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MIMARON

Volume 21 Number 3 Year 2026 - September

CONTENTS

ARTICLES

259 **The importance of the birdhouses at the Ayazma Mosque in eighteenth-century Ottoman architecture**
Miskine Akar, Nur Urfalıoğlu

278 **The invisible dynamics of migration: the new order established by Syrians under temporary protection in Ankara through social networks**
Eda Koçak, Demet Erol

296 **Mapping heat vulnerability in Esenler, Istanbul using equal and entropy weighting: A multi-dimensional GIS approach**
Elnaz Tajer, Kaan Ozgun

321 **Spatial analysis of sericulture and silk production in Southern Marmara Region**
Dilara Şenşar, Kunter Manisa

340 **From the "Principle of Dressing" to the "Law of Dressing": The contentious relation between Gottfried Semper and Adolf Loos**
Ela Kaçel

349 **Climate-responsive roof design: phase-change materials and cool-roof coatings across Türkiye's six climate zones**
Niloufar Ziasistani, İrem Sözen Aka, Andrés Meana-Fernández, Antonio J. Gutierrez Trashorras

361 **The heat preparedness Gap: Bridging urban heat risk and municipal heat governance**
Deniz Erdem Okumus

379 **Material-led design research through biomaterial transformation: Temporality, participation, and spatial production**
Zeynep Birgonul Martı Benet

393 **Integrating social resilience into the sustainable management of Edirne's historic city center**
Hülya Evcen, Hale Mamunlu Kocabaş

412 **From lived house to personality house museum: A spatial and ınstitutional comparison of Türkiye and the United Kingdom**
Cansu Eser Köse, Işıl Çokuğraş

427 **Integration of climate adaptation into spatial planning in Turkish cities: A comparative evaluation**
Gamze Akıncı, Aliye Ahu Gülümser

438 **The Society of the Friends of İstanbul (İstanbul Şehri Muhibleri Cemiyeti) in light of new documents**
Mekselina Gececi Gümüş, Nuran Kara Pilehvarian

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Article

The importance of the birdhouses at the Ayazma Mosque in eighteenth-century Ottoman architecture

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ABSTRACT

The Üsküdar Ayazma Mosque (1760–1761), commissioned by Sultan Mustafa III, is an important example of early Ottoman Baroque architecture. This research investigates the birdhouses incorporated into the facades, gates, and hünkâr pavilion, viewing them as micro-architectural elements that reflect the stylistic transformations of the eighteenth century. The methodological approach of this study encompassed direct observation and high-resolution photographic documentation of twenty extant birdhouses, conducted over a period from 2022 to 2024. These findings were cross-referenced with the official restoration plans from the Istanbul Foundations 2nd Regional Office and compared with contemporaneous Istanbul buildings to assess their spatial distribution. The results obtained demonstrate the exceptional status of the Ayazma Mosque, which features an unrivalled concentration and variety of birdhouses. The twenty documented examples are evenly distributed between ten multi-story kiosk-type structures and ten arched alcove-type units. This equilibrium is indicative of the architectural ambivalence that characterised the period's transition from classical to Baroque styles. The integration of traditional penci arches alongside elaborate palace-like pavilion forms further highlights the synthesis of Eastern and Western architectural influences. The study concludes that these birdhouses are not merely decorative but also represent the Islamic concept of merhamet (compassion) and the institutional framework of waqfs (charitable endowments). Furthermore, they symbolise sultanic visibility and global legibility in an era when the Ottoman Empire sought to redefine its global role.

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INTRODUCTION

It is evident that throughout history, birds have been occupying a uniquely privileged place in human culture. They have been revered as symbols of spirituality, freedom and divine grace across various different civilisations. In the Ottoman world, this deep-rooted veneration found a remarkably concrete architectural expression in the birdhouse, a purpose-built micro-architectural unit conceived not as a mere functional shelter but as a meaningful component of the built environment. These structures embodied the Islamic ethic of *merhamet* (compassion) and a broader cultural commitment to the welfare of living creatures, one formally embedded within the institution of waqfs (charitable endowments), which routinely made explicit provision for the care of animals alongside their more celebrated humanitarian functions. While comparable traditions can be traced across a vast geographical arc stretching from the Indian subcontinent and Central Asia to the Balkans — suggesting a history of sustained intercultural exchange — it was within the Ottoman context that the birdhouse evolved most visibly alongside broader transformations of monumental architecture, reaching a moment of particular sophistication during the eighteenth century, when the emergence of Baroque aesthetics began to fundamentally reshape the formal and symbolic language of imperial building.

In traditional societies, special structures were built for birds to benefit from them in the most effective way. In this respect, birdhouses stand out as special structures designed only for the shelter of birds, separated from other structures. Such structures were widely practiced in Ottoman geography and attracted attention by being located on the structures used by people. In the Ottoman social-religious environment, these birdhouses embodied the Islamic value of *merhamet* and the promotion of animal welfare. This social value was inculcated in the broader institution of waqfs (endowed foundations), which regularly included specific regulations concerning the welfare and maintenance of living creatures. Their deliberate placement on public and monumental buildings suggests that birdhouses were conceived not as incidental additions, but as meaningful components of the built environment. However, in the contemporary period, these elaborate micro-architectural units are not built in their traditional form, as changes in the social fabric and the development of contemporary construction methods and materials have resulted in the abandonment of this traditional form of architecture.

Birdhouses, which can be defined as "nests specially built on the walls of palaces, mansions, etc., or on the branches of large trees in their gardens to provide shelter and protection for birds" (Turkish Language Association Dictionary, 2022), according to Arseven (1984), were used to decorate the facades of houses as both a nest for birds and a miniature of the buildings (Arseven, 1984, p. 108). Birdhouses were also known as birdhouses/dovecotes (*kuşevi*), sparrow palaces (*serçe saray*), pigeon palaces (*güvercinsaray*), bird kiosks (*kuşköşkü*), and bird niches (*kuş takası*) (Hasol, 2020, p. 394; Urfalıoğlu, 2015). The typological variety and aesthetic sensitivity of birdhouses are reflected in the diversity of terms used to describe them. Located on the most visible and elevated parts of buildings, particularly along eaves and exterior walls, these structures provided shelter for birds such as sparrows, goldfinches, doves, pigeons, and swallows. Birdhouses were either integrated during the initial construction or added later to a wide range of buildings, including mosques, inns, baths, madrasahs, mausoleums, tombs, fountains, bridges, palaces, mansions, and churches.

The construction material of birdhouses in the Ottoman period was generally stone (marble, molded stone, etc.), although examples made of wood and reinforced concrete also exist today. These constructions vary between 10 cm and 40 cm according to the size of the birds (Göksal, 2021, p. 156). The cavities were formed by shaping cracked stones through crushing and combining them with adjacent stones. Over time, these cavities were transformed into kiosks and palaces with cantilevered pavilions and rising floors by adding balconies and eaves (Bektaş, 2004, p. 86). This transformation is analogous to more extensive stylistic evolutions observed within the domain of Ottoman architecture, notably during the eighteenth century.

In birdhouses, mosque, house, hollow/cavity, and kiosk-shaped are the main forms encountered. Other forms include balcony, alcove/oriel, iwan, cage, külliye-complex, masjid, sparrow palace, and viewing pavilion (Barışta, 2000, p. 251). The construction methods of birdhouses differ in terms of materials and wall thickness and were applied to masonry and stone walls through techniques such as carving, relief, seating, and facade cladding. Birdhouses are grouped differently by researchers according to their formal characteristics. Seyyide Göksal (2021) analyses them in three groups: Arched alcove-type (*kovuk*), carved (*oymalı*), and wall relief (Göksal, 2021, p. 135). Barışta (2000), on the other hand, analyses birdhouses in more detail in terms of facade arrangement, such as three-sided, rectangular facades with vertical or horizontal projections, pentagonal forms, round-lined overhangs, and arched-eyed compositions (Barışta, 2000, pp. 261–270). These classifications demonstrate that birdhouses offer a valuable lens through which architectural diversity and stylistic variation can be examined at the micro-level.

Birdhouses, one of the characteristic building types in Ottoman art, are also seen in Japanese culture. Apart from Istanbul, birdhouses can be found throughout Anatolia and Thrace, including Ankara, Edirne, Izmir, Bolu, Tokat, Amasya, Kayseri, Doğubeyazıt, Kastamonu, and Milas (Bektaş, 2004, p. 66). These examples date from the

Seljuk, Ottoman, and Republican periods, beginning in the 13th century. Until the late Ottoman period, arched alcove-type examples predominated, whereas more rectangular facade and pavilion-shaped examples emerged in the eighteenth and nineteenth centuries. This section's samples come from a variety of historical eras and cultural settings. These variations reflect the influence of successive architectural phases-classical, baroque, and neoclassical-on birdhouse design.

European travellers like Lady Mary Wortley Montagu and Gérard de Nerval highlighted birdhouses as materializations of the Islamic concept of *merhamet*. This cultural devotion was formally institutionalized through the framework of waqfs which frequently included specific provisions for the protection and welfare of living creatures. Consequently, these structures should be analysed as architectural manifestations of a religiously mandated philanthropic culture, where animal shelter became a visible component of sultanic and elite patronage. While the foundational works of Celal Esat Arseven (1984) and subsequent scholars provide rich descriptive inventories, the analytical link between birdhouses and broader eighteenth-century architectural transformations remains insufficiently explored.

Within this broader architectural, cultural, and historical framework, the present study focuses on the birdhouses of the Üsküdar Ayazma Mosque (1760–1761), one of the most significant monuments of the early Ottoman Baroque period. The article's objective is to evaluate the micro-architectural elements of the birdhouses integrated into the mosque's facades, courtyard gates, and hünkâr pavilion as indicators of stylistic transformation and cultural intention. This undertaking entails a thorough examination of the formal characteristics, spatial arrangement, and typological diversity observed in the birdhouses. The study repositions birdhouses as significant architectural manifestations, reflecting the coexistence of classical Ottoman traditions and emerging Baroque aesthetics in eighteenth-century Istanbul.

Architectural Characteristics of Birdhouses

Birdhouse samples can be seen in a wide geography, from Japan to India, from Pakistan to Anatolia and the Balkans. In addition to this situation, which shows that birdhouses are widespread in a wide geography, there have been cultural interactions in these geographies. Instead of these examples being considered as a unitary architectural ensemble, this section uses a historical narrative tracing the formal and stylistic evolution of birdhouses, beginning in their functional designs in the early period up until the more complex designs in the eighteenth century. Birdhouses built in the Ottoman period and Mongolian culture also have similarities. For example, birdhouses in places such as Lahore Fortress, Taj Mahal, Ahmet Yesevi Tomb and Arslan Baba Tomb reflect this similarity (Barışta, 2000, p. 55; Göksal, 2021, p. 19). In addition, research[1] has shown that late Ottoman buildings have 'eastern' influences.

There are many birdhouses made with various materials and techniques in and around Anatolia, from Ottoman and Seljuk buildings. It is possible to see the most beautiful birdhouse examples in Istanbul, the last capital of the Ottoman Empire. In addition, according to the existing studies, the most birdhouse examples are on buildings in Istanbul (Göksal, 2021, p. 135) (Figure 1). The earliest birdhouse in Istanbul is on the Bali Pasha Mosque (1504) built by Mimar Sinan in the early 16th century (Tanman, 2010, p. 189). Similarly,

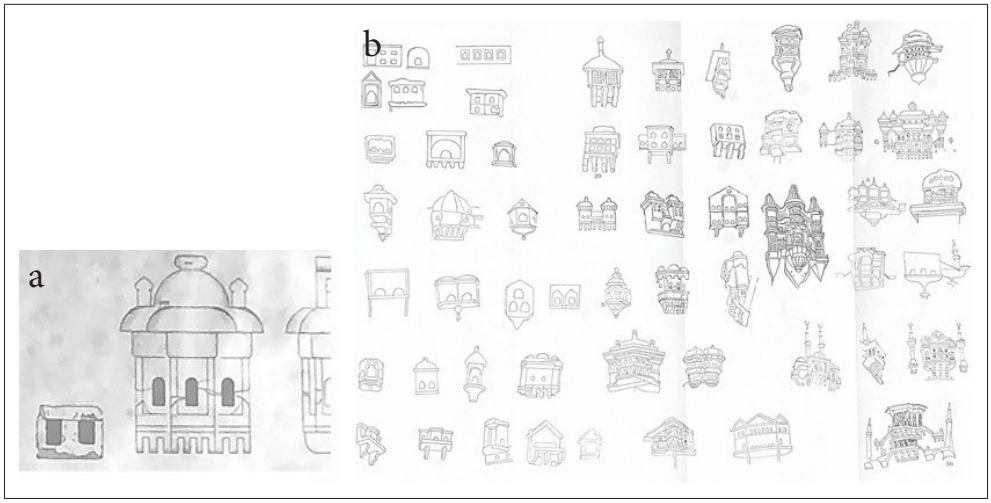


Figure 1. Drawing of the kiosk-shaped birdhouse on the facade of Bali Pasha Mosque (Drawing **a:** Tanman, 2010, p.189) and schematic drawings of some of the forms observed in Istanbul birdhouses (Drawing **b:** Pınar Dinçer; Barışta, 2000, p. 427).

1 Şahin, 2009; Göksal, 2021.

arched alcove-type birdhouses can be seen in the buildings of 16th century Sinan complexes such as Şehzade (1543), Süleymaniye (1554-59), Zâl Mahmud Paşa (1574) and Şemsi Paşa (1580) (Barışta, 2000, p. 105, 106, 122, 207, 232). Common in the 16th century, alcove shaped birdhouses evolved into new forms with carved and rectangular facades/kiosk-shapeds in the 17th century, as seen in the Yeni Valide Mosque. As Istanbul's growth outside the old city walls accelerated, birdhouses continued to spread in districts such as Üsküdar, Eyüp, and Beyoğlu. There are distinctive examples of birdhouses in eighteenth-century Istanbul. These examples are discussed in the following section through a comparative analysis with the birdhouses of the Üsküdar Ayazma Mosque, which constitutes the main subject of this article.

The birdhouses on the corner ledge of an apartment building on Sıraselviler Street in Beyoğlu exemplify the late 19th and early 20th-century architecture (Neftçi, 2010, p. 139). The birdhouses harmonizes with the architecture of the cylindrical ledge on which they are located and face three different directions. The wooden birdhouses face in three different directions and have three nest entrances with round arches on a semi-circular platform supported by four buttresses (Figure 2, left and middle sides-a). The Rahmi Koç Museum features a stone birdhouse that was added in the 20th century. The birdhouse has a pavilion shape and is supported by three buttresses. It features a rectangular platform, a prismatic frame with arched nests, and a conical roof (Figure 2, right side-b).

From the early days of the Republic to the present day, examples of birdhouses have been built in Istanbul, albeit rarely. An example of this is the stylized two-storey, rectangular facade, wide eaves, and buttress-supported birdhouse seen on a building on Bağdat Street in Kadıköy (Figure 3). A two-storey birdhouse with crenellations on the parapet is located at the intersection of Esnaf Loncası Sokağı and Yatağan Hamamı in Ayvansaray. It was built in the late 19th and early 20th centuries, representing the Republican period in Istanbul.

Birdhouses can be found in many cities in Anatolia such as Amasya, Kayseri, Nevşehir, Kastamonu, Safranbolu, Bolu, Isparta, Manisa and İzmir[2] in addition to the examples observed in İstanbul. For instance, in İzmir-Çeşme, there is a single-entrance birdhouse with a facade in the shape of an ancient Greek temple on the facade of a house (Figure 4).

As an example of birdhouses from the Republican era, a modern birdhouse built during Mehmet Çalık›s first term as mayor of Kayseri (1963-1968) can be shown (Urfalıoğlu & Baturayoğlu Yöney, 2013). The building is located in a public green area between Kayseri Provincial Public Library and Seyit Burhanettin Tomb. The birdhouse, located on a platform placed on a reinforced concrete base, consists of three prismatic intertwined masses. There are pointed arched openings of different sizes on the side facades of the masses (Figure 5).

Theoretical Framework: Ottoman Baroque and Global Context

During the eighteenth century, the Ottoman Empire's attitude towards Western states had begun to change, and its desire to benefit from Western technology had been growing. The concept of opening up to the West also manifested itself in the art field, and new branches and styles of art entered Ottoman culture (Cezar, 2002, p. 292). In the early eighteenth century, the Tulip Period marked the beginning of eastern and western influences in Ottoman architecture. As the century passed, Western influences became more dominant in art and architecture. The emergence of the Ottoman Baroque, influenced by the West during this period, is a significant example (Çelik, 2019). From the late eighteenth century onwards, the use of baroque was also extended to the structural elements of the buildings and

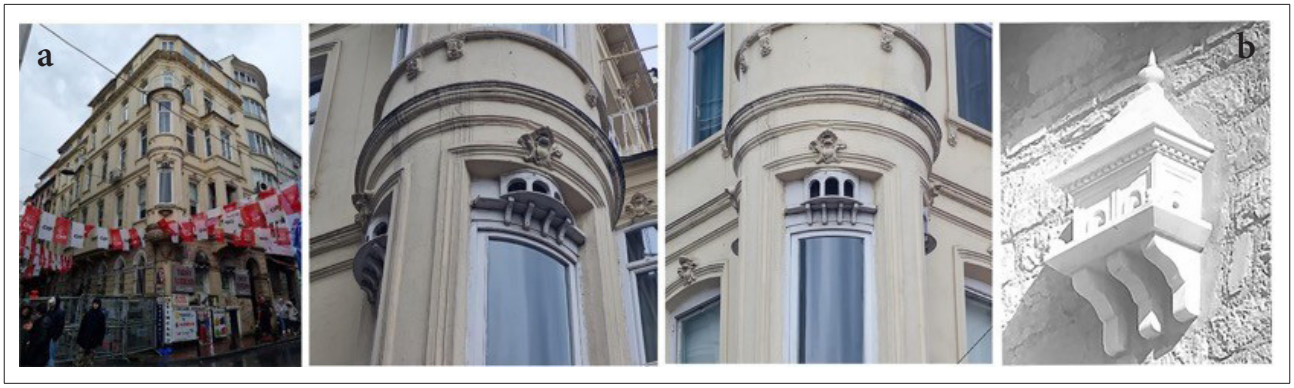


Figure 2. An example of a 19th-20th century birdhouse from an apartment building on Sıraselviler Street in Beyoğlu, Istanbul (Photo **a:** Elif Merve Gürer), and a birdhouse added to the Rahmi Koç Museum in the 20th century (Photo **b:** Neftçi, 2010, p. 157).

[2] Nur Urfalıoğlu's 2015 paper 'Birdhouse Tradition Examples from Kayseri and Isparta' provides a detailed examination of examples in Anatolia.



Figure 3. An example of a stylized birdhouse from a building on Bağdat Street in Kadıköy, Istanbul (Photo **a:** (Url-1, 2017)), **b:** (Photo b: Sibel Sürmeli)).



Figure 4. Detail of the birdhouse on the facade of the house in Çeşme, Izmir (Urfalıoğlu, 2015).

generally dominated the facade. The baroque style is characterized by rounded lines, curved, concave, and convex surfaces, S and C curves, sea shells, intricate surface ornamentation (Çelik, 2019, p. 36), composite and Corinthian capitals, long curved eaves, pairs of columns, emphasizing the load-bearing elements on the facades, and profiled mouldings (Bakır, 2003, p. 81). Some of the most important examples of Ottoman baroque architecture from the eighteenth century include the Nuruosmaniye Mosque (1755) and the Laleli Mosque (1763) (Çelik, 2019, p. 36).

However**,** this transformation extended beyond a superficial adoption of Western decorative motifs. The stylistic transformation in eighteenth-century Ottoman architecture was not merely a superficial Westernization but rather a process of "opening up" (*décloisonnement*) in which the patronage structure and aesthetic boundaries expanded (Hamadeh, 2010). During this period, architecture moved away from classical norms and acquired an identity focused on innovation, visual spectacle, and sensory pleasure (Hamadeh, 2010). On the other hand, Ünver Rüstem claims that "Ottoman Baroque" defines not only a taste but also a means of redefining the position of both the Ottomans and the sultanate on a global scale through a "globally readable" aesthetic (Rüstem, 2019).

The typology of birdhousing has been recorded in a wide geographical range of countries, including Japan, India, and the Balkans. As regards the Ottoman context, these build-



Figure 5. Example of a modern birdhouse in Kayseri, 1963-68 (Author, 2023-2024; Urfalıoğlu, 2015).

ings symbolize the Islamic concept of *merhamet*, a cultural value that is central in the travelogues of Lady Mary Wortley Montagu and Gérard de Nerval. Unlike previous descriptive inventories (e.g., Arseven, Barışta, Bektaş), which often overlook the institutional framework of waqfs, this study provides an analytical evaluation of the Ayazma Mosque's birdhouses as micro-architectural manifestations of the eighteenth-century Ottoman Baroque transformation. Consequently, this research fills a critical gap by positioning these 'miniature palaces' not merely as ornaments, but as indicators of global legibility and sultanic visibility.

In this context, the birdhouses at Ayazma Mosque exemplify the Ottoman palace's sophisticated vision of blending local heritage with global trends by presenting a "hybrid" synthesis of traditional forms and Western models. The birdhouses of Ayazma Mosque should be analysed as manifestations of this shift towards global legibility and sultanic visibility (Rüstem, 2013; Hamadeh, 2008).

Before proceeding to the case study analysis, Table 1 presents a comparative typological framework distinguishing the formal, structural, and cultural characteristics of the two principal birdhouse types identified across eighteenth-century Istanbul. While the traditional alcove-type (*kovuk*) remained the predominant form across all periods, the emergence of sophisticated kiosk-shaped examples reflects the broader stylistic transformation and Baroque 'opening up' of Ottoman monumental architecture. The Ayazma Mosque stands as the most complete expression of this typological duality, integrating both traditional and innovative forms within a single monumental complex (Table 1).

Birdhouses in Eighteenth-Century Istanbul

Since Ottoman architecture was predominantly centred in the capital, it is possible to see the changes and ruptures in the architecture of Istanbul in particular. In the early eighteenth century, construction activities began to revive with the widespread use of wooden mansions and kiosks, and instead of works of charity and endowment, there was more activity in residential civil buildings. This mobility, which emerged with the opening of new settlement areas, was seen in the inland part of the Golden Horn, the lower part of the Kağıthane stream, and the Bosphorus coasts such as Üsküdar (Figure 6). It can be said that this mobility in Istanbul architecture is also reflected in the birdhouses.

Built in the eighteenth century, birdhouses can be seen on a variety of buildings (Figure 7) such as Darphane-i Amire (1727), Taksim Maksem (1732), Fatih Mosque Library (1742), Seyyid Hasan Pasha Madrasah (1745), Atıf Efendi Library (1742), Laleli Mustafa III and Selim III Tombs (1763) as well as Üsküdar Yeni Valide Mosque (1713), Üsküdar Ayazma Mosque (1761). Selim Tomb (1763), Büyük Yeni Han (1764)[3] (Figure 7). They also appear on the facades of monumental mosques such as Üsküdar Yeni Valide Mosque (1713), Üsküdar Ayazma Mosque (1760), and Üsküdar Selimiye Mosque (1789-1801) (Figure 8) (Table 2).

When eighteenth-century Istanbul buildings are analysed, birdhouses can be seen on building types with various functions such as mosques, madrasahs, libraries, primary schools, imarets, mints, maksem (place of distribution or

Table 1. Comparative typology of Ottoman classical and baroque birdhouses

Feature	Classical Period (Alcove-Type / Kovuk)	Baroque Period (Kiosk-Shaped/Köşk-Saray)
Form	Arched alcove, hollow cavity	Multi-story rectangular facade, pavilion
Stylistic Period	16th–17th century (predominant)	18th–19th century (predominant)
Structural Character	Integrated into wall surface, flush	Cantilevered, projecting from facade
Roof Type	Simple arch cover	Domed, conical, or tiered roof
Decorative Elements	Minimal ornamentation, *penci* arches	Elaborate ornamentation, S/C curves, seashell motifs
Number of Floors	Single level	Multi-story, with balconies and cantilevers
Supports	Wall-integrated	Buttresses, corbels
Nest Configuration	Single or double cavity	Multiple nesting spaces, varied openings
Architectural Analogy	Modest niche	Miniature palace, maharajah's pavilion
Representative Examples	Şehzade Mosque (1543), Süleymaniye Mosque (1554–59)	Ayazma Mosque (1760), Eyüp Mosque (1798–1800)
Patronage Context	Waqf-based charitable tradition	Sultanic visibility, global legibility
Cultural Reference	Islamic *merhamet*	Eastern-Western hybrid synthesis

[3] It is stated that this birdhouse on Büyük Yeni Han is the only birdhouse with an inscription in Istanbul. The inscription reads "Mashallah year 1177 "(praise be! the year Hijri 1177-(Gregorian 1764)) (Barışta, 2000, p. 247).



Figure 6. Istanbul Üsküdar Şemsipaşa, 1891 (eskiistanbul.net, 2025).



Figure 7. Darphane-i Amire **(a)** (Göksal, 2021, p. 128), Seyyid Hasan Pasha Madrasa **(b)** (Kültür Envanteri, 2023), Taksim Maksem **(c)**, Laleli Mustafa III and Selim III Tomb **(d)** and birdhouses on Büyük Yeni Han **(e)** (Author, 2023-2024).

sharing out of the city water), tombs, inns, and churches. From the early eighteenth century to the end of the eighteenth century, these buildings were built by palace patrons/banis who were members of the dynasty, such as the



Figure 8. Birdhouses on Üsküdar Yeni Valide Mosque **(a)**, Üsküdar Ayazma Mosque **(b)** (Author, 2023-2024), and Üsküdar Selimiye Mosque **(c)** (Kültür Envanteri, 2023).

Table 2. Analysis of birdhouses on buildings constructed in eighteenth-century Istanbul

No	Building name	Building construction date	Bani (Patron/ founder)-restorer	Birdhouse shape	The facade on which the birdhouse is located	The position of the birdhouse on the facade
1	Çorlulu Ali Paşa Mosque	1707-09	Çorlulu Ali Pasha	Alcove-type	North-east	Under the eaves
2	Gülnüş Emetullah (Yeni) Valide Mosque Primary School	1711	Emetullah Rabia Gülnüş Sultan	Alcove-type	North-west	Under the eaves
3	Gülnüş Emetullah (Yeni) Valide Mosque	1711	Emetullah Rabia Gülnüş Sultan	Mosque, alcove-type	East-West	Under the eaves
4	Damat Ibrahim Pasha Masjid	1720	Damat Ibrahim Pasha	Alcove-type	North-west	Under the eaves
5	Ahmediye Mosque	1721	Shipyard Commander Ahmed Agha	Alcove-type	East	Window tops
6	Topkapi Palace Mint Building	1727	Ahmet III	Mansion, Kiosk-shaped	North	Under the eaves
7	Hagios Demetrios Church	1730	-	Alcove-type-house	South	Under the eaves
8	Çuhacı Han	1730	Damat Ibrahim Pasha	Alcove-type	South-west	Window tops, under the eaves
9	Taksim Maxim	1730-31	Ahmet III-Mahmut I	Kiosk-shaped	South	Window tops, under the eaves
10	Mahmud Sıbyan Mektebi	1740	Mahmut I	Alcove-type	North-south-east	Under the eaves
11	Atif Efendi Library	1741	Mahmut I	Alcove-type	East	Window tops and walls at different levels
12	Seyyid Hasan Pasha Madrasa	1745	Grand Vizier Seyyid Hasan Pasha	Alcove-type, mosque	South-west-north	Under the eaves
Table 2. (continued)						
13	Nuruosmaniye Mosque and Hünkâr Pavilion	1755	Osman III	Alcove-type	East	Window-side-weight domes
14	Nuruosmaniye Complex Madrasah	1755	Osman III	Alcove-type	East	Courtyard doors, *hünkâr mahfili,* under the floor moldings
15	Üsküdar Ayazma Mosque	1760	Mustafa III	The Seyir Kiosk-shaped - glazed palace - alcove-type	South-east-west	Floor molding and window tops
16	Çakmakçılar/III. Mustafa Mosque	1760	Mustafa III	Alcove-type	North	Under the eaves
17	Laleli Complex Mustafa III and Selim III Mausoleum	1760-64	Mustafa III	Alcove-type, masjid, Sparrow's Palace	South	Under the eaves
18	Laleli Complex Taşhan	1760-64	Mustafa III	Alcove-type	West-south	In the middle
19	Laleli Complex Imaret	1760-64	Mustafa III	Alcove-type	West-south	Floor wiping-under console

Table 2. Continued

No	Building name	Building construction date	Bani (Patron/ founder)-restorer	Birdhouse shape	The facade on which the birdhouse is located	The position of the birdhouse on the facade
20	Little New Inn	1761	Mustafa III	Alcove-type	East-north	Under eaves, window tops
21	Grand New Inn	1764	Mustafa III	Kiosk-shaped, alcove-type	East-north	Under the eaves
22	Ragıp Pasha Library Primary School	1763	Ragip Pasha	Alcove-type	West	Under the eaves
23	Fatih Mosque Mahmut I Library	1766	Mustafa III	Alcove-type	South	Under the eaves and in the middle parts
24	Fatih Mosque	1766	Mustafa III	Alcove-type	South-east	Door tops
25	Recai Mehmet Efendi Primary School	1775	Recai Mehmet Efendi	Alcove-type	North-east	Window tops
26	Sebsefa Primary School	1787	Fatma Şepsefa Hatun	Alcove-type	West	Under the eaves
27	Üsküdar Selimiye Mosque	1789-1801	Selim III	Mansion, Kiosk-shaped	South-East	Under the eaves
28	Mihrişah Vâlide Sultan Complex Imaret	1796	Mihrişah Vâlide Sultan	House-alcove-type	East	Courtyard gates
29	Eyüp Mosque	1798-1800	Selim III	Kiosk-shaped, Sparrow's Palace	South-east, west	Under the eaves
30	Şah Sultan Primary School	1800	Şah Sultan	House	East	Under the eaves

padishah and the sultan, or by state officials such as the grand vizier, vizier, and pasha, or by banis from the public. The forms of the buildings can be arched alcove-type, shelter, house, mosque, mansion, kiosk, palace (glazed palace, sparrow palace). Birdhouses are generally observed under the eaves of the east-south-west-facing, sunny, warm, and windless exterior facades of the buildings, under the eaves, tops of windows and doors, under the floor moldings, etc. in the high parts where people cannot reach them (Table 2).

METHOD

This study adopted a qualitative research methodology grounded in systematic architectural documentation and comparative typological analysis. The primary data were drawn from twenty extant birdhouses documented through direct observation and high-resolution photography conducted between 2022 and 2024, encompassing the exterior facades, courtyard gates, and hünkâr pavilion of the mosque. This original field survey forms the empirical core of the study. It is treated as analytically distinct from the broader historical and contextual information drawn from secondary sources.

To ensure spatial accuracy, the field documentation was cross-referenced with official restoration plans and archival drawings held by the Istanbul Foundations 2nd Regional Office (İstanbul Vakıflar II. Bölge Müdürlüğü). The birdhouses were subsequently classified into two typological categories — alcove-type (*kovuk*) and kiosk-shaped (*köşk-saray*) — following the established classification frameworks developed by Barışta (2000) and Göksal (2021). Each example was then analysed in terms of its structural supports, roof configuration, and surface ornamentation.

A comparative analysis was further conducted with selected contemporaneous Istanbul buildings to identify recurring patterns in spatial distribution and facade placement strategies. It should be noted that the scope of the analysis is confined to surviving exterior birdhouses, with a focus on formal characteristics and cultural significance. Structural testing and interior spatial analysis fall outside the boundaries of this study.

CASE STUDY

Üsküdar Ayazma Mosque and Its Birdhouses

The Üsküdar Ayazma Mosque is situated on the ridges of Üsküdar Salacak, providing a panoramic view of the Bosphorus and the historical peninsula (Figure 9). It was built by Mustafa III in 1760–61 on behalf of his mother, Mihrişah Emine Sultan, and his brother, Şehzade Süleyman. The building master was Ishak Ağa (Eyice, 1991, p. 230-231). Over time, some of the buildings in the complex, including

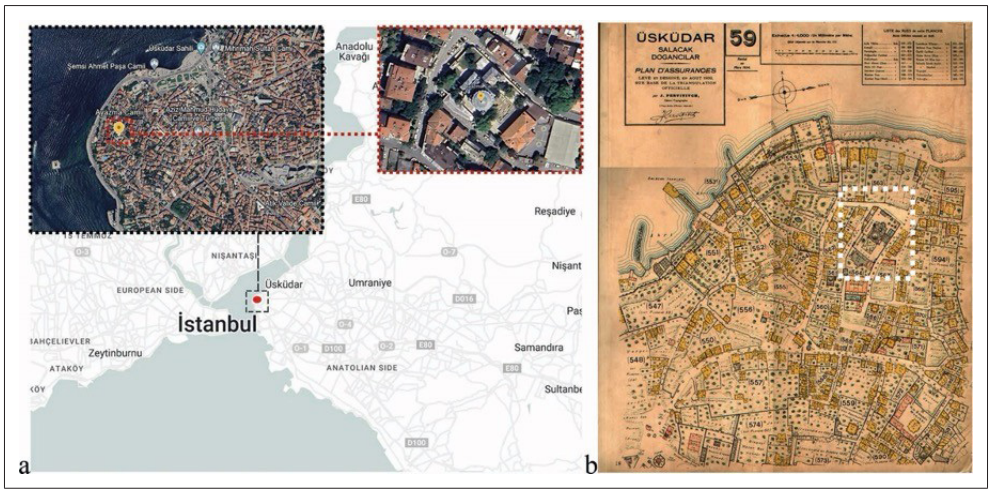


Figure 9. Location of Ayazma Mosque in Istanbul (Google Earth, 2023; Snazzymaps.com, 2023) and Ayazma Mosque on Pervititch map (istanbulium.net, 2019).

a primary school, a hammam, an inn, many shops, and a muwakkithane, became ruined. Only the mosque and the fountain have survived to the present day. The Ayazma Mosque was built during a period when foreign influences such as Baroque and Rococo were widespread in Ottoman architecture. The Nuruosmaniye Mosque stands out due to its dome tambour, large dimensions, and elevated location, making it visible from afar. These features clearly reflect the influence of the Baroque style on the mosque's architecture (Figure 10). Ayda Arel evaluates the architecture of the eighteenth-century Mustafa III period as a period in which classical Ottoman principles were observed (Arel, 1975). Semra Ögel highlights this reign (1757–1774) as a defining phase of creative transformation in eighteenth-century Ottoman architecture (Ögel, 2010). In this context, it can be said that the architecture of the Ayazma Mosque and the birdhouses on it reflect the characteristics of both the classical period and the baroque period.

