Altun (2007), the impact of scientific and technological research on the field of architecture was investigated, with a specific focus on the emerging morphogenetic approaches. These approaches are predicted to have a significant influence on the future of architecture, despite currently being viewed as unrealistic. Similarly, İnceköse (2008) questioned the use of natural scientific knowledge in contemporary architectural discourses within an epistemology centred on architecture and biology. In Akbulut's (2009) study, evolutionary design approaches, which assign a distinct role to the designer compared to traditional methods, are viewed as a creative process. Roudavski (2009) examined morphogenetic approaches in comparison to architectural design techniques and analysed the impact of this biological concept on current architectural discussions. Menges' (2012) research associates morphogenetic design methods with exploratory evolutionary computation and features two case studies showcasing the development of spatial morphologies. Erbaş Korur and Dülgeroğlu Yüksel (2013) examine the impact of genetic science on architecture. Vural and Mutlu Avinç (2015) comparatively analyze traditional design methods inspired by nature, morphogenetic, and computational design processes according to life criteria. In the study carried out by Sönmez and Balcı (2020), the concept of form in architecture and the processes of formation were analyzed by contrasting hylomorphism-morphogenesis. Şensoy and Özaslan's (2020) research discusses housing utopias through architectural representations of interdisciplinary proposals that prioritise the sustainability of life. The discussion examines the transformation of utopias, which were incorporated into the field of architecture with industrialisation, into contemporary utopian proposals as a result of the field of knowledge of the time. Bulu and Kavut's (2021) interdisciplinary research explored the application of the concept of morphogenesis in science fiction cinema, specifically within the fictional spaces of the movie Annihilation. On the contrary, Özer Yaman's (2022) research considered the role of morphogenetic design approaches in architectural education. These philosophical and interdisciplinary discussions—such as hylomorphism, utopia, and epistemology—are included not as isolated theoretical elements, but as complementary perspectives that reveal how morphogenetic thinking expands the conceptual scope of housing design. In this way, the literature review integrates theoretical, computational, and discursive layers that shape the foundations of this study.

The literature suggests that morphogenetic design approaches, which are currently being discovered and developed for the discipline of architecture, stand out in relation to biology and genetics, evolving design processes, sustainability-oriented utopian thought and representations in science fiction cinema. Furthermore, it can be inferred that morphogenetic design approaches are an important predictor for the future of architectural education and the profession. Based on this literature, the present study positions itself as a conceptual and analytical extension that explores how morphogenetic design approaches—previously discussed in relation to digital tools, biomimetic principles, and educational frameworks—can be critically examined through the lens of speculative housing design. The diversity of cited sources enables a multi-dimensional grounding for interpreting design strategies, while the selected housing examples serve to contextualize these theoretical perspectives in spatial and programmatic terms. Rather than presenting a general literature synthesis, this study attempts to operationalize and recombine these strands of thought into a specific interpretive model relevant to contemporary architectural experimentation.

## 2. Theoretical Framework



Philosopher and historian Robin George Collingwood divided the history of natural philosophy into three periods: Ancient Greek, Renaissance, and Modern periods. In ancient Greece, nature was often personified as a living being regulated by a competent intellect. However, during the Renaissance, it was commonly understood as a machine controlled by God. In contrast to the mechanical and static understanding of the Renaissance, the modern period was conceived on the basis of change and evolution (Collingwood, 1945, pp. 8-9). The theory of evolution, proposed by British biologist and natural historian Charles Darwin, states that the key to survival in the natural environment is adaptation to existing physical conditions. This theory highlights the fact that the ecological system is in a constant state of development due to ever-changing living conditions. Nature is described as a system that defines relationships, produces solutions to problems, and can organize itself. Furthermore, the continuous evolution of nature suggests that the concept of design created by nature is also constantly changing and developing (Von Sydow, 2012, p. 42).

According to Portoghesi (2000, p. 10), the human approach to incorporating nature into architecture involves creating unique conditions that correspond to different levels of interaction between the two. This process is dynamic in nature. In this framework, the definition of the communication between the natural and the artificial allows for a solution to the design of a specific situation or structure that emerges in line with multifaceted requirements. The use of tools and methods that reference design processes allows for speculative production approaches to emerge within the architectural discipline. This process allows designers to draw structural conclusions about natural systems and establish the appropriate experimental environment through the morphological approaches obtained.

At this point, nature contains a wealth of information for designers within the ecosystems it hosts. This information is useful for producing efficient and strong designs for biological structures and provides constructive guidance. In this framework, the design practice being evaluated gains a specific identity by including organic references in the intuitive process. The new meaning produced necessitates the entire design process to work with integrity. In particular, architects can use algorithm-based production environments to test various alternatives in a multidisciplinary setting. These environments are often referred to as 'designing the design process' and are facilitated by digitally mediated organizations. New formal experiments produced with the computational design capability of digital technologies enable architects to collaborate in interaction with different branches of expertise. In this context, computer-aided design orientations have facilitated the development of a new generation of architects who are adaptable to technology and have transformed traditional design approaches. This transformation has made it possible to interpret biological references on an architectural scale and adapt spatial ideas to an ecological organization. Furthermore, it is important to discuss and make sense of the approaches that remain valid on an international scale, considering the historical development of biomimicry. This approach is widely accepted as the predecessor of the morphogenetic design approach and its interaction with design disciplines, as well as its contribution to the architectural profession.

### *2.1. Biomimicry Overview*

The relationship and connection between architecture and nature has raised many questions, criticisms and solutions. Today, there is a new form of design that requires modern man to look to the natural processes found in nature for inspiration. The true potential of these processes, which have existed for decades, has only recently begun to emerge. According to Maglic (2012, p. iv), the philosophy behind living organisms in nature can be used to aid human development, and this is defined as 'biomimicry'. Kennedy (2017, p. 51) defines biomimicry as innovation achieved through the imitation of biological forms, processes, models and systems. The term 'biomimicry' or 'biomimetics' was first used in 1957 by Otto H. Schmitt, a biophysical engineer (Bhushan, 2009, p. 1445). Briefly defined as 'imitating nature', biomimicry as a scientific discipline was introduced by Janine M. Benyus. Janine M. Benyus, a science observer who took into account the suggestion of Robert A. Frosch and Nicholas E. Gallopoulos, who proposed the idea of imitating ecosystems, as the destructive communication of architecture with society and the physical environment became apparent, brought all the information she obtained as a result of her research into the literature with the book 'Biomimicry: Innovation Inspired by Nature', published in 1997.



Benyus, who defines the principles of biomimicry, which is etymologically identified with the combination of the Greek words 'bios' meaning 'life' and 'mimesis' meaning 'imitation' (Benyus, 1997, p. 64), and which aims to produce solutions to human-oriented needs by referring to the ecological system, imitating nature and interpreting the strategies developed by nature, defends the need to see nature as a 'model', 'advisor' and 'criterion'. Benyus also states that the specific solutions that nature provides to the problems it encounters should be considered as an important guide for design processes. These ideas of Benyus have been integrated into many design disciplines and these developments have expanded the meaning of the concept of biomimicry. The idea of building a sustainable environment in harmony with nature by using biological systems also enables the production of new, long-lasting solutions. In this process, understanding, learning and interpreting the complex relationship of living organisms integrated into the ecosystem is seen as an acceptable method to give an idea of how the built physical environment is created. The concept of biomimicry, which defines the process in general terms, is seen as a common design method with sustainable potential, based on imitating the networks of relationships in nature, where each living thing provides mutual benefit.

The basic concept and starting point of biomimicry is that nature develops highly effective and sustainable ways of performing its functions, which can benefit designers when dealing with similar challenges (De Pauw et al., 2014, p. 3). In this respect, biomimicry, which cuts across many different disciplines such as architecture, engineering, chemistry and biology, and operates on the principle of treating them as a common approach, has also inspired countless designers with the collective systems view it offers. In particular, the accelerating growth of global economies based on consumption and the excessive use of resources, which increases with the industrialisation that feeds this chaotic mechanism, have brought sustainability concerns to the fore and contributed to the development of biomimicry, which refers to the designs of nature, which has managed to survive for billions of years without causing any of these concerns. It is in this sense that we can understand man's attempt to protect himself by studying natural phenomena. However, this process often seems to be devoid of real biomimetic discoveries, and the organic references in question remain only as an analogy of form that can be traced in architectural structure, far from function. This method of emulation, which began in antiquity, seems to have taken its place in today's deconstructivist conditions.

Architect Maibritt Pedersen Zari, who carried out a comparative analysis of the existing literature on biomimetic possibilities, stated that the concept of biomimicry can be interpreted on two levels. The first is called 'design in search of biology (top-down approach)' and includes the stage of examining the ability of other organisms to solve these needs as a result of defining human needs (Zari, 2007, p. 33). This design approach, which describes the process of designers looking at the living world for possible answers to problems and then creating solutions by referring to organisms that have solved similar problems, appears as one of the conditions for designers to determine their goals (Aziz & El sherif, 2016, p. 708). The design process of the bionic vehicle, the prototype of which was designed by the German car manufacturer DaimlerChrysler, is a vivid example of this approach. In this design, inspired by the Ostracion Meleagris, known as the boxfish, the aerodynamic structure of the fish guided the formal structure of the vehicle. By referring to the postural data obtained as a result of analysing the shape of the fish in the water and transferring it to the digital environment, 40% more strength was achieved in the computerised designs of the vehicle produced.

The second approach is called 'Biology Influencing Design (Bottom-up Approach)' and refers to making a defined characteristic behaviour or function found in the ecosystem available in the design. This approach, which describes the identification of the behaviour of an ecosystem or organic reference and the use of the identified characteristics to respond to a specific need, requires designers and biologists to work together (Zari, 2007, p. 33). The working principle of the exterior paint called Lotusan, produced by the London-based insulation brand Sto, is a qualified example of this approach. Inspired by the nelumbo, also known as the lotus flower in the literature, the chemical structure of the paint is based on the static repellent properties of the flower. The lotus leaf, which has hydrophobic (water-repellent) properties due to the thin wax secretion covering its surface, is considered to be one of the materials with the most specific waterproofing properties in nature (Gruber, 2011, p. 51).



As can be seen from the literature, the interrelated relationship between nature and man has had a direct impact on design processes. As a result of this interaction, the connection between nature and design has not only been a source of formal inspiration but has also contributed to the design disciplines with the systems it contains. Volstad and Boks (2012, p. 190) classify the categories of biomimicry that contribute to design processes into four basic groups: material, space, structure and form. In design, concepts from the science of biology, such as mutation, morphogenesis, fluidity, continuity and collective movement, have enabled architecture to take on the complex but dynamic forms of natural systems. Thus, architecture has been transformed from a static and lifeless object into a dynamic and integrated structure with the environment. It is in the context of this transformation that the following part of the research addresses the relationship between biomimicry and the discipline of architecture.

### *2.2. Biomimicry in Architecture*

Nature contains adaptive capacity in the form and function of the physical environment. This capacity, which can be seen in all ecological systems from simple unicellular structures to complex multicellular organisms, includes systems that can be exploited at the architectural scale. In this vein, biological approaches in architecture should be taken beyond formal concerns and incorporate parameters like functionality and sustainability that nature offers. In this sense, the discipline of architecture, which makes use of organic references, should be able to transfer the orientations produced by nature to technical solutions and offer contemporary approaches to design, producing new criteria through the concept of space. However, the ambiguity created by the openness to possibilities of the biological references that contribute to the design disciplines and the static conditions of immutability offered by the accepted parameters both produce opposing ideas and create layers that can theoretically work together.

The discipline of architecture, by its very structure, also contains this opposition. In order to better understand the conditions under which the processes related to the experience of architectural design processes are programmed, which should be considered as an orientation on both intellectual and operational scales, it is necessary to clarify the approaches to the fundamental issues of biomimicry and the techniques related to the abstraction process. However, although designers have used biology as a source of inspiration for thousands of years, there is no normative process specific to biologically inspired design practice (Helms et al., 2009, p. 611). Therefore, it is expected that the proposed design searches will be defined by technical narratives produced in accordance with spatial boundaries, taking into account international trends in the inclusion of biology in design. In recent decades, there have been some extensive studies on the methodology of this approach to design. Research into the development of biomimetic systems is increasing in order to understand biological phenomena in detail and to develop technologies that mimic these phenomena (Elibol et al., 2021, p. 679).