There are a total of 20 birdhouses on the facades, courtyard gates, and *hünkâr mahfili* of the Ayazma Mosque, 10 of which are in the form of rectangular facades or kiosk-shapes and 10 of which are in the form of arched alcove-type. The restoration project plan in Figure 11 marks the locations of the birdhouses, which are found on the southeast (3 birdhouses) and southwest (1 birdhouse) facades (Figure 12), the courtyard gates (5 on the east portal and 6 on the west portal) (Figure 13), and the *hünkâr mahfili* (5 birdhouses) (Figure 14).

Ayazma Mosque Birdhouse Architectural Features:
Kiosk- and Pavilion-Shaped Birdhouses (Nos. 1-10)
There are ten bird refuges belonging to this type, which can be considered the most ornate and architecturally significant among all the bird refuges in the complex. These bird



Figure 10. Ayazma Mosque after the 2022 restoration (Author, 2023-2024).

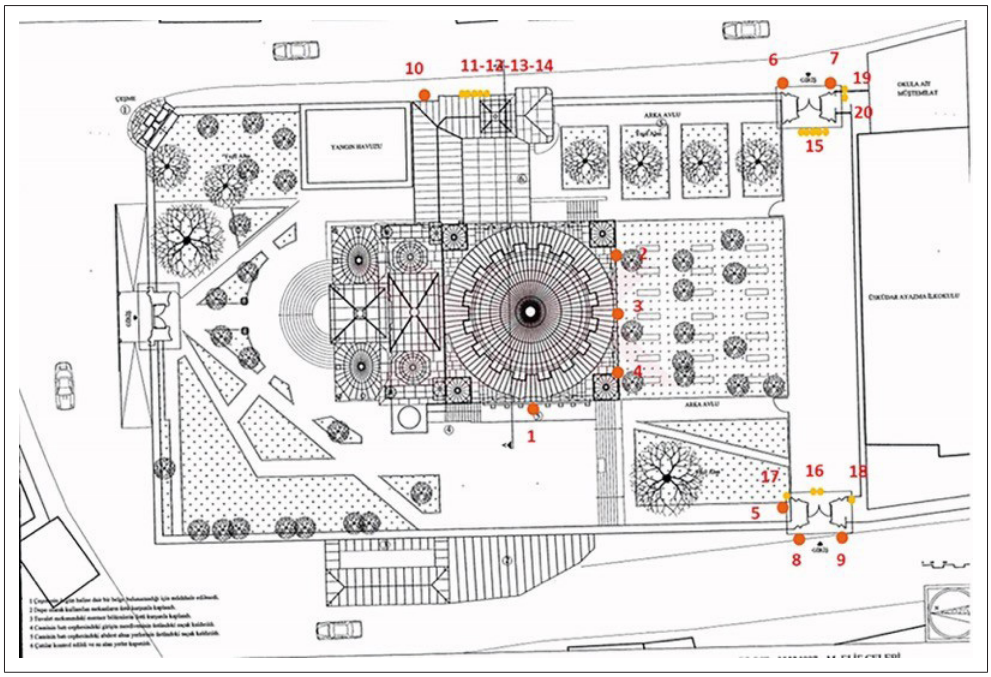


Figure 11. Birdhouse locations on the Ayazma Mosque restoration project plan (Çelebi, 2004, p. 222) (the ones in red are the locations of the birdhouses with rectangular facades/kiosk-shaped, and the ones in yellow are the locations of the birdhouses in the form of arched alcove-type).

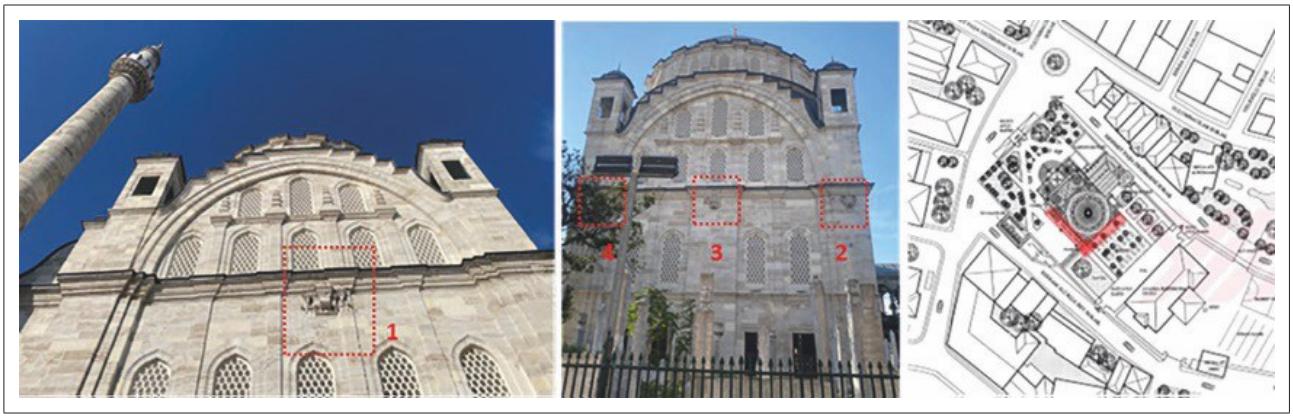


Figure 12. Birdhouses on the southwest and southeast facades of Ayazma Mosque (Çelebi, 2004, p. 222; Author, 2023-2024).

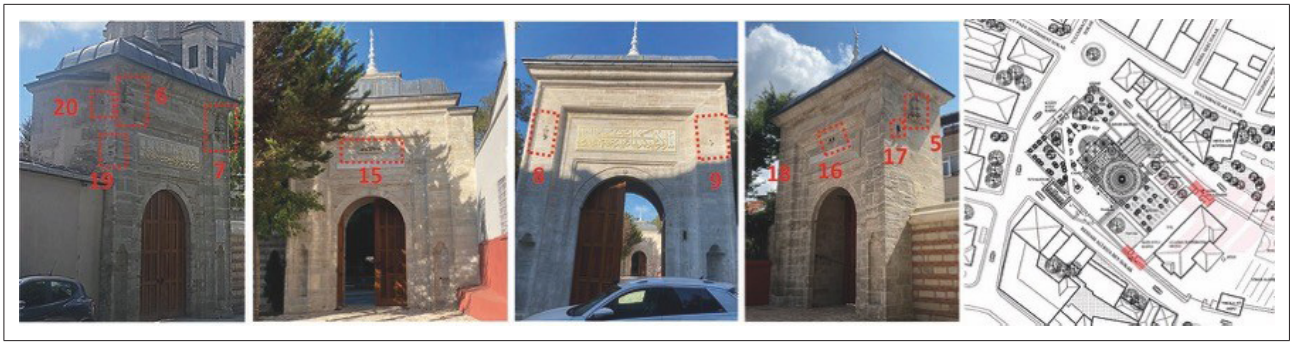


Figure 13. Birdhouses on the east and west courtyard gates of Ayazma Mosque (Çelebi, 2004, p. 222; Author, 2023-2024).

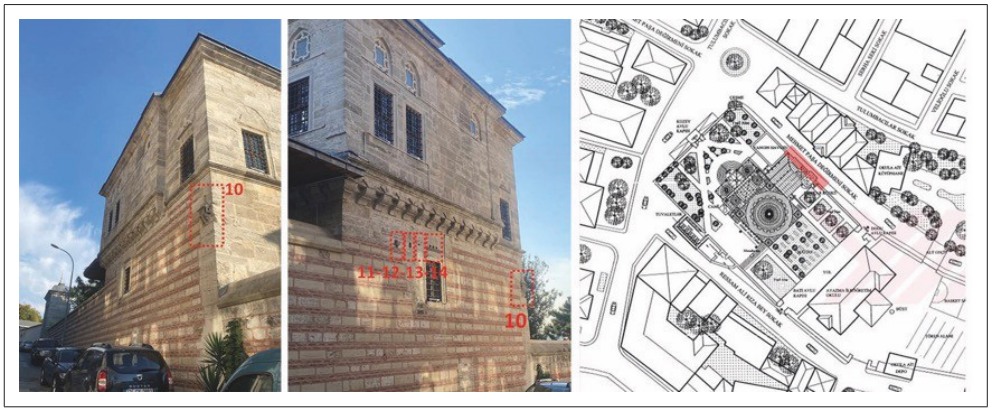


Figure 14. Birdhouses on the *hünkâr mahfili* of Ayazma Mosque (Çelebi, 2004, p 222; Author, 2023-2024).

refuges are generally multi-storied with buttresses or cantilevers and balconies, etc. Bird refuges 1, 3, 5, and 10 can be considered the most representative examples of this type.

Birdhouse No. 1, located on the southwest facade, has a palace-like configuration with various floor sizes and thus a dynamic facade with buttresses and cantilevers (Neftçi, 2010, p. 18). Birdhouse No. 3 on the southeastern facade has a two-storied configuration with a prominent cantilever and a vaulted cover on the upper floor, emphasizing verticality and depth (Neftçi, 2010, p. 22).

Birdhouse No. 5, which is situated at the gate of the western courtyard, is one of the most advanced examples, which is often referred to as a "glazed palace." The two-story structure, central oriel, and arch-shaped alcove-style nesting on the facades represent high architectural integration. The aesthetic consistency between the roof styles of the birdhouse and the courtyard gate indicates that the design was carried out in an integrated manner. Birdhouse No. 10, situated close to the *hünkâr mahfili,* features lattice-covered square windows with diamond motifs and vaulted covers.

Other birdhouses in this group, i.e., Nos. 2, 4, 6-9, feature similar design elements to those mentioned above. Therefore, they will be discussed collectively.

Hollow and Alcove-Shaped Birdhouses (Nos. 11-20).

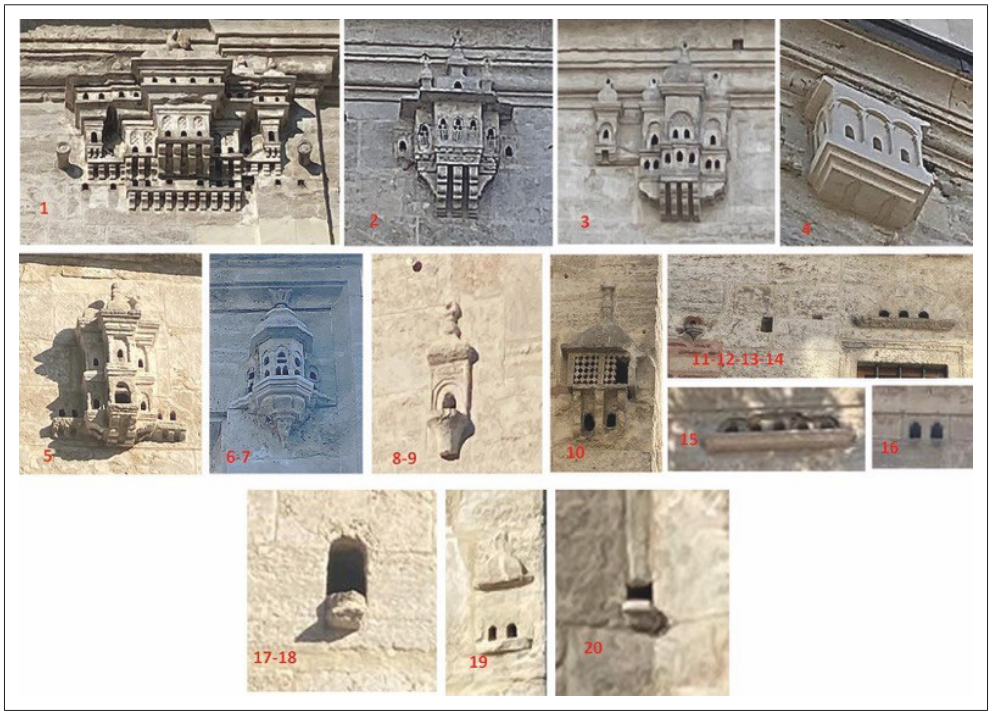


Figure 15. Details of the birdhouses on the facades, the courtyard doors and the *hünkâr mahfili* of Ayazma Mosque (Author, 2023-2024).

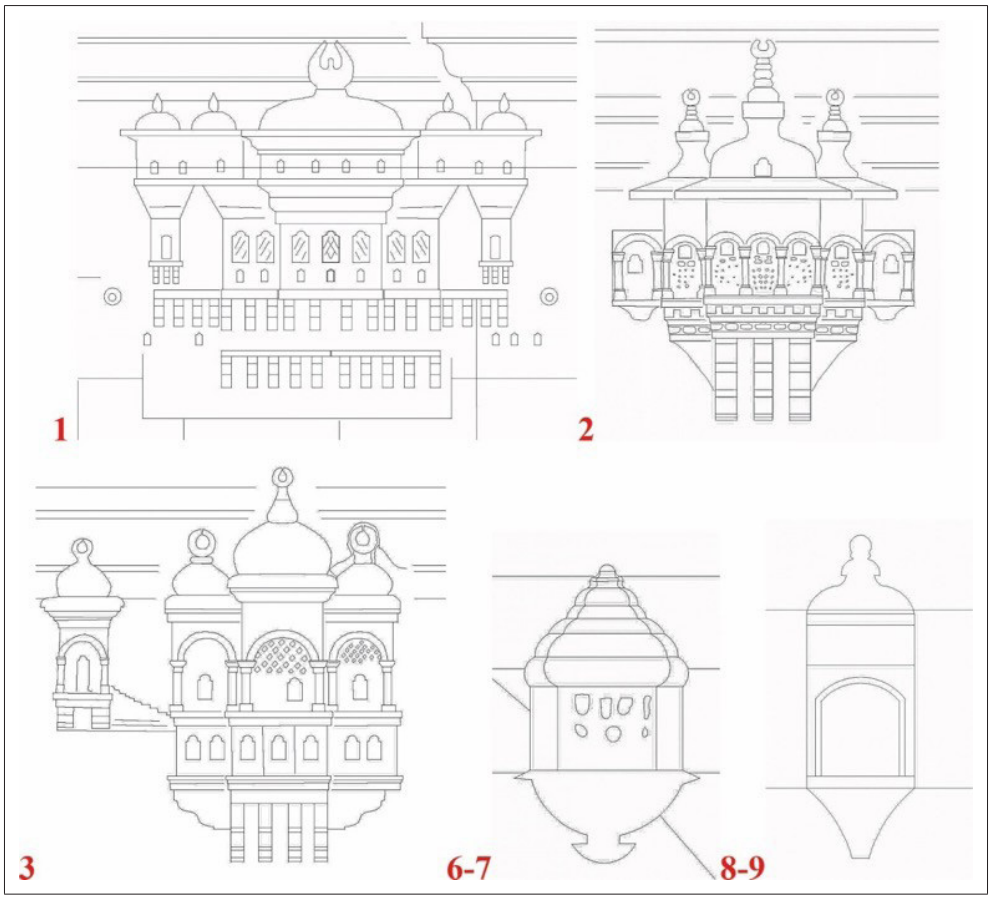


Figure 16. Scale-free restoration project drawings of the birdhouses numbered 1, 2, 3, 6, 7, 8 and 9 on the facades and courtyard gates of Ayazma Mosque (Istanbul Foundations 2nd Regional Office (İstanbul Vakıflar II. Bölge Müdürlüğü), 2022).

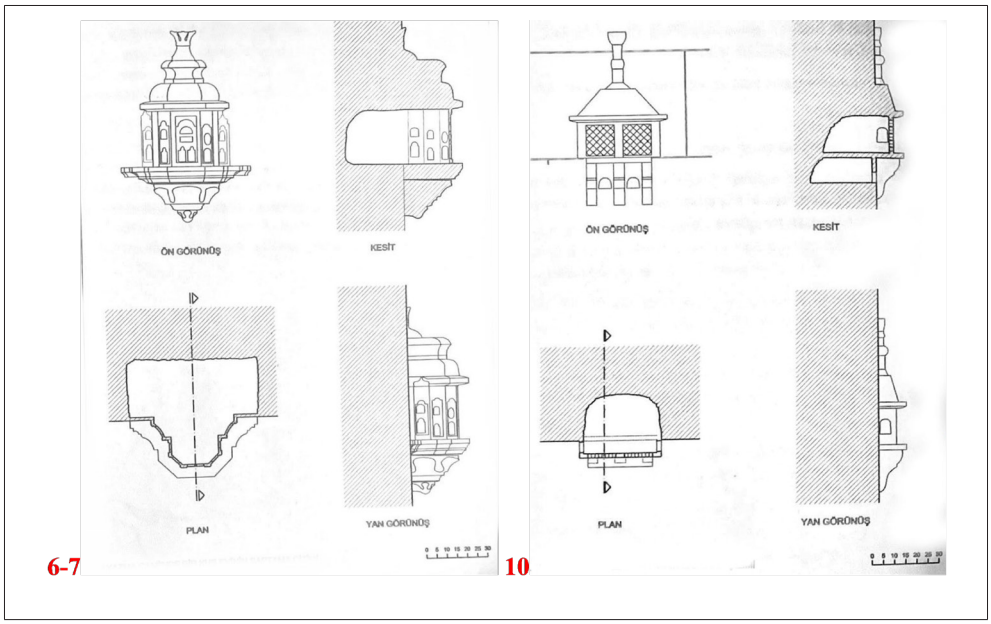


Figure 17. Survey drawings of the birdhouses numbered 6, 7 and 10 on the hünkâr mahfili and east portal of Ayazma Mosque (Bektaş, 2004).

The remaining ten birdhouses feature hollow or alcove-shaped elements integrated into existing architectural elements. These elements are mostly located in the existing architectural elements like the window arches, courtyard gates, and facades.

Birdhouses Nos. 14 and 15 belong to this group. Birdhouse No. 14 features multiple arch-shaped alcove-style nesting spaces arranged side by side. Similarly, Birdhouse No. 15 features multiple arch-shaped alcove-style nesting spaces arranged side by side. Birdhouse No. 16 is an exceptional example featuring *penci* arches, which is characteristic of classical Ottoman architecture.

Birdhouses Nos. 11-13 and 17-20 feature similar design elements to Birdhouse Nos. 14-15. These feature one or two nesting spaces with minimal balcony.

RESULTS

Table 2 lists 30 buildings in Istanbul, the capital of the Ottoman Empire in the eighteenth century, that were built by the palace or commoners and were found to have birdhouses. These buildings have various functions, such as mosques, madrasahs, libraries, primary schools, imarets, mint buildings, maksems, tombs, inns, churches, shops, *hünkâr* pavilions, etc. Among these buildings, 10 mosques, 6 primary schools, 4 inns, 2 libraries, 2 madrasahs, 2 imarets, 1 tomb, 1 church, 1 mint building, and 1 maksem have at least one birdhouse. Among the birdhouses in the forms of alcove, house, mosque, masjid, kiosk, mansion, and palace (*sırçasaray*) on the buildings given in the table, arched alcove-types are seen in almost all of them (in 24 buildings), while those in the form of kiosk-shaped are seen less frequently (in 6 buildings), and mosques, palaces, and other forms are rarely seen. Among these forms, especially arched alcove-types were the most widely used birdhouse form in Ottoman buildings from the 16th century to the 20th century. In Table 2, the fact that eighteenth-century buildings have the greatest number of arched alcove-types (24 buildings) supports this argument. The higher number of arched alcove-type birdhouses among the surviving birdhouses may be related to the fact that these types are more protected against external influences compared to other forms, such as pavilions protruding from the surface on which they are located. In the buildings examined, birdhouses are generally seen on the east (in 16 buildings), south (in 13 buildings), and west (in 11 buildings) facades, and less frequently on the north (in 10 buildings) facades. Birdhouses are located mostly on the high parts of the facade, such as under the eaves-storey molding and on top of the window door (see Table 2). This suggests that climatic and functional factors influenced the placement of birdhouses on eighteenth-century Istanbul buildings.

To evaluate the eighteenth-century birdhouses of the Ayazma Mosque among the mosques of the eighteenth century, it is necessary to examine the birdhouses in the mosques built at that time in more detail. Table 3 lists the 22 major mosques in Istanbul that were built or renovated during the eighteenth century by the sultan, female sultan, vizier, pasha, and commoners. According to the table, 10 of the mosques have birdhouses, while the remaining 12 do not. The following mosques have birdhouses shaped like arched alcove-types: Çorlulu Ali Pasha Mosque, Damat Ibrahim Pasha Mosque, Ahmediye Mosque, Çakmakçılar Mustafa III Mosque, Üsküdar Yeni Valide Mosque, Nuruosmaniye Mosque, Ayazma Mosque, and Fatih Mosque. The Ayazma Mosque, Üsküdar Selimiye Mosque, Eyüp Mosque, and Yeni Valide Mosque all have birdhouses that are shaped like kiosks in the eighteenth century architectural style; the Yeni Valide Mosque has birdhouses that are shaped like mosques and palaces; the Ayazma Mosque has birdhouses in the form of sparrow palace (*sırçasaray)*. The mosques built in the eighteenth century, including Hekimoğlu Ali Paşa, Büyük İhsaniye, Beşir Ağa, Sultan Mustafa III İskele, Laleli, Paşabahçe, Paşalimanı, Zeynep Sultan, Beylerbeyi, Emirgan, Şebsefa Hatun, and Teşvikiye, do not have birdhouses. It is observed that the birdhouses are located in the warmer parts of the mosques, which are situated to the east, south, and west, rather than in the relatively cold north-facing parts. The birdhouses were generally located at high points, such as under the eaves (14 buildings), on the tops of windows (3 buildings), on the floors (2 buildings), and in the middle of the facades (Table 3). Ayazma Mosque stands out among these buildings in terms of the variety and quantity of its birdhouses (Tables 3 and 4). This exceptional concentration is indicative of the deliberate patronage vision of Sultan Mustafa III, for whom the mosque served as a personal memorial. The architectural context of the mosque demanded a more intricate and symbolically significant integration of birdhouse forms than was customary for contemporary foundations. The birdhouses on Ayazma Mosque are classified in terms of variety in Tables 5 and 6 and Figure 18.

Some researchers have made comparisons between the eighteenth- and nineteenth- centuries Ottoman buildings, including the Üsküdar Ayazma Mosque, in terms of their stylistic features and stonework, mentioning their similarities to the Iranian (Ajam), Indian palaces, and mansions of the period (Göksal, 2021, p. 157; Şahin, 2009, p. 234). In eighteenth-century Ottoman architecture, the admiration for the "East" is also reflected in the architecture of birdhouses on the facades of buildings. In the eighteenth century, the birdhouses of which the most magnificent examples were given appeared as if they were small-scale Indian palaces or maharajah's pavilions designed for birds. It can be said that the birdhouses on the walls of Üsküdar Ayazma Mosque have many similarities with "Eastern" palaces such as the Udaipur Palace in India (Şahin, 2009, p. 234) (Figure 19). The Ayazma birdhouses, with their Eastern and Western references, have been shown to confirm their status as hybrid micro-architectural expressions of the broader Ottoman Baroque trans-

Table 3. Analysis of the eighteenth-century birdhouses in Istanbul mosques

No	Mosque name	Building construction date	Bani (Patron/ founder)- restorer	Birdhouse shape	The facade on which the birdhouse is located	The position of the birdhouse on the facade
1	Çorlulu Ali Pasha Mosque	1707-09	Çorlulu Ali Pasha	Alcove-type	North-East	Under the eaves
2	Damat Ibrahim Pasha Mosque	1720	Damat İbrahim Pasha	Alcove-type	North-west	Under the eaves
3	Gülnüş Emetullah (Yeni) Valide Mosque	1708-10	Emetullah Rabia Gülnüş Sultan	Alcove-type, Mosque	East-West	Under the eaves and in the middle parts
4	Ahmediye Mosque	1721	Tersane Emini Ahmed Ağa	Alcove-type	East	Window tops
5	Hekimoglu Ali Pasha Mosque	1735	Hekimoğlu Ali Pasha	-	-	-
6	Beşir Aga Mosque	1745	Haci Bashir Aga	-	-	-
7	Grand Ihsaniye Mosque	1755	Osman III	-	-	-
8	Nuruosmaniye Mosque and Hünkâr Pavilion	1748-55	Osman III	Alcove-type	East-West-North-South	Window sides - weight domes
9	Çakmakçılar/III. Mustafa Mosque	1760	Mustafa III	Alcove-type	North	Floor molding and window tops
10	Üsküdar Ayazma Mosque	1760	Mustafa III	Alcove type, Seyir Kiosk- Glazed Palace,	South- East-West	Under the storey molding, courtyard doors, the hünkâr pavilion
11	Sultan Mustafa III Iskele Mosque	1760	Mustafa III	-	-	-
12	Laleli Mosque	1763	Mustafa III	-	-	-
13	Paşabahçe Mosque	1763	Mustafa III	-	-	-
14	Fatih Mosque	1766	Mustafa III	Alcove-type	South- East	Under eaves and middle parts
15	Paşalimanı Mosque	1766	Mustafa III	-	-	-
16	Zeynep Sultan Mosque	1769	Zeynep Sultan	-	-	-
17	Beylerbeyi Mosque	1776-78	Abdülhamit I	-	-	-
18	Emirgan Mosque	1781	Abdülhamit I	-	-	-
19	Sebsefa Hatun Mosque	1787	Fatma Şebsafa Hatun	-	-	-
20	Üsküdar Selimiye Mosque	1789-1801	Selim III	Mansion, Kiosk-shaped	South- East	Under the eaves
21	Teşvikiye Mosque	1794-95	Selim III	-	-	-
22	Eyüp Mosque	1798-1800	Selim III	Kiosk-shaped, sparrow palace	South-East-West	courtyard doors

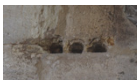
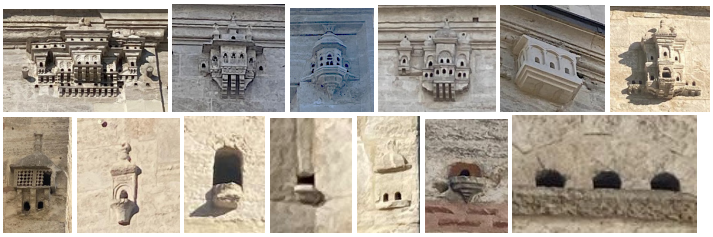
formation. These birdhouses are significant in that they are local, imperial, and global in their cultural resonance.

CONCLUSION

The use of bird motifs in Turkish culture has become more prominent since the rise of Islam, in various fields such as art and architecture. Birdhouses are one type of building that emerged within this theme, aiming to protect and shelter animals because of the importance of compassion and care for animals in Islam. These structures, typically located on the facades of monumental buildings but also found in civil architecture or as independent elements, evolved alongside architecture both functionally and decoratively.

The historical use of birdhouses in Anatolia can be observed from the Seljuk to the Ottoman periods. These structures are

Table 4. Comparison of the eighteenth-century birdhouses in Istanbul mosques

No	Mosque name	Photo
1	Çorlulu Ali Pasha Mosque	
2	Damat Ibrahim Pasha Masjid	
3	Gülnüş Emetullah (Yeni) Valide Mosque	
4	Ahmediye Mosque	
5	Nuruosmaniye Mosque and Hünkâr Pavilion	
6	Çakmakçılar/III. Mustafa Mosque	
7	Üsküdar Ayazma Mosque	
8	Fatih Mosque	
9	Üsküdar Selimiye Mosque	
10	Eyüp Mosque	

commonly found in many Anatolian cities, with the most beautiful examples located in Istanbul. In this study, various types of birdhouses were observed in buildings constructed in eighteenth-century Istanbul, including mosques, madrasas, libraries, primary schools, and inns (see Table 2). While the Üsküdar Yeni Valide Mosque, built during this period,

Table 5. Ayazma Mosque birdhouses according to the facade classification proposed in this study

Facade shape	**Arched alcove-type**	**Rectangular Facade/Kiosk-shaped**
Number of birdhouses	Number 11-12-13-14-15-16-17-18-19-20	Number 1-2-3-4-5-6-7-8-9-10
Total	10 Pieces	10 Pieces

Table 6. Facade layout of the birdhouses of Ayazma Mosque according to H. Örçün Barışta's (2000) classification

Facade shape	**Pentagonal Facade**	**Rectangular Facade with Overhang**	**Arch Eye Facade**	**Round Lined Facade with Overhangs**
Number of birdhouses	Number 6-7	Number 1-2-3-5-8-9-10	Number 12-13-14-15-16-19	Number 11-17-18-20
Total	2 Pieces	7 Pieces	6 Pieces	4 Pieces

features birdhouses, other mosques such as Nuruosmaniye Mosque, Fatih Mosque, Üsküdar Selimiye Mosque, and Eyüp Mosque do not have such ornate and intricate use of birdhouses as seen in Üsküdar Ayazma Mosque (Table 3, Table 4 and Figure 18).

The birdhouses on the Üsküdar Ayazma Mosque, which are qualified architectural artworks belonging to the period of Mustafa III, reflect the dominant understanding of the period. The Baroque style in the architecture of Üsküdar Ayazma Mosque is also remarkable in the birdhouses. Among the birdhouses of the mosque, those in the form of kiosk-shapes with rectangular facades display the stylistic characteristics of the period, while those in the form of arched alcove-types show the characteristics of the classical period. In a period when Baroque architecture developed in monumental buildings, the use of classical period elements such as *penci* arches in the architecture of birdhouses, which are simply arranged on the facades of Üsküdar Ayazma Mosque, supports this opinion. The characteristics of the form and stonework of birdhouses, built in the eighteenth and nineteenth centuries, such as those on the Ayazma Mosque, show similarities with Iranian/Ajamese and Indian palaces and mansions. These similarities point to a cultural interaction between these structures. This interaction suggests the possibility of a transfer of style in the production of the birdhouses or the role of eastern artisans who came to Istanbul. In this regard, the birdhouses on the building can be seen as a blend of eastern and western influences in terms of these characteristics.

The birdhouses, which once provided shelter and food for birds and can still be found in every neighbourhood in Istanbul, are in danger of being destroyed due to a lack of care. Without any intervention, the rap-

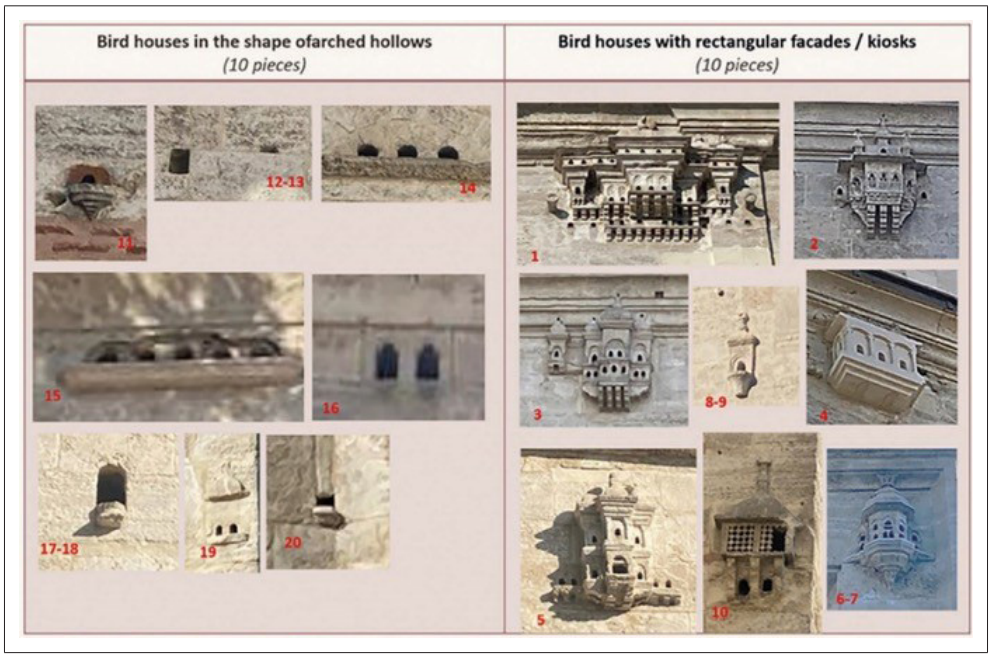


Figure 18. Facade and shape classification of Ayazma Mosque birdhouses.

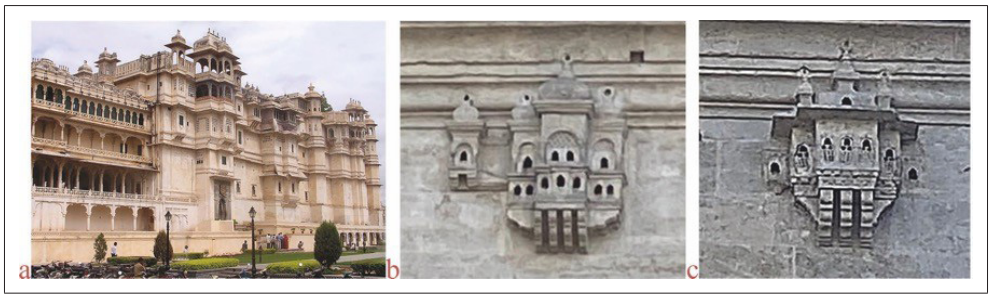


Figure 19. Kiosk-shaped birdhouses on the facades of Üsküdar Ayazma Mosque (Author, 2023-2024) and their similarity with Udaipur Palace (16th century, India) (Wikipedia, 2023).

id disappearance of these buildings seems unavoidable. In conclusion, there are a total of 20 birdhouses on the facades of Üsküdar Ayazma Mosque, courtyard entrance gates, and the facades of the *hünkâr mahfili*. Ten of these birdhouses are in the form of arched alcove-types, while the other ten are in the form of kiosks with rectangular facades. These birdhouses are significant examples of the eighteenth-century Ottoman architecture, as well as some of the features of classical Ottoman architecture, such as the *penci* arch. It is also important to document the current condition of the birdhouses that can be seen in many districts of Istanbul and are generally being restored to preserve them for future generations.

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Article

The invisible dynamics of migration: the new order established by Syrians under temporary protection in Ankara through social networks

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ABSTRACT

This study deals with the effect of social networks in Syrians' access to housing, employment and urban services in Ankara which is one of the first applications of Social Network Theory in Turkish Urban and Regional Planning. Focusing on Syrian holders of Temporary Protection identification documents, the study explores how informal links affect everyday life and migrants' navigation within the city. The study is conducted in two neighborhoods, one (Önder) with a high density of Syrian residents and the other (Bostancık) with much less. The analyses reveal how different demographic patterns are connected to the structure and efficacy of social networks. Using face-to-face interviews and social network analysis implemented in R Studio, the paper highlights how relational connections shape migrants' choice of housing, work, and access to metropolitan amenities. The results illuminate pathways of access and opportunities across the urban environment through bonding and bridging networks. This research contributes to planning studies by enabling a sociological approach and it illuminates the mechanisms often neglected, which enable migrants to get along in urban life. The findings highlight that social networks are not just support mechanisms but essentially spatial tools for how migrants negotiate their urban environments.

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INTRODUCTION

Migration refers to the movement of people from one geographical area to another, regardless of the reason behind it or the distance involved (IOM, 2019; Bartram et al., 2019). While this phenomenon has always been a part of human history, the factors driving migration and the ways it unfolds have transformed significantly over time—especially under the influence of globalization, which has reshaped traditional mobility patterns. To better understand these shifts, various disciplines— particularly economics and sociology—have developed theoretical frameworks that examine migration from different perspectives. These theories generally fall into two main categories: macro-level approaches (Todaro, 1969; Harris & Todaro, 1970; Wallerstein, 2004; Stouffer, 1940; Lee, 1966; Taylor,

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1986; Stewart, 1941; Zipf, 1946; Isard, 1960) and micro-level perspectives (Sjaastad, 1962; Crawford, 1973; Mincer, 1978; Stark, 1991). What both levels have in common is the recognition of social networks as a key factor influencing migration decisions and outcomes. In this context, Social Network Theory—serving as the conceptual foundation for this study—offers valuable insights into how individuals' connections shape not only the migration process itself but also the adaptation and integration experiences that follow.

Although Social Network Theory was originally developed by sociologists, it has since been embraced by a wide range of disciplines, including philosophy, anthropology, and psychology (Quatman & Chelladurai, 2008). At its core, the theory focuses on the ties and interactions among individuals or groups within a particular social context (Wasserman & Faust, 1994). The theoretical development of social networks emerged from a need to better understand the social and functional outcomes of these connections. Scholars widely agree that individuals gain access to information, opportunities, and various forms of support through their social networks (Hazzard-Robinson, 2012). Accordingly, Social Network Theory aims to examine these connections to uncover the tangible and intangible benefits they provide (Chang, 2018).

When viewed through the lens of migration, social networks play a pivotal role—not only in shaping the initial decision to migrate (Ethier, 1985; Grieco, 1998), but also in supporting individuals throughout the migration journey and during their post-migration integration (Massey et al., 1990; Massey & Espinosa, 1997). Access to social and financial capital often influences whether and how individuals choose to relocate. For example, chain migration is often facilitated by pre-established networks that offer guidance and support (Lee & Roseman, 2006; Portes, 1997; Chiswick, 2005).

In the case of Syria, the civil conflict that erupted in 2011 led to a large-scale displacement of people, with Turkey becoming the primary destination due to its geographical proximity (Harunoğulları & Cengiz, 2014). What began as forced international migration gradually evolved into a pattern of chain and voluntary migration. To manage the unprecedented influx, Turkey introduced a legal status known as "temporary protection," which grants Syrians specific rights such as non-refoulement, access to basic services, and open-border policies (General Directorate of Migration Management, 2024). Although refugee camps were initially established to accommodate early arrivals, many were later closed, resulting in the relocation of a growing migrant population into urban settings.

The migration wave that began in 2011 surged rapidly until 2017, after which it plateaued. As of August 2024, the number of Syrians under temporary protection in Turkey stands at 3,096,157, of whom 89,241 reside in Ankara (General Directorate of Migration Management, 2024). Given the prolonged migration process since 2011 and the recent stagnation, there is a need to analyze migrants' social networks and resources both during and after their movement. It is essential to investigate the factors influencing their choice of settlement, the social networks and resources they rely on to secure housing and employment, their access to urban services, and their participation in urban transportation.

This study aims to elucidate the role of social networks in facilitating access to housing, the labor market, and urban services for Syrians under temporary protection. The existing literature lacks comprehensive studies that examine the impact of social networks across these three dimensions. A review of the literature indicates that most studies tend to focus on a single aspect, such as housing or labor markets, without providing a holistic analysis. Furthermore, there are no comparable field studies in this area. Thus, this study's uniqueness lies in its comprehensive analysis of all relevant factors— housing, labor market, and access to services—along with a comparative field study conducted in two distinct neighborhoods. Consequently, this study fills a significant gap in the literature.

This study adopts a distinctive approach by comparing three key dimensions—housing, labor market access, and urban services—across two neighborhoods in Ankara, selected based on the demographic distribution of Syrians and Turks. Önder, the first neighborhood, has a notably high concentration of Syrian residents and represents one of the densest migrant settlements in the city. In contrast, Bostancık hosts a significantly smaller Syrian population relative to its total number of residents. By examining these two distinct urban contexts, the research seeks to uncover how social networks shape the experiences of Syrians under temporary protection—particularly in their access to essential resources and their patterns of urban movement.

Beyond its focus, the study brings several methodological and conceptual innovations to the field:

It applies Social Network Theory to analyze spatial mobility, highlighting how personal connections influence where and how migrants navigate the city.

It introduces this theory—most often used in sociology and anthropology—into the domain of urban and regional planning, providing a fresh analytical lens to examine the intersection between social ties and spatial behavior.

Through this interdisciplinary approach, the study not only contributes to a deeper understanding of migrant integration in urban spaces but also expands the potential applications of Social Network Theory within planning research.

Literature Review

Migration is now commonly recognized to be a complex, multi-dimensional process shaped by the interplay of a host of economic, political and social factors. It is not one monolithic migration but resides at a spectrum of forced

and voluntary migration. Drivers are the outcome of a combination of structural imperatives and individual agency (Castles et al., 2014). The dynamic nature of displacement since 2011 is a showcase for this intricacy: while the initial displacement was mostly caused by urgent conflict-related needs, later shifts have been defined by chain migration and family-based connections exploiting established urban networks in host cities.

Migration spatiality is deeply shaped by opportunity structures as much as social networks. Classic migration theories like Todaro (1969) and Harris and Todaro (1970), have explained movement in terms of economic disparities. But more recent research suggests that urban form is also determined by housing markets, governance systems, and informal economies (Massey et al., 1990). For the temporary protection holders, such migration is owed not only to a search for stable work, but also to the gravitational pull of established social networks in neighborhoods like Önder and Bostancık.

Models of integration provide another useful lens for this inquiry. Historically, assimilationist approaches have constructed integration as a linear process of acculturation, however more contemporary views underscore not only the importance of social inclusion and network participation, but also people's access to rights and assistance. These models show that the participation of migrants in urban life depends not only on institutional arrangements but also on how they are able to insert themselves into support networks offering crucial information, trust and hands-on assistance.

This wider arena of popular anti-immigrant debate collides in particular with Social Network Theory, which you will see is the theoretical framework for this research. According to Social Network Theory, the quality and strength of relational connections has a profound impact on an individual's opportunities, constraints and options for adaptation (Wasserman & Faust, 1994; Granovetter, 1973). Alternatively, for migrants social networks can map out the ways of accessing housing, work and urban services. Bonding may help meet needs and provision within rather cohesive groups, whereas bridging and linking can enable to enter new information and institutions. These relational dynamics become more prominent for Syrians on temporary protection, whose legal status restricts them to formal systems with significant gaps, which are frequently filled through personal relationships.

Drawing from migration literature in conversation with Social Network Theory, this study reframes migration as an embodied movement not only across borders but also a relational process that is deeply nested within social networks. This integrated approach enables a nuanced understanding of how migrants' everyday practices in the city and their spatial mobility through the urban space are shaped by the networks they produce and rely on.

The concept of social networks can be traced back to early structural approaches in sociology, particularly the work of Ferdinand Tönnies on social ties and community structures (Tönnies & Loomis 1999), Émile Durkheim's analysis of social relations as embedded within broader social structures (Durkheim, 1982)., and anthropologist Radcliffe-Brown (Quatman & Chelladurai, 2008). A social network is defined as a finite set of actors and the relationships that are formed among them. These relationships are explained through social connections based on nodes and ties. "Nodes" represent individuals or entities, while "ties" refer to the relationships that connect one node to another within a network structure (Wasserman & Faust, 1994; Hazzard-Robinson, 2012; Wellman, 1982 as cited in Chang, 2018; Abbasi et al., 2012; Freeman, 2004; Granovetter, 1977; White, 2002).

In the era of globalization, patterns of relationships between individuals have shifted significantly, prompting individuals to re-evaluate their connections and safeguard their resources. Consequently, the importance of social ties has increased, as individuals aim to maintain existing relationships, foster new interpersonal connections, and build new relationships. Social network ties help individuals categorize people and their relationships. Through social network analysis, a systematic method for studying social structures using network frameworks, individuals can identify and evaluate these connections. Such networks are characterized by nodes (individuals or groups) and ties (the relationships between them) (Mehreen et al., 2019).

Social network theory uses social network analysis as a method to assess relational links. Social network analysis comprises a set of approaches and techniques used to examine the exchange of resources between actors (Wellman & Berkowitz, 1997). It explores the phenomenon of organizational relationships from a micro perspective through three key elements: actors, relationships, and ties. Additionally, social network analysis helps to understand the impact of these relational ties on individual behavior (Chang, 2018).

White (2002) argued that social network analysis focuses on the patterns of ties between actors within a social system or the links through which one unit of an entity is related to other units. These patterns are examined to understand how social structures may either constrain or enhance the behavior of actors. Rather than providing categorical descriptions of social systems, network analysis examines the patterns of ties that connect actors (Berkowitz, 1982; Wellman, 1983; Emirbayer & Goodwin, 1994).

One method to reveal a social network involves asking questions about the ego-other relationship, focusing on the characteristics of the ties between the ego (the focal individual) and members of their network. The type of ties reflects the nature of the relationship between the ego and the alter (Marsden, 2012; McCarty, 2002). Parameters re-

lated to these questions vary in the literature according to different institutions, organizations, and researchers. For instance, the OECD measures social networks at five basic levels (Harper, 2002), while the World Bank defines two main axes and six sub- dimensions of these axes (Grootaert et al., 2004; Grootaert & Bastelaer, 2002; Jones & Woolcock, 2009). Other studies examine social networks at three levels: micro, meso, and macro (Grootaert, 2001; Coleman, 1990; Lin, 2000; Granovetter, 1973; Durlauf & Fafchamps, 2005; Putnam, 1993; Norris, 2000; Ostrom, 2000).

In this study, the parameters used to measure the social network include Practical Help (Strang & Quinn, 2021; Lamba & Krahn, 2003), Emotional Support (Strang & Quinn, 2019; Lamba & Krahn, 2003), Access to Rights (Strang & Quinn, 2021; Lamba & Krahn, 2003), Trust (Putnam, 2000), Collaboration (Putnam, 2000), Adaptation Assistance (McMichael & Manderson, 2004), Information Gain (Putnam, 2000), Social Capital as a formation throughout the integration process (Lamba & Krahn, 2003), Definition of Community (Aizlewood & Pendakur, 2007), Power (Morrice, 2007), Safety (Deuchar, 2011), Reciprocity (Putnam, 2000), and Social Bridging, Bonding, and Linking (Putnam, 2000; Strang & Quinn, 2021).

MATERIAL AND METHODS

Study Area

As of August 2024, there are 89,241 Syrians under temporary protection registered in Ankara, constituting 1.51% of the city's total population (General Directorate of Migration Management, 2024). In the Altındağ district, where the Önder Neighborhood (the first study area) is located, 41,660 Syrians under temporary protection reside, making up 11.38% of the district's population. Meanwhile, in the Mamak district, which includes the Bostancık Neighborhood (the second study area), 5,008 Syrians under temporary protection live, accounting for 0.80% of the district population (General Directorate of Migration Management as cited in Savran, 2020). According to the Address-Based Population Registration System data for 2022 from TÜİK, the population of the Önder Neighborhood is 1,770, while the Bostancık Neighborhood has a population of 3,759 (TÜİK, 2022).

The study area was chosen from these two neighborhoods because of their contrasting population patterns. The study aims to uncover how different population patterns shape social networks that influence the daily practices and intra-city movement of migrant individuals, by selecting neighborhoods in Ankara with the highest and lowest proportions of the Syrian population. Figure 1 depicts the city's Central Business District (CBD), the urban study area, and the selected neighborhoods' locations. The figure highlights Ulus and Kızılay, defined as the CBD of Ankara, as well as Siteler, one of the province's key urban employment areas. According to the Health and Safety Labour Watch Report (2019), most Syrians living in Ankara are employed in the Siteler district. This area is referred to as "Little Aleppo" due to its proximity to employment opportunities and the

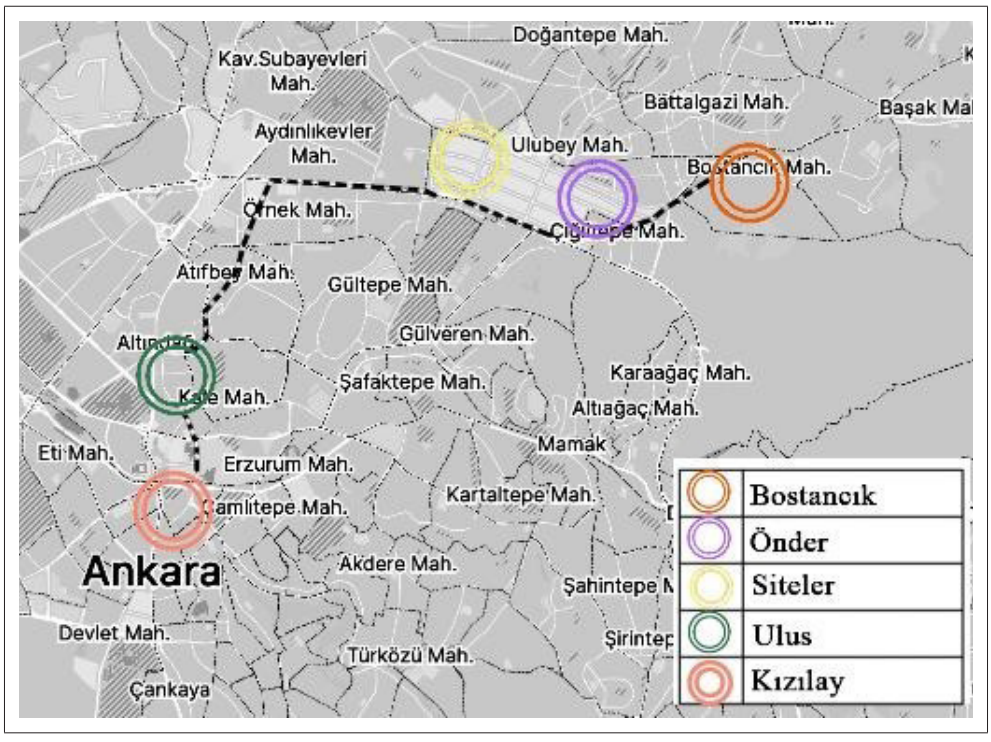

Figure 1. Location of the study area within the city.

development of affordable housing stock created by the urban transformation processes that began in the Önder and Ulubey neighborhoods.

Research Design, Sampling and Analysis

This research is grounded in Social Network Theory and adopts a qualitative methodology, specifically a phenomenological design. This approach is particularly useful for exploring phenomena that people are aware of but do not fully comprehend. Such phenomena may include experiences, perceptions, events, or social patterns that are familiar yet difficult to articulate or understand in depth (Yıldırım & Şimşek, 2013). The central goal of phenomenological research is to uncover the essence of a phenomenon by analyzing individuals' lived experiences (Ersoy, 2017). By identifying shared or contrasting experiences among participants, researchers aim to construct a deeper understanding of the issue at hand (Creswell, 2014; 2018; Fraenkel et al., 2012).

In this study, the phenomenological design was used to explore how Syrians under temporary protection make sense of their migration experiences and daily urban lives in Ankara. Structured interview questions were developed to guide data collection, resulting in a comprehensive form consisting of 74 items. These questions address demographic and economic characteristics, migration trajectories, and the adjustments migrants have made in their new environments.

The study population consists of Syrians under temporary protection in Turkey. The sample focuses specifically on residents of two neighborhoods in Ankara: Önder in the Altındağ district and Bostancık in the Mamak district. Fieldwork was conducted through face-to-face interviews, involving 113 participants in Bostancık and 114 in Önder, offering a robust dataset for examining both shared and neighborhood-specific migration experiences.

The data analysis phase commenced after the fieldwork was completed and consists of two stages. In the first stage, the collected data were subjected to a Two-Way ANOVA analysis using SPSS software to identify significant relationships between the variables that would serve as inputs for social network analysis. ANOVA was conducted with the understanding that questions with a significance value greater than 0.05 indicate homogeneity of variances, as tested by the homogeneity of variances test. A significance value below 0.05 indicates a statistically significant relationship between the variables. Subsequently, social network analysis was performed on these groups of questions.

Social network analysis examines individual behavior at the micro level and the structural patterns of relational ties at the macro level, highlighting the dynamic interactions between actors and the networks they form (Wasserman & Faust, 1994). Social networks function simultaneously as both causes and consequences of individual behavior, shaping opportunities while being actively shaped by individuals who initiate, maintain, or terminate ties (Wellman, 1983; Emirbayer & Goodwin, 1994). As noted in the literature, the instrumental value of these relationships determines whether particular network structures and positions generate opportunities or impose constraints on actors (Wellman & Berkowitz, 1997). To capture these dynamics, social network analysis employs a range of measures used to characterize and compare network structures, including various forms of centrality (Freeman, 1979; Borgatti, Everett & Johnson, 2013), the identification of strongly connected clusters, and the detection of actors who occupy unique or strategic positions within networks (Freeman, 2004; Borgatti et al., 2013).

For the social network analysis component of this study, the R Studio software was utilized, incorporating three key packages: Igraph, Haven, and Tidyr. The Igraph package offers a robust set of tools for building, analyzing, and visualizing complex network structures. Haven was used to seamlessly import data from statistical programs such as SPSS and STATA, ensuring smooth integration of previously collected datasets. Tidyr assisted in organizing and transforming the data into tidy formats suitable for analysis.

Once the necessary packages were loaded, network models were constructed using graph-based methods. Among these, Graph Neural Networks (GNNs) played a central role by representing individuals and their connections as nodes and edges within the network. These models enable the analysis of relational patterns by incorporating the unique attributes of each node, such as behavioral traits or information flow.

To further enhance the visualization and interpretability of these networks, the Fruchterman-Reingold algorithm was employed. This force-directed layout algorithm calculates optimal distances and positions between nodes, allowing for a clearer representation of the social network's internal structure. By using this method, the spatial arrangement of connections becomes more intuitive, offering deeper insight into the relational dynamics at play within the migrant communities studied.

Social network analysis identifies nodes, hubs and authorities. The concepts of hubs and authorities in social networks represent people's relationships and interactions with each other. Hubs are often focused on popularity and having a wide circle, while authorities are characterized by deep knowledge and expertise. Authorities are people who have deep knowledge and expertise on a particular topic. They are individuals who generate valuable content on a specific subject, earning the trust of other users. Given people's roles and interactions in social networks, some users may stand out as hubs, while others are defined as authorities.A favorable hub represents a node that points

to many other nodes, while a favorable authority represents a node connected by many different hubs. In other words, hubs represent people and categories that are numerically more networked with others, while authority represents the node that hubs are more connected to. In social networks, large nodes and small nodes refer to the importance of a node, usually calculated based on a user's connections in the social network. Large nodes are high-ranking nodes in the social network. In social networks, distance refers to the strength or closeness of the relationship between nodes. This distance is usually calculated based on factors such as connections, interactions or shared characteristics between nodes.

RESULTS

Demographic and Socio-Economic Structure

The age range of the interviewees is between 15-68. The cluster is between the ages of 26 and 40. It is known that individuals mostly live with 5-8 people at home. Women in the working age range commonly view themselves as housewives. Among all participants, those who had professions in Syria such as architects, laborers, officers and teachers are employed in unskilled jobs in Turkey. When asked about the participants' migration processes, the most common year for migration to Turkey was 2014. Parallel to this, the participants received temporary protection status in the years 2014 and 2015. Some of the interviewees stated that they lived in provinces such as Kilis, Hatay, Gaziantep, which are closer to the Syrian border, before Ankara, which was selected as the sample area. Those who came to Turkey in the 2nd or 3rd stage of their migration stated that they migrated to Ankara through acquaintances or relatives as an example of chain migration.

Along with the demographic information given in Table 1, the demographic and socio-economic structures and migration processes of the participants who were interviewed face-to-face within the scope of the study, despite the neighborhood differences, are similar.

Social Network

To measure the social networks of individuals, questions were developed based on the parameters identified in the literature review. However, when the research focuses on migration, not all parameters may effectively explain all migration flows and the social networks of migrants. Therefore, while questions related to all parameters were included in the field study, the Two-Way ANOVA analysis (as shown in Table 2) was used to identify questions with significant relationships. These questions were subsequently used as the basis for the social network analysis. Separate social network analyses were conducted for the two neighborhoods that constitute the study's sample, and the results were compared.

First, the social network analysis results for individuals living in the Bostancık Neighborhood, focusing on the independent variable "education level" and various dependent variables, were interpreted. For individuals in Bostancık Neighborhood, relatives serve as a reliable center during emergencies, while both public institutions and relatives function as authoritative entities. This differentiation aligns with the literature on social capital stratification, particularly Putnam's (2000) distinction between bonding and bridging social capital. The cluster analysis shows that public institutions, and those with undergraduate and graduate education levels, form one cluster, while another cluster comprise individuals with secondary school education and their relatives. This pattern suggests that those with

Table 1. Demographic information of participants

		Bostancık Neighborhood	Önder Neighborhood
Gender	Female	49.6%	59.6%
	Male	49.6%	39.5%
	Unanswered	0.8%	0.9%
More than one family in the Same Household	Yes	22.1%	8.8%
	No	75.2%	90.3%
	Unanswered	2.7%	0.9%
Year of Migration	2010-2013	20%	11%
	2014-2017	69%	85%
	2017-Present	11%	4%
Legal Status	Unregistered	6.3%	14%
	Temporary Protection ID	83.2%	83.3%
	Citizen	8%	0.9%
	Unanswered	2.7%	1.8%

Table 2. Results of the Two-Way ANOVA

Dependent Variable	Independent Variable	Significance
Person from whom a loan can be requested	Educational Level	0.009
	Neighborhood of Residence	0.028
	Educational Level * Neighborhood of Residence	0.178
Emergency contact person	Educational Level	0.177
	Neighborhood of Residence	0.236
	Educational Level * Neighborhood of Residence	0.522
People who receive help in the job finding process	Educational Level	0.045
	Neighborhood of Residence	0.007
	Educational Level * Neighborhood of Residence	0.034
People who receive help in the dwelling finding process	Educational Level	0.917
	Neighborhood of Residence	0.023
	Educational Level * Neighborhood of Residence	0.368
Places to visit outside the neighborhood	Educational Level	0.017
	Neighborhood of Residence	0.369
	Educational Level * Neighborhood of Residence	0.401
Leisure time activities	Educational Level	0.047
	Neighborhood of Residence	0.042
	Educational Level * Neighborhood of Residence	0.389
Person from whom a loan can be requested	Arrival Date in Turkiye	0.048
	Neighborhood of Residence	0.014
	Arrival Date in Turkiye * Neighborhood of Residence	0.038
Emergency contact person	Arrival Date in Turkiye	0.040
	Neighborhood of Residence	0.926
	Arrival Date in Turkiye * Neighborhood of Residence	0.595
People who receive help in the job finding process	Arrival Date in Turkiye	0.023
	Neighborhood of Residence	0.049
	Arrival Date in Turkiye * Neighborhood of Residence	0.018
People who receive help in the dwelling finding process	Arrival Date in Turkiye	0.021
	Neighborhood of Residence	0.148
	Arrival Date in Turkiye * Neighborhood of Residence	0.826
Places to visit outside the neighborhood	Arrival Date in Turkiye	0.484
	Neighborhood of Residence	0.022
	Arrival Date in Turkiye * Neighborhood of Residence	0.387
Leisure time activities	Arrival Date in Turkiye	0.149
	Neighborhood of Residence	0.149
	Arrival Date in Turkiye * Neighborhood of Residence	0.278

a bachelor's degree or higher tend to rely on institutional structures—forms of bridging social capital— that facilitate access to wider, more heterogeneous networks and higher institutional trust (Putnam, 2000; Lamba & Krahn, 2003). In contrast, individuals with lower education levels rely more heavily on kinship-based ties, reflecting bonding social capital, which is commonly observed in marginalized or tightly-knit migrant communities (Granovetter, 1973; Morrice, 2007). In the context of job searching, Syrian friends, relatives, and public institutions are identified as key nodes, with Syrian friends emerging as the primary authority. The cluster analysis indicates that individuals

at nearly all education levels, except those who are literate or illiterate, form a common cluster with Syrian friends—again illustrating how bonding ties play a central role in securing employment among refugees. In housing searches, Syrian friends, relatives, and public institutions are also among the most connected nodes, with Syrian friends notably prominent. According to the cluster analysis, one cluster consists of Syrian friends and individuals with postgraduate education, while another includes relatives and individuals with lower education levels. Finally, the analysis of urban service use shows that as education level increases, individuals' engagement with services outside the neighborhood also increases. This aligns with existing research indicating that higher education is associated with broader networks, increased mobility, and greater interaction with formal institutions, while individuals with lower education levels tend to engage primarily within their immediate social circles (Putnam, 2000; Lamba & Krahn, 2003).

When analyzing the social network results for individuals in the Önder Neighborhood concerning the independent variable "education level" and various dependent variables, relatives and Syrian friends emerged as central figures during emergencies. The predominance of kin- and community-based ties in crisis situations reflects strong bonding social capital, which is typically more salient in tightly knit or socio-economically constrained migrant settings (Putnam, 2000; Morrice, 2007). Although public institutions form part of the networks of individuals with postgraduate education, they remain relatively peripheral for the broader community—consistent with research showing that lower education levels often correlate with reduced institutional trust and limited engagement with formal systems (Lamba & Krahn, 2003).

Cluster analysis further indicates that relatives and individuals with primary and secondary education form one cluster, while Syrian friends and individuals with high school education form another. This pattern aligns with Granovetter's (1973) distinction between strong ties, which dominate among close kin and co-ethnic peers, and weaker ties, which are more likely to facilitate access to broader resources but appear less developed in Önder. Unlike in Bostancık Neighborhood, associations and public institutions emerge as weak ties in the job search process—a finding consistent with literature on marginalized migrant communities where employment is typically accessed through bonding-based networks rather than through bridging institutional channels (Granovetter, 1973; Putnam, 2000).

Similarly, in the housing search process, relatives and Syrian friends remain the most central nodes. While individuals with higher education incorporate public institutions into their networks, associations again represent the weakest ties. This reliance on strong familial and co-ethnic ties reflects bonding- oriented strategies commonly observed in refugee communities facing socio-spatial isolation (Morrice, 2007; Strang & Quinn, 2021). The relatively low level of urban service utilization among residents of Önder Neighborhood—and its increase with rising education levels—also mirrors broader findings that higher education enhances the likelihood of forming bridging ties and interacting with formal urban systems (Putnam, 2000; Lamba & Krahn, 2003).

The social network analysis results based on the "dates of arrival in Turkey" also resonate with migration literature, particularly regarding the transition from initial, more institutional forms of support to chain migration dynamics. For individuals who migrated in the early phases of the Syrian civil war, public institutions served as stable centers during emergencies. This early reliance on institutional actors corresponds to integration frameworks suggesting that newcomers initially depend on formal support structures when social networks are not yet established (Ager & Strang, 2008). However, after 2013, relatives became the primary centers—a clear indication of chain migration processes in which bonding ties increasingly structure settlement patterns (Massey et al., 1990; Granovetter, 1973).

In job searching, Turkish friends emerged as central nodes for those who migrated before 2014, but after this period, Syrian friends became the primary authorities. This shift reflects the gradual consolidation of co-ethnic networks, which often become the dominant channels for economic participation as migrant communities grow (Morrice, 2007). The housing search process shows a similar pattern. Before 2014, public institutions and Turkish friends were important; after 2014, relatives and Syrian friends became central. This aligns with the literature on refugee settlement, which highlights that as communities expand, bonding networks increasingly replace bridging networks as the primary means of securing housing and daily resources (Putnam, 2000; Lamba & Krahn, 2003).

A different trend was observed in urban service utilization, residents of Önder exhibited a much more closed social structure and a lower rate of urban engagement compared to those in Bostancık. This mirrors findings from social capital research indicating that communities with dense bonding networks but limited bridging networks often have restricted access to broader urban opportunities (Putnam, 2000; Strang & Quinn, 2021).

Urban Mobility

The visible form of social networks among Syrians under temporary protection in Ankara is reflected in their patterns of urban mobility. This connection between social ties and spatial movement aligns with the concept of navigational or spatial capital, which refers to individuals' capacity to move through the city and access opportunities based on the strength and diversity of their social networks (Strang &

Quinn, 2021). To understand these patterns, mapping was conducted based on responses to questions such as where their Syrian acquaintances live, where they meet with these acquaintances, where their active workplaces are located, where they spend their free time, and where they prefer to shop. The density of network connections shown in the maps illustrates the frequency and reach of mobility across Ankara.

Mapping the locations where individuals meet their Syrian acquaintances—strong nodes in their social networks (Figure 2)—reveals that those living in Bostancık Neighborhood exhibit significant urban mobility toward Önder and Hüseyingazi Neighborhoods. This mobility is shaped not only by spatial proximity but also by the presence of dense co-ethnic clusters in these neighborhoods. Such clustering is widely discussed in the migration literature, where ethnic enclaves are known to attract mobility due to shared cultural resources, familiarity, and perceived safety (Portes, 1997; Massey et al., 1990). Following Önder and Hüseyingazi, Karapürçek, Ulubey, and Battalgazi Neighborhoods also show substantial levels of mobility, suggesting that Bostancık residents maintain a more extensive network of bridging ties compared to residents of Önder.

According to Figure 3, intra-neighborhood mobility is particularly intense in Önder Neighborhood, where residents frequently interact with acquaintances living in the same neighborhood. This highly localized mobility pattern reflects a form of bonding social capital, common in communities with limited economic resources or a history of marginalization (Morrice, 2007; Deuchar, 2011). Although Önder displays limited inter-neighborhood movement compared to Bostancık, it does have notable mobility with a few nearby neighborhoods such as Battalgazi, Ulubey, and Hüseyingazi. Notably, while Önder is a primary destination for residents of Bostancık, there is relatively little movement from Önder to Bostancık. This asymmetry is consistent with research showing that residents of dense migrant enclaves often have less navigational capital and thus more restricted mobility patterns (Strang & Quinn, 2021).

Interview responses further indicate that acquaintances of Bostancık residents are dispersed across the city, whereas acquaintances of Önder residents are highly concentrated within their own neighborhood. This pattern reinforces the idea that Önder Neighborhood is characterized by localized bonding ties, while Bostancık residents rely on a more diverse set of relationships that encourage broader spatial movement.

This pattern suggests that the social networks of Syrians in these two neighborhoods operate differently: Önder Neighborhood's networks are more localized, while Bostancık Neighborhood's networks extend more broadly across Ankara.

Work-related mobility provides another lens into how social networks shape spatial patterns. According to Figure 4, the majority of people from Bostancık Neighborhood commute to Siteler due to the concentration of employment opportunities in the furniture sector. Proximity and affordability are central determinants of this mobility, yet the fact that many residents also travel to Ulus, Önder, and Hüseyingazi suggests the presence of both bonding and bridging ties supporting employment access. Workers in Ulus and

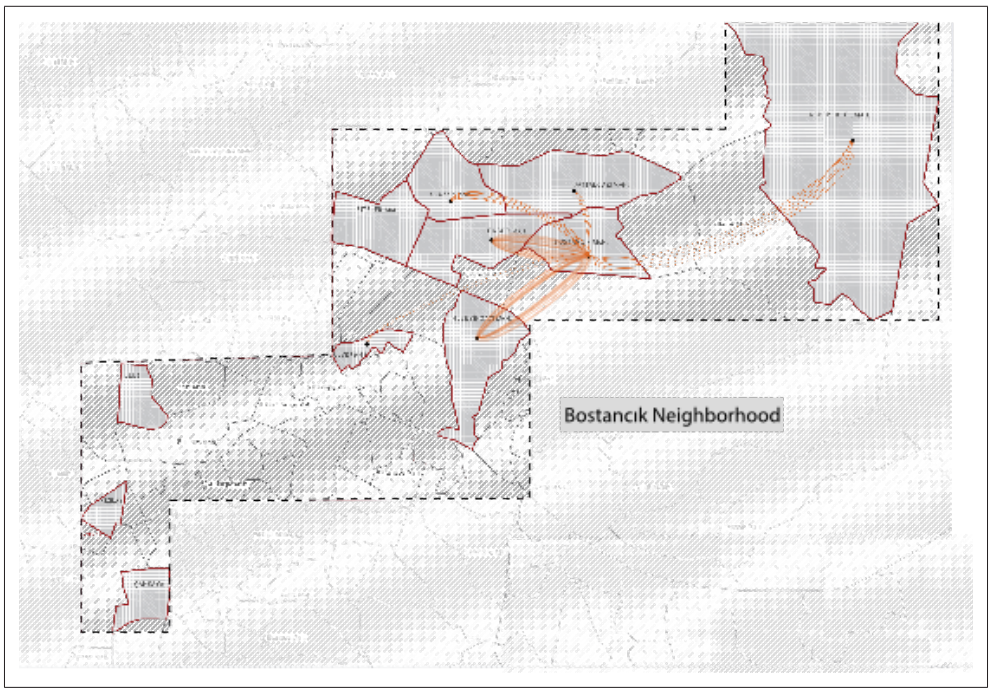

Figure 2. Meeting activities of people living in Bostancık neighborhood with their friends.