In this vein, Helms et al. (2009, pp. 611-612) from the 'Design Intelligence Lab' at the 'Georgia Institute of Technology', which established the 'Centre for Biologically Inspired Design' to ensure the representation of biology at the architectural scale, defined biologically inspired design approaches with a six-tier structure: (1) problem definition; (2) reframe the problem; (3) biological solution search; (4) define the biological solution; (5) principle extraction; and (6) principle application. This six-tiered structure, aimed at preserving common behaviours and metabolic balances in natural environments, has also made it possible to create living environments that directly participate in organic design processes, that can react, evolve, self-organise and develop by adapting to their environment.

Lakhtakia and Martin-Palma, who examine design at three basic levels in the context of biological references, suggest that the primary approach is to compare a functional system with other organisms. This method, which evaluates how different organisms perform the same function, aims to provide more detailed information about functions and increase the diversity of solutions. It is recommended to study the model organism in isolation in the secondary approach. This method, which assesses current functioning rather than understanding the diversity of organisms, aims to develop an understanding of the system. The third and final approach is based on theory and modelling. This method, which attempts to discover dynamics in nature with virtual experiments, aims to mimic biological systems, test them under alternative conditions and improve designs with the data generated (Eryılmaz, 2015, p. 471).

Biomimicry, which is widely used in many design disciplines, especially in engineering and architecture, has found its place in all fields, from the simplest objects of daily use to the most complex architectural fictions involving human beings, and has paved the way for the production of many qualified designs. Contrary to the artificial structural fictions that shape today's understanding of design, the natural architectural fiction, which allows unlimited production of resources and efficient use of energy, also provides the necessary motivation for an ecological and sustainable living space that can evolve or organise itself, fed by organic references.

Within the concept of biomimicry, formal approaches produced by imitating natural events, flowering systems of plants and physiological qualities of living beings can find a response in the discipline of architecture as surface material, lighting, furniture, spatial envelope and building stock. Here it is possible for the organic reference to convey symbolic values, to be represented figuratively with a resemblance, or to evoke the functions of the product used to inspire. However, the spatial representations constructed through the use of biological systems in the processes of abstraction in question should not be limited to formal concerns, and these approaches, based on the production of ideas, should refer to the principles of formation, operation and survival of the organic concept to which they refer, both in terms of sustainability and functionality, and should move beyond being a mere visual imitation of nature.

The field of biomimicry, which recognises flora, fauna or whole ecosystems as a basis for design, has attracted worldwide interest in architecture and engineering. This is both because it is an inspiring source of possible new innovations and because of the potential it offers to create a more sustainable built environment. However, although various forms of bio-inspired design have been discussed by researchers in the field of sustainable architecture, the widespread and practical application of biomimicry as a design method has remained largely unrealised. In the discipline of architecture, biology is often used as a library of forms or decoration but imitating or being inspired by natural-looking forms, textures and colours is not in itself biomimetic. For a design to be truly biomimetic, it must be informed not only by the appearance of nature, but also by its biology (El-Zeiny, 2012, pp. 502-503). In this context, this paper develops a framework for the concept of 'morphogenetic design', which underpins the biological necessity for understanding different forms of biomimicry.

### 2.3. Morphogenetic Design Approach

Technology is rapidly changing physical environments and has a significant impact on modern design. During the first quarter of the 21st century, living spaces have become both receivers and transmitters of electronic information due to the continued flow of digital revolution. The need for flexible design constructs has led to the theoretical representation of mechanical systems on a universal scale. Mitchell (1996) evaluated the current conditions of the interaction between virtual reality and the concept of space. He predicts that in the near future, dwellings will become an indispensable part of users, like organs or nervous systems.



In contemporary architectural practice, some researchers and architects are utilising nature's internal systems and fundamental principles to construct a more sustainable and distinctive built environment. In these studies, the goal is not to simply imitate nature, but rather to understand the reasons behind the structural transformations of living organisms and to uncover the problems to which these transformations provide solutions in nature. In this context, computer-based technologies are used to design a product by determining all parameters and finding the most appropriate solution to the design problem. This approach enables designers to utilise straightforward descriptions of the principles of organism systems to address ecological concerns, such as enhancing mobility, creating new materials, providing natural air conditioning, and utilising solar energy. The architectural literature refers to these practices as ‘Morphogenetic Design’ or ‘Digital Morphogenesis’. They also define areas of research on the concept of sustainability.

The book 'Biomimetics in Architecture: Architecture of Life and Buildings', published by Petra Gruber in 2011, discusses inferences about the distinctive features of biological organizations. It suggests that an analogical relationship can be established between the vitality criteria, referred to as life criteria, and the discipline of architecture. Gruber (2011, p. 124) examines the criteria of life under eleven headings: openness, information, order, reproduction, growth, energy, reaction, homeostasis, evolution, self-organization, and limitation. The author compares the life cycle of architecture with the natural processes of organisms. Morphogenetic design combines the Greek words 'morph', meaning change of form, and 'genesis', meaning creation. It expresses the development of an organism on a formal scale and intersects with a contemporary understanding of architecture. An organism can only differentiate as much as the possibilities offered by its genetic realities. The evolutionary design ideologies expressed in the book 'An Evolutionary Architecture', published by John Frazer in 1995, in which the basic form processes produced from ecological morphogenetic theories are examined at the architectural scale, directly refer to morphogenetic design approaches in terms of the metamorphosis of organisms.

## 3. Morphogenetic Design Through Hypothetical Housing Examples

Building on the theoretical framework discussed above, this section introduces four speculative housing projects—Embryological House, Multistory Apartment, Molecular Engineered House, and Fab Tree Hab—as conceptual case studies to explore how morphogenetic design approaches manifest within residential architecture. These examples serve as analytical tools to examine the generative principles, material strategies, and ecological logics embedded in morphogenetic thinking.

### 3.1. Embryological House

Greg Lynn's Embryological House project proposes six parent housing prototypes with different genetic algorithms, exploring the communication between morphogenetic design approaches and the concept of organic algorithms at the architectural interface. These carrier housing models have different geometric identities despite sharing similar constructional features. They can create numerous living spaces that respond to the biological demands of the natural physical environment (Lynn, 1999, pp. 19-20). This is a digital simulation of embryonic development processes realised through computer-generated algorithms. It is also considered a spatial production control in terms of the diversity and continuity it offers to the user. The morphology of the embryo has been interpreted allegorically, allowing for the examination of embryonic design processes in architecture. The housing prototypes' plan scheme matches the circle form in terms of topological characteristics. It is controlled by 12 parametric reference points, which allow the formation of prime geometric forms (Figure 1).



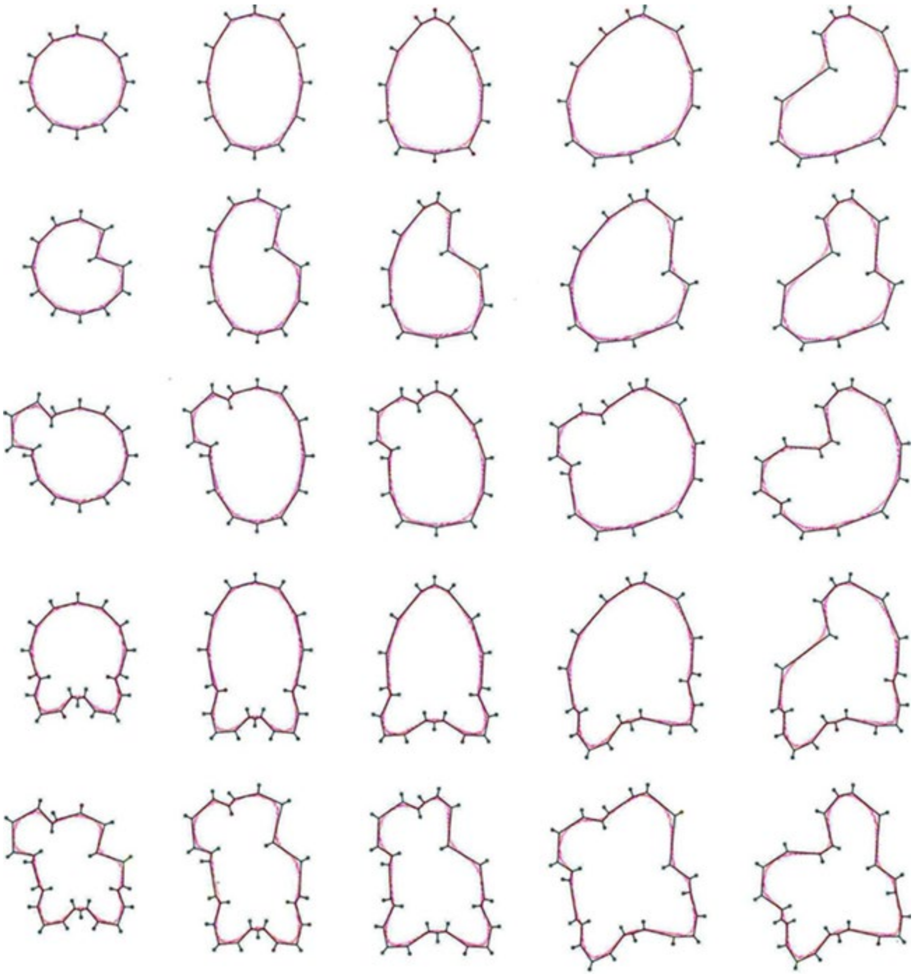


**Figure 1** Embryological house - Generative plans (Keller, 2012)

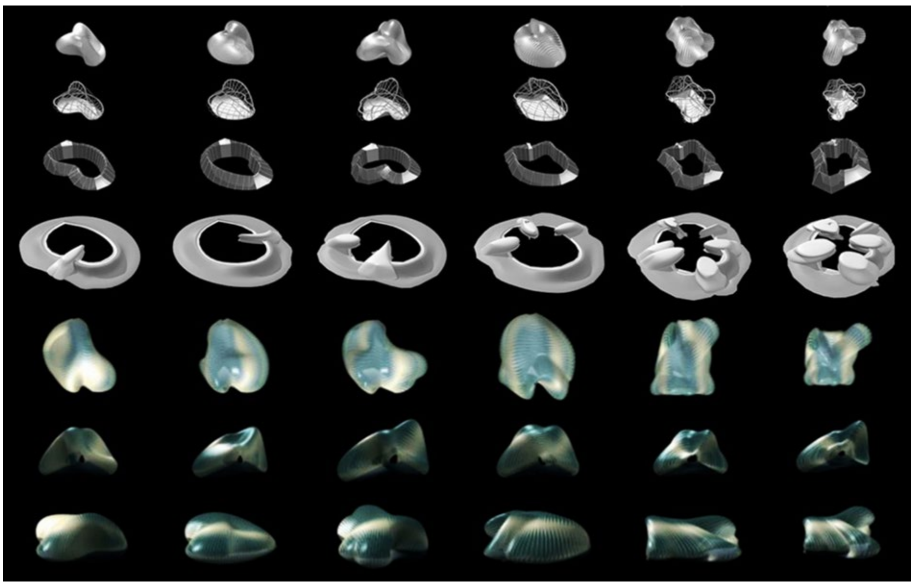


**Figure 2** Embryological house - Prototype process (Keller, 2012)

The Embryological Housing project explores the concept of variation through architecture and the geometric limits of diversity at the scale of space. By following a standardised production procedure for each dwelling, this project is able to create numerous geometric iterations while maintaining a set of common parameters. This approach enables the production of optimal forms. Variations of the embryological house can be adapted to suit the user's living conditions, needs, or aesthetic preferences. This parametric variation, also known as mutation, ensures that each housing prototype is both unique in form and function (Figure 3).



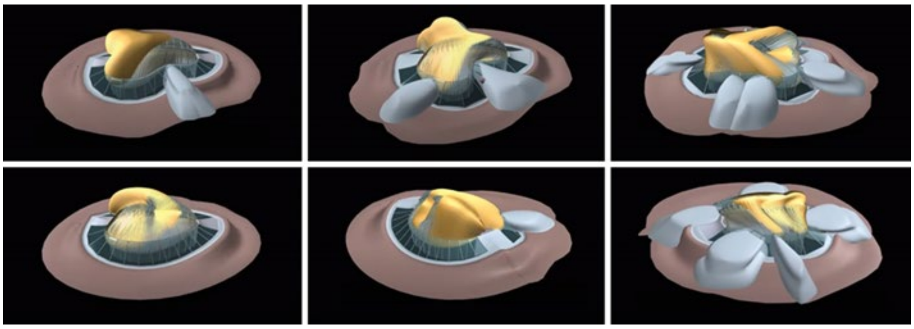


**Figure 3** Embryological house - Prototype perspectives (Glform, 2008)

The construction of the Embryological house, which is layered with the help of a vertically moving structure and surrounded by a double-walled shell, is supported by panels connected to circular steel beams. The initial layer comprises semi-permeable glass panels attached to aluminium profiles. This layer serves two purposes: to allow natural light into the space and to create a visual connection with the surrounding environment. The second shell can respond to the intensity of daylight with the help of computer-generated algorithms. It can also cast shadows on the first layer when necessary, allowing for the control of natural lighting conditions. This communication between the shells of the house not only reduces the lighting and heating costs of the building, but also proposes an approach that represents efficient energy use on a sustainability scale (Lynn, 2000, p. 28). The spatial fittings in the embryonic house are designed with reference to a movement that can realise the stages of change and development of an embryo within its own structure. In this context, the sleeping environments, seating areas, and storage elements are not considered as individual pieces of furniture, but rather as multifunctional environments with dynamic characteristics (Figure 4).

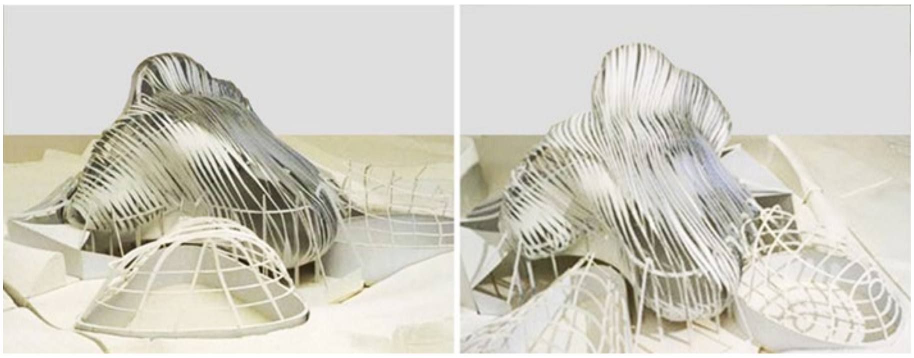


**Figure 4** Embryological house - Prototype (CCA, n.d.)

The morphogenetic design approach shares the same theoretical foundation as the evolutionary design ideas proposed by John Frazer, in terms of the metamorphosis of organisms. This understanding, interpreted as an imitation of evolutionary processes carried out with the help of genetic algorithms produced in a computer environment, has also contributed to the modeling of a design process similar to the modern evolutionary synthesis concept of Neo-Darwinism. Suggesting that there are flaws in the design process of CAD programs, which can only work within limited patterns and are inadequate to create original forms, Frazer proposes that instead of constructing a new system based on commands, a digital model should be fed by genetic parameters and be able to make inferences on its own (Frazer, 1995, pp. 20-26). Frazer, who developed a design process for the production of forms that could grow or organize themselves in a manner similar to the evolutionary process in nature, enabled the processing of information as in the DNA chain and the production of unpredictable complex forms with the help of a computer technology in which biological change is expressed numerically with hereditary algorithms.

### *3.2. Multistory Apartment Building*

The Multistory Apartment Building project by J. M. Johansen presents a mass housing proposal that shares the same processes as Molecular Designed Housing in terms of growth strategy but needs to be controlled by more obscure genetic information and demonstrates that morphogenetic design approaches can be used as a production method even in multi-storey buildings (Figure 5).

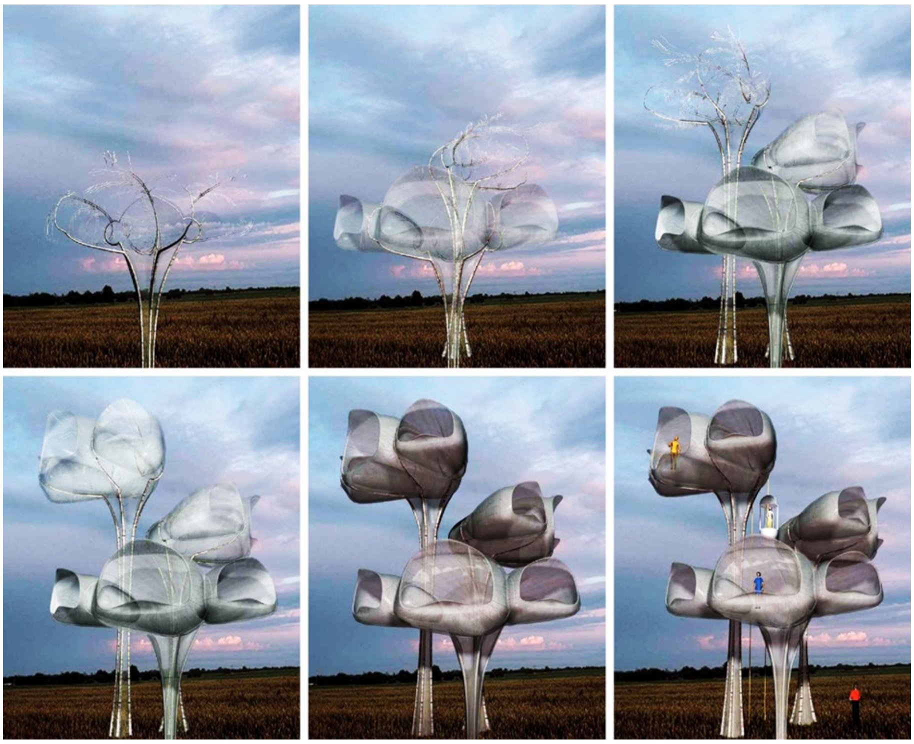


**Figure 5** Multistory apartment building - Organic growth process (Johansen, 2002)

This housing proposal, in which J. M. Johansen's ecological concerns intersect with morphogenetic design processes, preserves all the genetic parameters necessary for repair requirements in its seed. Using homeostatic mechanisms to maintain its metabolic balance, the building also responds to the desires and needs of the user within the possibilities of its natural physical environment. The design, which senses and adapts to changing terrain and climate conditions, can also produce its own energy. This biologically generative design interprets and organises all its structural reinforcements according to the differences in humidity, heat and light, and aims to optimise the total amount of energy used in the production of the installations that control these parameters.

### *3.3. Molecular Engineered House*

The Molecular Engineered House project developed by J. M. Johansen for the year 2200 refers to evolutionary design principles. The project, which is based on the principle of organising the designer's structural ideas in the computer environment using algorithms and encoding all the resulting genetic information in a seed and planting it in the ground, develops like a plant after a nine-day evolutionary process (Johansen, 2002, p. 133) (Figure 6). In order to create new living spaces, the design of the house, which can be expanded and subdivided, takes into account the physical needs of the users and can, if necessary, extend its formal limits in order to provide answers to these needs. This ecological structure, fed by morphogenetic algorithms and behaving like a living organism, can also reason for itself and take evolutionary decisions based on environmental conditions.

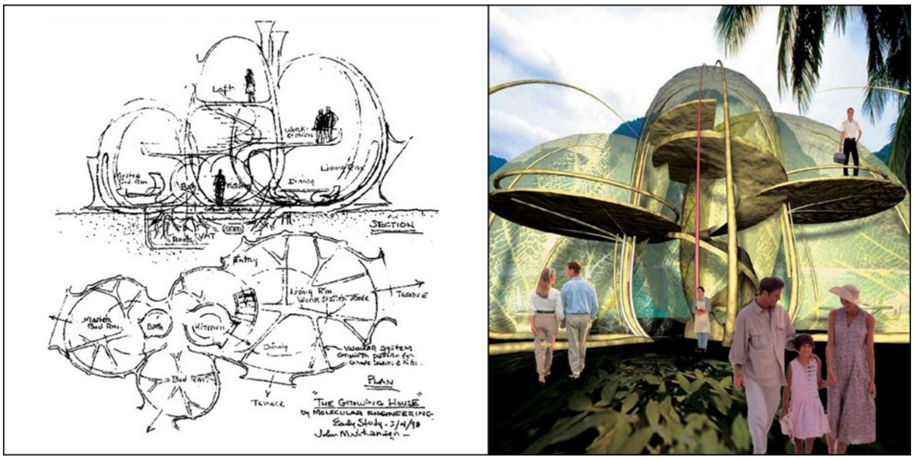



Figure 6 Molecular engineered house (Johansen, 2002)



As a morphogenetic fictional proposal, the roots that form the basis of the Molecular Designed Housing form the truss system, vertical spines, platforms (floors), walls and openings respectively. In this context, the house, which can renew its form, organisation and material density according to the conditions in which it finds itself, can also respond to the needs of its users. This open system design, which is self-sufficient, independent of public services and able to exchange materials with its immediate surroundings, contains the materials needed for repair processes in its core and maintains its spatial conditions in balance thanks to its homeostasis mechanism against physical effects. The membrane layer, which completes its development at the end of the eighth day, both communicates with the natural environment through its permeability and assists the structure in directing daylight into the space. This organic envelope proposal, which reduces the building's lighting and heating loads, also offers a system proposal in terms of efficient energy use (Figure 7).

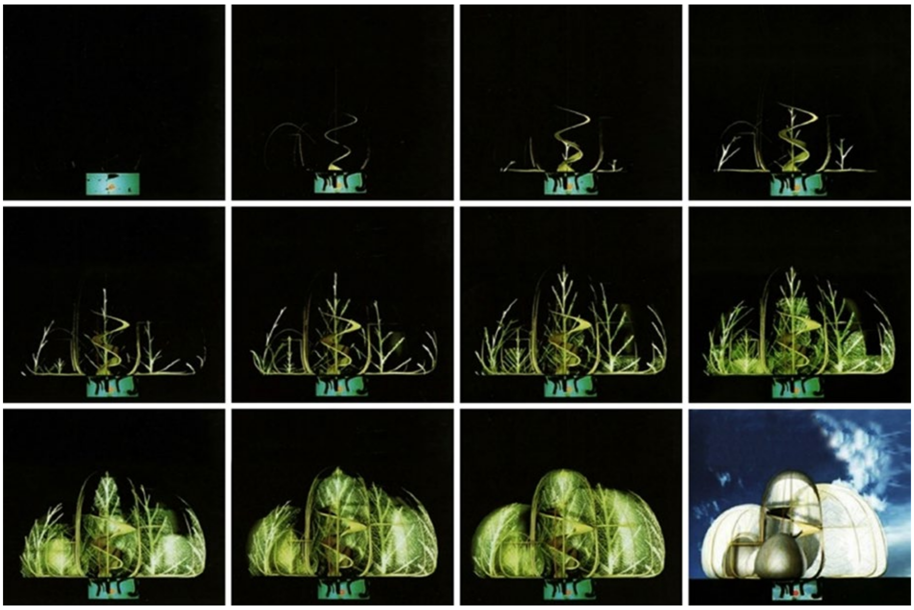


Figure 7 Molecular engineered house - Organic growth process (Johansen, 2002)

The design proposal, which aims to preserve the common behaviour and metabolic balance of the natural environment, participates directly in the organic design process and acts like an organism. In this respect, the molecular dwelling, which can react, evolve, self-organise and develop by adapting to its environment, both adapts its construction to seasonal conditions (light, temperature, humidity, etc.) and minimises the total amount of energy and material costs spent on the production of building stock.