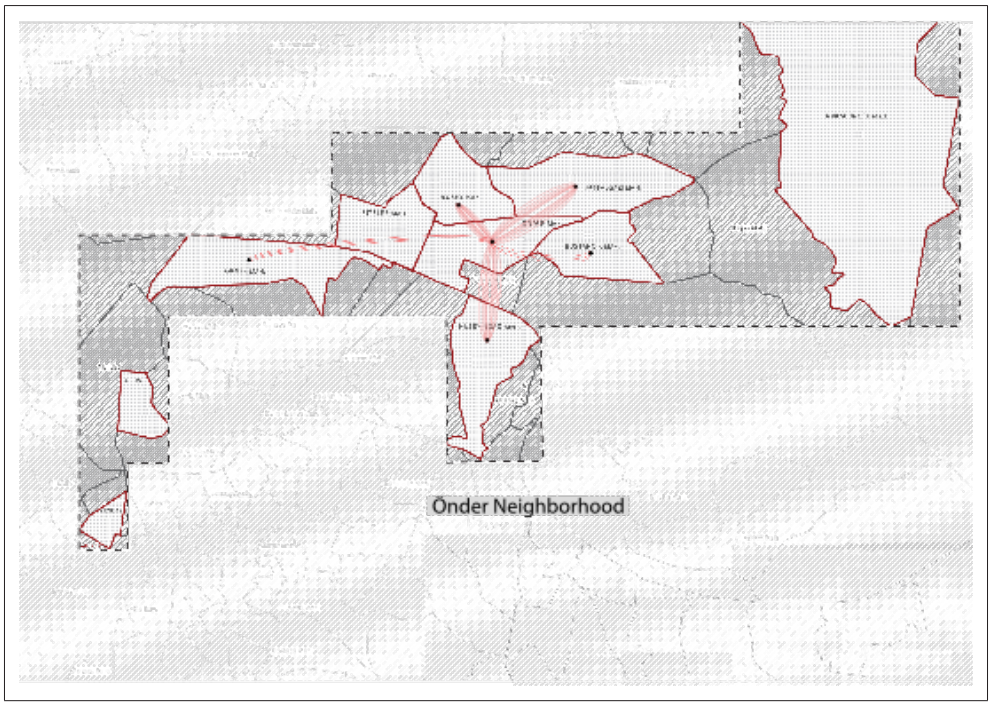

Figure 3. Meeting activities of people living in Önder neighborhood with their friends.

Kızılay—primarily individuals with higher education—illustrate the role of bridging capital in enabling access to more formal or diversified labor markets (Putnam, 2000; Lamba & Krahn, 2003).

Figure 5 shows that Siteler is likewise the most common destination for work-related mobility among residents of Önder Neighborhood. However, unlike Bostancık, Önder's work mobility remains more neighborhood-bound, with fewer connections to citywide labor markets. This again reflects localized bonding structures, which, while offering strong internal support, may constrain opportunities for socio- economic mobility (Morrice, 2007).

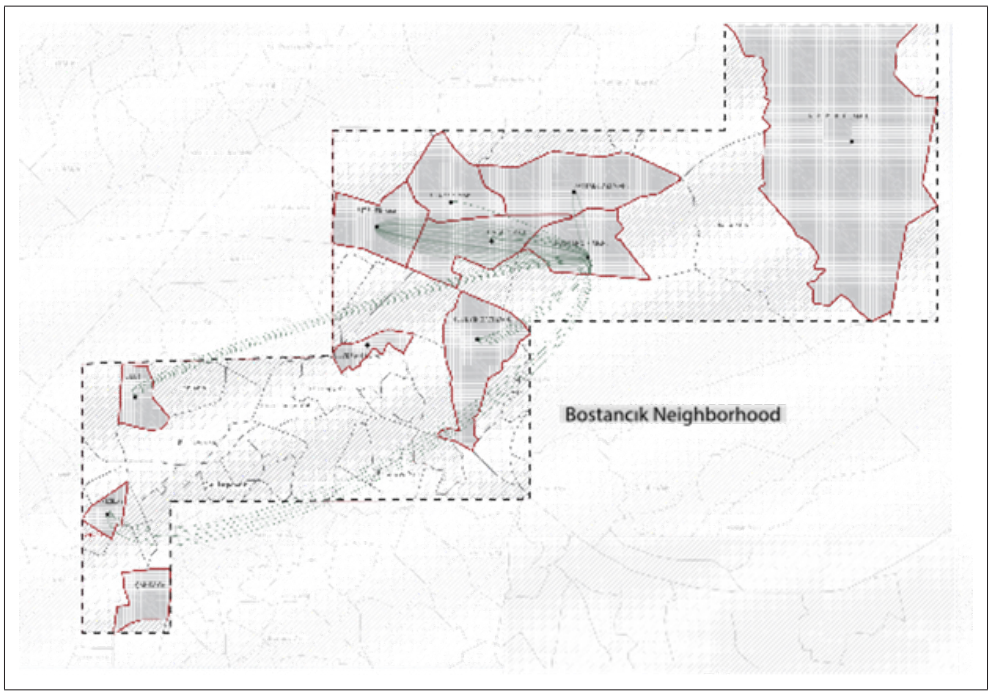

Figure 4. Work-related mobility of Bostancık neighborhood residents.

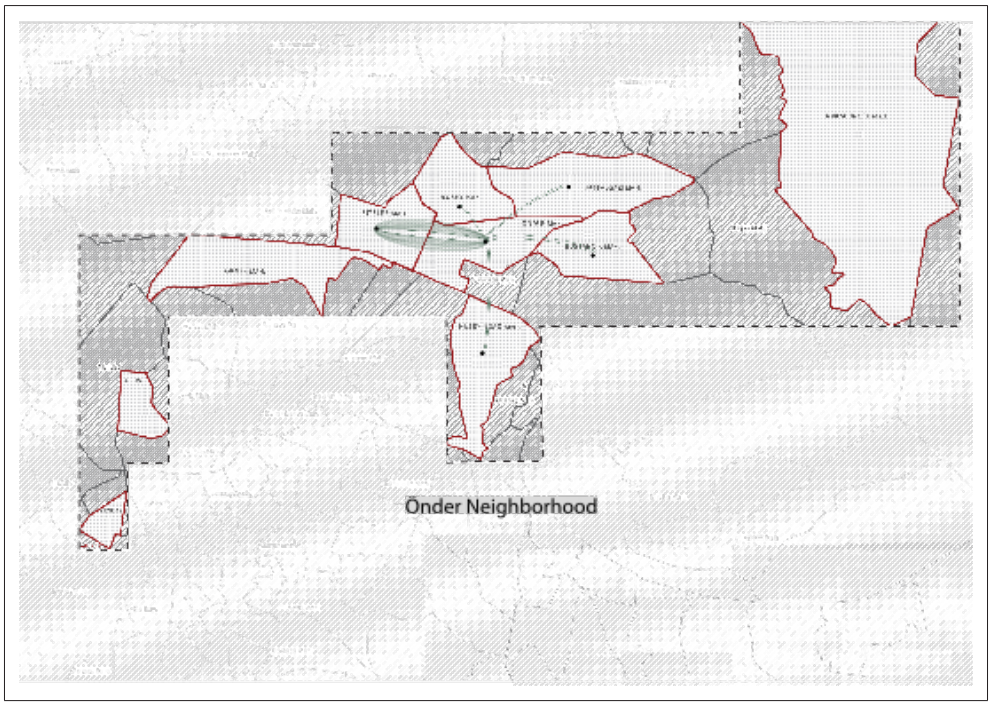

Figure 5. Work-related mobility of Önder neighborhood residents.

Shopping-related mobility also highlights significant differences between the two neighborhoods. According to Figure 6, Bostancık residents frequently choose Önder for shopping due to the availability of culturally familiar products and affordable options—patterns consistent with enclave-based consumption behaviors described in migrant geographies (Portes, 1997). The preference for Hüseyingazi relates to the presence of a local market, while trips to Ulus and Kızılay indicate higher levels of navigational capital among some residents.

In contrast, Figure 7 shows that residents of Önder largely shop within their own neighborhood, resulting in limited urban-scale movement. While they do visit Hüseyingazi

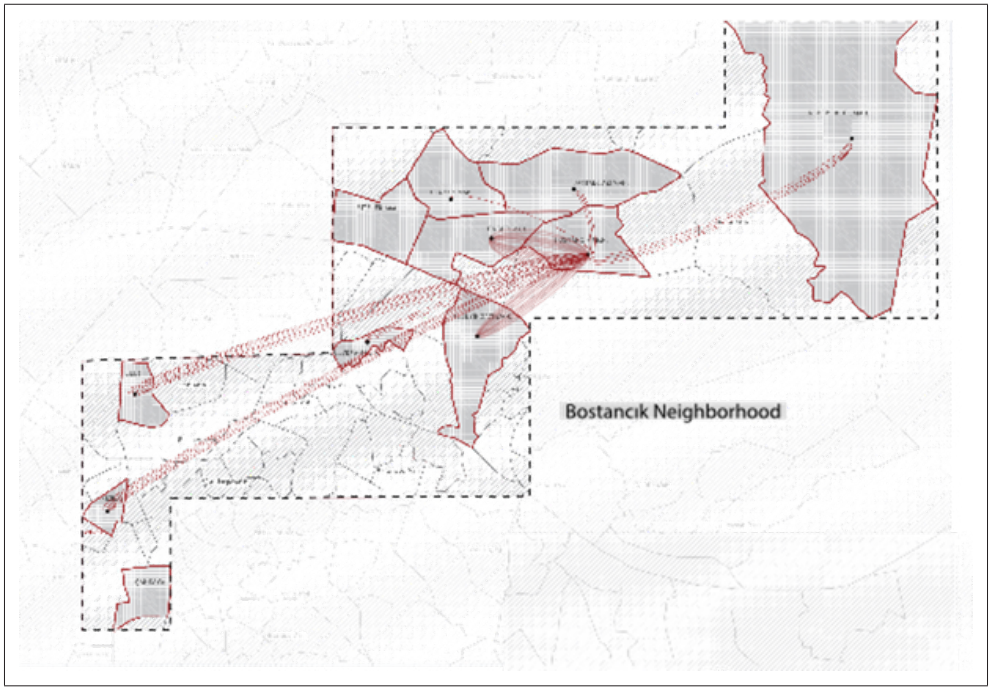

Figure 6. Shopping-related mobility of Bostancık neighborhood residents.

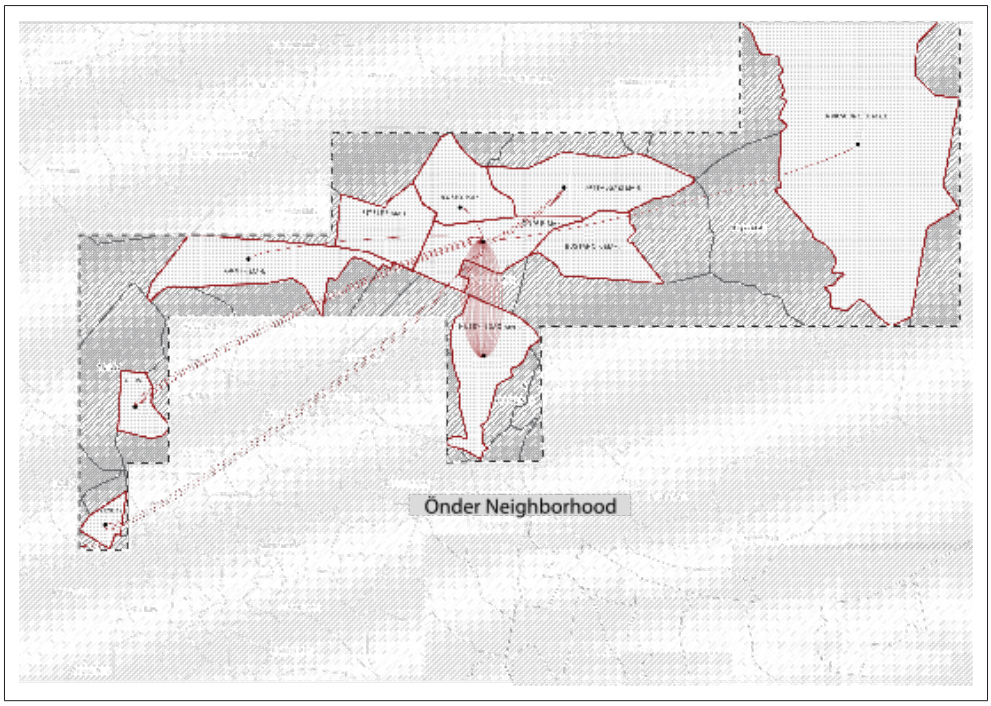

Figure 7. Shopping-related mobility of Önder neighborhood residents.

and occasionally Battalgazi or Ulubey, their mobility remains comparatively constrained. Such restricted spatial behavior aligns with findings on urban marginality, wherein dense bonding ties and limited institutional engagement reduce individuals' ability—or perceived ability—to navigate broader urban environments (Deuchar, 2011; Morrice, 2007).

Taken together, the mobility patterns of both neighborhoods reflect the broader argument of the study: bonding-dominant networks produce localized mobility, while bridging-oriented networks facilitate broader spatial reach. Bostancık residents' wider mobility aligns with their more diverse social connections, whereas Önder's enclave-like structure reinforces inward-looking, spatially limited patterns of everyday movement.

DISCUSSION

Three types of social networks influence the labor market participation of Syrians under temporary protection. Individuals who were unemployed upon arrival in Turkey but were previously employed in Syria have utilized various social networks to access the labor market. However, the neighborhood's population pattern affects the type of social network and social capital utilized. Unifying social networks, such as those involving public institutions and associations, are more effective in neighborhoods with smaller Syrian populations than in those with larger Syrian populations. Conversely, binding social networks (e.g., connections with relatives or friends) play a more dominant role in job-finding processes in neighborhoods with a higher density of Syrians.

Beyond describing social network structures, the findings reveal how everyday access to housing, employment, and urban services is actively shaped by the configuration of social ties. Rather than functioning as neutral background conditions, social networks emerge as dynamic mechanisms that mediate migrants' spatial choices, mobility patterns, and forms of urban participation.

The population pattern of neighborhoods where Syrians under temporary protection live directly affects their access to housing, the labor market, and urban services. The primary reason for this is that the population pattern causes changes and diversification in individuals' social networks. A relatively high concentration of Syrians in a neighborhood strengthens the bonds among them but reduces their interactions with people of different languages and ethnicities. While this may strengthen intra-group connections, it limits access to information and services. In such cases, individuals may miss out on valuable information and services from other groups or public institutions/organizations, resulting in a more restricted framework for accessing housing, the labor market, and urban services. Field studies conducted in Bostancık and Önder Neighborhoods support this conclusion. The proportion of Syrians

in the population of Bostancık Neighborhood is lower than in Önder Neighborhood. Research findings indicate that the social networks of Syrians under temporary protection residing in Bostancık are more diverse compared to those

in Önder. Furthermore, in terms of access to housing, the labor market, and urban services, residents of Bostancık Neighborhood benefit more from their social networks and have a broader network. In contrast, those living in Önder Neighborhood remain within a narrower framework in these areas.

In this respect, the findings partially align with previous studies on Syrian migrants in Turkey, which emphasize the central role of kinship and co-ethnic networks in accessing employment and housing. However, unlike much of the existing literature that treats migrant communities as relatively homogeneous, this study demonstrates that neighborhood-level population patterns create significant internal differentiation in social network structures and spatial mobility outcomes.

The length of stay in Turkey and the education level of Syrians under temporary protection are crucial parameters that shape their social networks and capital. As the length of stay increases, individuals' social networks and capital diversify. The date of arrival also significantly affects this diversification. Those who arrived during the initial years of the migration flow tend to have stronger unifying social networks than those who arrived later. For those arriving after the first wave, the binding social network became more dominant as the migration took the form of a chain migration model. From the perspective of education level, a higher education level leads to more diverse social networks. For example, Syrians with bachelor's and graduate degrees are more likely to engage in unifying and bridging social networks—networks that are less common at other education levels. It has been concluded that these connecting and bridging social networks are particularly effective in accessing housing. In the early years of migration, the influence of unifying social networks was more prominent among newcomers. However, as the migration evolved into a chain migration model, the connecting social networks gained importance. The population pattern of a neighborhood also plays a role: in neighborhoods with fewer Syrians, public institutions and associations are more effective in the housing process, while in areas with a higher number of Syrians, binding social networks—such as relationships with relatives and Syrian friends—become more prominent.

Although Syrians living in Bostancık and Önder Neighborhoods display similarities in demographic and migration characteristics, they diverge significantly in processes like finding housing, participating in the labor market, and benefiting from urban services. This divergence is primarily due to differences in population patterns. Önder Neighborhood has a high Syrian population that relies heavily on binding social capital for urban processes. In contrast, Bostancık Neighborhood has a relatively smaller Syrian population, allowing Syrians under temporary protection to diversify their social networks by interacting with other residents beyond their own relatives and acquaintances. The literature suggests that individuals who form their social networks exclusively through acquaintances and relatives face more limitations in accessing information, finding employment, and participating in urban mobility. On the other hand, those who diversify their social networks—engaging with people outside their ethnic group and with different languages or beliefs—find it easier to access information and the resources they need. The differences between Bostancık and Önder Neighborhoods illustrate this point: Syrians in Bostancık, with their more diverse social networks, have broader opportunities compared to those in Önder, who mainly rely on their binding social capital.

Figure 8 presents a map of the total urban mobility of individuals living in Bostancık Neighborhood. According to the total urban mobility map formed within the framework of the social networks of individuals living in Bostancık Neighborhood, the neighborhood with the most intense ties and the highest mobility is determined as Hüseyingazi Neighborhood. Khüseyingazi Neighborhood is the neighborhood where individuals have both work, shopping and acquaintances outside of themselves and where the frequency of visits is high. In addition, Gülveren Neighborhood, Önder Neighborhood and Karapürçek Neighborhood were determined as the places where they both have acquaintances and go for shopping. There is a relationship with Çankaya, Solfasol, Siteler and Ulubey neighborhoods only for work purposes. The neighborhoods that create mobility for both working and shopping are Ulus and Kızılay. In Bostancık Neighborhood, the radius of the inner belt, where intense relations and mobility are observed, is 3.7 kilometers, while the radius of the outer belt is 8.7 kilometers. The movement areas within this belt were calculated as 43.3 km2 in the inner belt and 236.4 km2 in the outer belt.

According to the total urban mobility map (Figure 9) formed within the framework of the social networks of individuals living in Önder Neighborhood, the neighborhoods with the densest ties are Ulubey, Battalgazi and Hüseyingazi Neighborhoods. These neighborhoods are both work foci and shopping and visiting foci where acquaintances are located. In addition, Örnek Neighborhood was identified as a place where they both have acquaintances and where they go for shopping. Siteler Neighborhood is the place where they are only active for work purposes. There is a mobility with Ulus, Kızılay and Karapürçek neighborhoods only for shopping. The neighborhoods where they have only acquaintances and where they provide mobility for visiting purposes are Demirlibahçe, Bostancık, Doğantepe and Solfasol. The radius of the inner belt, where intense relations and mobility are observed in Önder Neighborhood, is 2.5 kilometers, while the radius of the outer belt is measured as 5.7 kilometers. The movement areas within this belt were calculated as 20 km2 in the inner belt and 101.6 km2 in the outer belt.

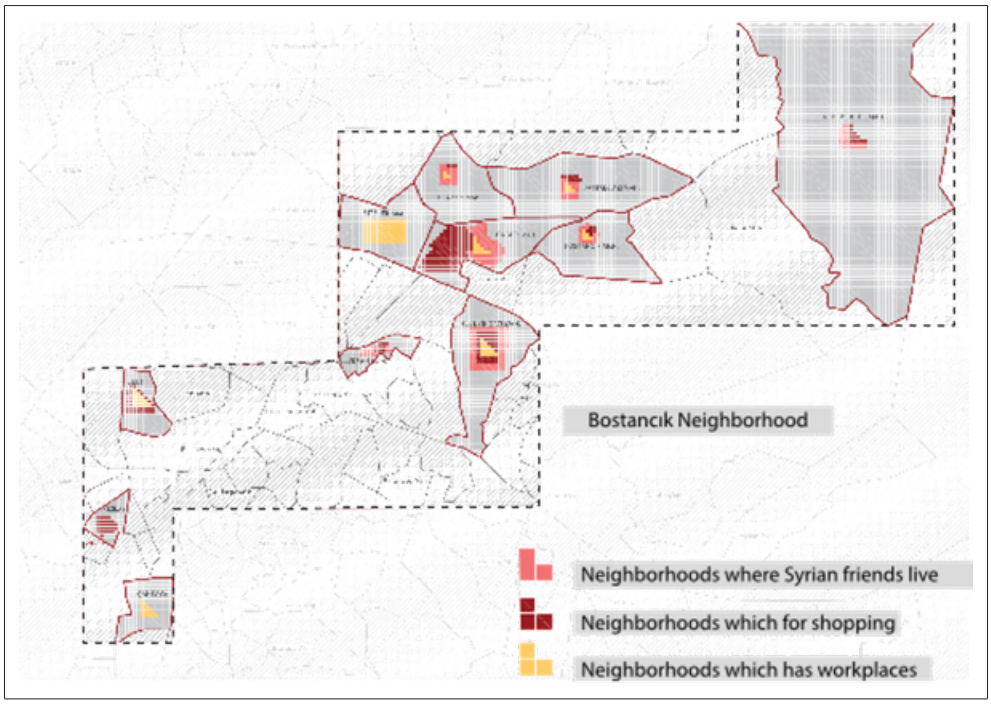

Figure 8. Urban mobility of Bostancık neighborhood residents.

When the mobility of the two neighborhoods within the city is compared, it is determined that Önder Neighborhood has a stronger relationship with the neighborhoods spatially close to it. For this reason, both the inner and outer belt radius were measured to be less than Bostancık Neighborhood. Bostancık Neighborhood, on the other hand, establishes more relations with the rest of the city than Önder Neighborhood.

The significance of these findings lies in demonstrating that integration outcomes cannot be explained solely by individual characteristics such as education or length of stay. Instead, they are deeply shaped by the interaction between

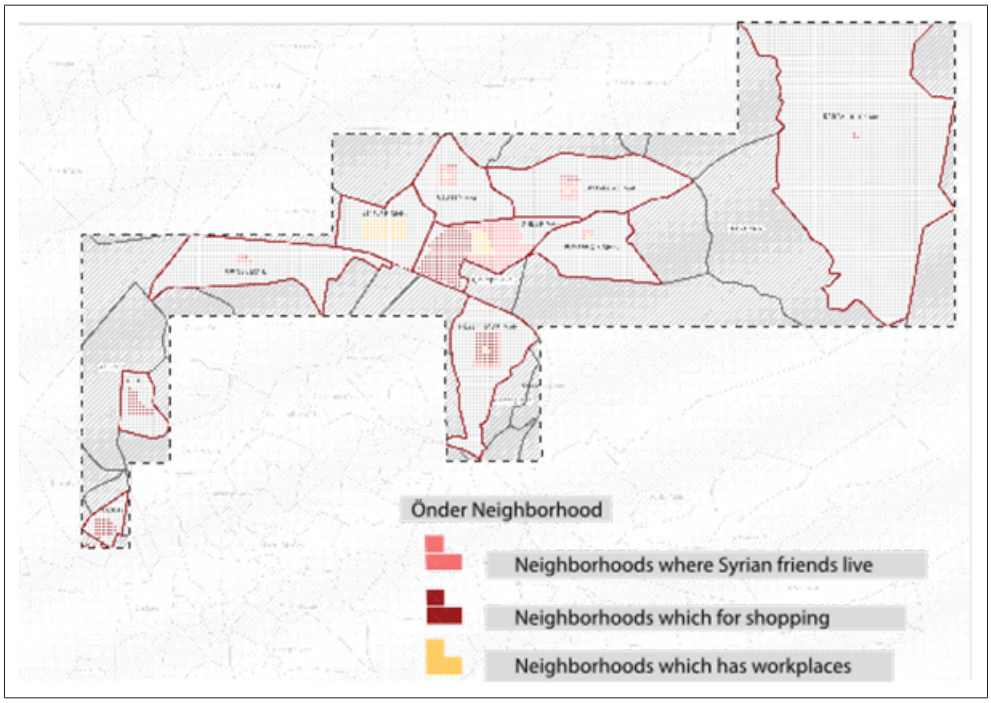

Figure 9. Urban mobility of Önder neighborhood residents.

social networks and urban spatial structures. From an urban planning perspective, this highlights the importance of considering neighborhood-level social dynamics when designing policies aimed at improving migrants' access to housing, employment, and urban services.

CONCLUSION

For migrants, three fundamental challenges typically arise following the migration process: (1) access to housing, (2) access to the labor market, and (3) access to urban services. Previous research has shown that intense migration movements often lead to rising rental prices, thereby reducing the stock of affordable housing for migrant populations. Access to housing becomes particularly challenging in cases where migrants lack pre-existing social networks or contacts in destination areas. In this context, social networks play a critical role not only in securing housing but also in facilitating participation in the labor market. The coexistence of bonding, bridging, and linking social networks has been shown to accelerate job access and labor market integration. However, when migrants' networks are predominantly bonding-based and limited to co-ethnic ties, access to employment opportunities and information tends to remain constrained, placing individuals at a relative disadvantage.

Migrants also face difficulties in accessing urban services such as education and healthcare. While legal status and institutional frameworks are important determinants of access, existing studies emphasize that the integration of social networks and social capital significantly shapes these processes. The findings of this study align with earlier research in demonstrating that social networks are central to migrants' integration into urban life. At the same time, the results suggest that integration trajectories and patterns of urban mobility differ even among migrant groups with similar socio-economic and demographic characteristics. In the case of Syrians under temporary protection in Turkey, variations in neighborhood population patterns, length of stay, and education levels contribute to differentiated access to housing, employment, and urban services. Individuals who arrived during the earlier phases of migration and who possess relatively higher educational levels tend to occupy more advantageous positions in these domains, a pattern also noted in previous empirical studies.

The contribution of this study lies in its comparative, neighborhood-scale analysis and its integration of social network analysis with spatial mobility mapping. By examining how social networks operate differently across neighborhoods with contrasting demographic compositions, the research provides additional empirical evidence on how local population patterns shape migrants' everyday practices and access to urban resources. Rather than positioning itself as superior to existing studies, this research builds on and extends previous findings by offering a spatially grounded perspective on the interaction between social networks and urban structures.

From a policy perspective, the findings underscore the importance of considering neighborhood-level social dynamics in the design of housing, labor market, and urban service policies targeting migrant populations. Recent policy measures in Turkey, such as restrictions on foreign population concentration at the neighborhood level, may further reshape migrants' social networks and access mechanisms. In this sense, the study provides a contextual framework for assessing how evolving migration policies influence social networks and urban integration processes over time.

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PEER-REVIEW: Externally peer-reviewed.

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Article

Mapping heat vulnerability in Esenler, Istanbul using equal and entropy weighting: A multi-dimensional GIS approach

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ABSTRACT

Urban heat vulnerability is an emerging challenge for rapidly densifying cities, where socio-economic inequalities intersect with physical exposure. This study assesses neighborhood-level heat vulnerability in Esenler District, Istanbul, by integrating environmental and socio-demographic indicators within a composite Heat Vulnerability Index (HVI). Using satellite-derived indicators, including Land Surface Temperature (LST), Normalized Difference Vegetation Index (NDVI), and Normalized Difference Built-up Index (NDBI), combined with socio-economic and adaptive capacity measures, the analysis applies both Equal Weighting and Entropy Weighting Methods to evaluate spatial variability and methodological robustness. Results reveal significant intra-district disparities, with HVI values ranging from 0.15 to 0.69 ($\Delta = 0.54$). The majority of neighborhoods (15 of 17) fall within the high-vulnerability category, representing approximately 96% of the population, while only one neighborhood exhibits low vulnerability and one shows moderate vulnerability. The strong correlation ($r = 0.94$) between Equal and Entropy-weighted results confirms the index's methodological stability. Spatial clustering of high vulnerability in central Esenler underscores how dense urban morphology and social disadvantage co-produce climatic risk. This study addresses a critical gap in Istanbul's urban climate literature by providing one of the first data-driven, neighborhood-scale HVI applications. A Heat Vulnerability–Adaptive Capacity matrix translates results into a neighborhood-level prioritization scheme, identifying critical hotspots (N3, N7, N10) for immediate adaptation. Integrating entropy-based weighting enhances the interpretation of diverse environmental and social datasets, offering a replicable model for other contexts. The results emphasize targeted adaptation measures such as expanding green infrastructure, improving thermal comfort, and prioritizing vulnerable communities.

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INTRODUCTION

Rapid urbanization has intensified the frequency and severity of extreme heat events, posing significant threats to human health, ecosystems, and urban infrastructure (Chen et al., 2025b; Wang et al., 2024). The Intergovernmental Panel on Climate Change (IPCC, 2022) projects that global mean surface temperature will likely exceed the 1.5 °C threshold within the next two decades, amplifying the frequency, duration, and severity of heatwaves (Chen et al., 2025a). The Urban Heat Island (UHI) effect exacerbates these risks, as built-up areas absorb and retain more heat than surrounding rural regions (Shen et al., 2025; Leal Filho et al., 2018). Conversion of vegetated, permeable surfaces into impervious construction materials alters the surface energy balance, driving persistent microclimatic changes (Patel et al., 2024). Consequently, urban residents face prolonged heat stress, which elevates health risks (Hossain et al., 2024), reduces labor productivity (Kimmich et al., 2025; Lai et al., 2023), and exacerbates social inequalities (Macharia & Kiage, 2025; Leal Filho et al., 2018). Growing evidence indicates that heat-related impacts are distributed unequally, with low-income populations, older adults, and children disproportionately affected (Uejio et al., 2024). Heat vulnerability thus emerges from the intersection of environmental exposure, socio-demographic sensitivity, and adaptive capacity, where limited access to green infrastructure and public services magnifies local thermal stress (Lopes et al., 2025; Li et al., 2024). Addressing these interconnected challenges requires integrating spatial risk mapping with socio-economic support systems, ensuring that adaptation measures are both data-driven and socially equitable (Randazza et al., 2023; Berisha et al., 2017). Because these interactions occur unevenly across space, neighborhood-scale assessments are crucial for identifying localized risk patterns and supporting targeted adaptation (Ho et al., 2025; Cangüzel & Coşkun Hepcan, 2024).

These patterns are particularly pronounced in Istanbul, one of Europe's fastest-growing megacities. Uncontrolled urban sprawl, high building density, and loss of natural land cover have produced temperature contrasts exceeding 4 °C between urban and rural zones (Kuru & Okay, 2025; Sari et al., 2025; Okumuş & Terzi, 2021). Within the city, Esenler exemplifies the convergence of intense UHI effects and socio-economic vulnerability. Home to over 427,000 residents distributed across 17 neighborhoods (TÜİK, 2023), it combines extreme density, minimal vegetation, and limited public space. Remote-sensing studies consistently identify Esenler as one of Istanbul's warmest districts (Khorrami & Gündüz, 2019; Zaeemdar & Baycan, 2017). Dogru et al. (2019) described its compact, poorly ventilated morphology and low environmental quality, linked to informal housing, limited education, and restricted healthcare access. Children under fifteen account for more than 20 % of the population, amplifying health risks from heat and pollution. Consequently, Esenler ranks 36th out of 39 districts in Istanbul's Quality-of-Life Index (Şeker et al., 2022). These conditions make Esenler a representative case for investigating neighborhood-scale heat vulnerability in the context of a Mediterranean megacity. Moreover, its social composition provides an opportunity to explore how spatially explicit vulnerability mapping can inform equitable Heat Action Planning and community-based adaptation.

Recent empirical research has revealed Istanbul's escalating thermal stress. Sari et al. (2025) recorded Physiologically Equivalent Temperature (PET) values exceeding 45 °C during the 2021 heatwave, while Yılmaz et al. (2024) confirmed that compact districts experience substantially higher heat stress than vegetated zones. Anticipated increases in heat-related mortality, particularly among elderly residents and women, highlight the city's need for targeted adaptation (Yılmaz et al., 2024). Furthermore, uneven access to green infrastructure perpetuates a "green divide" between redeveloped and older neighborhoods (Yazar et al., 2023). Such disparities illustrate how rapid urbanization and socio-economic inequality jointly exacerbate environmental risks (Yılmaz et al., 2024). These interlinked vulnerabilities position Esenler as a critical testbed for evaluating integrated approaches to urban heat resilience. By linking environmental exposure with social sensitivity and adaptive capacity, this study contributes to an emerging body of research advocating equitable, data-informed climate adaptation.

Heat Vulnerability Index (HVI)

HVI, grounded in the IPCC's framework of exposure, sensitivity, and adaptive capacity (IPCC, 2014; IPCC, 2022), offers a multidimensional means of identifying populations most at risk from extreme heat (Chen et al., 2025b). Environmental exposure is typically quantified through indicators such as land surface temperature (LST), vegetation (NDVI), and built-up density (NDBI). Sensitivity captures demographic and socio-economic factors such as age distribution, gender, and education (Chen et al., 2025a; Li et al., 2025; Parker et al., 2025; Zeng et al., 2022), while adaptive capacity reflects access to green space, healthcare, and social infrastructure (Munoz-Pizza et al., 2023; Li et al., 2025). Together, these dimensions generate spatially explicit vulnerability maps that inform climate-adaptation policies and public health planning.

Despite their value, HVI frameworks remain methodologically heterogeneous, differing in indicator selection, weighting, and spatial granularity (Parker et al., 2025; Chen et al., 2025b). Among weighting techniques, Equal Weighting and Principal Component Analysis (PCA) dominate due to simplicity and reproducibility (Cheng et al., 2021; Li et al., 2022). Expert-based methods such as the Analytic Hierarchy Process (AHP) incorporate subjective judgment, while data-driven alternatives like the Entropy

Weighting Method (EWM) derive indicator weights from statistical information content, reducing human bias (Yang & Zhao, 2023). EWM is particularly effective for neighborhood-scale analyses that integrate diverse environmental and socio-economic datasets (Guo et al., 2024). Although the selection and categorization of indicators vary across contexts, spatial scales, and data availability, neighborhood-scale HVI applications consistently integrate multiple dimensions to capture local heterogeneity in exposure, sensitivity, and adaptive capacity (Li et al., 2025; Parker et al., 2025; Chen et al., 2025b).

Research Gap and Objectives

Previous studies in Istanbul can be broadly grouped into two categories. First, several studies have examined urban heat island dynamics and the influence of land-use change, urban morphology, and vegetation patterns on urban temperatures (Kuru & Okay, 2025; Sari et al., 2025; Yılmaz et al., 2024). Second, more recent research has applied integrated heat vulnerability assessment frameworks that combine environmental and socio-demographic indicators at the metropolitan scale (Okumuş, 2025). While these studies have advanced understanding of urban heat risks in Istanbul, neighbourhood-level analyses within specific high-risk districts remain scarce, limiting the spatial resolution available for targeted adaptation planning. In particular, studies that simultaneously integrate exposure, sensitivity, and adaptive capacity at the neighbourhood scale are still lacking. Esenler, with its high density, limited greenery, and socio-economic disparities, provides an ideal context for applying such a framework at the intra-district level. Moreover, although various global studies have compared weighting schemes, including Equal Weighting, Entropy Weighting, PCA, and AHP, no empirical comparison of these methods has been conducted in Istanbul's urban context. Building on these gaps, this study represents the first neighborhood-scale HVI for Istanbul that assesses the robustness of results using both subjective (Equal Weighting) and objective (Entropy Weighting) approaches. By integrating environmental exposure, socio-demographic sensitivity, and adaptive capacity into a unified IPCC-based framework, it provides both contextual and methodological advancements in assessing urban heat vulnerability. Specifically, the study addresses the following research questions:

Q1: Which neighborhoods in Esenler are most vulnerable to UHI effects when environmental exposure, socio-demographic sensitivity, and adaptive capacity are considered together?

Q2: How do different weighting approaches (Equal Weighting vs. Entropy Weighting Method) influence the assessment of heat vulnerability at the neighborhood scale?

Q3: Which neighborhoods should be prioritized for climate adaptation interventions based on the combined assessment of heat vulnerability and adaptive capacity?

MATERIALS AND METHODS

Study area

Esenler (41.06°N, 28.86°E), located approximately 18 km west of the Bosporus on Istanbul's European side, covers an area of 18.43 km² and had a population of 454,569 in 2023 (Turkish Statistical Institute [TÜİK], 2023) (Figure 1). The district exhibits a compact urban form, high residential density, and limited publicly accessible green spaces, all of which contribute to elevated surface temperatures and a pronounced UHI effect (Okumuş & Terzi, 2021; Dogru et al., 2019; Zaeemdar & Baycan, 2017). As one of Istanbul's most densely populated districts, Esenler is characterized by intense residential concentration and urban congestion, conditions that can exacerbate urban heat accumulation and exposure (Sari et al., 2022). Socio-economic characteristics, including low household incomes and moderate educational attainment, further reduce residents' adaptive capacity to heat stress (Dogru et al., 2019). In terms of socio-economic structure, 75% of the population belongs to the low-income group, while the remaining 25% falls within the middle-income category (Sari et al., 2022). These conditions illustrate heightened sensitivity to environmental stressors and restricted adaptive capacity at the household level.

Esenler is administratively divided into 17 neighborhoods, the smallest administrative units considered in this study. Neighborhood-level socio-demographic data, including population, population density, age distribution (% children under five and % elderly ≥65), female population percentage, literacy rates, educational attainment (basic and higher education), and per-capita household income, were compiled to capture intra-district variability (Table 1). Unusually low population densities in neighborhoods such as Çifte Havuzlar (18.7 persons/ha) and Oruçreis (39.45 persons/ha) reflect specific land use characteristics, including university campuses and military zones, respectively. In contrast, densely populated neighborhoods such as Fatih reach 810.8 persons/ha, reflecting the district's heterogeneous urban structure. Per-capita household income ranges from TL 13,290 in Tuna to TL 18,717 in Davutpaşa. Household income data were obtained from Endeksa in 2025 and are reported as estimated monthly per-capita income (TL/person/month) at the neighborhood level. During the data collection period, the net monthly minimum wage in Türkiye was 22,104 TL (Ministry of Labour and Social Security, 2024). Estimated neighborhood income values ranged from 13,290 to 18,710 TL/person/month. Although per-capita income and minimum wage are not directly comparable measures, the observed values provide contextual evidence of relatively limited economic resources across the study area, which may constrain households' capacity to cope with heat-related risks. At the same time, the proportions of children under five and elderly residents also vary across neighborhoods, highlighting demographic differences relevant to heat vulnerability.

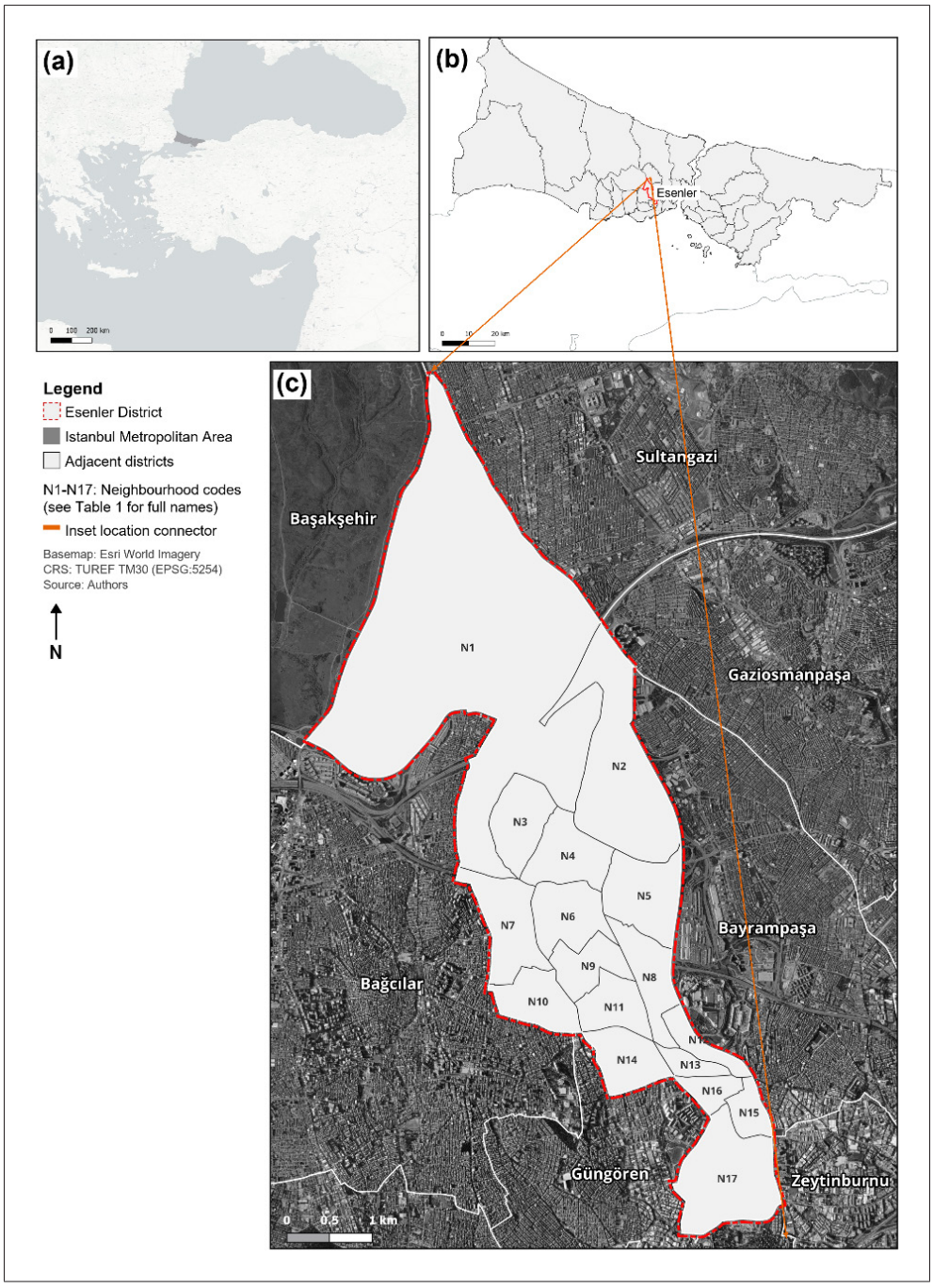

Figure 1. Study area: **(a)** location of Istanbul within Türkiye; **(b)** Esenler district (red dashed boundary) within the Istanbul Metropolitan Area; **(c)** Esenler neighbourhoods (N1–N17) with adjacent districts, overlaid on Esri World Imagery satellite basemap. Neighbourhood codes correspond to Table 1. Coordinate reference system: TUREF TM30 (EPSG:5254). (Designs by Authors).

Meteorologically, Esenler experiences a Mediterranean climate (Csa), characterized by hot, dry summers and mild, wet winters. The warm season spans from June to September, with average daily high temperatures exceeding 25°C and August representing the hottest month, with average highs around 28°C and lows near 18°C (WeatherSpark, 2025; Climate Data, 2025). Extreme events pose significant risks: a study analyzing heatwaves in Istanbul between 2013 and 2017 found that three major heatwaves resulted in 419 excess deaths over 23 days, underlining the vulnerability of urban populations (Can et al., 2019). At the national scale, Turkish provinces have experienced measurable increases

Table 1. Neighborhood-level socio-demographic characteristics of Esenler.

Neighborhood	ID	Population	Population Density (persons/ha)	% Children <5	% Elderly ≥65	% Female population	Illiteracy Rate (%)	Basic Education (%)	Higher Education (%)	Per-capita Income (TL/ person/month)
Oruçreis	N1	34657	39.45	6.7	4.7	48.78	2.5	82.0	9.9	14.312
15 Temmuz	N2	8174	471.7	4.92	3.84	37.65	0.24	34.7	2.85	17.713
Turgut Reis	N3	43970	750.7	6.3	4.6	49.29	2.1	73.1	9.4	14.516
Havaalanı	N4	33452	541.8	6.82	4.46	49.50	1.33	66.4	13.0	17.335
Kemer	N5	21554	288.3	6.58	5.35	49.28	1.64	70.3	11.0	17.048
Birlik	N6	26216	429.7	6.20	5.43	49.54	1.90	73.0	10.8	16.195
Tuna	N7	31762	435.5	7.2	5.1	48.61	2.5	69.9	8.6	13.290
Fevzi Çakmak	N8	31081	579.7	6.41	5.21	49.44	1.73	69.1	12.6	14.253
Kazım Karabekir	N9	34092	792.4	6.37	5.35	49.50	2.17	70.9	11.1	15.815
Fatih	N10	41515	810.8	6.83	4.69	48.95	2.00	71.3	9.6	14.765
Menderes	N11	30888	687.9	6.01	5.64	49.42	1.82	68.1	11.96	17.219
Yavuz Selim	N12	3517	145.9	6.0	7.8	48.20	1.5	68.4	14.2	16.741
Mimar Sinan	N13	13216	762.5	5.86	8.41	49.76	1.49	65.7	14.8	16.485
Nine Hatun	N14	40028	793.7	6.1	6.0	49.46	2.2	69.7	10.9	16.374
Namık Kemal	N15	15817	671.5	5.98	5.83	47.90	1.75	68.7	11.7	17.417
Davutpaşa	N16	15757	754.5	5.48	7.47	49.43	1.67	69.5	12.4	18.717
Çifte Havuzlar	N17	2205	18.7	5.17	7.80	46.96	2.40	67.66	11.30	16.696

in annual mean temperatures, drought frequency, and extreme weather events over the past two decades, with built environment characteristics identified as significant drivers of these changes (Bektaş & Sakarya, 2023).

The temporal scope of this study focuses on summer 2024, with the Landsat 8-derived LST map of 13 August 2024 selected to represent peak summer thermal conditions across Esenler. A single cloud-free image was used to capture spatial variations in surface temperature and identify relative heat-exposure hotspots at the neighborhood scale. This approach is widely applied in urban heat vulnerability studies to assess intra-urban thermal variability and evaluate the socio-environmental drivers of heat risk. Although a single-date analysis cannot capture seasonal or temporal fluctuations in temperature, it provides a consistent snapshot of peak heat conditions and a robust basis for identifying priority areas for localized adaptation strategies.

Methodology/Analytical Framework

Neighborhood-scale heat vulnerability in Esenler was assessed using the IPCC Exposure–Sensitivity–Adaptive Capacity framework. Environmental, socio-demographic, and adaptive capacity indicators were preprocessed in GIS, normalized, and prepared as thematic layers. The composite HVI was first calculated using the EW method to represent neighborhood-level vulnerability. To evaluate the robustness and sensitivity of the results to the weighting choice, EWM was subsequently applied as a robustness check. Following the HVI calculation, the results were mapped in QGIS to identify spatial patterns of vulnerability across neighborhoods. Finally, the HVI results were integrated with Adaptive Capacity classes through an HVI–Adaptive Capacity (HVI–AC) Priority Matrix to classify neighborhoods according to adaptation priority levels and support targeted heat adaptation and mitigation planning (Figure 2).

Indicator selection

The construction of the HVI for Esenler was guided by the IPCC framework, which conceptualizes vulnerability as a function of exposure, sensitivity, and adaptive capacity (IPCC, 2014; IPCC, 2022). Indicator selection was informed by a PRISMA-guided systematic literature review. A search was conducted in the Scopus database using the search string ("Heat Vulnerability Index" OR HVI OR "urban heat vulnerability") AND (exposure OR sensitivity OR "adaptive capacity"). Studies published between 2015 and 2025 were identified and screened according to predefined eligibility criteria. Following the review process, 41 studies were retained and used to identify, evaluate, and justify the

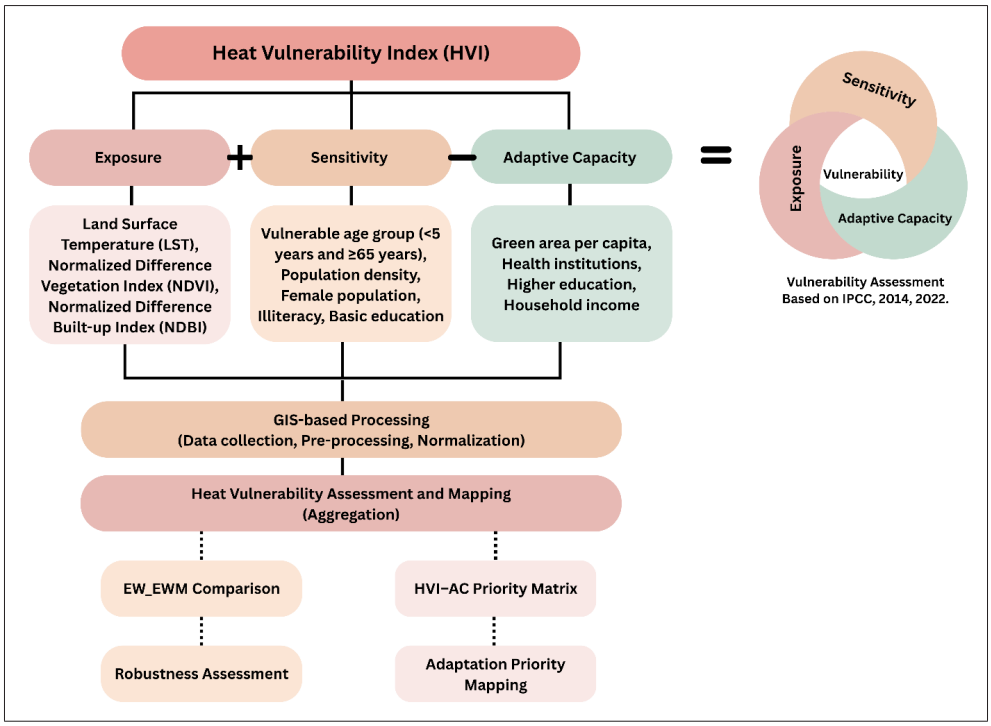

Figure 2. Methodological framework of the study showing the workflow for neighborhood-scale HVI assessment in Esenler (Design by Authors).

indicators included in this research. These studies reveal substantial variation in indicator selection, reflecting differences in local environmental conditions, data availability, and methodological choices. In particular, population density, impervious surfaces, and vegetation cover are inconsistently categorized across studies as exposure, sensitivity, or adaptive capacity, underscoring the flexibility but also the need for contextual tailoring in HVI construction (Chen et al., 2025b; Li et al., 2025; Parker et al., 2025; Cangüzel & Coşkun Hepcan, 2024).

The full list of reviewed studies is presented in Appendix A. Based on methodological precedent and the constraints of neighborhood-scale data availability in Esenler, a set of indicators was selected (Table 2). This framework balances rigor with contextual relevance, ensuring that the HVI reflects environmental heat exposure and socio-demographic factors influencing vulnerability.

Exposure Indicators

Exposure refers to the degree to which Esenler's residents are subjected to intensified thermal stress. In this study, three indicators were adopted, consistent with approaches identified by prior urban heat vulnerability research (Parker et al., 2025; Kim et al., 2023; Zeng et al., 2022):

a. Land Surface Temperature (LST): LST directly reflects surface heat intensity and is widely used as a proxy for localized thermal environments. Higher LST is consistently associated with increased heat exposure and related health risks (Parker et al., 2025; Adnan et al., 2024). Since ground-based meteorological stations in Esenler were not accessible, satellite-derived LST data were employed as a proxy to assess neighborhood-scale heat exposure. While this approach captures spatial variability effectively, it may slightly overestimate temperatures experienced at human height. As highlighted by Parker et al. (2025), LST represents the thermal state of urban surfaces rather than direct air temperatures, and its relationship with surface air temperature can vary depending on season, weather, and urban morphology. Nevertheless, its high spatial resolution provides valuable insights into intra-urban thermal variations (Parker et al., 2025).

b. Normalized Difference Vegetation Index (NDVI): NDVI quantifies vegetation cover, which mitigates surface heat through shading and evapotranspiration. Higher NDVI values indicate greater cooling potential (Zhang et al., 2023).

c. Normalized Difference Built-up Index (NDBI): NDBI measures built-up density and impervious surface cover, both of which increase heat storage and nocturnal warming (Parker et al., 2025).

These indicators are among the most frequently applied in urban heat vulnerability assessments, as documented in the reviewed studies, and they capture the spatial variation of urban morphology and greenery, the two primary drivers

Table 2. Indicators used in constructing the HVI for Esenler, including justification and expected effect on vulnerability.

Dimension	ID	Indicator	Justification	Expected effect on HVI	References	Frequency in literature (%)
Exposure	E-01	Land Surface Temperature (LST)	Proxy for surface heat intensity; widely adopted in neighborhood-scale HVI studies	+	Chen et al. (2025a); Li et al. (2025); Parker et al. (2025); Guo et al. (2024); Kitchley (2024); Fall et al. (2023); Sun et al. (2022)	76%
	E-02	Normalized Difference Vegetation Index (NDVI)	Captures vegetation cover and the cooling effect of greenery	-	Chen et al. (2025b); Parker et al. (2025); Kim et al. (2023); Zeng et al. (2022)	51%
	E-03	Normalized Difference Built-up Index (NDBI)	Reflects urban morphology and impervious surface density influencing heat retention	+	Parker et al. (2025); Adnan et al. (2024); Cangüzel and Coşkun Hepcan (2024); Zeng et al. (2022)	29%
Sensitivity	S-01	% of children (<5 years)	Higher vulnerability to heat-related health risks	+	Li et al. (2025); Li et al. (2024); Guo et al. (2024); Bu et al. (2024); Kamal et al. (2022); Inostroza et al. (2016)	63%
	S-02	% of elderly (≥65 years)	Physiological susceptibility to extreme heat	+	Chen et al. (2025a); Wang et al. (2025); Li et al. (2025); Li et al. (2024); Wang et al. (2024); Guo et al. (2024); Bu et al. (2024); Mallen et al. (2019)	81%
	S-03	% Female population	Women face higher risks of heat-related mortality	+	Kitchley (2024); Wang et al. (2024); Raja et al. (2021); Tran et al. (2020)	17%
	S-04	Population density	Proxy for concentrated human exposure and limited cooling opportunities	+	Chen et al. (2025a); Chen et al. (2025b); Li et al. (2025); Wang et al. (2024); Kitchley (2024); Fall et al. (2023); Salleh et al. (2023); Zuhra et al. (2019)	71%
	S-05	Illiteracy	Low literacy increases vulnerability by limiting awareness of heat risks	+	Kitchley (2024); Raja et al. (2021); Tran et al. (2020)	10%
	S-06	Basic education	Limited formal education reduces coping capacity	+	Li et al. (2025); Hammer et al. (2020); Zhang et al. (2018)	10%
Adaptive Capacity	AC-01	Green area per capita (m^2/person)	Environmental resource mitigating heat stress	-	Chen et al. (2025a); Cangüzel and Coşkun Hepcan (2024); Shartova et al. (2024); Ramsey et al. (2024); Zhang et al. (2019); Weber et al. (2015)	42%
	AC-02	Health institutions	Institutional resource for responding to heat-related health risks	-	Parker et al. (2025); Shartova et al. (2024); Wang et al. (2024); Sianturi et al. (2023); Munoz-Pizza et al. (2023); Singh (2023); Bhattacharjee et al. (2019); Oh et al. (2017)	29%
	AC-03	Higher education	Higher education enhances knowledge and adaptive behaviors	-	Chen et al. (2025b); Jiang (2023)	20%
	AC-04	Household income	Socio-economic vulnerability influencing coping capacity; higher income reduces vulnerability	-	Wang et al. (2025); Chen et al. (2025b); Bu et al. (2024); Yang and Zhao (2023)	20%

of neighborhood-scale heat exposure in Esenler's dense urban fabric.

Sensitivity Indicators

Sensitivity represents the demographic and socio-economic characteristics that influence how severely populations experience heat stress. In this study, six indicators were selected, consistent with patterns identified in the reviewed studies and supported by prior evidence linking them to heat-related morbidity and mortality (Chen et al., 2025b; Li et al., 2025; Fall et al., 2023):

a. Children under 5 years (%) and the Elderly population ≥65 years (%): Frequent and intense heatwaves pose serious health risks to residents, particularly vulnerable groups such as young children and the elderly (Li et al., 2025).

b. Gender (female population %): Gender is an important indicator of heat sensitivity. Physiological differences and health status can increase women's vulnerability, particularly during pregnancy or menopause (Raja et al., 2021). In Istanbul, women have shown higher risks of heat-related mortality (Yılmaz et al., 2024). Similar findings were reported in a Czech study, which observed higher excess female mortality during heat waves (Vésier & Urban, 2023). Zhou et al. (2025b) also found that females are at greater cardiovascular risk under extreme heat.

c. Population density: Higher population density intensifies anthropogenic heat emissions, since densely built urban areas trap heat, leading to elevated temperatures relative to nearby rural zones (Chen et al., 2025a). Esenler is characterized by a compact urban form and high residential density, conditions that contribute to elevated urban heat accumulation and increased heat exposure (Sari et al., 2022).

d. Illiteracy rate and basic education attainment: Lower literacy and education levels limit awareness of heat risks and adaptive behaviors, increasing vulnerability. They are also associated with higher heat-related mortality, likely due to limited economic resources and reduced adaptive capacity (Kitchley, 2024; Li et al., 2024; Hammer et al., 2020).

Adaptive Capacity Indicators

Adaptive capacity is conceptualized in this study as the socio-economic and infrastructural resources that enable communities to cope with heat-related risks. Adaptive capacity reflects the resources and infrastructure that enable communities to cope with or reduce heat exposure. Four indicators were selected, building on previous HVI studies (Cresswell et al., 2023; Guo et al., 2024; Kitchley, 2024; Chen et al., 2025a):

a. Green area per capita (m^2/person): Availability of green space mitigates urban heat stress and provides thermal comfort (Chen et al., 2025a).

b. Health institutions: Access to healthcare facilities strengthens institutional capacity to respond to heat-related health risks (Wang et al., 2025; Guo et al., 2024).

c. Higher education attainment: Higher education levels enhance risk awareness, access to information, and adaptive behavior (Chen et al., 2025a).

d. Household income: Higher income enhances the ability to afford adaptive measures (e.g., cooling devices, quality housing), thereby reducing vulnerability (Wang et al., 2025). In Esenler, where 75% of the population belongs to the low-income group, limited financial capacity increases residents' sensitivity to heat and constrains adaptive options (Sari et al., 2022).

Health-related indicators (e.g., chronic disease prevalence) and housing indicators (e.g., building quality, household crowding) were excluded due to the lack of reliable neighborhood-scale data. While housing quality and health status could further refine sensitivity, their absence may slightly underestimate vulnerability in low-income neighborhoods, an acknowledged limitation for future data integration. Nevertheless, the selected indicators capture the most relevant adaptive resources in Esenler's context. This tailored framework reflects both established practices in HVI construction and the specific socio-environmental conditions of Esenler, ensuring methodological robustness and practical relevance for urban heat mitigation planning.

Data collection and processing

Data for the HVI were collected from multiple spatial, environmental, and socio-demographic sources. Table 3 summarizes all indicators, including source, year, expected effect on vulnerability, normalization approach, spatial resolution/unit, and processing notes.

LST served as the principal indicator of heat exposure. Daytime LST values were derived from the Landsat 8 OLI/TIRS Collection 2 Level 2 Surface Reflectance product (Scene ID: LC08_L2SP_180031_20240813_20240822_02_T1), which provides a surface temperature band (TIRS Band 10; ST_B10) from the Thermal Infrared Sensor (Zhang et al., 2023; Méndez-Lázaro et al., 2018). The dataset corresponds to Path 180/Row 031 under the Landsat World Reference System and was acquired on 13 August 2024 at 09:51 UTC (12:51 local time in Türkiye). It was preprocessed by the USGS at 30-m spatial resolution and used to generate a cloud-free scene representing peak summer heat in Esenler. LST captures intra-urban variations in surface heating and is widely used in neighborhood-scale heat vulnerability assessments (Parker et al., 2025; Guo et al., 2024). The raw satellite data were converted to degrees Celsius using the calibration metadata provided with the product according to:

Table 3. Data sources and processing details for HVI indicators.

ID	Indicator	Source / Year	Normalization	Spatial Resolution/Unit	Notes / Processing
E-01	LST	Landsat 8 OLI/TIRS, 13 August 2024	Min–max, positive	30 m	Extracted from the ST_B10 band, DN → °C
E-02	NDVI	Landsat 8 OLI/TIRS, 13 August 2024	Min–max, inversely aligned	30 m	Calculated from NIR and Red bands
E-03	NDBI	Landsat 8 OLI/TIRS, 13 August 2024	Min–max, positive	30 m	Calculated from SWIR & NIR bands
S-01	% of children (<5 years)	Endeksa, 2025	Min–max, positive	Neighborhood	Census-based, aggregated
S-02	% of elderly (≥65 years)	Endeksa, 2025	Min–max, positive	Neighborhood	Census-based, aggregated
S-03	Female population	Endeksa, 2025	Min–max, positive	Neighborhood	% of total population
S-04	Population density	TÜİK, 2023	Min–max, positive	Neighborhood	Population per neighborhood area
S-05	Illiteracy	Endeksa, 2025	Min–max, positive	Neighborhood	% non-literate population
S-06	Basic education	Endeksa, 2025	Min–max, positive	Neighborhood	% with only basic education
AC-01	Green area per capita (m^2/person)	YAYSIS, 2024	Min–max, inversely aligned	Neighborhood	Green area/population
AC-02	Health institutions	National Smart City Open Data Platform, 2024	Min–max, inversely aligned	Neighborhood	Health institutions per neighborhood
AC-03	Higher education	Endeksa, 2025	Min–max, inversely aligned	Neighborhood	% of population with university education
AC-04	Household income	Endeksa, 2025	Min–max, inversely aligned	Neighborhood	Median household income per neighborhood

$$LST(^{\circ}C) = (DN \times 0.00341802 + 149.0) - 273.15 \quad (1)$$

where DN represents the digital number of Landsat 8 Band 10 thermal pixels, and the rescaling coefficients (0.00341802 and 149.0) were obtained from the Landsat Collection 2 Level-2 metadata (MTL) file provided by the USGS.

NDVI was calculated from OLI Bands 5 (NIR) and 4 (Red) to represent vegetation cover and its cooling potential (Kitchley, 2024; Kim et al., 2023). NDVI values theoretically range from −1 to +1, with higher values indicating greater vegetation density and associated cooling effects. NDBI was derived from OLI Bands 6 (SWIR1) and 5 (NIR) from the same Landsat 8 scene to quantify impervious surfaces and urban density, reflecting heat retention potential in built-up areas (Zhang et al., 2023). Higher NDBI values correspond to more urbanized areas, typically associated with higher surface temperatures.

$$\mathrm{NDVI} = \frac{NIR-Red}{NIR+Red} \quad (2)$$

$$NDBI = \frac{SWIR-NIR}{SWIR+NIR} \quad (3)$$

Data on population density were obtained from TÜİK (2023). Data on age structure (% children under 5, % elderly ≥65), educational attainment (basic education), literacy, and female population proportion were obtained from Endeksa (2025). Green area per capita was calculated by dividing the total green space area by the neighborhood population. Health institutions were represented by the number of hospitals, clinics, and healthcare centers per neighborhood. Data on urban green spaces were obtained from the Istanbul Green Area Management System (YAYSIS) maintained by the Istanbul Metropolitan Municipality (2024). Only publicly accessible green spaces, such as parks and recreational areas, were included in the analysis, while cemeteries, roadside vegetation, and median strips (refüj) were excluded to better represent usable community greenery. Health-service locations were retrieved from the National Smart City Open Data Platform (2024), which includes both public and private health facilities as well as community-based clinics. For consistency, the metric followed the World Health Organization's Health System Strengthening Handbook (2010) definition of static health facilities, adapted to represent the number of health institutions per 1,000 residents. This provides a standardized indicator of healthcare accessibility and social infrastructure relevant to neighborhood-level adaptive capacity. Although both datasets represent key elements of neighborhood resilience, a spatial accessibility analysis was also conducted to assess

the walkable reach of these facilities. Isochrone buffers of 500 metres for green spaces (WHO Regional Office for Europe, 2016) and 400 metres for healthcare facilities (Alshuwaikhat & Aina, 2006) were generated in QGIS. Higher education attainment was measured as the percentage of the population with university-level education, and household income per capita was included as an adaptive capacity indicator, both based on data from Endeksa (2025).

All spatial datasets were standardized before analysis to ensure spatial and thematic consistency. Raster and vector layers were processed in QGIS 3.34.15 "Prizren," projected to the Turkish National Coordinate Reference System (TUREF / TM30, EPSG: 5254). All indicators were normalized to a 0–1 scale using the min–max normalization method, allowing comparability across differing units and value ranges. Within the exposure and sensitivity dimensions, indicators where higher values represent lower vulnerability, namely NDVI, were inverted so that higher normalized values correspond to higher vulnerability. The four adaptive capacity indicators (green area per capita, health institutions, higher education attainment, and household income) were deliberately retained in their natural direction, such that higher normalized values represent greater adaptive capacity. Interpretive consistency in the composite index is instead achieved through the HVI formula (Section 3.4), in which the adaptive capacity component is subtracted: neighbourhoods with greater capacity thereby obtain lower vulnerability scores. The resulting standardized dataset provided a harmonized spatial foundation for subsequent weighting (Section 2.2.3) and spatial integration to generate neighborhood-level heat vulnerability maps (Section 2.2.4).

Weighting and aggregation of indicators

Heat-vulnerability studies employ various weighting approaches depending on study design, indicator set, and data availability. In our review of 41 urban heat vulnerability studies, weighting approaches were distributed as follows: PCA (31.7%), equal weighting (24.4%), entropy weighting (9.8%), expert-based weighting (9.8%), machine learning (2.4%), factor analysis (4.9%), and combination approaches (17.1%). This pattern is consistent with previous reviews, which also found that statistical approaches (e.g., PCA) and equal weighting are the most commonly used methods for indicator aggregation (Cheng et al., 2021; Li et al., 2022). Although PCA is commonly used in HVI research (Parker et al., 2025; Adnan et al., 2024; Kitchley, 2024), it was not suitable here because the Esenler dataset includes only 13 indicators across 17 neighborhoods, yielding approximately 1.3 cases per indicator, well below the recommended 5–10 cases for stable component loadings (Tabachnick & Fidell, 2013; Mundfrom et al., 2005). Moreover, rigorous evaluation of weighting choices is often overlooked in heat-vulnerability research; nearly two-thirds of current HVI studies lack rigorous testing against observed outcomes (Li et al., 2025), underscoring the need for more transparent and replicable evaluation frameworks. Accordingly, the Equal Weighting (EW) approach was adopted as the primary method for HVI construction, assigning identical importance to all indicators to ensure transparency and interpretability. The EWM was subsequently applied as a robustness check by recalculating the exposure, sensitivity, and adaptive capacity indices and the resulting HVI, using entropy-derived indicator weights. This parallel application enabled the assessment of how different weighting schemes influence neighborhood-level vulnerability patterns without altering the overall analytical framework of the study.

Equal Weighting

All indicators were assigned equal importance. After normalization, values were aggregated using a simple arithmetic mean to produce three intermediate component scores for each neighborhood: Exposure (EXP_n), Sensitivity ($SENS_n$), and Adaptive Capacity ($ADAP_n$).

Exposure, Sensitivity, and Adaptive Capacity each contributed one-third to the composite HVI. This approach is well-suited to small-sample, neighborhood-scale studies, improving transparency and avoiding methodological instability. However, it involves trade-offs: equal weighting may mask the disproportionately strong influence of certain socio-economic indicators, such as household income or education, which are known to drive vulnerability in Esenler.

Entropy Weighting Method (EWM)

To complement equal weighting and incorporate the intrinsic variation of each indicator, the Entropy Weighting Method was applied. EWM assigns weights based on the distribution of each indicator across neighborhoods: indicators with higher variability are given greater influence in the aggregation, reflecting their relative contribution to overall heat vulnerability. This method is widely recognized as an objective approach for assessing value dispersion in decision-making, as it minimizes human bias and enhances the objectivity of composite evaluations compared to subjective weighting techniques (Guo et al., 2024; Yang & Zhao, 2023). This makes it particularly suitable for small, data-limited urban studies such as Esenler. The procedure for the calculations is outlined below (Guo et al., 2024; Yang & Zhao, 2023):

An initial index matrix $X = [x_{ij}]$ was created, where $i = 1, \ldots, n$ represents the samples (e.g., neighborhoods) and $j = 1, \ldots, m$ represents the indicators. To remove dimensional inconsistencies, the matrix was normalized.