### 3.4. Fab Tree Hab House

The Fab Tree Hab House, developed in 2003 by Javier Arbona, Mitchell Joachim and Lara Greden, is a hypothetical ecological housing project. It aims to articulate the idea of lightening the burden of humanity by growing living and breathing tree houses with traditional housing in an ecological environment. The idea aims to replace the old solutions produced by Habitat for Humanity International and proposes an alternative method of growing houses from endemic trees. The organic reference is formed on a computer-generated prefabricated structure, and the resulting envelope integrates the dwellings into a sustainable physical environment and ecological organisation (Figure 8).

**Figure 8** Fab tree hab - Organic growth process (Arbona et al., 2003)

Rejecting traditional anthropocentric doctrines and composed entirely of nutrients, Fab Tree aims to adapt the user directly to the terrestrial environment. In this context, the indeterminate housing also adapts to the surrounding ecosystem in a symbiotic way (Arbona et al., 2003, p. 48). The project, developed with pleaching systems, incorporates a contemporary methodology for the discipline of architecture, even if it is traditional for landscape approaches, and enables the production of sustainable natural systems by exploiting morphogenetic possibilities at the molecular level. In this respect, Fab Tree, which is directly involved in the organic design process, proposes a sustainable housing model that is organised, adapts to the metabolic balance, and allows efficient energy use.

**Figure 9** Fab tree hab - Prototype perspectives (Arbona et al., 2003)

## 4. Methods

### 4.1. Model

This study adopts a qualitative research design based on a general inductive approach. Rather than testing hypotheses, this approach seeks to build understanding through the interpretation of data within its natural context. The aim is to explore how morphogenetic design approaches relate to housing production by generating insights grounded in theory and conceptual reasoning. In this framework, the researcher interprets selected examples not to validate predetermined claims, but to construct a reflective understanding based on emerging patterns and thematic associations.

### 4.2. Sample

The research sample consists of four hypothetical housing projects: Embryological House, Multistory Apartment Building, Molecular Engineered House, and The Fab Tree Hab. These projects were developed using morphogenetic design approaches after the year 2000. These projects were selected through purposeful sampling, specifically homogeneous sampling, as they collectively provide a coherent foundation for conducting a comparative analysis within a shared conceptual domain. The selected examples represent distinct approaches to morphogenetic design within residential architecture. Each project reflects a different interpretation of form generation, material strategy, ecological responsiveness, or biological integration. Despite their diversity, they share a common speculative character and were all conceived within a theoretical or conceptual framework rather than as conventional construction proposals. This makes them particularly suitable for comparative theoretical analysis.



### 4.3. Data Collection Tools

A comprehensive literature review was conducted to examine the theoretical background and limitations of morphogenetic design approaches in the context of housing production. This process involved identifying, analyzing, segmenting, and synthesizing relevant academic sources to construct the conceptual framework of the study. In addition to secondary sources, primary materials written by the designers of the selected projects were also utilized, including research articles, project reports, and conceptual texts. Both printed publications and digital resources such as articles, theses, and project documents accessed online were used in this context.

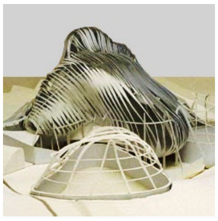
### 4.4. Data Analysis

The data were analyzed in two stages using descriptive content analysis, with the aim of clarifying the research problem and contributing to the development of a conceptual framework. In the first stage, a descriptive analysis was conducted to identify general patterns and thematic tendencies in qualitative studies related to morphogenetic design and housing. In the second stage, content analysis was applied to the selected hypothetical housing projects. The data were categorized and interpreted based on a set of parameters defined by the researcher in alignment with the study's theoretical framework. These parameters emerged from recurring conceptual themes identified during the literature review on morphogenetic design. Aspects such as generative form logic, material organization, spatial configuration, sustainability emphasis, and the use of biological metaphors appeared as common strategies across both the literature and the selected examples. These themes were then adapted as analytical categories to support a coherent comparison of the case studies.

## 5. Findings and Discussion

In the context of the study aimed at understanding the impact of morphogenetic design approaches on housing production processes, the literature review method was preferred to seek answers to the research questions. The data obtained from the research was subjected to a descriptive content analysis, and the resulting findings – organised by key parameters and thematic categories – are systematically presented in Table 1.

**Table 1** Comparison of Hypothetical Housing Samples

| | **Sample 1** | **Sample 2** | **Sample 3** | **Sample 4** |
|---|---|---|---|---|
| | **Embryological House (2000)** | **Multistory Apartment Building (2001)** | **Molecular Engineered House (2002)** | **The Fab Tree Hab House (2003)** |
| **Parameters** |  |  |  |  |
| Designer | G. Lynn | J. M. Johansen | J. M. Johansen | J. Arbona et al. |
| Institution | UCLA | FAIA | FAIA | MIT |

| | | | | |
|---|---|---|---|---|
| Generation time | unknown | unknown | nine days | five years |
| Procedure | self-determination | self-development | self-selection | natural selection |
| Structure | steel construction | none | none | plywood scaffold |
| Variation | very-high | high | high | fair |
| Homeostasis | high | high | very-high | very-high |
| Feasibility | very-low | low | fair | high |
| Symbiotic relations | fair | high | high | very-high |
| Human interference | low | fair | high | very-high |
| Sustainable energy | high | high | high | very-high |

The diversity in institutional affiliations and professional identities across the selected housing projects reflects the cross-disciplinary origins of morphogenetic design thinking. This variation suggests that morphogenetic design is less a singular architectural style and more a framework for hybrid research and production practices, often shaped by the epistemologies of the institutions or fields in which they are developed. The hypothetical housing examples developed by diverse institutional affiliations (e.g., UCLA, FAIA, MIT) and professional titles (e.g., architect, academic, researcher) illustrate that morphogenetic design is not merely an 'architectural innovation' but also a 'research-production' model grounded in interdisciplinary collaboration. The involvement of experts from related fields, including building biology, ecology, computational design and materials science, within the same project, reinforces both design continuity and innovation (Picon, 2010). Consequently, it can be inferred that the concept of 'housing' will evolve into more flexible, multi-layered, and adaptive systems through the interaction of various fields of expertise in the future.

The disparity in 'generation time' among the projects reveals how morphogenetic thinking encompasses both computational speed and biological duration. The iterative short-cycle process seen in digitally driven projects contrasts with the slow-growth logic of biologically integrated designs, signaling two distinct temporalities in architectural speculation. This temporal duality is further explored in the literature, as advanced digital frameworks have enabled projects to generate new variations in an iterative and rapid manner, thereby undergoing numerous design cycles within a short period. By contrast, projects utilising natural/biological materials require a longer timeframe for the growth and environmental adaptation of plant- or living tissue-based building elements. This approach is consistent with Armstrong's (2015) theoretical framework of 'vibrant architecture', which aims to integrate buildings with organic systems as a transformative agent in ecological processes. In this context, the 'generation time' parameter in the hypothetical housing examples varies across all stages of design, construction, and sustainability.

The classification of procedural logics across the projects demonstrates a spectrum of design agency, ranging from designer-led authorship to autonomous, nature-influenced processes. These procedural terms serve not just as technical labels but as indicators of philosophical orientation in design methodology. This conceptual nuance is also articulated in the theoretical literature, where DeLanda (2013) associates the perception of design as an iterative and multiparametric process with approaches that liken architecture to the evolutionary development of living organisms or biological forms. In this context, the expressions 'self-determination,' 'self-development,' 'self-selection,' and 'natural selection,' found under the 'procedure' parameter in the hypothetical housing examples, also correspond to the 'evolutionary' or 'organic' line of thinking that underlies morphogenetic design. Consequently, it can be asserted that each project represents its own unique algorithmic principles, ranging from those involving user scenarios to those relying almost entirely on automation, in generating its design methodologies.

The contrasting structural approaches observed in these cases reflect not just material or formal variety but conceptual repositioning of tectonic logic. In some examples, the 'structure' becomes an emergent property rather than a pre-defined system. This perspective is further supported by architectural research. It has been posited by researchers such as Hensel et al. (2010) that bio-inspired structural models have the potential to establish the foundations for adaptive, lightweight, and low-energy housing in the future. In this context, the various approaches – such as 'steel construction' and 'plywood scaffold' – listed under the 'structure' parameter offer insights not only into the external form shaped by morphogenetic design but also into the extent to which a building can be assembled in an 'organic' manner. Furthermore, the seemingly 'completely structureless' approaches proposed by architects like Johansen suggest that structural elements may either be dispensed with in the traditional sense or arranged in fundamentally different configurations.

The emphasis on high homeostasis, symbiotic relations, and sustainable energy suggests an underlying aim to simulate or participate in ecological systems. These values point to morphogenetic architecture's ambition to function not only as form but as environmental agent. This alignment between conceptual intent and design outcome is reflected in the literature, where the data obtained under the 'Homeostasis', 'Symbiotic relations' and 'Sustainable energy' parameters reflect the degree of ecological sensitivity in the hypothetical housing examples. In particular, the fact that 'The Fab Tree Hab' addresses sustainable energy at a 'very-high' level suggests that the structure is conceived as a 'living' system capable of directly supporting ecological cycles. This approach is analogous to Reiser and Umemoto's (2006) concept of 'architecture embedded in the ecosystem'. However, while sustainability is emphasised in these examples, their low or limited feasibility indicates that these concepts remain at an experimental stage and highlights the challenges of integrating them into conventional construction practices.

The inverse relationship between variation and user interference observed in certain cases raises critical questions about authorship and participation. High morphological complexity generated by autonomous systems may come at the cost of end-user agency in design outcomes. These tensions are similarly acknowledged in scholarly discourse, as the observed discrepancies in the 'Variation' and 'Human interference' parameters necessitate a consideration of the extent to which users can be active in housing design, as well as the degree to which the building's inherent "systematics" may exert a determining influence. For instance, combining 'very-high variation' with 'low human interference' suggests that the designer's or the algorithm's initiative is dominant. This scenario brings to mind the existing literature that interrogates the relationship between digital design technologies and users. The more algorithmically the building's form, spatial organization, and even material choices are determined, the more user flexibility and participation may be constrained or redefined (Kolarevic & Malkawi, 2005).

The analysis indicates that morphogenetic design has the capacity to substantially transform the formal, functional and ecological dimensions of future residential buildings (RQ1). Digital design methods, biologically inspired production techniques and user-participatory design strategies have rendered it feasible for buildings to self-renew, establish symbiotic relationships with their environment and adapt to various living scenarios. This process is characterised by the integration of sustainability and user experience across multiple stages, ranging from design to construction (RQ2). Consequently, architects, engineers, and users interact within a continuous feedback mechanism, exploring pathways to produce housing solutions that are more responsive to both technological and environmental demands.

However, all the projects included in this analysis were evaluated only on the basis of the scientific documents published by the designers. Of course, it is possible that all the projects presented here serve different purposes in different contexts and can therefore be evaluated on the basis of different parameters. This analysis should therefore be regarded as rudimentary and in need of improvement.

## 6. Conclusion

The concept of morphogenetic design is one of the driving forces behind modern design orientations shaped by the constantly changing and evolving rules of nature. In this context, it is essential to observe the measurements, behaviors, and structural transformations that nature undergoes when confronted with physical challenges. The data obtained from such observations must be critically interpreted and translated into architectural strategies, and the generation of solutions that can be integrated into design stages contributes to the advancement of morphogenetic thinking.

This study highlights that morphogenetic design is not merely a response to material and environmental constraints, but a paradigm that redefines the ontological status of form in architecture—shifting it from an object to a processual, systemic construct. This refers to evolutionary perspectives in architecture. Morphogenetic design does not aim to change production techniques in architecture but instead seeks to transform design concepts themselves. It brings new identities to architecture in professional practice and allows for the reinterpretation of residential buildings on an organic scale. These innovations shape today's understanding of design and necessitate the articulation of current architectural discourses with morphogenetic paradigms.

In this context, morphogenetic design, which has developed its own terminology through its early examples, is defined as a new field that encourages collaboration between biology, engineering, and architecture through computer-based technologies. The morphogenetic design approach aims to solve design problems by referencing continuous systems observed in nature. It strives to create physical environments that are responsive to their surroundings and behave as living systems with all their components. This approach integrates concepts from various disciplines—such as genetics, coding, algorithms, and parameters—into the architectural profession through advancing technology. Morphogenetic design is gaining increasing recognition in both architectural literature and practice through the experimental works of designers such as Greg Lynn, John Frazer, M. Johansen, Mitchell Joachim, Javier Arbona, Lara Greden, Steffen Reichert, Achim Menges, and Angelica Lorenzi.

By using speculative housing examples as conceptual testbeds, this study investigates how designers transform spatial exploration into ecological organization through algorithmic processes. In doing so, it proposes an alternative model of architectural inquiry—one that integrates ecological reasoning with computational form generation within the experimental framework offered by residential design. Based on the comparative analysis in this study, it can be asserted that morphogenetic design does not merely function as a conceptual ideal, but actively generates alternative logics for material organization, spatial variability, and environmental responsiveness within residential architecture. Unlike purely descriptive studies, this research provides an integrated reading of how design concepts such as variation, structure, homeostasis, and generative logic are operationalized across different projects. Thus, it offers an original contribution by bridging the gap between conceptual theory and speculative application in architectural research. Furthermore, the research underscores how morphogenetic frameworks may inform future design education and practice by modeling alternative workflows that integrate generative systems and environmental parameters from the earliest design stages.

As a result, the study consolidates and extends morphogenetic discourse by articulating how ecological principles are operationalized through speculative design scenarios in architecture. It provides critical insight into the evolving relationship between digital technologies, ecological intelligence, and architectural form-making. In doing so, the study positions morphogenetic thinking not only as a theoretical discourse but as a practice-oriented paradigm that has the potential to reshape residential architecture.

However, a significant methodological limitation of this study is that the data were collected solely from four projects developed after the year 2000. The limited sample size reduces the generalizability of the findings and negatively impacts the external validity of the study. Therefore, it can be concluded that the analyses provided are explanatory rather than evidential. To improve external validity and enable the generalization of the data, it is recommended that future studies include a wider range of architectural cases developed using morphogenetic design approaches. Moreover, the advantages and limitations of morphogenetic design may not be fully understood without comparing them to conventional architectural approaches. Comparative analyses are often useful in identifying the strengths and weaknesses of different design strategies and evaluating the results in a broader and more integrated context. This framework points to a promising future research direction: a comparative analysis of morphogenetic and conventional design models.



## References


Akbulut, D. (2009). The method of evolutionary design and creativity within the process. *Sanat ve Tasarım Dergisi*, *1*(2), 21-33.

Akyol Altun, D. (2007). Architecture of future: The effects of scientific-technological transformations on architecture. *Dokuz Eylül University Faculty of Engineering Journal of Science and Engineering*, *9*(1), 77-91.

Arbona, J., Greden, L., & Joachim, M. (2003). Nature's technology: The fab tree hab house. *Thresholds*, *26*, 48-53.

Armstrong, R. (2015). *Vibrant architecture: Matter as a codesigner of living structures*. De Gruyter Open.

Aziz, M. S., & El Sherif, A. Y. (2016). Biomimicry as an approach for bio-inspired structure with the aid of computation. *Alexandria Engineering Journal*, *1*(55), 707-714.

Benyus, J. M. (1997). *Biomimicry: Innovation inspired by nature*. Quill.

Bhushan, B. (2009). Biomimetics: Lessons from nature-an overview. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, *367*(1893), 1445-1486.

Bulu, A., & Kavut, İ. E. (2021). Research on morphogenesis effects in fictional spaces. *Architecture and Life*, *6*(3). 831-844.

CCA. (n.d.). *Greg Lynn's embryological house: Case study in the preservation of digital architecture*. Docam. Retrieved December 22, 2023, from https://www.docam.ca/conservation/embryologicalhouse/index.html

Collingwood, R. G. (1945). *The idea of nature*. The Clarendon Press.

DeLanda, M. (2013). *Intensive science and virtual philosophy*. Bloomsbury Publishing.

De Pauw, I. C., Karana, E., Kandachar, P., & Poppelaars, F. (2014). Comparing biomimicry and cradle to cradle with ecodesign: A case study of student design projects. *Journal of Cleaner Production*, *78*, 174-183.

Elibol, G. C., Türkkan, V. D., & Bezci, İ. (2021). Biologically inspired design: A case study on furniture design experiences of interior architecture students. *Gazi University Journal of Science Part C: Design and Technology*, *9*(4), 679-689.

El-Zeiny, R. M. A. (2012). Biomimicry as a problem solving methodology in interior architecture. *Social and Behavioral Sciences*, *50*, 502-512.

Erbaş Korur, Z. N., & Dülgeroğlu Yüksel, Y. (2013). Effects of genetic science on architecture discipline. *Beykent University Journal of Science and Engineering*, *6*(1), 11-25.

Eryılmaz, H. (2015). Biomimicry and ergonomics: Innovative inspiration from nature for design. *Journal of Engineering Sciences and Design*, *3*(3), 469-474.

Frazer, J. (1995). *An evolutionary architecture*. AA Publication.

Glform. (2008, October 21). Embryological house [Video]. YouTube. https://www.youtube.com/watch?v=59wFguSjorA

Gruber, P. (2010). *Biomimetics in architecture: Architecture of life and buildings*. Springer.

Helms, M., Vattam, S. S., & Goel, A. K. (2009). Biologically inspired design: Process and products. *Design studies*, *30*(5), 606-622.

Hensel, M., Menges, A., & Weinstock, M. (2004). *Emergence: Morphogenetic design strategies*. Wiley.

Hensel, M., Menges, A., & Weinstock, M. (2013). *Emergent technologies and design: Towards a biological paradigm for architecture*. Routledge.

İnceköse, Ü. (2008). Çağdaş mimarlık söylemleri ve doğabilimsel bilgi: “Yeni” mimarlık için “yeni”den bilimsel kavramlar. *Mimarlık*, *341*, 32-34.

Johansen, J. M. (2002). *Nanoarchitecture: A new species of architecture*. Princeton Architectural Press.

Keller, S. (2012). Beauty, genius, epigenesis: The Kantian origins of contemporary architecture. *Journal of Architectural Education*, *65*(2), 42-51.

Kennedy, E. B. (2017). Biomimicry: Design by analogy to biology. *Research Technology Management*, *60*(6), 51-55.
Kolarevic, B. (2000). Digital morphogenesis and computational architectures. *Sigradi*, 1-6.
Kolarevic, B., & Malkawi, A. (2005). *Performative architecture: Beyond instrumentality*. Routledge.
Lynn, G. (1999). *Animate form*. Princeton Architectural Press.
Lynn, G. (2000). Embryologic houses. *Architectural Design*, *70*(3), 26-35.
Maglic, M. J. (2021). *Biomimicry: Using nature as a model for design*. [Master's thesis, University of Massachusetts Amherst] UMASS AMHERST.
Menges, A. (2012). Biomimetic design processes in architecture: Morphogenetic and evolutionary computational design. *Bioinspiration and Biomimetics*, *7*(1), 015003.
Mitchell, W. J. (1996). *City of bits: Space, place, and the infobahn*. MIT Press.
Özer Yaman, G. (2022). Güncel tasarım yaklaşımlarının mimarlık eğitim sürecine katkılarının deneyimlenmesi. In A. Çabuk & H. S. Aşıkkutlu (Eds.), *Mimarlık, Planlama ve Tasarım Alanında Yeni Trendler* (pp. 200-228). Duvar Yayınları.
Picon, A. (2010). *Digital culture in architecture: An introduction for the design professions*. Birkhäuser.
Portoghesi, P. (2000). *Nature and architecture*. Skira Press.
Reiser, J., & Umemoto, N. (2006). *Atlas of novel tectonics*. Princeton Architectural Press.
Riley, T. (1999). *The un-private house*. The Museum of Modern Art.
Roudavski, S. (2009). Towards morphogenesis in architecture. *International journal of architectural computing*, *7*(3), 345-374.
Volstad, N. L., & Boks, C. (2012). On the use of biomimicry as a useful tool for the industrial designer. *Sustainable Development*, *20*(3), 189-199.
Von Sydow, M. (2012). *From Darwinian metaphysics towards understanding the evolution of evolutionary mechanisms*. Universitätsverlag Göttingen.
Vural, S., & Mutlu Avinç, G. (2015). Doğadan esinli geleneksel ve sayısal tasarım yöntemlerinin yaşam kriterlerine göre değerlendirilmesi. In S. Yazıcı, C. Akoğlu, A. Özbil Torun, I. Tekçe & C. Bayazıtoğlu (Eds.), *IX. Mimarlıkta Sayısal Tasarım Ulusal Sempozyumu (MSTAS 2015) Bildiri Kitabı* (pp. 25-26). Istanbul/Türkiye.
Zari, M. P. (2007). Biomimetic approaches to architectural design for increased sustainability. *Sustainable Building, Regional Sustainable Building Conference*, Auckland/New Zealand.

## Resume

*Graduated from Marmara University Faculty of Fine Arts, Department of Interior Design in 2012 and wrote his postgraduate thesis on the topic of "Fictionalization of Hotel Shared Spaces for Disabled Users" at the Interior Design Department of the same university in 2018. Graduated from Mimar Sinan Fine Arts University with his doctoral dissertation titled "A Curriculum Proposal Affecting the Development of Spatial Ability through Multiple Intelligence Theory in Basic Design Education" in 2023. Employed at the Istanbul Gedik University Faculty of Architecture and Design, Department of Interior Design and Environmental Design as Lecturer since 2016. Their research focuses on interior architecture education, basic design, spatial skills, multiple intelligence theory, creativity, and cinema.*

JOURNAL OF DESIGN FOR RESILIENCE
IN ARCHITECTURE & PLANNING

*Research Article*
*Online:* www.drarch.org
*Volume 6, Issue 1 (182-192), 2025*
*DOI: 10.47818/DRArch.2025.v6i1163*

# Conflict of virtual and reality in interior design studio: Assessment of student success rates

Kamil Güley*
Nisan Akalın**

## Abstract

This study evaluates the relative efficiency of interior architecture education programs delivered through face-to-face education (FFE) compared to online education (OE), from the perspectives of both students and educators. The quality of learning, as perceived by educators, was assessed through the analysis of semester grades assigned after each academic term. Conversely, the student perspective was gathered via a structured questionnaire. This research addresses a notable gap in existing literature regarding student success by incorporating the educators' viewpoints into the analysis with a comparative analysis examining student success rates between FFE and OE. This investigation, from the student perspective, found the FFE model to be a more effective educational approach compared to the OE model. The disparity between the instructors' perspectives was not significant. Nevertheless, valuable insights were obtained from educators utilizing the OE model, especially regarding their experiences during the pandemic. These insights could inform future research on hybrid educational models. As a result, this study advocates for the implementation of a hybrid educational model as a progressive direction for interior architecture education.