For positive indicators (larger values indicate higher vulnerability), the normalized value y_{ij} was calculated as shown in Equation (4):

$$y_{ij} = \frac{x_{ij} - \min(X_j)}{max(X_j) - \min(X_j)} \quad (4)$$

For negative indicators (smaller values indicate higher vulnerability), the normalized value y_{ij} was calculated as shown in Equation (5):

$$y_{ij} = \frac{max(X_j) - x_{ij}}{max(X_j) - \min(X_j)} \quad (5)$$

The proportion of the *j*-th indicator for the *i*-th sample was calculated using Equation (6):

$$p_{ij} = \frac{y_{ij}}{\sum_{i=1}^{n} y_{ij}} \quad (6)$$

The information entropy of each indicator was then computed using Equation (7):

$$H_j = -k \sum_{i=1}^{n} p_{ij} \ln(p_{ij}),\ k = \frac{1}{ln(n)} \quad (7)$$

The redundancy (degree of information) for each indicator was calculated as shown in Equation (8):

$$d_j = 1 - H_j \quad (8)$$

The weight of each indicator was obtained using Equation (9):

$$w_j = \frac{d_j}{\sum_{i=1}^{m} d_j} \quad (9)$$

This procedure ensures that indicators with greater variability across neighborhoods contribute more to the overall heat vulnerability index. All calculations were performed in Excel using these formulas. In this study, the Equal Weighting method was used to calculate the Exposure, Sensitivity, and Adaptive Capacity indices and to construct the final HVI. The Entropy Weighting Method was applied separately to the same set of indicators to generate an alternative HVI as a robustness check. Therefore, the entropy-derived weights were not used in the calculation of the component indices reported in the main analysis.

Mapping and Spatial Analysis

Following indicator weighting and aggregation, spatial integration was performed in QGIS to visualize the neighborhood-level HVI across Esenler. Raster exposure layers (LST, NDVI, NDBI; 30 m) were summarized to neighborhoods via Zonal Statistics (mean) and integrated with vector socio-demographic and adaptive-capacity indicators in QGIS 3.34. The resulting Equal-weighted HVI map illustrates the spatial distribution of heat vulnerability across Esenler District. To evaluate the robustness of the results, an additional set of HVI values was generated using the Entropy Weighting Method. Statistical agreement metrics, including mean difference, standard deviation of differences, and the Pearson correlation coefficient, were calculated to quantify the agreement between the two methods. This comparison enabled the evaluation of how weighting approaches influence vulnerability outcomes and ensured consistency in the identified high-risk neighborhoods.

Heat Vulnerability–Adaptive Capacity Priority Matrix

To support climate adaptation planning, neighborhoods were prioritized through the combined assessment of the Heat Vulnerability Index (HVI) and Adaptive Capacity (AC). This approach follows vulnerability assessment frameworks that emphasize the interaction between vulnerability and adaptive capacity in determining adaptation needs and intervention priorities (IPCC, 2022; Inostroza et al., 2016). The prioritization framework was designed to identify neighborhoods requiring different levels of intervention according to both their heat vulnerability and their capacity to respond to climate-related risks.

Priority levels were assigned using a decision matrix that integrated neighborhood-level HVI scores with AC classes. The HVI results were first classified into three vulnerability categories (low, medium, and high) using the Natural Breaks (Jenks) classification method, and these classes were subsequently combined with adaptive capacity categories to define adaptation priorities. The matrix generated five priority categories representing different levels of adaptation urgency. Priority 1 corresponds to neighborhoods characterized by high vulnerability and low adaptive capacity, indicating the greatest need for immediate intervention. Priority 2 and Priority 3 represent neighborhoods with high vulnerability but varying levels of adaptive capacity, requiring short-term interventions or continuous monitoring. Priority 4 corresponds to areas with relatively low vulnerability and higher adaptive capacity, while Priority 5 represents neighborhoods with the lowest vulnerability and highest adaptive capacity, where resilience maintenance and periodic monitoring are considered sufficient. The resulting priority categories were subsequently mapped to visualize the spatial distribution of adaptation priorities across Esenler District.

RESULTS

Before integrating exposure, sensitivity, and adaptive capacity into a composite HVI, the individual components were examined to explore their spatial variability and underlying drivers across the Esenler District. The analysis highlights substantial variability in thermal, demographic, and socio-economic conditions, revealing patterns that shape neighborhood-level vulnerability to heat.

Exposure Index

Neighborhood-level analysis of LST, NDVI, and NDBI revealed distinct spatial heterogeneity across Esenler District (Table 4). Mean LST values ranged from 42.39°C in N1 to

45.92°C in N9, indicating a temperature difference of more than 3 °C between the coolest and hottest neighborhoods. NDVI values varied between 0.05 and 0.17, while NDBI ranged from -0.04 to 0.08. Higher LST values corresponded with lower NDVI and higher NDBI values; for instance, N9 recorded an average LST of 45.92 °C with NDVI = 0.05 and NDBI = 0.06. Conversely, N1, with NDVI = 0.15 and NDBI ≈ 0.00, exhibited relatively lower surface temperatures. Maps of the individual exposure indicators (LST, NDVI, and NDBI) are provided in Appendix B.

The spatial distribution of the exposure index derived using the Equal Weighting approach (Figure 3) further visualizes this relationship, forming a clear gradient from low to high exposure across neighborhoods. Lighter yellow areas (index ≤ 0.25) represent zones with lower heat exposure, while dark red tones (index > 0.74) denote highly exposed regions. The central and northwestern neighborhoods exhibit the most intense exposure levels, corresponding to high built-up density and limited green cover. In contrast, peripheral zones such as N1 and N17 display relatively moderate to low exposure levels, where greater vegetation coverage contributes to local cooling effects. This spatial gradient provides a visual confirmation of how land surface composition and vegetation patterns shape the microclimatic variability across Esenler.

Sensitivity Index

Socio-demographic indicators used to assess sensitivity show substantial variability among neighborhoods (Table 5). Population density averages 516 persons/ha (SD = 268), reflecting the district's compact urban form, which can intensify exposure to heat. Vulnerable age groups constitute a moderate share of the population: children account for 6.17% and the elderly for 5.74%. The proportion of women is relatively balanced at 47.84%, while educational attainment levels suggest limited adaptive awareness: 1.77% of residents are illiterate, and 67.11% have only a basic education.

The spatial distribution of the sensitivity index (Figure 4) reveals a pronounced north–south gradient across Esenler. Neighborhood N2 shows the lowest sensitivity (index ≤ 0.22), while N9, N10, N13, and N14 display the highest sensitivity values (index ≥ 0.61). The spatial clustering of high sensitivity in the central and southern neighborhoods corresponds to densely populated areas with lower education levels, as detailed in Table 1.

Adaptive Capacity Index

Indicators of adaptive capacity reflect socio-economic and infrastructural resources available to mitigate heat-related risks (Table 6). The mean household income is 16.07 thousand TRY, ranging from 13.29 to 18.71 thousand TRY, re-

Table 4. Neighborhood-level exposure indicators in Esenler (LST, NDVI, NDBI).

Neighbourhoods	LST (Min)	LST (Max)	LST (Mean)	LST (SD)	NDVI (Min)	NDVI (Max)	NDVI (Mean)	NDVI (SD)	NDBI (Min)	NDBI (Max)	NDBI (Mean)	NDBI (SD)
N1	37.42	48.32	42.39	1.91	-0.0198	0.3869	0.15	0.07	-0.2066	0.1333	0.002	0.05
N2	37.72	45.7	42.56	1.36	-0.0059	0.3864	0.11	0.08	-0.2307	0.1767	-0.01	0.05
N3	42.06	48.08	45.84	1.01	0.0184	0.1523	0.05	0.01	-0.0711	0.1341	0.06	0.03
N4	39.37	46.84	44.28	1.76	0.007	0.3697	0.07	0.05	-0.1836	0.1266	0.02	0.05
N5	39.75	48.17	44.49	1.7	0.0255	0.4525	0.11	0.07	-0.1891	0.1322	0.008	0.06
N6	40.96	47.86	44.99	1.51	0.0074	0.3862	0.09	0.06	-0.1714	0.1277	0.02	0.06
N7	41.52	47.99	44.84	1.26	-0.0068	0.3608	0.09	0.07	-0.1702	0.1801	0.02	0.07
N8	40.21	46.7	44.43	1.28	0.0024	0.3948	0.09	0.07	-0.1672	0.1642	0.02	0.07
N9	43.98	48.33	45.92	0.76	-0.0068	0.2492	0.05	0.02	-0.1485	0.1447	0.06	0.04
N10	43.92	47.99	45.52	0.76	0.0121	0.2378	0.05	0.02	-0.0897	0.1471	0.06	0.03
N11	42.09	47.04	44.92	1.02	0.0023	0.2906	0.06	0.03	-0.1256	0.1713	0.05	0.04
N12	42.88	47.62	45.05	1.11	-0.0081	0.2287	0.06	0.04	-0.1135	0.1187	0.01	0.04
N13	42.96	45.88	44.11	0.47	0.0243	0.1011	0.05	0.01	-0.0084	0.1454	0.08	0.03
N14	42.63	46.73	45.05	0.73	0.0178	0.2212	0.05	0.02	-0.0944	0.1903	0.07	0.03
N15	43.71	46.19	45.27	0.43	-0.0012	0.2387	0.07	0.03	-0.0973	0.1455	0.05	0.04
N16	43.19	45.89	44.68	0.49	0.0229	0.2821	0.06	0.03	-0.1143	0.1481	0.06	0.04
N17	37.9	45.98	42.75	1.8	-0.0153	0.4018	0.17	0.08	-0.226	0.179	-0.04	0.06

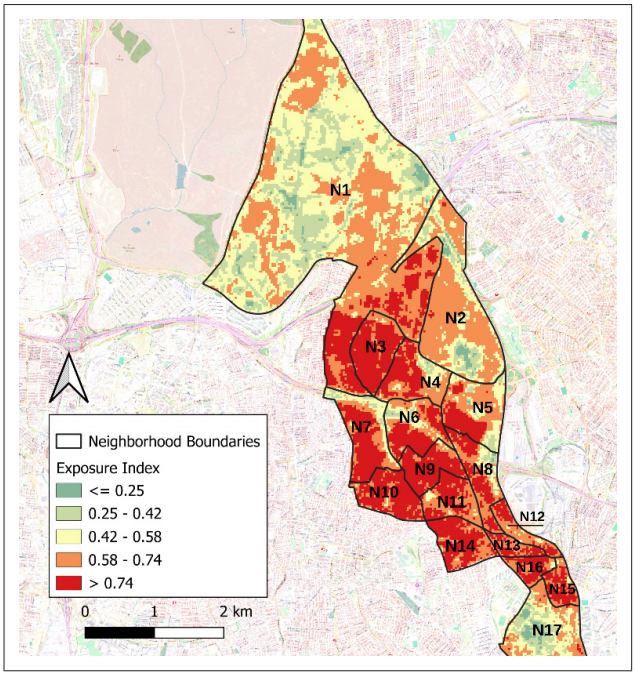

Figure 3. Spatial distribution of exposure index across neighborhoods in Esenler District, integrating LST, NDVI, and NDBI to illustrate variations in thermal stress (Design by Authors).

vealing income disparities across neighborhoods. Green space availability is notably limited, averaging 3.50 m²/person (SD = 5.45), with several neighborhoods containing almost no vegetated areas. Health infrastructure accessibility is also low, with an average of 0.12 health institutions per 1,000 people, suggesting limited service capacity. Higher education levels range from 2.85% to 14.8%, averaging 10.72%.

Substantial variation is also evident in the distribution of environmental and infrastructural resources across neighborhoods. While N2 and N17 exhibit comparatively higher green area per capita (22.84 m² and 5.9 m² per person, respectively), densely populated neighborhoods such as N9, N10, N14, and N16 possess less than 0.2 m² per person, indicating severe shortages of cooling and recreational spaces. Healthcare infrastructure also varies widely, from neighborhoods such as N17, N6, and N8 (0.45, 0.19, and 0.12 facilities per 1,000 people, respectively) to those lacking any institutions, such as N2 and N12 (Table 7). These disparities highlight unequal access to adaptive resources and support services that may constrain the capacity of some neighborhoods to cope with heat-related risks. The complementary buffer analysis further indicated generally good walkable accessibility across neighborhoods, suggesting that while per-capita variation reflects structural provision within administrative boundaries, actual use patterns may extend beyond them. Together, these metrics provide a more comprehensive representation of adaptive capacity by capturing both the structural availability and functional accessibility of key urban infrastructure that supports resilience to heat stress.

Table 5. Sensitivity indicators describing socio-demographic characteristics of the district.

Indicator	Min	Max	Mean	SD
Population Density	18.7	810.8	516.01	268
% Children	4.92	7.20	6.17	0.59
% Elderly	3.84	8.41	5.74	1.33
% Female	37.65	49.76	47.84	2.84
Illiteracy	0.24	2.5	1.77	0.53
Basic Education	34.7	82	67.11	9.34

The adaptive capacity index map (Figure 5) illustrates these differences spatially, showing that neighborhoods N1, N3, N7, and N10 have the lowest capacity (index = 0.17–0.26), while N17 exhibits the highest (0.64). Lower-income areas with limited green space and healthcare access correspond with reduced adaptive capacity.

Equal-weighted HVI

Following normalization and alignment of all indicators, the composite HVI was computed using the Equal Weighting Method, where exposure, sensitivity, and adaptive capacity contributed equally to the final score:

$$HVI = \frac{Exposure + Sensitivity - Adaptive\ Capacity}{3}$$

Raster-based exposure data were summarized using zonal statistics to ensure comparability with vector-based socio-economic indicators. Resulting HVI values range from 0.068 to 0.414, reflecting considerable intra-district variation (Figure 6). Neighborhoods N2 and N17 recorded the lowest vulnerability (0.068–0.21), whereas N3, N7, N9, N10, and N14 showed the highest (0.35–0.41). Cross-referencing Table 1 and component indices reveals that these highly vulnerable neighborhoods combine multiple risk factors: N9 and N10, for instance, exhibit the highest population densities (≈790–810 persons/ha) and lower high-

Table 6. Adaptive capacity indicators describing economic, infrastructural, and educational conditions across neighborhoods.

Indicator	Min	Max	Mean	SD
Higher Education	2.85	14.8	10.72	2.65
Household Income	13.29	18.71	16.07	1.46
Green area per capita (m²/person)	0	22.84	3.50	5.45
Health Institutions per 1,000 people	0	0.45	0.12	0.10

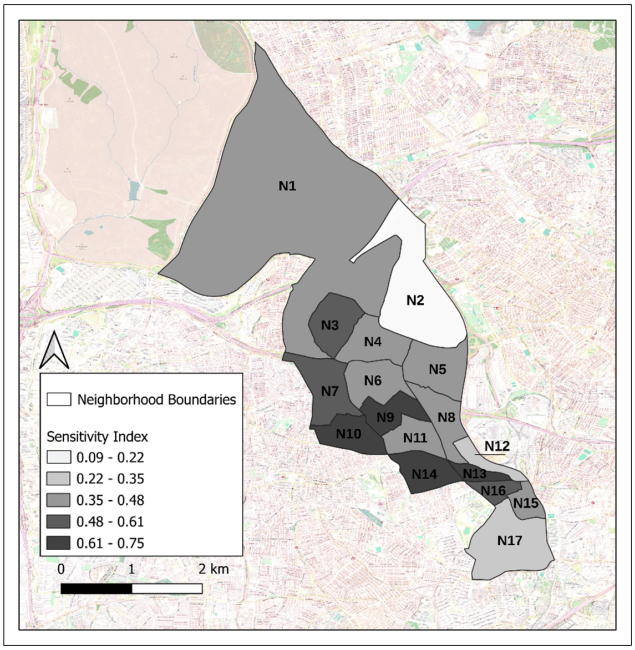

Figure 4. Spatial distribution of the sensitivity index across Esenler District, highlighting neighborhoods with higher demographic and educational vulnerability (Design by Authors).

er-education rates (≈9–11%), coupled with limited green space and higher mean LST values (≈45.5–45.9 °C). Conversely, N2 and N17, which recorded the lowest vulnerability, have lower population densities and relatively higher income levels, alongside cooler surface temperatures and greater vegetation coverage.

These neighborhoods combine high exposure and demographic sensitivity with relatively low adaptive capacity. The equal-weighted HVI map (Figure 6) provides a baseline representation of heat vulnerability across Esenler, clearly differentiating low-, medium-, and high-risk zones. These vulnerability classes were derived using the Natural Breaks (Jenks) classification method, which identifies statistically meaningful thresholds based on the distribution of HVI values. Although this approach assumes equal contribution of each component, it offers a transparent, balanced measure that facilitates comparison between neighborhoods.

Robustness Assessment

To evaluate the reliability of the HVI, the Equal-weighted results were compared with those derived from the Entropy Weighting Method, which objectively determines indicator importance based on data variability. Table 8 presents neighborhood-level HVI values for both methods, along with differences and standardized deviations. Most neighborhoods exhibited small deviations ($|\Delta HVI| < 0.05$), indicating strong consistency between methods. Larger deviations appeared in a few central neighborhoods, notably N4, N7, and N10, where entropy weighting slightly increased vulnerability scores due to greater dispersion among indicators.

Table 7. Neighborhood-level environmental and infrastructural indicators of Esenler.

Neighborhood	ID	Green Area (m²)	Green Area per Capita (m²/person)	Health Institutions	Health Facilities per 1,000 People
Oruçreis	N1	17,437	0.50	3	0.086
15 Temmuz	N2	186,760	22.84	0	0
Turgut Reis	N3	8,574	0.19	4	0.09
Havaalanı	N4	54,671	1.63	4	0.11
Kemer	N5	44,949	2.08	1	0.046
Birlik	N6	41,282	1.57	5	0.19
Tuna	N7	62,544	1.96	2	0.062
Fevzi Çakmak	N8	22,035	0.70	4	0.12
Kazım Karabekir	N9	6,028	0.17	4	0.11
Fatih	N10	2,609	0.06	4	0.096
Menderes	N11	14,845	0.48	4	0.12
Yavuz Selim	N12	14,723	4.18	0	0
Mimar Sinan	N13	5,601	0.42	2	0.15
Nine Hatun	N14	6,448	0.16	4	0.099
Namık Kemal	N15	15,957	1.00	1	0.063
Davutpaşa	N16	0	0	1	0.063
Çifte Havuzlar	N17	13,027	5.90	1	0.45

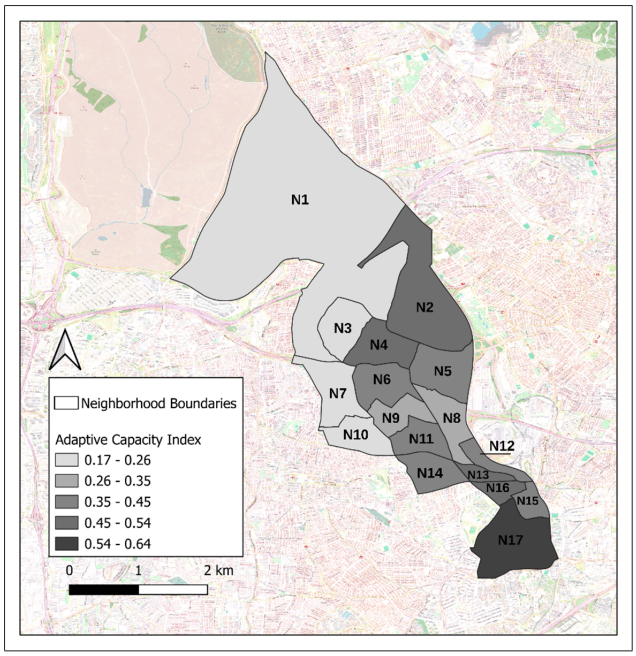

Figure 5. Spatial distribution of the adaptive capacity index across Esenler District, showing higher resilience in darker areas and lower capacity in lighter areas (Design by Authors).

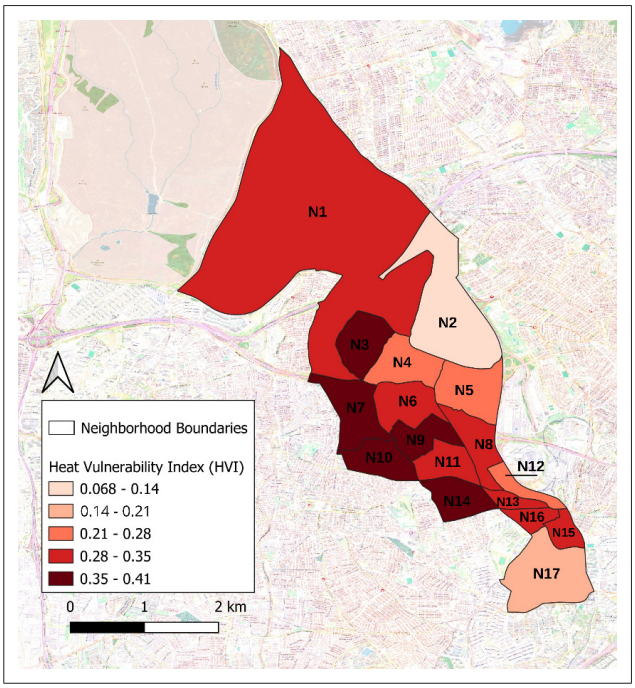

Figure 6. Spatial distribution of the Heat Vulnerability Index (HVI) across Esenler District, illustrating neighborhood-level variations in vulnerability based on exposure, sensitivity, and adaptive capacity indicators (Design by Authors).

Summary statistics (Table 9) show a mean difference of 0.017, a standard deviation of 0.049, and a Pearson correlation coefficient of r = 0.94 ($p<0.001$), confirming strong statistical agreement between the two weighting approaches. This high correlation demonstrates that the equal-weighted HVI reliably represents neighborhood-level heat vulnerability while

Table 8. Validation statistics indicating consistency and reliability between Equal- and Entropy-weighted HVI results.

Neighborhood	Equal-weighted HVI	Entropy-weighted HVI	Difference (Entropy – Equal)	Standardized Deviation (SD)
N1	0.599	0.594	-0.005	-0.022
N2	0.151	0.216	0.065	0.048
N3	0.689	0.696	0.007	-0.010
N4	0.515	0.601	0.086	0.069
N5	0.574	0.582	0.008	-0.009
N6	0.584	0.575	-0.009	-0.026
N7	0.690	0.770	0.080	0.063
N8	0.604	0.624	0.020	0.003
N9	0.670	0.694	0.024	0.007
N10	0.685	0.775	0.090	0.073
N11	0.583	0.585	0.002	-0.015
N12	0.525	0.547	0.022	0.005
N13	0.589	0.627	0.038	0.021
N14	0.646	0.661	0.015	-0.002
N15	0.602	0.584	-0.018	-0.035
N16	0.573	0.548	-0.025	-0.042
N17	0.428	0.315	-0.113	-0.130

Table 9. Summary statistics and validation metrics demonstrating the consistency and reliability of Equal- and Entropy-weighted HVI results across neighborhoods in Esenler District.

Metric	Formula	Value
Mean Difference	$\bar{d}_{=} \frac{\sum(HVI_{entropy} - HVI_{equal})}{n}$	0.017
Standard Deviation of Differences	$s = \sqrt{\frac{\sum(d_i - \bar{d})^2}{n-1}}$	0.049
Mean Absolute Difference (MAD)	$MAD = \frac{\sum(HVI_{entropy} - HVI_{equal})}{n}$	0.0369
Pearson Correlation Coefficient	$r = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum(x_i - \bar{x})^2 \sum(y_i - \bar{y})^2}}$	p <0.001)

maintaining simplicity and transparency. The close spatial correspondence between the two HVI values validates the robustness of the applied framework and supports its use for further spatial and temporal analyses of heat vulnerability.

DISCUSSION

The analysis reveals that Esenler's most densely built and socio-economically disadvantaged neighborhoods exhibit the highest heat vulnerability, whereas areas with greater green space or improved infrastructure display lower vulnerability. In particular, clusters of extreme heat risk were observed in neighborhoods combining high land surface temperatures with low adaptive capacity. This pattern directly addresses Research Question 1, revealing that dense urban form and social disadvantage jointly produce localized hotspots of heat risk, while urban greenery and improved amenities can buffer against extreme heat. Hence, heat vulnerability in Esenler arises from the compound effects of physical exposure and social inequality, highlighting the need for targeted, equity-focused adaptation strategies. This finding is consistent with recent research in Istanbul, which demonstrates that urban heat vulnerability is fundamentally shaped by socio-spatial inequalities, where densely built environments, high population densities, and limited access to cooling resources disproportionately increase heat risk in disadvantaged communities (Okumuş, 2025).

Spatial Patterns of Heat Vulnerability

In Esenler, neighborhoods with the highest Land Surface Temperatures (LSTs), notably N3, N7, N9, and N10, also exhibit limited vegetation and low adaptive capacity. This overlap of dense urban morphology and socio-economic disadvantage illustrates how physical exposure and social sensitivity reinforce each other, creating concentrated heat-risk hotspots. Such an interplay mirrors broader findings from Istanbul (Yılmaz et al., 2024) and other global cities (Li et al., 2025; Parker et al., 2025; Chen et al., 2025b), where the co-occurrence of built-up density, poverty, and insufficient greenery produces clusters of vulnerability. Similar patterns were reported by Inostroza et al. (2016), who found that highly vulnerable neighborhoods in Santiago were characterized by the combined effects of elevated heat exposure, limited green infrastructure, and lower adaptive capacity, reinforcing the importance of assessing vulnerability through the interaction of exposure, sensitivity, and adaptive capacity. Likewise, Okumuş (2025) identified land surface temperature, population density, and building compactness as the dominant drivers of urban heat vulnerability in Istanbul, while green spaces and cooling infrastructure exerted significant mitigating effects. These findings closely align with the spatial patterns observed in Esenler, where neighborhoods characterized by high surface temperatures, dense urban form, and limited adaptive resources exhibited the highest vulnerability levels.

These outcomes align with the IPCC's conceptualization of vulnerability as a product of exposure, sensitivity, and adaptive capacity (IPCC, 2022). In Esenler, limited green space and lower-income levels clearly compound the population's exposure to heat. The district's scarcity of green areas (averaging only ~3.5 m² per person) and its concentrated low-income population jointly reduce resilience, while high population density amplifies anthropogenic heat emissions and inhibits natural ventilation. This spatial inequality in adaptive resources corresponds to the 'green divide' described by Yazar et al. (2023), wherein recent urban regeneration projects have improved microclimates in some zones, while leaving older, denser areas still exposed. Similar disparities were identified by Wang et al. (2025), who showed that urban greening initiatives in New York disproportionately benefited high-income areas, intensifying existing heat vulnerabilities in low-income districts. Macharia and Kiage (2025) similarly found that areas with limited vegetation and high impervious cover in Reno exhibited elevated heat exposure and social vulnerability, reinforcing the global pattern that unequal land-cover dynamics amplify heat risk in marginalized communities.

Overall, our results highlight that urban heat vulnerability is not merely an environmental issue; it reflects the cumulative effects of long-standing unequal planning and socio-economic stratification. The case of Esenler demonstrates how morphological compactness and limited adaptive infrastructure can translate social disadvantage into climatic risk. Addressing heat risk, therefore, requires integrated strategies that span urban planning, public health, and social equity. In other words, efforts must move beyond only physical heat mitigation toward a more systemic approach to building urban resilience.

Influence of Weighting Methods

Addressing Research Question 2, the Comparison between Equal and Entropy weighting methods provides a robustness check of the HVI approach. A high Pearson correlation ($r = 0.94$, $p<0.001$) and a very small mean difference (0.017) between the two sets of results indicate that both weighting schemes yielded nearly identical spatial patterns of vulnerability. This strong agreement suggests that the underlying vulnerability structure in Esenler is robust and not an artifact of any particular weighting choice.

The entropy-weighted HVI did slightly amplify the scores in neighborhoods where indicator variability was greater, particularly in socio-economically diverse areas such as N4 and N10. This reflects the Entropy method's data-driven nature, which assigns greater influence to indicators with higher informational dispersion (Guo et al., 2024). Similar to Chen et al. (2025b), who emphasized the objectivity and data-driven robustness of the Entropy Weight Method in minimizing human bias, our findings confirm that EWM can enhance methodological transparency in vulnerability assessment. Additionally, Li et al. (2025) noted that explicit and statistical weighting approaches often introduce subjectivity or fail to capture non-linear relationships among indicators, underscoring the value of objective, information-based weighting techniques like EWM. Nevertheless, the minimal deviations observed confirm that even a simple equal-weighting scheme provides reliable outcomes for a small-area dataset.

This comparative analysis strengthens confidence in the robustness of the Equal-weighted HVI map. Applying Equal Weighting for its transparency and Entropy Weighting as an objective robustness check provides a useful framework for urban studies in data-limited contexts.The demonstrated stability across weighting schemes establishes a solid methodological foundation for constructing vulnerability indices that can be replicated in other districts of Istanbul or similar urban contexts. Overall, the high consistency between methods validates the robustness of the HVI framework and provides a sound basis for the spatial and planning analyses discussed in the following section.

Implications for Climate Adaptation

Building on the third research question, which examines what specific adaptation interventions the HVI identifies as priorities for different neighborhoods in Esenler, this section translates the spatial findings into actionable urban and policy interventions. The HVI results clearly identify clusters of high vulnerability, particularly in neighborhoods N3, N7, N9, N10, and N14, where limited vegetation and socio-economic disadvantage coincide. These high-risk zones represent priority areas for targeted adaptation efforts.

Applying the HVI–AC Priority Matrix described in Section 2.2.5 resulted in five adaptation priority categories across Esenler (Table 10; Figure 7). Priority 1 areas (N3, N7, and N10) combine the highest HVI values with the lowest adaptive capacity, identifying critical hotspots that demand immediate adaptation measures. Priority 2 neighborhoods (N1, N8, N9, and N14) exhibit high vulnerability coupled with limited adaptive capacity, indicating the need for targeted short-term interventions. Priority 3 neighborhoods represent areas where moderate adaptive capacity partially offsets high vulnerability, suggesting that continuous monitoring and incremental resilience-building measures are appropriate. Priority 4 areas, represented by N2, exhibit relatively low vulnerability and higher adaptive capacity, indicating that existing resilience should be maintained through routine planning measures. Finally, Priority 5 (N17) corresponds to the neighborhood with the lowest vulnerability and highest adaptive capacity, where periodic monitoring and the preservation of existing resilience conditions are considered sufficient.

This prioritization framework provides a spatially explicit basis for staging adaptation actions and allocating resources according to neighborhood-specific needs. Similarly, Okumuş (2025) emphasizes that effective urban heat adaptation requires integrating ecological measures, such as urban greening, with socio-infrastructural interventions, including cooling facilities and public services, highlighting the importance of multi-dimensional and equity-oriented adaptation strategies. By integrating both vulnerability and adaptive capacity, the matrix moves beyond identifying areas of risk and supports the development of targeted and equitable adaptation strategies across Esenler District.

Based on the prioritization outcomes summarized in Table 10, adaptation efforts in Esenler should focus first on the highest-risk neighborhoods (Priority 1–2), while reinforcing resilience in lower-priority zones through sustainable, small-scale interventions. Expanding urban greenery emerges as the most critical and immediate mitigation strategy (Parker et al., 2025; Shartova et al., 2024). Numerous studies have confirmed that increasing urban vegetation can reduce local surface and air temperatures (Parker et al., 2025; Kim et al., 2023). In Esenler, where impervious surfaces account for nearly 80% of total land cover, as reflected by predominantly positive NDBI values (0.02–0.08) across most neighborhoods, large-scale park development is severely constrained. Although a few zones, such as N1 and N17, show slightly negative NDBI values due to institutional or vegetated land, these represent minor exceptions in an otherwise compact urban landscape. Consequently, distributed, small-scale greening emerges as the most feasible and context-sensitive adaptation strategy. In Esenler, the implementation of such measures could be integrated into ongoing municipal urban regeneration, streetscape improvement, and public-space enhancement programs. Given the district's limited availability of vacant land, local authorities may achieve greater benefits by prioritizing street-tree planting, schoolyard

Table 10. Neighborhood Prioritization Matrix for Climate Adaptation in Esenler District.

Neighborhood	HVI	Vulnerability Class	AC Index	AC Class	Priority Level	Interpretation
N1	0.599	High	0.17–0.26	Low	Priority 2	High vulnerability but slightly lower HVI than critical hotspots; very low AC (Short-term intervention)
N2	0.151	Low	0.45–0.54	Medium-High	Priority 4	Low vulnerability and higher AC (Maintain resilience)
N3	0.689	High	0.17–0.26	Low	Priority 1	Highest HVI and lowest AC (Immediate action)
N4	0.515	High	0.45–0.54	Medium-High	Priority 3	High vulnerability but above-average AC (Monitor)
N5	0.574	High	0.35–0.45	Medium	Priority 3	High HVI but moderate AC (Monitor)
N6	0.584	High	0.35–0.45	Medium	Priority 3	Moderate AC balances high vulnerability (Monitor)
N7	0.690	High	0.17–0.26	Low	Priority 1	Extreme vulnerability and lowest AC (Immediate action)
N8	0.604	High	0.26–0.35	Medium-Low	Priority 2	High HVI + limited AC (short-term interventions)
N9	0.670	High	0.26–0.35	Medium-Low	Priority 2	High vulnerability + weak AC (Short-term intervention)
N10	0.685	High	0.17–0.26	Low	Priority 1	High HVI + lowest AC (Immediate action)
N11	0.583	High	0.35–0.45	Medium	Priority 3	High HVI but moderate AC (Monitor)
N12	0.525	High	0.35–0.45	Medium	Priority 3	High HVI but adequate AC (Monitor)
N13	0.589	High	0.45–0.54	Medium-High	Priority 3	High HVI but strong AC (Monitor)
N14	0.646	High	0.35–0.45	Medium	Priority 2	High HVI + moderate AC (Short-term intervention)
N15	0.602	High	0.35–0.45	Medium	Priority 3	High HVI but moderate AC (Monitor)
N16	0.573	High	0.45–0.54	Medium-High	Priority 3	High HVI offset by higher AC (Monitor)
N17	0.428	Medium	0.54–0.64	High	Priority 5	Lowest vulnerability + highest AC (maintain and monitor)

greening, courtyard retrofits, façade greening, and the conversion of underutilized spaces into pocket parks within the neighborhoods identified as Priority 1 and Priority 2. The HVI–Adaptive Capacity Priority Matrix developed in this study can support municipal decision-makers in targeting these interventions where adaptation needs are greatest. Ma et al. (2023) show that small pocket parks (~2,000 m²) cool the air by ~0.4–1.1 °C, extend ~100 m beyond their edges, and boost comfort. A 50% increase in trees cuts daytime PET by ~2.1–2.8 °C. Similarly, Ren et al. (2021) demonstrate that increasing street tree density significantly enhances pedestrian-level comfort, raising canopy cover lowered mean radiant temperature by 13–17 °C and reduced PET by up to 10 °C, confirming the strong cooling benefits of even modest green additions. Complementing these findings, Zhou et al. (2025a) reported that pocket parks ranging from 1,000–9,000 m² in Shanghai decreased air temperature by ~1.2 °C and improved thermal comfort, with greater canopy height and uneven tree distribution amplifying these effects. Unlike Istanbul's lower-density districts, where new urban parks remain feasible, Esenler's adaptation requires micro-scale, embedded greenery integrated into the existing built form. Yılmaz et al. (2024) demonstrated that strategically distributed vegetation can provide significant cooling effects even in areas with limited space. This finding reinforces that context-sensitive and modular greening represents the most practical approach to mitigating urban heat within Esenler's densely built environment.

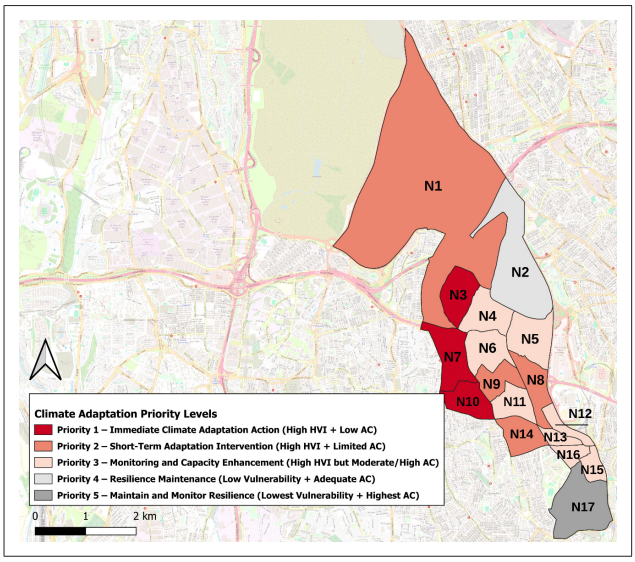

Figure 7. Neighborhood adaptation priority categories derived from the Heat Vulnerability Index–Adaptive Capacity (HVI–AC) Priority Matrix (Design by Authors).

Crucially, spatial interventions should be integrated with socio-economic support mechanisms to protect the most vulnerable residents. Localized Heat Action Plans should prioritize low-income households, older adults, children, and people with chronic health conditions. As demonstrated in several global cities, such frameworks combine early warning systems, accessible cooling centers, resource distribution, and targeted health outreach to reduce heat risks (Uejio et al., 2024; Randazza et al., 2023). Cooling centers, when equitably located and supported by outreach, remain a proven, low-cost measure to lessen heat burden (Bedi et al., 2022; Berisha et al., 2017). Aligning spatial heat-risk mapping with public health and social services can shift municipalities from reactive response to proactive prevention, embedding equity and resilience into local adaptation systems.

At the governance level, Esenler's experience highlights the need to mainstream heat adaptation within Istanbul's broader urban resilience and disaster risk management frameworks. Despite growing policy awareness of climate impacts, extreme heat remains marginally addressed in Türkiye's national and municipal disaster plans, with limited actionable guidance. Integrating heat-risk considerations into urban planning regulations, design standards, and municipal budgeting processes is therefore critical to close this institutional gap, as also emphasized in recent policy analyses highlighting the absence of coordinated frameworks for managing urban heat in Türkiye (Tokaç, 2025). District-level vulnerability maps, such as the HVI produced by this study, can serve as actionable decision-support tools by identifying priority areas for intervention and optimizing the allocation of resources for heat adaptation. City officials could use these maps to target zones for new parks, enhanced infrastructure, or focused social support. For Esenler Municipality, this may include incorporating heat-vulnerability criteria into neighborhood-scale investment decisions, prioritizing adaptation funding for high-risk areas, and coordinating heat-related interventions across planning, environmental management, public health, and social-support departments. Such an approach would help translate vulnerability assessment results into operational planning and resource-allocation decisions. The spatial distribution of heat vulnerability and adaptive capacity observed in Esenler highlights the importance of incorporating equity considerations into future adaptation planning. Similar concerns have been raised by Wang et al. (2025), who demonstrated that urban greening initiatives often disproportionately benefit wealthier districts, worsening supply–demand mismatches and reinforcing socio-ecological inequalities. Their findings underscore the need for policies that explicitly integrate equity considerations into green infrastructure planning to ensure that adaptation investments are directed toward the neighborhoods with the greatest need.

Equity must guide adaptation; the IPCC emphasizes that climate-resilient development requires prioritizing risk reduction, equity, and justice via inclusive governance (IPCC, 2022). In Istanbul, neighborhoods such as Esenler illustrate how socio-economically disadvantaged communities may experience disproportionately higher exposure to heat-related risks, raising important concerns regarding equity in climate adaptation planning. Establishing dedicated adaptation funds or incentives for vulnerable districts and involving residents in participatory planning can ensure that interventions are both adequately financed and tailored to community needs. Such inclusive governance mechanisms would help ensure that local perspectives inform project design and implementation, improving both the fairness and effectiveness of heat adaptation initiatives.

Finally, the Esenler case offers transferable lessons for other rapidly urbanizing cities facing similar challenges. The spatial and socio-environmental characteristics observed in Esenler, marked by dense construction, limited greenery, and low adaptive capacity, are not unique but mirror conditions commonly found in other rapidly growing urban districts. The approach taken in this study, which integrates spatial data with socio-demographic indicators and uses a comparative weighting analysis, provides a replicable model for identifying heat-vulnerable zones in these urban settings. Embedding such vulnerability assessment frameworks into routine urban management and climate action plans can help cities anticipate and mitigate the growing heat risks under a warming climate. Proactively employing data-driven tools to pinpoint hotspots and guide interventions will become increasingly important as extreme heat events become more frequent and intense.

Limitations and Future Directions

Despite its contributions, this study has several limitations. The first limitation concerns the accuracy, temporal scope, and resolution of the Landsat 8–derived LST data. While the 30 m spatial resolution provides valuable insights into neighborhood-scale heat variations, it may not capture micro-scale temperature heterogeneity in Esenler's densely built environment, such as narrow streets, courtyards, or rooftop surfaces. Additionally, the analysis relied on a single-date LST map (13 August 2024) representing peak summer conditions. Although this snapshot effectively identifies spatial hotspots, it limits the generalizability of findings, as it may not capture seasonal dynamics, interannual variability, nighttime heat retention, or extreme heatwave events. Future research could integrate multi-temporal or seasonal satellite imagery, complemented by ground-based temperature monitoring, to improve the temporal robustness and accuracy of heat exposure assessments. A second limitation relates to the spatial aggregation of data at the neighborhood level. Although this scale supports administrative and planning applications, it can obscure intra-neighborhood variations, especially in compact areas where vulnerability may fluctuate significantly over short distances. Future research could adopt parcel- or block-level analyses to better capture spatial inequities and micro-scale heat risks.

Another important limitation involves missing data on building characteristics and health outcomes. Neighborhood-scale information on housing quality, construction materials, energy use, or heat-related morbidity was unavailable. Because neighborhood-level health outcome data are not publicly accessible, this study could not validate the HVI results against observed heat-related illness or mortality patterns. The absence of such data may lead to an underestimation of vulnerability in low-income or poorly built neighborhoods. Incorporating these variables in future assessments would enable a more comprehensive and empirically grounded representation of both structural and physiological vulnerability. Lastly, this study primarily emphasizes structural and environmental indicators, without directly addressing behavioral adaptations or community-level coping strategies that shape lived heat experiences. Integrating qualitative methods, such as interviews or focus groups, would help connect statistical vulnerability with human perception and adaptation behaviors.

In summary, while this research demonstrates the utility of combining Equal and Entropy Weighting in a multi-dimensional HVI framework, its findings should be interpreted in light of data and scale constraints. This study contributes a localized and data-driven assessment that fills a critical gap in Istanbul's urban climate literature, where comprehensive, neighborhood-scale analyses of heat vulnerability have been lacking, particularly for socio-economically disadvantaged districts such as Esenler. Addressing current limitations through finer-resolution, interdisciplinary, and participatory approaches will further strengthen the precision, inclusivity, and policy relevance of future urban heat resilience planning in Esenler, Istanbul, and comparable high-density urban districts.

CONCLUSION

This study developed a comprehensive, neighborhood-scale HVI for Esenler District, Istanbul, integrating environmental exposure, socio-demographic sensitivity, and adaptive capacity within the IPCC vulnerability framework. By combining Equal and Entropy Weighting Methods, it provided both a transparent baseline and a data-driven robustness assessment of indicator weighting, enhancing the robustness and interpretability of vulnerability outcomes. The results reveal pronounced spatial disparities, with vulnerability concentrated in densely built, low-income neighborhoods characterized by limited greenery and reduced adaptive capacity. Beyond its empirical findings, this research contributes methodologically by localizing and comparing alternative weighting approaches within Istanbul's context, addressing a gap in the city's heat-vulnerability literature, which has largely lacked neighborhood-level analyses and comparative weighting assessments. The strong agreement between Equal Weighting and Entropy Weighting results demonstrates that the proposed framework produces robust and consistent vulnerability patterns while remaining transparent and replicable. The Entropy Weighting Method further proved suitable for heterogeneous, small-sample urban datasets, offering a practical complementary approach for similar data-constrained urban environments. The findings underscore the need for targeted climate adaptation strategies, prioritizing green infrastructure expansion, equitable distribution of cooling resources, and socio-economic capacity building in the most heat-vulnerable neighborhoods. The proposed framework is transferable to other districts and cities, as it draws on widely accessible spatial and socio-demographic datasets and adaptable indicator categories consistent with the IPCC structure. Its modular design enables researchers and planners to calibrate indicators, weights, and thresholds according to local data and policy contexts, enhancing replicability across diverse urban settings. Ultimately, this study provides an evidence-based framework for urban heat resilience planning in Istanbul by identifying priority neighborhoods for targeted, equity-oriented adaptation interventions. The HVI–Adaptive Capacity prioritization approach offers decision-makers a practical tool for directing resources toward the communities most vulnerable to heat-related risks, contributing both to Esenler's local adaptation planning and to broader efforts to support equitable climate action in rapidly urbanizing cities.

Appendix: https://jag.journalagent.com/megaron/abs_files/MEGARON-24922/MEGARON-24922_(1)_Appendix-revised.docx

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Article

Spatial analysis of sericulture and silk production in Southern Marmara Region

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Silk production; Southern Marmara; cultural heritage; spatial analysis; silkworm.

ABSTRACT

Silk production has been one of the most fundamental industrial activities shaping the economic and cultural structure of Anatolia from 130 BC to 1453 AD. The Southern Marmara Region has played a central role in the historical process of transforming silk from raw material to finished product. In this context, traditional houses, workshops, cocooning facilities, and silk factories located in the Southern Marmara Region were studied to systematically identify and document the development of silk production structures in the region through the relationship between production processes and spatial organization. Within the scope of the research, the process extending from traditional residential-scale production to industrial factories has been documented considering field studies, on-site observations, and archival documents. This study, which adopts qualitative research methods, is supported by literature data, institutional reports, interviews with local people, architectural fieldwork, and architectural documentation data. Considering the data obtained, the architectural features of silk production structures in the region, their production processes, and the social and cultural reflections of this production have been examined within a holistic framework. In conclusion, this study analyzes the heritage of silk production from an architectural perspective, offering a scientific framework based on qualitative and empirical methods for the preservation and transmission of this unique industrial heritage to future generations.

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INTRODUCTION

Silk trade, a value that has influenced the world economy from 130 BC to 1453 AD (Sheriff & Akeje, 2021), spread throughout the world, and the Silk Road trade became a focal point that countries tried to control (Alkan, 2005; Altun, 2007). China is the birthplace of silkworm domestication and the origin of silk production. China's keeping its silk production techniques a state secret for over a thousand years triggered an intense desire in the Western world to unravel this mystery (Feltham, 2009). Simple silk extraction from cocoons and weaving were also first carried out in China. Silk production became an art in China, bringing

This article is based on a PhD dissertation examining the constitution and creative potential of Gilles Deleuze's philosophy of repetition in the context of Bernard Cache's architectural practice, and prepared by Nehir Sanrı Doğan under the supervision of Prof. Dr. Çiğdem Polatoğlu Serter at the Department of Architecture, Yıldız Technical University.

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fame and great profit to the country (Tuncel et al., 1995). In this context, silk can be considered as the high technology of the pre-Industrial Revolution era due to the production of this valuable fiber requires both biological knowledge and a complex processing art.

China's absolute dominance came to an end in the 6th century AD with the rise of knowledge that transcended borders. During the reign of Byzantine Emperor Justinian, two monks smuggled silkworm eggs from China to Constantinople inside hollowed-out canes, changing the course of global technology transfer (Mola, 2000). Silk production began in Anatolia around 550 AD (Boulnois, 2004). This secret operation reduced dependence on foreign sources for silk production and paved the way for the development of local textile industries.

The Silk Road and other routes connected to this road system have historically contributed to the economic development of the regions they passed through, raising the living standards of their people, while also serving as a bridge between Eastern and Western civilizations (Figure 1). This enabled many different nations to engage meeting, trade, and cultural exchange (Günel, 2010). Long-distance trade conducted via historical road systems has also led to cross-cultural transmission between different societies (Darkhan, 2016). The most important product transported by camel train trade was silk (Drijvers, 1994).

From the 14th century onwards, Bursa became a global center where raw silk from Iran was processed and marketed to Europe (Dalsar, 1960). During the Ottoman period, caravanserais and resting complexes along the Silk Road created the architectural infrastructure that ensured the safe transportation and storage of this valuable product (İnalcık, 1994). It is known that during the Ottoman period, silk fabrics were both produced in Bursa and largely marketed through these cities (İnalcık, 2008). Silk production in Anatolia was not only a craft but also an architectural program that directly determined the settlement pattern and building forms. Especially in the 15th and 16th centuries, the silk inns in Bursa are the most concrete evidence of how the centrality of trade and production intertwined

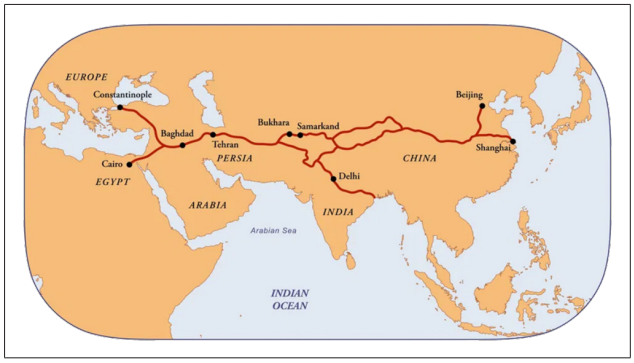

Figure 1. Silk Road (KE Adventure Travel, 2023).

with spatial design (Baykal, 1950). Access to high-quality fabrics, a symbol of luxury and status until the 18th century, was replaced by the ideal of inexpensive and practical clothing with the Industrial Revolution. In this process, textiles became not only an industry but also a locomotive connecting global trade networks, agricultural production, and technological innovation (Beckert, 2014).

The Historical and Economic Context of Silk Production in Southern Marmara Region

Sericulture is inherently dependent on mulberry trees, as mulberry leaves constitute the sole natural foods form silkworms. This dependence directly shapes the location and logistical setup of the production facilities (houses, cocooning areas, factories). In traditional sericulture houses, the lower floors or large halls are used as production areas. Mulberry trees are located right in the garden of the house or in fields very close to it. In rural areas, production begins in the raw material center where mulberry trees are most abundant. At this stage, the freshness of the leaves is vital; because mulberry leaves picked from the branch quickly wilt and lose their nutritional value (Başkaya, 2014). The placement of cocooning areas is such that it minimizes the distance of leaf transport, right on the edge of the mulberry groves or on the outskirts of the village. At the factory stage, live caterpillars are no longer involved in the process; instead, cocoons are processed. Therefore, the factory does not necessarily have to be physically close to mulberry trees. For the subsequent stages of production, the equipment located inside the structures is of great importance.

Examining the historical development of silk production buildings reveals that their spatial configurations were shaped not only by production techniques but also by the social and economic organizations in which they operated. The transition from small-scale, family-based production models to industrial organizations brought about both a diversification of building types and a redefinition of their spatial programs (Bozpınar, 2021). Production-oriented building types such as traditional houses, workshops, silkworm cocoon drying buildings and silk factories are not isolated architectural formations rather, they reveal direct spatial reflections of the transformation in economic relations. Therefore, the development of these typologies should be evaluated not only through the diversity in form, scale, and materials but also through the connection between production and social organization and market relations.

Silk production, which began in Southern Marmara using traditional methods, accelerated industrialization in the region from the 19th century onwards by integrating with the demands of the global market, changing the structure of the local workforce (especially women's employment), and transforming Bursa and its surroundings into pioneering industrial centers of Ottoman modernization. (Oral, 2004). Traditional silk production is passed down from generation

to generation as a cultural heritage. Cultural heritage is a treasure that introduces members of society to their shared past, strengthening feelings of solidarity and unity among them. It enables understanding of the experiences people have accumulated throughout history, the continuity of their shared past, and the proper planning of the future (Erkal, 1994). In other words, cultural heritage can be defined as "the totality of physically existing artifacts created by people, inherited from the past and intended to be passed on to the future for various reasons, as well as the values belonging to a society." (Çapar & Yenipınar, 2016).

The preservation and transmission of cultural heritage to future generations is possible not only through the physical maintenance of structures, but also by integrating them into contemporary social life; in this context, reuse is the process of revitalizing historical fabric by equipping it with new functions that can meet contemporary socio-economic and cultural needs without damaging its original identity and architectural values (Ahunbay, 1996). Therefore, historical structures involved in the traditional silk production process are of great importance in terms of cultural heritage.

The research problem is to address the lack of a holistic architectural reading of traditional silk production methods and traditional production structures under a single framework. In other words, the research aims to define the spatial counterparts of silk production stages by examining silk production structures holistically. The article will first describe the structures involved in the production process and their place in the production processes. Then, the architectural features of the structures and their relationships with their locations will be explained. Next, information about the production capacities of the structures will be provided.

The main objective of the research is to examine the spatial impact of silk production processes, the morphological transformation from traditional houses, workshops, and cocoon houses to silk factories, and the interaction between production and space. In addition, it aims to comprehensively examine the spatial counterparts of the technical equipment and operational processes necessary for silk production, to document the structures, to identify the technical equipment, and to explain their architectural relationships.

This study is a reference work that comprehensively defines, classifies, and spatially analyzes silk production structures. Its interdisciplinary approach to the relationship between production processes and architectural analysis makes it an important resource for both architectural history and cultural heritage. The study aims to convey the production processes of buildings, reflect their cultural heritage values, and present their architectural features.

RESEARCH METHODOLOGY

The geographical development of silk production in Türkiye has a multifaceted structure shaped by the country's natural environmental conditions, rural settlement characteristics, agricultural diversity, and regional production habits (Figure 2). The climate conditions suitable for mulberry cultivation, which are essential requirements for silkworm farming, seasonal temperature variations, humidity levels, and the topographical advantages of the production areas are the main factors determining the distribution of production throughout the country. Therefore, instead of being concentrated in a single region, silk production in Türkiye takes place with varying intensity in different geographical sub-regions, and this diverse distribution can be considered a direct reflection of the country's rich ecological structure on production (Bilgin, 2009; Öktem, 2018).

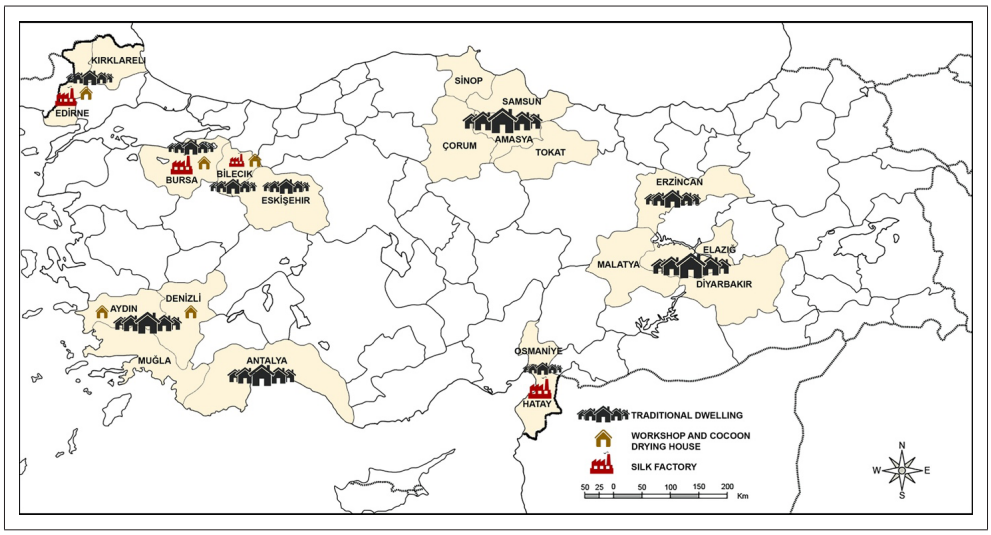

Figure 2. Map of Türkiye by showing sericulture centers (İnginar Kemaloğlu, 2023; Yıldırım, 2022) (Design by the Author, 2026).

In this study, the spatial transformation of silk production activities from traditional dwelling to factory scale is evaluated as a structural continuity encompassing all stages of production, and as a complementary whole. The importance of the research lies in describing traditional production processes through historical silk production structures and providing a detailed account of the technical equipment. This study aims to document the relationship between traditional production processes and architecture by illustrating silk production processes through architectural structures.

This research aims to conduct a comprehensive reporting study on the identified structures using observation and documentation methods (Figure 3). This includes a literature review of national and international literature, primarily focusing on industrial heritage, sericulture, and silk factories, as well as on-site visits to photograph and document the structures. Analyses were conducted on the different types of structures documented. Furthermore, the production processes of these structures have been documented, showing how the architecture was shaped by interpreting the building itself. The field research and producer interviews that constitute the methodology of the study were chosen to identify traditional production processes, which are not sufficiently documented in the literature, and to analyze the direct relationship between these processes and spatial organization. This approach allowed for the scientific recording of the technical details of the living production culture, as well as the physical texture of the structures.

In the field study conducted in the Southern Marmara Region, structures related to silk production were identified in the Bursa and Bilecik regions (Figures 4, 5, 6). Information regarding silk production and the functioning of these structures was obtained through discussions with the Bursa Eskişehir Bilecik Development Agency (BEBKA) and the Bursa Silk Cocoon Agricultural Sales Cooperatives Union (KOZABİRLİK). In addition, interviews were conducted with local people to explain the relationship between the production process and the silk production structures.

Located within Bursa's historical fabric, these factories served not only as production areas but also as vital components of the city's economic cycle during their operational period. Proximity to transportation networks, commercial markets, and labor resources was a decisive factor in the location of these factories. The settlement context now encompasses not only natural conditions but also the urban socio-economic structure. Since each of the large-scale production processes—drying, storage, sorting, spinning, weaving, and dyeing—requires a specific spatial organization, factory buildings are constructed on large plots using modular or courtyard layouts. In many of these structures, the proximity of production units ensures the continuity of the production line and provides logistical convenience. Another consequence of being in city centers is the use of innovative solutions in building materials and structural systems.

Structures related to silk production are grouped under three main headings: Traditional dwellings where silkworms were raised, silk workshops and cocoon drying buildings, and silk factories. All types of structures are involved in different processes in silk production and contribute to the overall production. The study first examines how the stages of silk production, from raw material to final product, determine the spatial organization of the structures. The structural characteristics of the buildings, such as their plan schemes, material uses, and construction techniques, are detailed. In addition to the physical boundaries of the space, the decisive role of the settlement in which the buildings are located on the architectural character is emphasized.

The research examines traditional houses, workshops, cocoon drying houses, and silk factories involved in the silk production process. A spatial analysis of the structures



Figure 3. Map of site visit in the Southern Marmara Region (Google Earth, prepared by the Author, 2026).

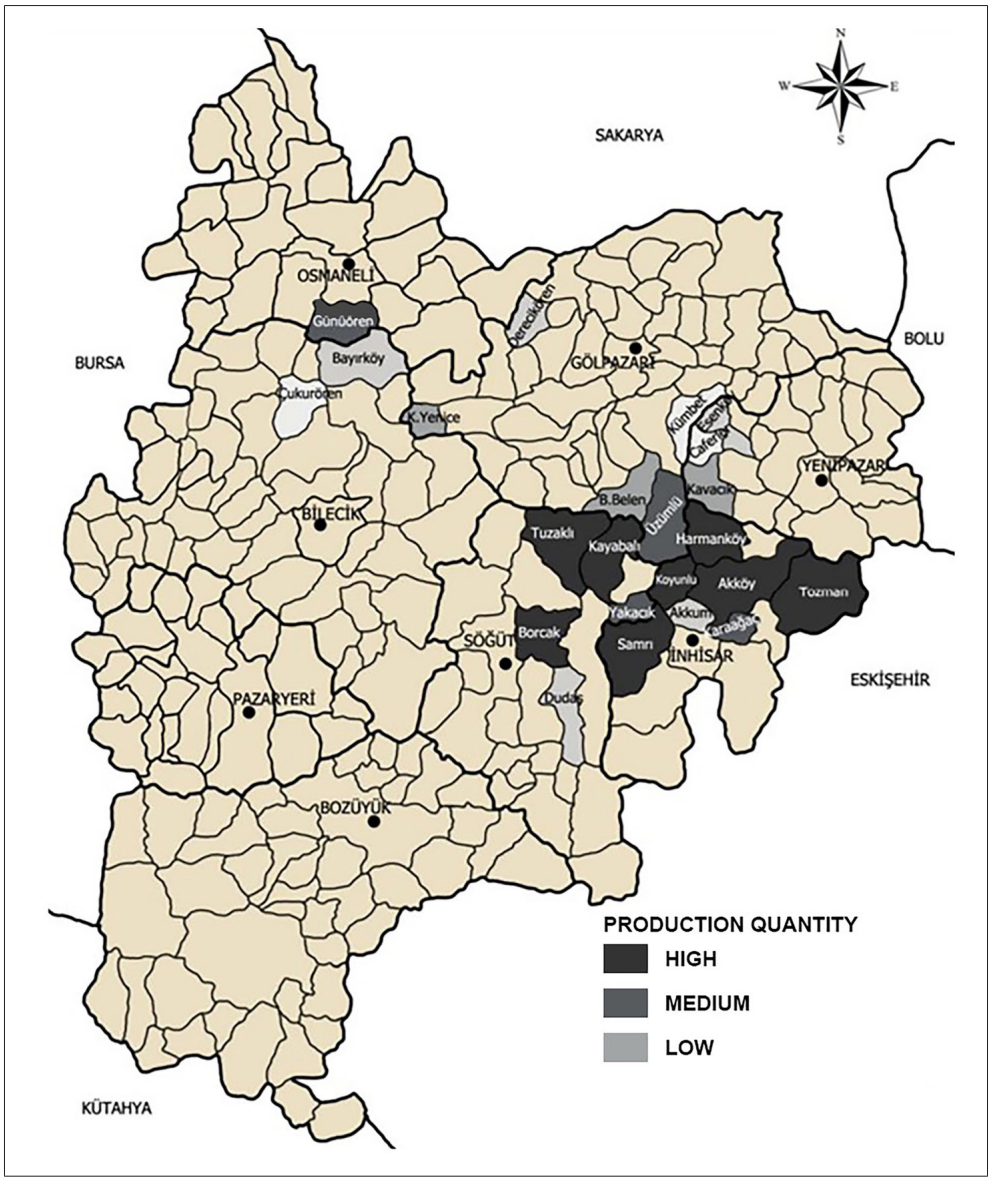

Figure 4. Settlements of traditional silkworm dwellings in Bilecik (Başkaya, 2014, prepared by the Author, 2026).

identified through fieldwork will be conducted, production processes will be interpreted through the structures themselves, and building types will be documented.

EVALUATION OF SILK PRODUCTION STRUCTURES

Definition of Buildings and Production Process

The traditional silkworm house reflects a micro-production model based on agriculture and manual labor, where family life and production are carried out under the same roof. The biological stages of production—from egg hatching to silkworm feeding and cocoon formation—are organized within the house (Çiftçi, 2013). Fieldwork conducted in Tuzaklı village, located in Söğüt, Bilecik, documented traditional houses, settlements, street views, facades, insect areas, and interior views (Figure 7).

A workshop is a small-scale facility where cocoons are transformed into raw silk yarn. It represents the transformation of local production, transitioning from residential settings into a semi-industrial intermediate form under the pressure of increasing demand and commercialization. Cocoon house is a technical building designed for drying, classifying, and storing cocoons. The cocoon drying facility acts as a functional interface to ensure the quality of the cocoons after harvest, thus ensuring continuity in the supply chain (Oral, 2004). Workshops and cocoon houses provide a continuity of production and space between traditional housing and factories. Cocoon house ensures the preser-

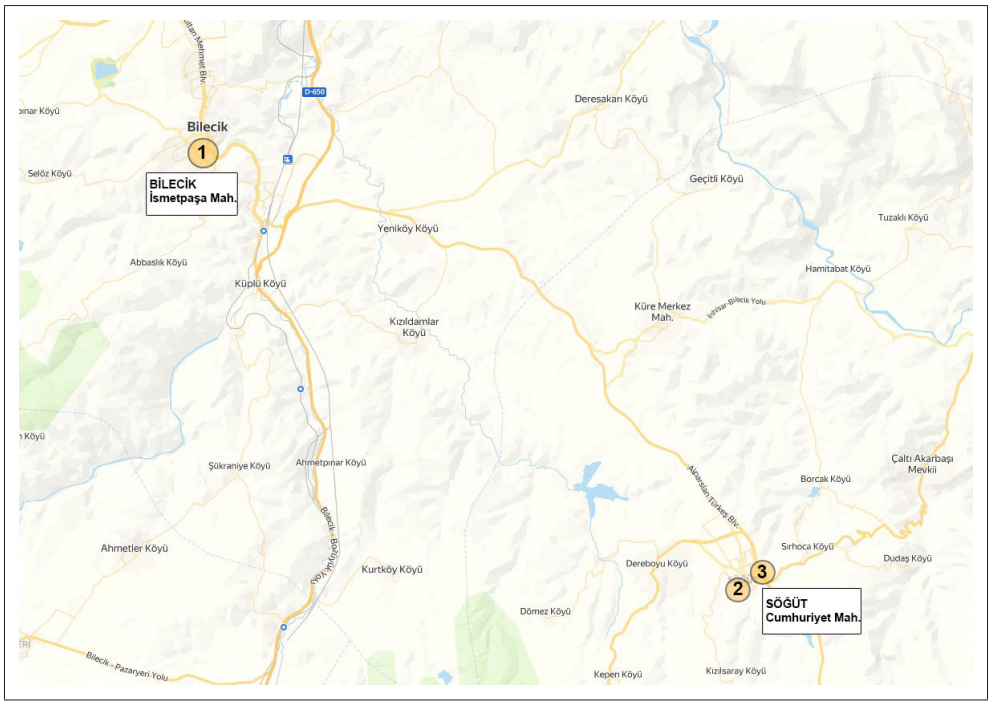

Figure 5. Settlements of silkworm cocoon houses and workshops in Bilecik (Google Maps, prepared by the Author, 2026); (1-Bilecik Silk Factory, 2-Söğüt Cocoon House-1, 3-Söğüt Cocoon House-2).

vation and standardization of the harvest, while workshops create a rational spatial separation that meets the heat, humidity, and water requirements of the physical processing stage (Oral, 2004). This dual structure is a critical step in

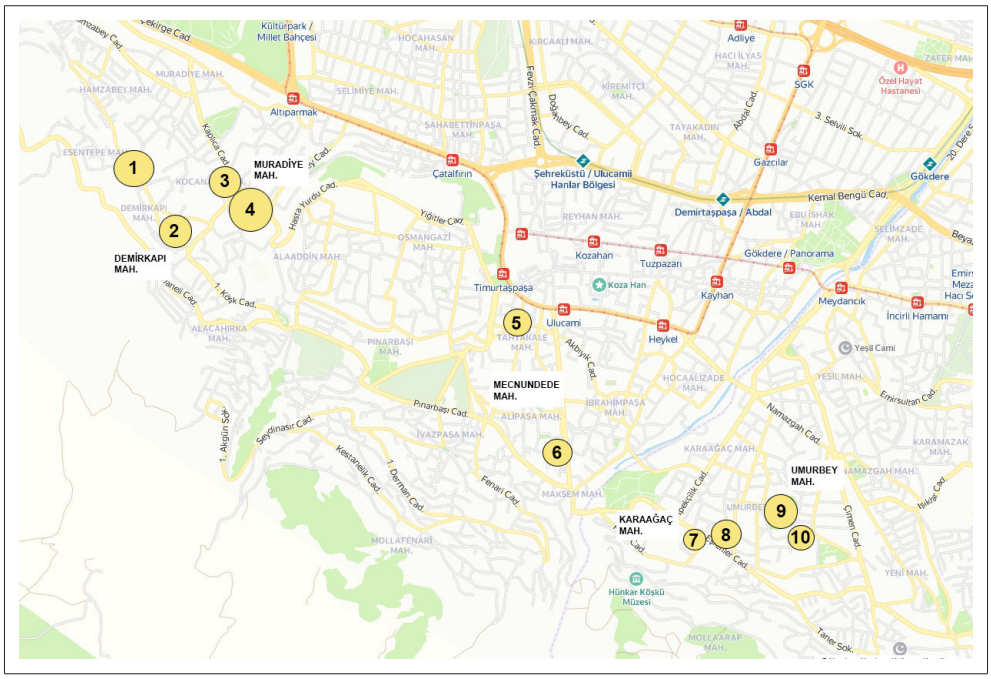

Figure 6. Settlements of silk production buildings in Bursa (Google Maps, prepared by the Author, 2026); (1-Doğan Yılmazipek silk factory, 2-Duruer silk factory, 3-Fabrika-i Hümayun, 4-Turgut Yılmazipek silk factory, 5-Resulzade dying house, 6-Rıfat Özbek silk factory, 7-Mehmet Yüksel silk factory, 8-Osman Fevzi silk factory, 9-İpeker silk factory, 10-Ete Mensucat dying house, 11- Mustafa Dörtçelik silk factory).