*Keywords:* face-to-face education (FFE), online education (OE), design studio courses, student success, pandemic

## 1. Introduction

With the declaration of COVID-19 as a pandemic, as of March 2020, every aspect of life has changed dramatically. One of these dramatic changes was that educational institutions urgently had to stop face-to-face education (FFE) and switch to online education (OE). In these emergencies, the pace of implementing the interventions was crucial. Hence, educational institutions had to adapt to this change urgently. In the case of this study, the investigated OE system was implemented rapidly, and the same education program was revised in 2017. This study adopts a holistic approach, comparing the experiences and outcomes of the OE model from the perspectives of students and educators concerning the impact on student success rates before and during the pandemic. Therefore, this research encompasses a seven-semester-long examination dating before and during pandemic experiences. In light of the changes instigated by the pandemic, the responsibility of educators and institutions to perpetually enhance the educational system has come under increased scrutiny. Thus, this study aims to explore innovative strategies for the further development of design education, informed by the insights gleaned from the OE experience.

## 2. Changes in the Interior Design Education System Due to the Pandemic

The design studio education model, which forms the core of interior design education, aims to reflect the one-to-one communication between the student and instructor and the interactive working studio atmosphere of the learning environment (Afacan, 2016; Ahmad et al., 2020; Dreamson, 2020; Gul & Afacan, 2018; Marshalsey & Sclater, 2020). Therefore, design studio education goes beyond solemnly being space as a studio to an educational approach in which

*(Corresponding author), Assist. Prof. Dr., Eastern Mediterranean University, Turkish Republic of Northern Cyprus
kamil.guley@emu.edu.tr **Lecturer, Eastern Mediterranean University, Turkish Republic of Northern Cyprus
nisan.akalin@emu.edu.tr *Article history: Received 23 February 2025, Accepted 08 April 2025, Published 30 April 2025*

theoretical and practical knowledge is regularly applied with one-to-one critiques between the student and the instructor. Due to the pandemic and the transition of the education system to the online education system, design studio education had to switch to online education. As already mentioned, the one-to-one relationship between student and instructor and the interactive studio environment forms the core of design studio education, and it is of great importance that these issues are adapted to online education as effectively and unaltered as possible. In this respect, adapting the design studio courses to online education housed a complication. Sketches are the tool of expression and communication in design, starting from the formation of the initial design idea, development, creation of technical and 3d drawings, and the critics between the instructor and student. In this case of online education due to the pandemic, it was predicted that this communication tool used in design courses would not be much easier to carry out in the online education system compared to face-to-face education (Oktay et al., 2021).

Online education was one of the educational methods that existed before the pandemic, developed over many years with the development of globalization and modern technology, and used by educational institutions (Afacan, 2016; Dreamson, 2020; Ginns & Ellis, 2007; Ioannou, 2017). This online education method, which has been used for years to support education, has become the only education method used by almost all educational institutions during the pandemic. However, it is also known that online training used in response to a crisis or disaster during the pandemic period is different from a thoroughly planned online training experience (Hodges et al., 2020). Therefore, online education before and during the pandemic, which was developed to sustain the learning experience amid the closure of educational institutions, should not be considered the same. According to Gümüş (2007), the online education system was traditionally defined before the pandemic as learning and teaching through electronic tools such as internet technologies and mobile communication tools. However, the online education system mentioned in this study also deprived the students of the university campus and its services, which became the only possible way of sustaining education.

As Gümüş (2007) and McCormack and Jones (1998) said, several issues must be considered when implementing online education. These are referred to firstly as online education's purpose, the reasons behind its adoption, and the achievements that are aimed at in the end. Secondly, a suitable pedagogical approach and appropriate online tools must be defined. Lastly, the adaptation through effective interaction, not just with appropriate software tools but through encouraging the students' participation (Gümüş, 2007; McCormack & Jones, 1998).

Another part of this changing age is the changing students (Prensky, 2001). Today's students are no longer the people our education system, which has been used for many years, designed to teach. This new generation has grown up with the changes brought about by the digital age and technology. As a result of the growth in this digital world, we know that today's students think and use information differently than before (Bhattacharjee, 2019; Oblinger, 2004; Prensky, 2001). In addition, these new generation students can communicate more easily in the online education environment than previous generations, as they have mastered different usage styles of online environments (Pektaş, 2015). However, online education has started to be used primarily to remedy an extraordinary situation due to a pandemic that suddenly appeared rather than adapting to this changing age and students. Therefore, while the online education system was quickly set up in a crisis, it did not have the time and equipment to construct the infrastructure a newly created education system would need. Instead, there was a rush to adapt existing course models to the new lifestyle as quickly as possible. While it may be possible to transfer courses and curricula in different disciplines in this way, it should be noted that this process in Interior Architecture education is particularly challenging within the scope of studio courses (Marshalsey & Sclater, 2020). In addition, many students and educators thought online education to be unsuccessful within the scope of interior architecture education (Ginns & Ellis, 2007; Ioannou, 2017). In other words, the traditional perception of Interior Architecture education is that design education is not learned outside of the studio environment and cannot be sustained without a mutual and face-to-face dialogue between the student and the instructor. In other words, there were concerns that the one-to-one dialogue between the student and the instructor developed in the studio environment would be interrupted by online education (Ioannou, 2017). Therefore, converting the traditional studio model education to an online environment had multiple difficulties (Dreamson, 2020). Asserting these concerns, design studios' social interaction and character-enhancing experiences have been some of the most damaged elements in online Interior Architecture education (Dreamson, 2020; Iranmanesh & Onur, 2021). Although online education provided convenience in many areas, such as the increase in the use of computer-based drawing programs (McConnell & Waxman, 1999; McLain-Kark, 2000; Zuo & MaloneBeach, 2010), unfortunately, the sociocultural development of a student could not be provided in online education (Salama & Wilkinson, 2007).

## 3. Definition of Success in Education Models

It is believed that the evaluation of the success or failure of the Interior Architecture education method can be measured by the extent to which it reaches its ethical and ideological goals (Afacan, 2016; Ginns & Ellis, 2007; Gul & Afacan, 2018). Therefore, whether it is FFE or OE, the success rate of a design course can be measured by the level of fulfillment of the learning outcomes (Ginns & Ellis, 2007). Nevertheless, the depth of achievement of the learning outcomes of a design course by the student is not the absolute signifying quality of the success of the course. Such a superficial point of view does not provide detailed foresight to identify and develop the advantages and disadvantages of the education model used, especially within the purpose of this study, which is to compare two different education models.

Crowther and Briant (2020) present various definitions of academic achievement, one of which is the course grade average this study adopts. Hence, the paper investigates the grade evaluations, accounting for the design courses and the semester grades. Therefore, the grade given at the end of the semester in design courses identifies the success rate from the instructor's perspective.

Various methods used to assess the quality of education named as course experience questionnaire [CEQ] (Lizzo, Wilson & Simons, 1997; Richardson, 1994), study process questionnaire [SPQ], and revised two-factor version of the study process questionnaire [R-SPQ-2F] (Biggs et al., 2001) offers a more detailed investigation on the success rate of education models. However, the perspective used by these surveys is only student-oriented. Nevertheless, the success rate of an education model should be investigated from multiple perspectives. Analyzing an education model with only one perspective as a student perspective limits an in-depth investigation and understanding.

According to the article by Entwistle et al. (2002), six factors determine the quality of an education model, interacting and influencing the quality of learning (Figure 1). Firstly, the student's pre-experience, knowledge, judgment, and motivation. The student's knowledge and expectations before starting education also influence two other factors: learning approaches and the student's perception of the learning environment. The factors mentioned so far and their influence on the achieved learning are entirely student-centered. Therefore, the next factor in this concept is the instructor's pedagogical knowledge and teaching approaches. Regardless of the educational model employed, it is not an exaggeration to say that every instructor imparts a unique perspective to their teaching style. Lastly, another factor is how course material is selected, organized, presented, and evaluated, all contributing to the education and learning environment provided by the end of the day (Figure 1). These factors guide the analysis this study has adopted as its methodology.

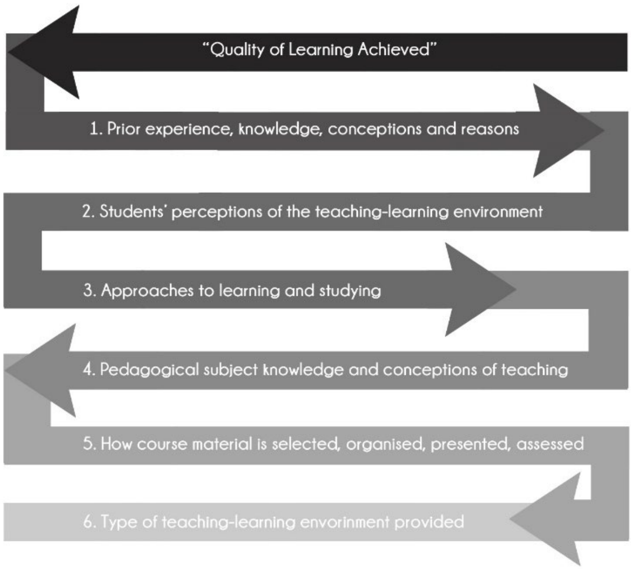



**Figure 1** Six steps in identifying the quality of learning achieved (Entwistle et al., 2002)

## 4. Assessment of FFE and OE Model in Student Success Rates

Within the scope of this study, the data collected in FFE was five semesters following 2017 due to the renewal of the education program. However, OE was applied to the following two semesters with the same structure, which is a rather vital point to acknowledge. The OE model was the same as FFE, with no alterations in the course structure, but it was done on online platforms. Hence, the education program was not subjected to any changes.

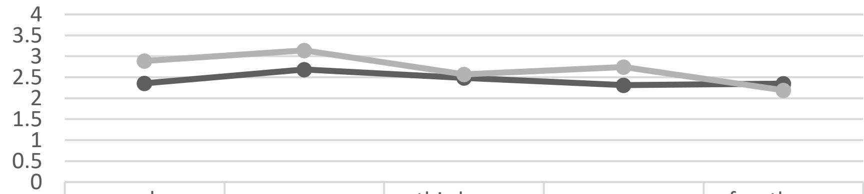
Within the scope of this study, the crucial part of interior design education, such as design courses, is examined. Nevertheless, the focus of this study is limited to ten design courses of a single University only as the analyses must be done on the students who have experience with both education models. From the instructor's perspective, the success of the learning achieved was evaluated with the grades given at the end of each semester. On the other hand, for the student perspective analysis, a questionnaire was used in which 159 students participated. Considering the expected number of students not attending classes at the expected rate of 10 percent each semester, this survey has collected these data with a deficit even below this rate.

### *4.1. Analysis of Student Success Rates Through the Instructor Perspective*

In the assessment of the instructor perspective, the semesters covered by the study were divided into fall and spring education periods. The reason for this is the differences in the success rates and factors in each period. Additionally, the mentioned ten design courses are investigated in the study, from the second year second semester to the fourth year second semester, as these students are the only candidates who experienced both education models. Consequently, with these defining criteria, the course grade averages as a definition of academic achievement stated by Crowther and Briant (2020) were divided into three groups as the students who passed (Figures 2 and 3), failed (Figures 4 and 5) and absent (Figures 6 and 7).

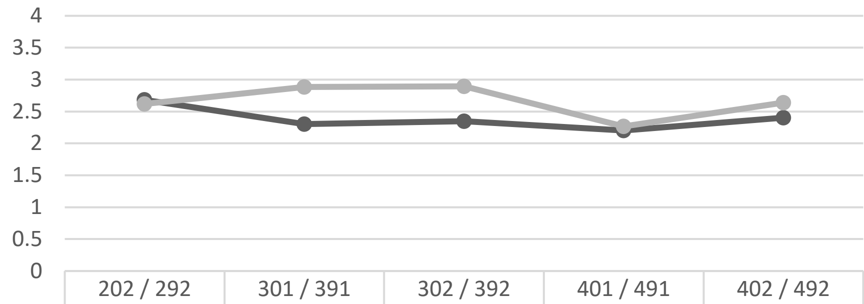
In the detailed analysis of the success rate of both education models from the instructor's perspective on the passing students, while there is no significant difference, the OE model has been observed to be slightly more successful (Figures 2 and 3). Nevertheless, in the third year second semester students of the fall semester and when they proceeded to the fourth year in the spring semester, the instructors observed no significant difference between the two education models (Figures 2 and 3). Furthermore, the failing grade was much higher in the OE model during the fall and the opposite in the following semester (Figure 4). Although there were variations in the proportions of students who received failing marks between the education models, the failure rates have progressed in the same ratio within the semesters (Figures 4 and 5). In other words, the design courses fail averages have shown similar trends of decrease and increase in both education models. The last detailed analysis where student success rates are evaluated from the instructor's perspective is the comparison of FFE and OE class participation rates (Figures 6 and 7). When both education models and semesters are examined, a significant drop is observed in the withdrawal (W) and absence (NG) rates following the third-year design courses. In other words, while higher rates of absence are observed in the earlier design courses, students try less to drop out of class as they get closer to graduation, with a higher drop rate in the OE model in the early years.





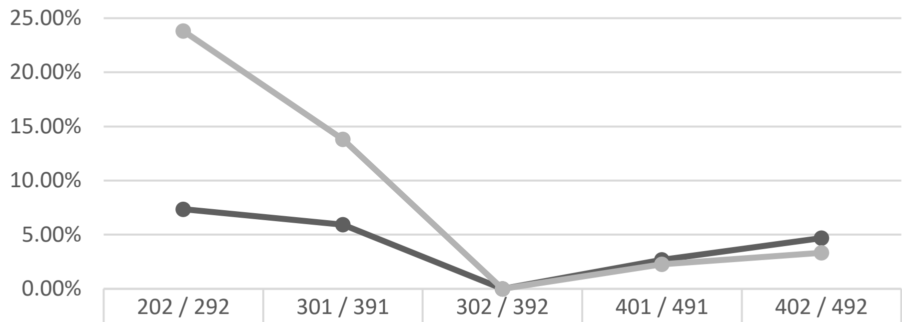

| | second year second semester | third year first semester | third year second semester | fourth year first semester | fourth year second semester |
|---|---|---|---|---|---|
| Face-to-Face Education | 2.357 | 2.686 | 2.486 | 2.313 | 2.352 |
| Online Education | 2.89 | 3.141 | 2.571 | 2.743 | 2.19 |

**Figure 2** The fall semester design courses pass grade averages



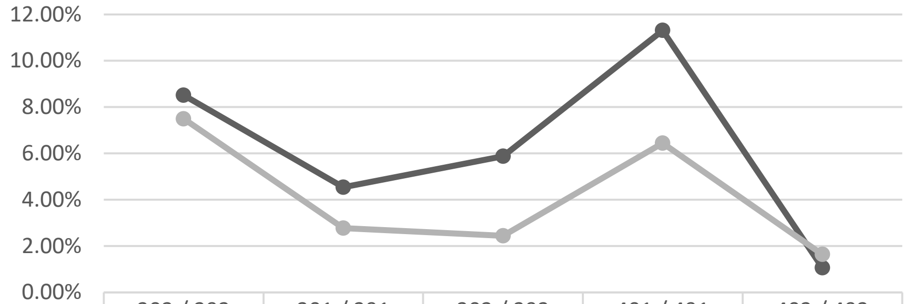

| | 202 / 292 | 301 / 391 | 302 / 392 | 401 / 491 | 402 / 492 |
|---|---|---|---|---|---|
| Face-to-Face Education | 2.682 | 2.305 | 2.349 | 2.203 | 2.401 |
| Online Education | 2.619 | 2.883 | 2.895 | 2.267 | 2.641 |

**Figure 3** The spring semester design courses pass grade averages



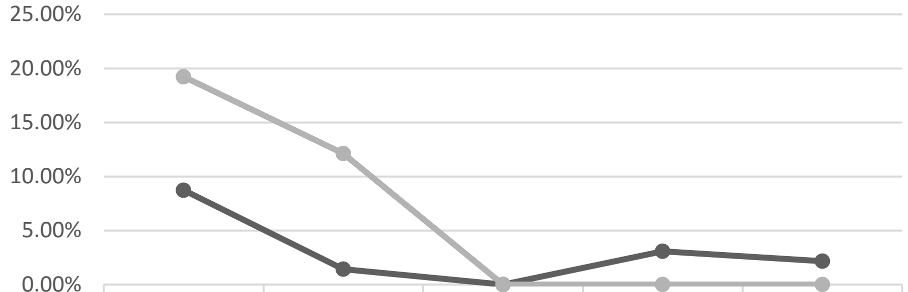

| | 202 / 292 | 301 / 391 | 302 / 392 | 401 / 491 | 402 / 492 |
|---|---|---|---|---|---|
| Face-to-Face Education | 7.36% | 5.92% | 0.00% | 2.68% | 4.69% |
| Online Education | 23.81% | 13.79% | 0.00% | 2.27% | 3.33% |

**Figure 4** The fall semester design courses fail averages



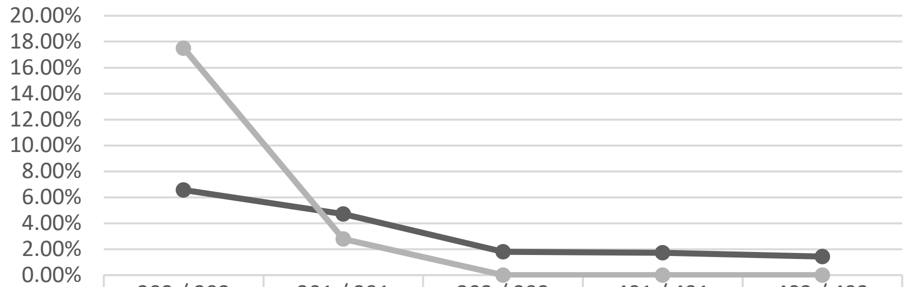

| | 202 / 292 | 301 / 391 | 302 / 392 | 401 / 491 | 402 / 492 |
|---|---|---|---|---|---|
| Face-to-Face Education | 8.51% | 4.55% | 5.88% | 11.31% | 1.06% |
| Online Education | 7.50% | 2.78% | 2.44% | 6.45% | 1.64% |

**Figure 5** The spring semester design courses fail averages




| | 202 / 292 | 301 / 391 | 302 / 392 | 401 / 491 | 402 / 492 |
|---|---|---|---|---|---|
| Face-to-Face Education | 8.74% | 1.43% | 0.00% | 3.08% | 2.15% |
| Online Education | 19.23% | 12.12% | 0.00% | 0.00% | 0.00% |

**Figure 6** The fall semester design courses absence averages




| | 202 / 292 | 301 / 391 | 302 / 392 | 401 / 491 | 402 / 492 |
|---|---|---|---|---|---|
| Face-to-Face Education | 6.56% | 4.70% | 1.80% | 1.72% | 1.43% |
| Online Education | 17.50% | 2.78% | 0.00% | 0.00% | 0.00% |

**Figure 7** The spring semester design courses absence averages

### *4.2. Student Success Rates Through Student Perspective*

The quality of education in a university environment can be evaluated as an integrated concept formed by the combination and interaction of certain factors. These can be referred to as prior education knowledge, experiences, and expectations, the learning environment provided, course material selection, organization and approaches to study, approaches to learning and studying, and the quality of the education obtained (Entwistle et al., 2002). Hence, considering these five main points, the questionnaire was prepared from the student's perspective. Consequently, the survey results are presented under the five headings given.

**Table 1** Prior Knowledge, Experience, and Expectations

| | Mean | SD | Disagree % | Neutral% | Agree % |
|---|---|---|---|---|---|
| I had experience with OE before the pandemic. | 2 | 1.27 | 74.2 | 6.9 | 18.9 |
| I had experience with FFE in studios before the pandemic. | 4.5 | 1.12 | 9.4 | 0.6 | 90 |
| I had positive thoughts about OE before starting. | 3.1 | 1.17 | 31.5 | 32.7 | 35.8 |

When the students' education model experiences before the pandemic are observed, FFE model experiences are more than double the OE experience (Table 1). Hence, it is understood that prior knowledge of the OE model and its functioning was limited and insufficient to start it as successfully as FFE. This difference in the competence of the education model meant that the students had comparatively less mastery over OE model learning methods and tools. It is essential to state that this issue had a compelling effect on students' success at the beginning of the OE period. In addition, students' expectations and prior opinions before starting OE were also very influential. According to the survey results, an even distribution of opinions was seen with a trend toward a neutral-positive attitude.

**Table 2** Learning Environment Provided

| | Mean | SD | Disagree % | Neutral % | Agree % |
|---|---|---|---|---|---|
| I could get feedback from my teacher in OE. | 4.1 | 1.05 | 8.8 | 8.8 | 82.4 |
| I could get feedback from my teacher in FFE. | 4.3 | 0.8 | 6.3 | 5.7 | 88.1 |
| My teacher's interaction with me in OE motivated me. | 3.9 | 1.07 | 11.3 | 18.9 | 69.8 |
| My teacher's interaction with me in FFE motivated me. | 3.9 | 1.16 | 11.8 | 17 | 71.6 |
| In OE, what was expected of me and what I had to do was clear and understandable. | 3.6 | 1.18 | 17.6 | 23.3 | 59.1 |
| In FFE, what was expected of me and what I had to do was clear and understandable. | 3.97 | 0.93 | 6.9 | 22 | 71.1 |
| The critics received by other students in OE helped me in my work. | 3.79 | 1.22 | 18.2 | 15.7 | 66 |
| The critics received by other students in FFE helped me in my work. | 3.54 | 1.15 | 20.2 | 27.7 | 52.2 |
| Interaction with my classmates in OE was helpful in the context of the lesson and projects. | 3.41 | 1.27 | 23.9 | 21.4 | 54.7 |
| Interaction with my classmates in FFE was helpful in the context of the lesson and projects. | 4.03 | 0.96 | 5.6 | 19.5 | 74.9 |

In general, students expressed positive feedback on the survey's topic of the learning environment provided (Table 2). Respectively, the students' satisfaction with the accessibility of instructors received the highest rate in the survey on this topic for both education models. However, FFE has been defined with a slightly higher rate. This higher rate in FFE can be interpreted as the positive influence of being on a campus and having closer and easier access to instructors. Following, the motivation raised from this interaction between instructor and students has been defined as being done successfully for both of the education models. Another important assessment of the learning environment was clarifying what was expected from students in the relevant education model. Again, in this aspect, the students' evaluations were positive, but with a slight value difference, it was stated that the expectations from the students were clearer in the FFE period. As mentioned before, this is thought to be proportional to the interaction between the student and the instructor, and it can be said that the removal of the campus environment created a compelling factor in the student's general communication with the instructor and the course. The last matters discussed in the learning environment provided were related to students' interaction within and outside of classes. The only issue discussed within this topic of the learning environment provided, which OE had more positive feedback on, was that the criticisms received by classmates were more helpful in OE. The critics received in OE by other students served as guidance to individual projects because in the OE platforms in which design courses were held, critics were given in a more open and accessible way to all. Previously, in FFE, a critic of each student was given in a more personal and private interaction rather than in front of the whole class. However, with OE this became more open and accessible to the whole class. Design course instructors, with OE, could easily provide general comments and advice to the whole class while criticizing a student's project online. In other words, the criticism of a single student's project became an example for the whole class. In addition, courses are now recorded with OE, and a student who did not attend the course retrospectively could make self-criticism about his project by looking at the critics of his/her other classmates. Despite this, yet again, the results have stated that the interaction between classmates was more successful in FFE, and as it was in the previous statements, this can be associated with the positive influence of the campus environment.

**Table 3** Course Material Selection, Organization, and Approaches to Study

| | Mean | SD | Disagree % | Neutral % | Agree % |
|---|---|---|---|---|---|
| Design courses were better organized and handled in OE. | 3.51 | 1.25 | 22 | 20.8 | 57.3 |
| Design courses were better organized and handled in FFE. | 3.83 | 1.03 | 8.2 | 27 | 64.8 |
| Design jury organization in OE was successful. | 3.47 | 1.29 | 23.9 | 20.1 | 56 |
| Design jury organization in FFE was successful. | 3.74 | 1.10 | 11.9 | 31.4 | 56.6 |
| In OE, the virtual environment and platform in which the training was continued were understandable and supportive. | 3.79 | 1.13 | 12.6 | 24.5 | 62.9 |
| In FFE, the spatial environment in which the training was continued was supportive. | 4.03 | 0.97 | 6.2 | 17 | 76.8 |

As stated before, the positive influence of being on campus on the quality of learning is shown in the course material selection, organization, and approaches to study (Table 3). Even though the students have stated satisfaction with the online platforms used during OE, the spatial environment of FFE received a higher satisfaction rate. Last but not least, other discussion issues under the topic of course material selection, organization, and approaches to study were the juries' organization, teaching, and success. While students in both education systems showed satisfaction, it was observed that they had provided more positive preferences towards FFE, with a slight difference.

**Table 4** Approaches to Learning and Studying

| | Mean | SD | Disagree % | Neutral % | Agree % |
|---|---|---|---|---|---|
| In OE, I was able to do research and work on my projects in a superficial way rather than deep research. | 2.77 | 1.31 | 49 | 18.9 | 32.1 |
| In FFE, I was able to do research and work on my projects in a superficial way rather than deep research. | 2.77 | 1.22 | 48.5 | 21.4 | 30.2 |
| In OE, I have successfully fulfilled what my teachers asked for me and the 'learning outcomes. | 3.9 | 1.12 | 12 | 15.1 | 72.9 |
| In FFE, I have successfully fulfilled what my teachers asked for me and the 'learning outcomes. | 3.95 | 0.99 | 9.4 | 13.2 | 77.3 |

| | | | | | |
|---|---|---|---|---|---|
| The workload was high in OE. | 3.97 | 1.22 | 15.7 | 14.5 | 69.8 |
| The workload was high in FFE. | 3.63 | 1.19 | 20.7 | 18.2 | 61 |

The initial issue discussed under this topic was the depth of the research and study done by the student, and the same statement was made for both education models (Table 4). Following the issue of reaching the learning outcomes of the courses, both education models have been stated as successful with a slightly higher rate in FFE. In other words, there was no significant difference between education models in this learning outcome issue. In addition, the workload during the education models has been identified as being high for both but with being the highest in OE.



**Table 5** Quality of Learning Achieved

| | Mean | SD | Disagree % | Neutral % | Agree % |
|---|---|---|---|---|---|
| The grades I got for design courses in OE were high. | 3.4 | 1.25 | 21.4 | 28.9 | 49.6 |
| The grades I got for design courses in FFE were high. | 3.46 | 1.14 | 17.6 | 29.6 | 52.9 |
| I believe that design courses are taught more successfully in OE. | 3.23 | 1.42 | 32.7 | 22 | 45.3 |
| I believe that design courses are taught more successfully in FFE. | 3.72 | 1.21 | 12.6 | 27.7 | 59.7 |

The final topic within the questionnaire is the quality of learning achieved in which students' opinions about the success of the education models were provided (Table 5). The initial issue is about the design course grades. Contradicting the data collected from the previous method of instructor perspective, the students have stated that they had higher grades in FFE. Relative to the previous finding, the more successful education model was stated as the FFE model, according to the students' perspective. From a general point of view, it is stated that both education systems are successful, but when a more detailed examination was made, it could be seen that FFE received a much higher rate. Another significant issue is the percentage of disagreeing statements made by students who found the OE successful. While 45.3 percent of the answers agreed with OE being more successful a 32.7 per cent of the students disagreed. This contradicting statement is too important not to overlook. However, only 12.6 percent of the students disagreed with the FFE model being the most successful education model to be carried out in design courses.

## 5. Conclusion and Further Suggestions

Education aims to introduce and provide essential knowledge, values, and skills for individuals to achieve specific objectives in their future professional endeavors. Consequently, certain goals consistently direct, support, and motivate the educational process. These objectives, established by educators and institutions, are subject to continuous evolution in response to the demands of contemporary society and geographic contexts. In light of the pandemic, educators and educational institutions, having been entirely unprepared, were compelled to transition their educational programs to a wholly online format. Although it was anticipated that conditions would not revert to their previous state, it became apparent that interior architecture education would transform similarly to those experienced in other fields.

This study examines the pandemic's changes to design studio education in Interior Architecture and compares the education models on the quality of learning achieved. Following this, two perspectives have been adopted: student and instructor. Through this assessment of the instructor perspective, the OE model was found to be slightly more successful in terms of student success in grades. On the other hand, from the student perspective, the FFE model was more successful with a significant difference.

In design studio education, the student's grade at the end of the term consists of the evaluation of the design projects. The project, which emerged at the end of the semester, symbolizes the accumulation and success of the learning outcomes acquired during this period. The design studio training is based on the one-to-one relationship between the instructor and the student, also, the student's project is shaped by the ongoing critics conducted throughout the course. Hence, student projects finalized at the end of the semester are considered to be proportional to the success of these critics. However, beyond the apparent project success is the knowledge acquired by the student. Therefore, it should be kept in mind that in some cases, the student does not reflect the quality of education provided in the design course through their grades. For these reasons, it is not reliable to describe the success of the education model based only on grade evaluations. Further, although students got higher grades in OE, they have given the opposite statement of having higher grades in FFE with the questionnaire. In addition to this contradiction, this study has suggested further implementation of statistical programs to analyze course grades and research on investigating the successful tools found in the OE model according to both perspectives that could be adopted within traditional design studio education.

Today's students have been born and raised in a digital environment. Thus, the evolving nature of the global landscape has significantly influenced the characteristics of contemporary learners (Prensky, 2001). The current cohort of students is no longer aligned with the educational frameworks in place for many years. Immersed in the transformations instigated by the digital age and technological advancements, this new generation processes information and engages with it in fundamentally different ways than previous generations (Bhattacharjee, 2019; Oblinger, 2004; Prensky, 2001). Consequently, there is an urgent need to adapt educational models to meet the evolving needs of this generation. This necessitates further research into the implementation of design studios within the field of interior architecture, leveraging insights from the OE model and its relevance in a digital context.

In light of these insights, this study proposes the adoption of a hybrid education model as a progressive path forward for Interior Architecture education—one that harmoniously intertwines the strengths of both Fully Face-to-Face (FFE) and Online Education (OE) paradigms (Doering & Veletsianos, 2008; Valadares et al., 2005). Informed by the lived experiences and perspectives of educators and students alike, this model is further shaped by the recommendations outlined in this research. Crucially, educators and institutions must remain responsive and agile as the world evolves—often in subtle yet significant ways. The pandemic served as a powerful catalyst, underscoring the urgent need for educational models that are flexible, and resilient, but also forward-thinking and inclusive.

## References


Afacan, Y. (2016). Exploring the effectiveness of blended learning in interior design education. *Innovations in Education and Teaching International, 53*(5), 508-518.

Ahmad, L., Sosa, M., & Musfy, K. (2020). Interior design teaching methodology during the global COVID-19 pandemic. *Interiority, 3*(2), 163-184.

Bhattacharjee, S. (2019). Using a hybrid pedagogical method in undergraduate interior design education. *Design and Technology Education: An International Journal, 24*(2), 93-109.

Biggs, J., Kember, D., & Leung, D. Y. (2001). The revised two-factor study process questionnaire: R-SPQ-2F. *British Journal of Educational Psychology, 71*(1), 133-149.

Crowther, P., & Briant, S. (2020). Predicting academic success: A longitudinal study of university design students. *The International Journal of Art & Design Education, 39*(4), 1-15.

Doering, A., & Veletsianos, G. (2008). Hybrid online education: Identifying integration models using adventure learning. *Journal of Research on Technology in Education, 41*(1), 23-41.

Dreamson, N. (2020). Online design education: Meta-connective pedagogy. *The International Journal of Art and Design Education, 39*(3). 483-497.

Entwistle, N., McCune, V., & Hounsell, J. (2002). Approaches to study and perceptions of university teaching – learning environments: Consepts, measures and preliminary findings. *Enhancing Teaching-Learning Environments in Undergraduate Courses Project, Occasional Report*. 1-21.

Ginns, P., & Ellis, R. (2007). Quality in blended learning: Exploring the relationships between online and face-to-face teaching and learning. *The Internet and Higher Education, 10*(1), 53-64.

Gul, G. G. C., & Afacan, Y. (2018). Analyzing the effects of critique techniques on the success of interior architecture students. *The International Journal of Art and Design Education, 37*(3), 469-479.

Gümüş, S. (2007*). Çevrimiçi işbirliği ekiplerinde öğrenenlerin sorun çözerek öğrenmeyle ilgili tutum ve görüşleri* (Master). Anadolu Üniversitesi, Sosyal Bilimler Enstitüsü, Uzaktan Eğitim ABD.

Hodges, C., Moore, S., Lockee, B., Trust, T., & Bond, A. (2020). The difference between emergency remote teaching and online learning. *EDUCAUSE Review.*

Ioannou, O. (2017). Design studio education in the online paradigm: Introducing online education tools and practices to an undergraduate design studio course. *IEEE Global Engineering Education Conference, EDUCON*, 1871–75.

Iranmanesh, A., & Onur, Z. (2021). Mandatory virtual design studio for all: Exploring the transformations of architectural education amidst the global pandemic. *The International Journal of Art and Design Education, 39*(4).

Marshalsey, L., & Sclater, M. (2020). Together but apart: Creating and supporting online learning communities in an era of distributed studio education. *The International Journal of Art and Education, 39*(4). 826-840.

McConnell, M., & Waxman, L. (1999). Three-dimensional CAD use in interior design education and practice. *Journal of Interior Design, 25*(1), 16–25.

McCormack, C., & Jones, D. (1998). *Building a web-based education system*. New York:Wiley Computer Publishing.

McLain-Kark, J. (2000). A strategic story of using computer technology: The EPA project by HOK. *Journal of Interior Design, 26*(2), 25–40.

Oblinger, D., G. (2004). The next generation of educational engagement. *Journal of Interactive Media in Education, 8*(1), 1-18. Doi:10.5334/2004-8-oblinger

Oktay, H. E., Mutlu, H., Unvan M., Kavas K. R., & Bakır İ. (2021). Mimarlık eğitiminde sanal eğitim denemeleri ve değerlendirme süreci. *Journal of Qualitative Research in Education, 25*, 311-324. doi: 10.14689/enad.25.13

Pektaş, Ş. T. (2015). The virtual design studio on the cloud: A blended and distributed approach for technology-mediated design education. *Architectural Science Review, 58*(3), 255–65.

Prensky, M. (2001). Digital natives, digital immigrants. *MCB University Press, 9*(5).1-6.

Richardson, E., T., J. (1994). A British evaluation of the course experience questionnaire. *Studies in Higher Education, 19*(1), 59-68.

Salama, A. M., & Wilkinson, N. (2007). *Design studio pedagogy: Horizons for the future*. Gateshead, UK: The Urban International Press.

Valadares, K., Slavkin, M., & Reasons, G, S. (2005). Questioning the hybrid model: Student outcomes in different course formats. *Journal of Asynchronous Learning, 9(*1). Doi:10.24059/olj.v9i1.1804

Zuo, Q., & MaloneBeach, E. E. (2010). A comparison of learning experience, workload, and outcomes in interior design education using a hand or hybrid approach. *Family and Consumer Sciences Research Journal, 39*(1), 90-106.

## Resume

*Kamil Güley holds a PhD in architecture. Since 2014, he has been working in the Department of Interior Architecture at Eastern Mediterranean University. He became an assistant professor that same year. His research areas encompass the use of color on building façades, color psychology, identity, interior atmosphere, and architectural education. He has published nationally and internationally on these topics.*

*Nisan Akalın completed her foundation degree at the University for the Creative Arts in Art & Design and her undergraduate education at London Metropolitan University in Furniture and Product Design. Following, she proceeded with her master's studies in Interior Design, followed by Ph.D. in Architecture, and is working as a Senior Instructor in the Department of Interior Architecture at EMU.*