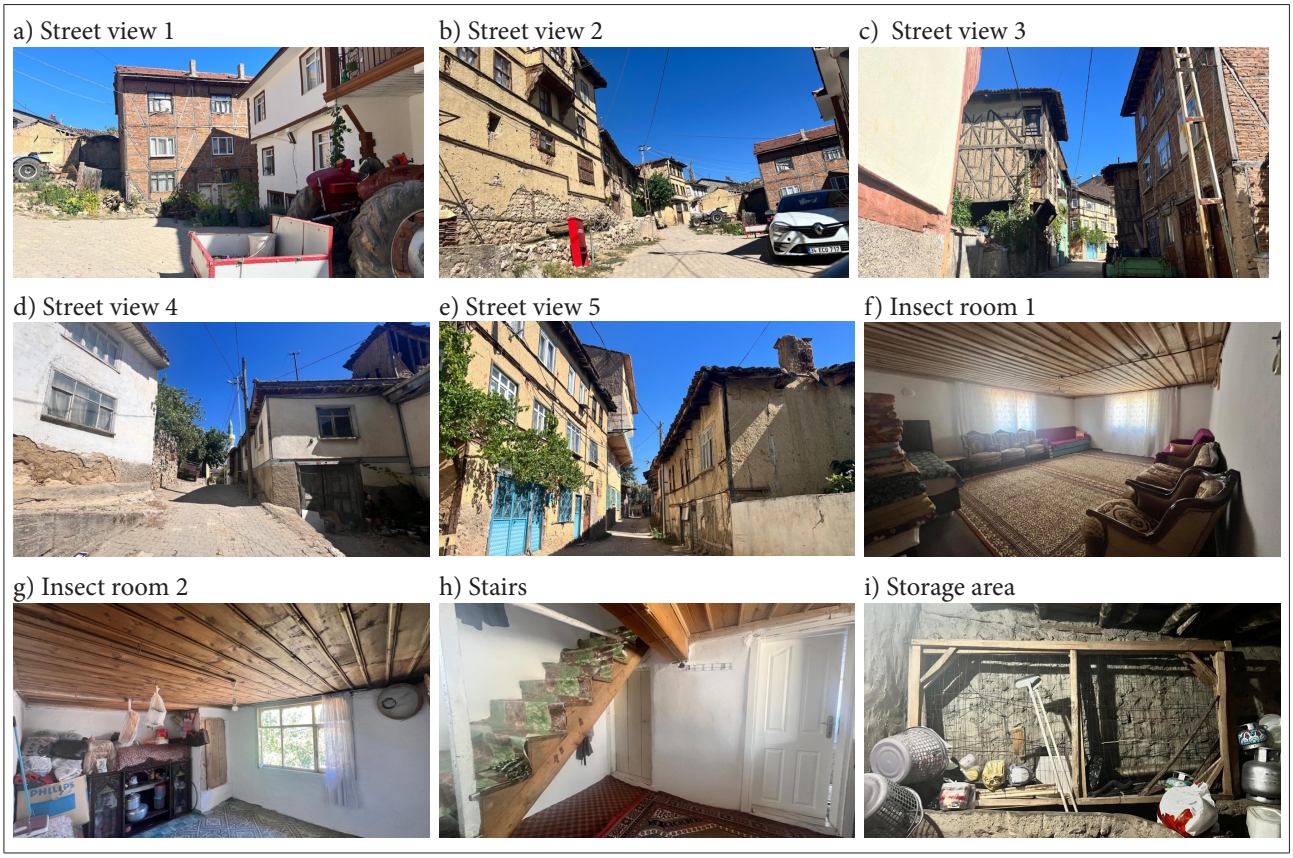

Figure 7. Traditional house in silkworm raising (These photos have been documented through field work in Söğüt, Tuzaklı village, 2024): **a)** Street view 1, **b)** Street view 2, **c)** Street view 3, **d)** Street view 4, **e)** Street view 5, **f)** Insect room 1, **g)** Insect room 2, **h)** Stairs, **i)** Storage area.

scaling up rural production and institutionalizing knowledge. Fieldwork in Söğüt, Bilecik, has documented cocoon house and workshop structures (Figures 8, 9).

Silk factories are a type of industrial building where cocoons are transformed into yarn and finished products using industrial-scale mechanical systems. The structures appearing in the Bursa and Bilecik regions from 19th century onwards embody the spatial transition from domestic and workshop-scale activities to large-scale mass production (Çiftçi, 2013). Built using the technical and typological influences of European models from Italy, France, and Switzerland, these facilities utilized steam power and later electric spinning machines, significantly increasing production efficiency and standardization. The processes of cocoon supply and storage, steam boiling, mechanical reeling, drying, and twisting followed by dyeing and weaving preparation were planned sequentially and modularly. Fieldwork conducted in Bursa has documented images of the Turgut Yılmazipek silk factory (Figure 10).

Spatial Organization and Architectural Features of Silk Production Buildings

The architectural and spatial characteristics of structures associated with the silk production process change and diversify in parallel with the nature, scale, and technological development of production. The building types examined in this study are considered as parts of a successive production chain within the historical continuity of sericulture. Since each stage of production requires different spatial conditions, sericulture structures exhibit significant spatial differentiations depending on the settlement environment. This differentiation can be most clearly observed in three basic structural models: Traditional dwellings in rural areas, workshops and silkworm cocoon drying buildings located in border regions between rural and urban areas, and finally, large-scale silk factories emerging in urban centers (Table 1).

The architectural examination of numerous traditional dwellings reveals a systematic relationship between domestic spaces and the technical requirements of silk production. It was determined that the architectural diagrams of all the structures visited showed similarities. Within the scope of this article, a sample house in Tuzaklı village is documented (Figures 11, 12, 13, 14, 15). Traditional housing examples stand out with their spatial arrangements that accommodate the early stages of production. The spatial organization in these structures integrates both residential and production functions within the same building. The use of the upper floors for silkworm



Figure 8. Silkworm cocoon house (These photos have been documented through field work in Söğüt, 2024): **a)** Street view, **b)** Windows, **c)** Cocoon house area, **d)** Interior view 1, **e)** Interior view 2, **f)** Interior view 3.

rearing and cocoon formation has been decisive in terms of the orientation of the spaces, their light intake capacity, and their heat storage capabilities. The fact that the upper floor generally opens to the warmer south and east, and the large openings that allow natural light to enter, are spatial decisions shaped by the biological needs of production. Generally, when we look at the characteristics of these houses, we see that they have tiled roofs, are suitable for silkworm breeding, are limited to one or two floors, have a limited number of rooms, and are constructed using a wood-frame and adobe infill technique. (Karşıyaka, 2019). The thermal and moisture performance of the material is critical for this production phase. The spatial transformation that the traditional house undergoes during its production periods demonstrates the high capacity for flexible use of the structure, and production directs the entire spatial organization at the scale of the house.

In Bilecik and its districts, many workshops and silkworm cocoon houses belonging to non-Muslims and Armenians were constructed. Records from 1906 indicate 11 workshops and silkworm cocoon houses in Bilecik and 4 in Söğüt (Demiryürek, 2018). Currently, only one silk factory has been identified in Bilecik, and two cocoon houses in Söğüt. This article focuses on the Söğüt silkworm cocoon house as an example (Figures 16, 17, 18, 19).



Figure 9. Workshop (These photos have been documented through field work in Söğüt, 2024): **a)** Street view 1, **b)** Street view 2, **c)** Street view 3, **d)** Interior view 1, **e)** Interior view 2.

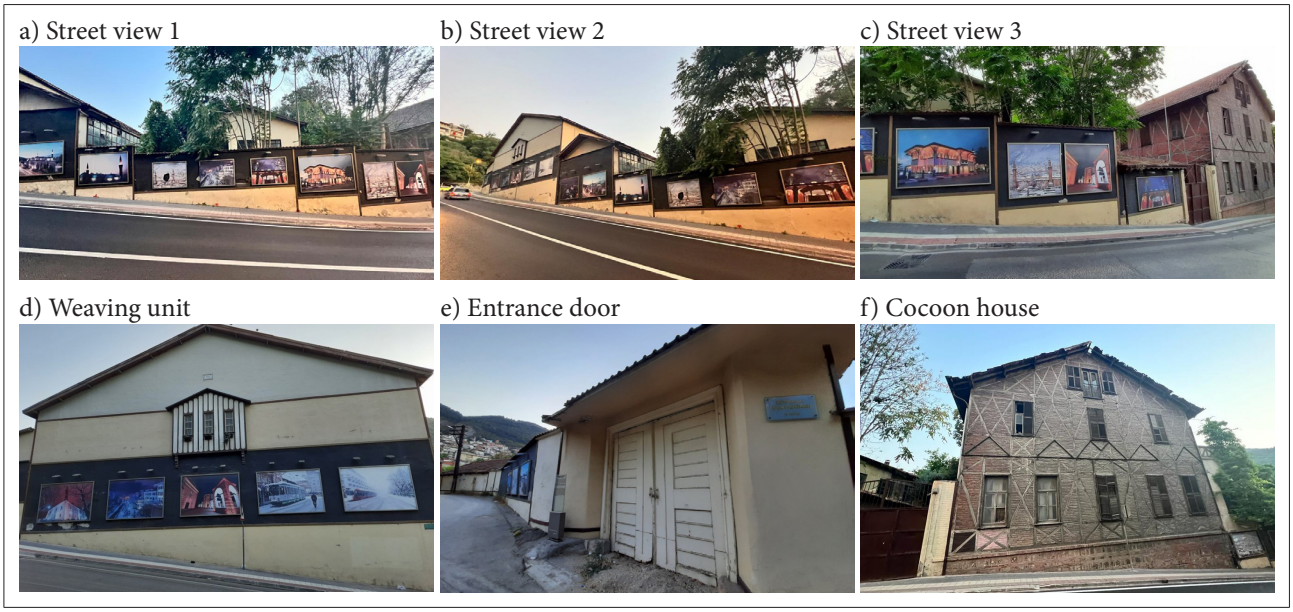

Figure 10. Silk factory (This photo has been documented through field work in Bursa, 2024, Turgut Yılmazipek silk factory): **a)** Street view 1, **b)** Street view 2, **c)** Street view 3, **d)** Weaving unit, **e)** Entrance door, **f)** Cocoon house.

Silkworm cocoon houses represent one of the most characteristic spatial solutions of silk production. The silkworm cocoon house is constructed using brick masonry. The ground floor was designed as an undivided space containing a stable and food storage area, as well as a storage area for mulberry leaves necessary for silkworm breeding. This allowed fresh mulberry leaves to be preserved without losing moisture and quickly transported to the upper floors for feeding the silkworms. The first floor, accessed by stairs from the ground floor, was the living floor; the sofa area, where the room doors opened, was located here. On the upper floors, verandas were positioned in the areas where

Table 1. Documented buildings in the Southern Marmara Region (Prepared by the Author) (The structures shown in the table were identified through fieldwork, 2026)

No	Building Name	Province	District	Current Status
1	Traditional Houses	Bilecik	Söğüt/Tuzaklı	Dwellling
2	Traditional Houses	Bilecik	Söğüt/Kayabalı	Dwellling
3	Traditional Houses	Bilecik	Söğüt/Harmankoy	Dwellling
4	Söğüt Cocoon House-1	Bilecik	Söğüt	Unused
5	Söğüt Cocoon House-2	Bilecik	Söğüt	Unused
6	Bilecik Silk Facto	Bilecik	Merkez	Unused
7	Doğan Yılmazipek Silk Factor	Bursa	Osmangazi	Unused
8	Duruder Silk Factory	Bursa	Osmangazi	Office
9	Fabrika-i Humayu	Bursa	Osmangazi	Educational Building
10	Turgut Yılmazipek Silk Factor	Bursa	Osmangazi	Unused
11	Resulzade Dyehouse	Bursa	Osmangazi	Ruined
12	Rıfat Özbek Silk Factory	Bursa	Osmangazi	Unused
13	Mehmet Yüksel Silk Factory	Bursa	Yıldırım	Unused
14	Osman Fevzi Silk Factor	Bursa	Yıldırım	Cultural Center
15	İpeker İpek Silk Factory	Bursa	Yıldırım	Museum
16	Ete Mensucat Dyehouse	Bursa	Yıldırım	Art Center
17	Mustafa Dörtçelik Silk Factor	Bursa	Yıldırım	Ruined

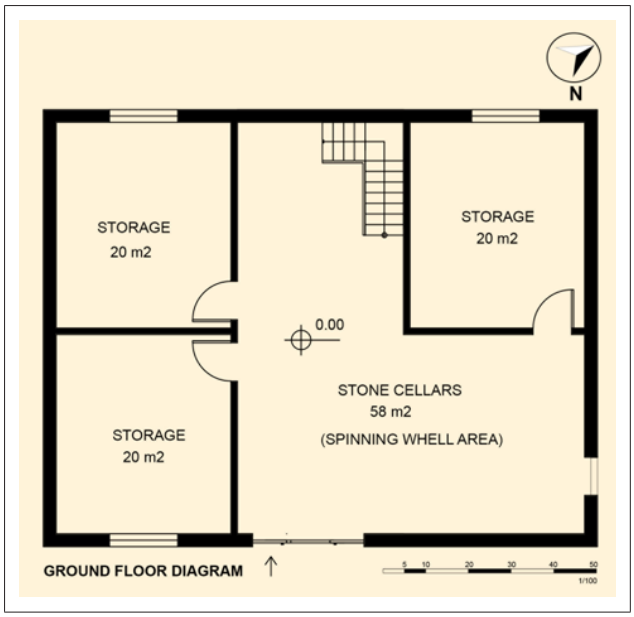

Figure 11. Traditional house plan 1 (Söğüt, Tuzaklı) (Design by the Author, 2026).

the sofa opened to the outside, and scaffolding was erected for storing mulberry leaves, enabling silkworm breeding. A special space known as the silkworm cellar was created on the top floor, giving the house plans a unique identity (Bilecik Governorship, n.d.). The upper floors were bright and spacious areas where cocoon production took place. Vertical spatial organization is a key determinant in these structures. The high air circulation required for the cocoon drying process has led to the building shell becoming a surface almost entirely defined by ventilation elements.

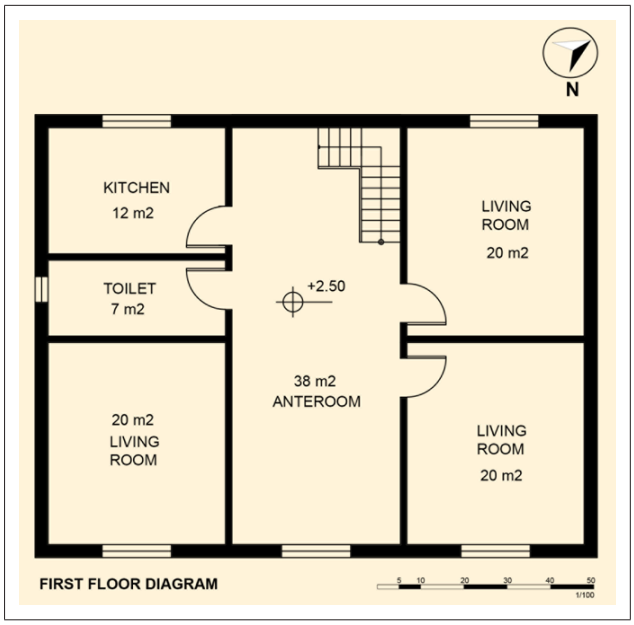

Figure 12. Traditional house plan 2 (Söğüt, Tuzaklı) (Design by the Author, 2026).

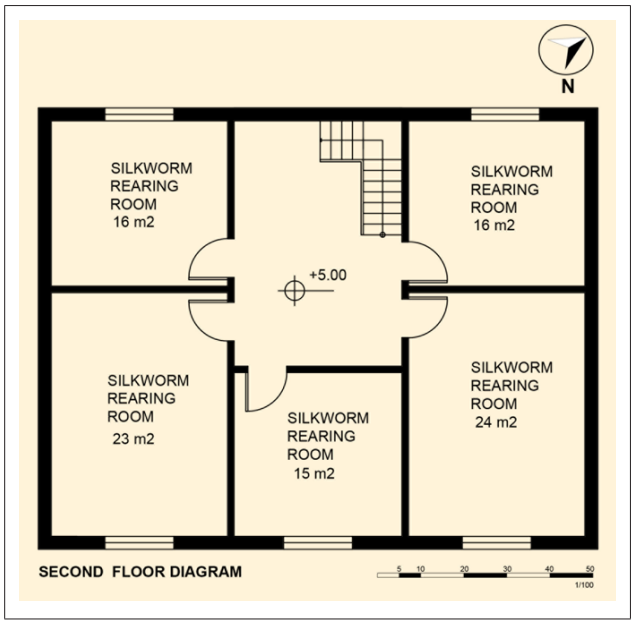

Figure 13. Traditional house plan 3 (Söğüt, Tuzaklı) (Design by the Author, 2026).

Small, frequent, and opposite openings placed at regular intervals along the floors create a continuous airflow within the space. This flow ensures that the drying process takes place simultaneously and efficiently on all floors. The lightness and permeability of the wooden floors in the interior contribute both to continuous ventilation and to the portability of the cocoon baskets. The weaving looms on the lower floors of the houses completed this production cycle, as they were the spaces where the silk obtained from the produced cocoons was directly processed. Thus, this vertical production chain, extending from the storage function on the ground floor to the cocoon drying on the top floor, completely shaped the inter-floor organization of the dwelling. The structure has been transformed from a mere shelter into a fully designed silk production facility (Bilecik Governorship, n.d.). These unique qualities are the defining characteristics that distinguish silk production architecture

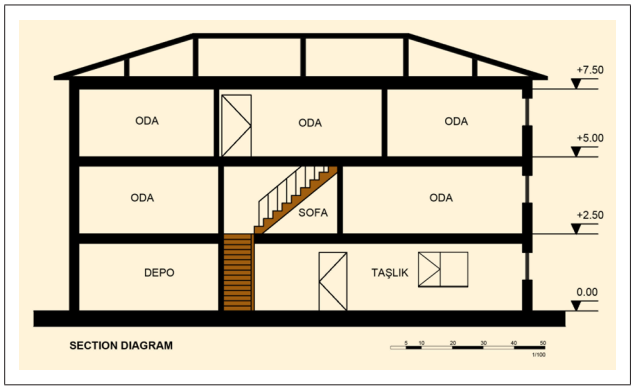

Figure 14. Traditional house section (Söğüt, Tuzaklı) (Design by the Author, 2026).



Figure 15. Traditional house facade (Söğüt, Tuzaklı) (This photo has been documented through field work in Söğüt, Tuzaklı village, 2024).

from other forms of industrial heritage.

The fact that cocoon drying chambers are mostly 3-4 stories high, with a narrow rectangular plan and a repeating mass composition, is an architectural decision that directly meets the requirements of spatial repetition and vertical cyclicality of the production process. Silkworm cocoon structures feature skylights, while the narrow, long windows on the upper floors utilize wooden shutters. These skylights and the narrow, long side windows, along with their shutters, directly control air circulation and light balance, which are critical to the silkworm's development. Maintaining constant temperature and humidity during the cocoon-spinning phase, and ensuring rapid airflow during the drying phase, are made possible through these architectural openings (Ministry of Culture and Tourism, n.d.). The workshops consist of single-story structures located adjacent to the cocoon house, where medium-scale yarn spinning and cocoon boiling operations are carried out. The workshop, located adjacent to the building, houses wet processing steps such as unwinding the cocoons and winding the yarn, thus forming an integrated production line together with the dry volume of the cocoon factory. The hearth and chimney arrangement provides the controlled heat environment necessary for suffocating the wet cocoons and performing the initial drying processes, while the large window openings in the single-story section allow this heat to escape evenly, preventing excessive moisture accumulation (Ministry of Culture and Tourism, 2024).



Figure 16. Silkworm cocoon drying building (Söğüt Cocoon House-2) (This photo has been documented by author through field work in Söğüt,2024).



Figure 17. Silkworm cocoon house facade (Söğüt Cocoon House-2) (This photo has been documented by author through field work in Söğüt, 2024).

Silk factories evolved into more complex structures as silk production reached an industrial scale, with the production line directly reflecting the space. The silk filigree factories in Bursa were industrialized from the mid-19th century onwards by being equipped with steam technology, and this transformation radically changed the scale and organization of the production spaces (Quataert, 1987). The spatial organization of the factories was designed to follow a linear production flow; the cocoon receiving area, drying units, boiling section, spinning halls, twisting, and weaving areas, and large-volume warehouses were built in a sequential order (Figures 20, 21, 22, 23, 24, 25). The factory complex incorporates a combination of different construction systems. The factory features timber frame systems, stone masonry, and stone systems, as well as reinforced concrete and steel systems used in later constructions (Erder, 1978). The structural system, utilizing iron columns and beams and early reinforced concrete techniques, allowed for the creation of large, open spaces (Kıvılcım Çorakbaş et al, 2026). High-ceilinged production halls provided a spatial environment compatible with the working principles of the machines, while tall chimneys and a steam room

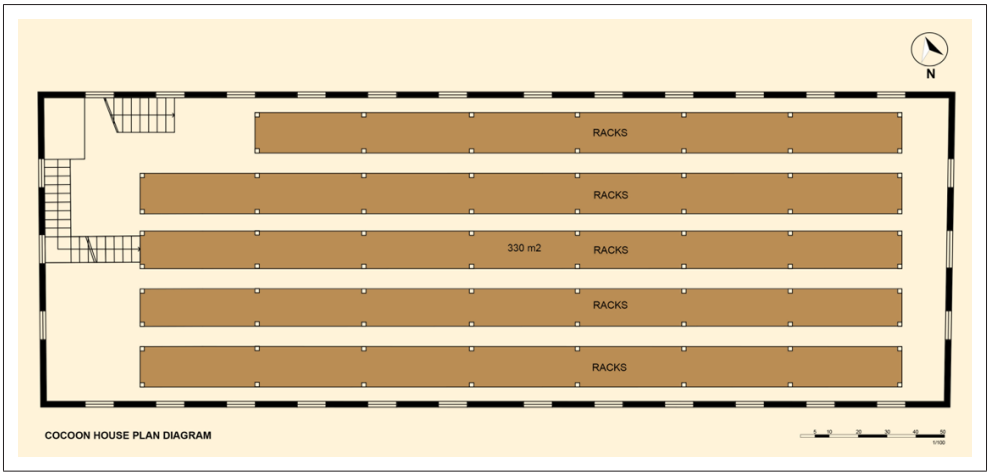

Figure 18. Silkworm cocoon house plan (Söğüt Cocoon House-2) (Design by the Author, 2026).

played a significant role in controlling the circulation of heat and steam within the space. The process of extracting silk threads from cocoons involves boiling hot water and the disposal of the resulting waste, which is a crucial step. Therefore, a large amount of fast-flowing water is required (Çiftçi, 2017). For this reason, silk factories are generally located near flowing water.

As a general comparison, traditional houses offer a small-scale production type suitable for the initial stages of production and sensitive to environmental conditions, while rural cocoon houses form functionally specialized linear types suitable for the drying and storage stages of production. Silkworm cocoon house within factories, on the other hand, emerge as large-scale industrial types that develop with spatial standardization, modular repetition, and mass production logic as production volumes increase. This transition directly reflects the transformation of sericulture from a traditional agricultural activity to an industrial form of production. This situation reveals a continuous structural synthesis in the architectural evolution of sericulture structures in the Southern Marmara Region, reflecting the transition from traditional family farming to heavy industrialization. This developmental trajectory demonstrates a clear morphological shift parallel to the growth of production volumes and technological advancements. Initially, traditional dwellings housed the entire biological cycle under a common roof, relying on the highly flexible and adaptable use of residential space. As commercial demands intensified, production broke away from the arrangements within the dwelling, leading to the emergence of specialized cocoon houses and workshops. This semi-industrial transition institutionalized regional know-how through distinctive architectural expressions such as upper-floor insect traps and window shutter systems designed solely to control ventilation and microclimatic parameters. Ultimately, with the integration of steam power in the late 19th century, this evolutionary trajectory culminated in the birth of large-scale silk factories. In these industrial spaces, the former organic integration of life and labor was completely replaced by a highly standardized, modular, and linear production flow. When this seamless architectural evolution

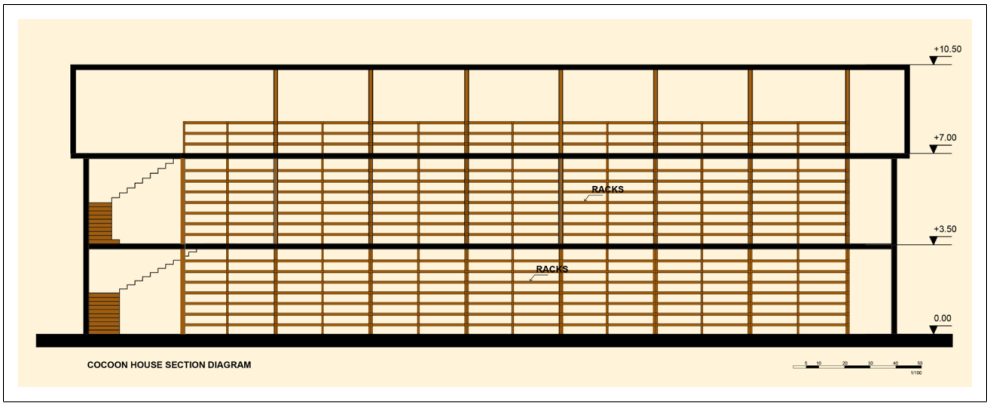

Figure 19. Silkworm cocoon house section (Söğüt Cocoon House-2) (Design by the Author, 2026).



Figure 20. Turgut Yılmazipek silk factory (Bursa) (Osmangazi Municipality, 2025).

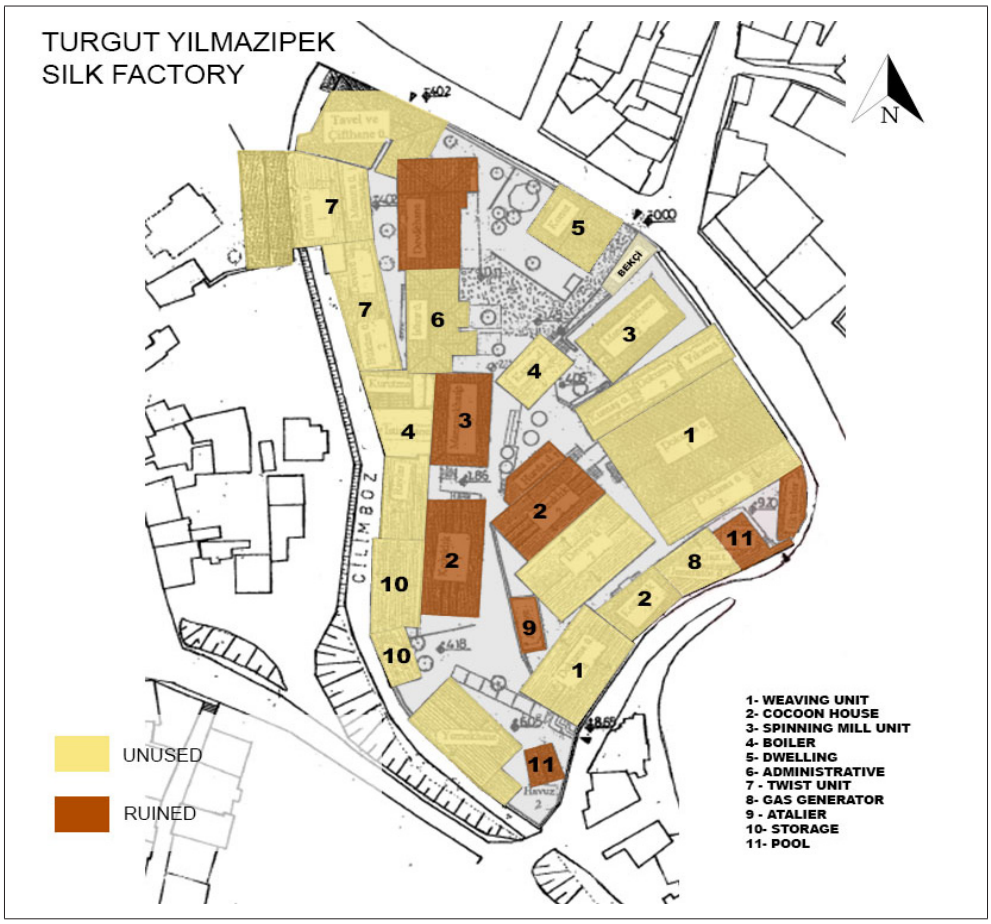

Figure 21. Silk factory site plan (Turgut Yılmazipek Silk Facotry, Bursa) (Adapted by the Author based on the site plan taken from Oral, 2004).

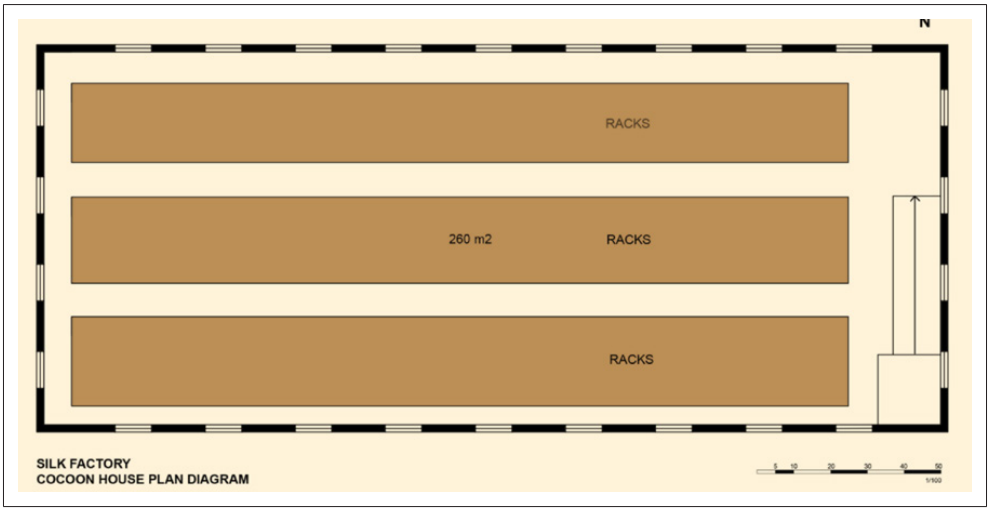

Figure 22. Cocoon house plan (Turgut Yılmazipek Silk Factory, Bursa) (Prepared by the Author using plan drawings produced by Oral, 2004).

from rural housing to urban factories is traced, it becomes clear that each technical stage of silk production generated a precise and enduring spatial counterpart, making sericulture a defining catalyst for regional industrial heritage.

Production Capacity of Buildings

One of the most important factors influencing the architecture of sericulture facilities is production capacity. Although the silk production process consists of many stages, from egg to larva, from cocoon formation to spinning, and from spinning to weaving, the basic equipment that directly determines this process is: Silkworm rearing looms, cocoon drying racks, traditional and industrial spinning mill, and weaving machine (Figure 26). Therefore, the main elements that determine the production scale and spatial dimensions of the structures are the number, size, and arrangement equipment.

Field research, technical visits, and archival research have revealed that in traditional production periods, small-scale residential production typically involved a single area for insect rearing, cocoon spinning, and drying on the upper floors of houses. A small workshop containing spinning equipment was usually located either below or adjacent to this area. Silkworms that have turned into cocoons are sent to the nearest cocooning facility or factory. In earlier times, before the establishment of workshops and factories, silk spinning was done using hand-operated slingshots located in homes. These types of small-scale production units had limited production capacity and were usually run by a single family. The production cycle begins with biological processes such as the hatching of larvae (caterpillars) and cocoon spinning; these activities are carried out in special rooms within the dwelling called "silkworm feeding room". The process continues by boiling the cocoons in water and

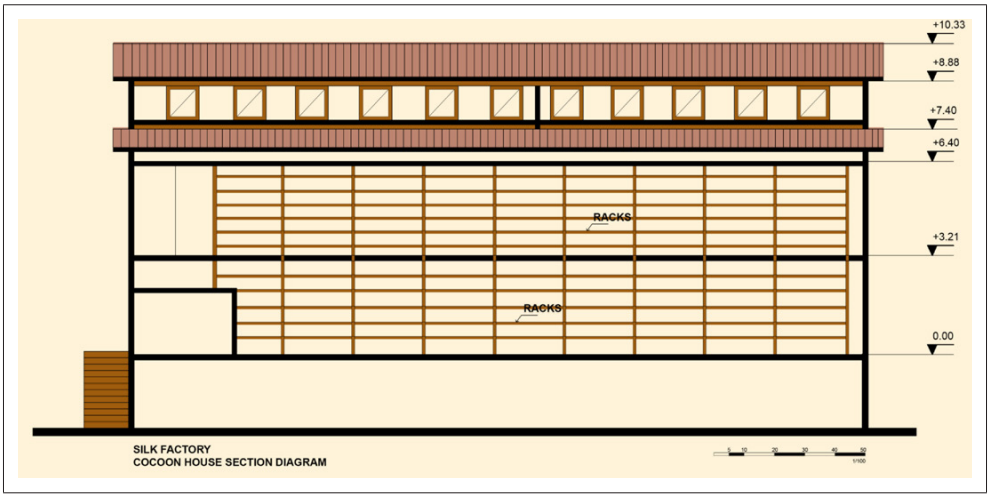

Figure 23. Cocoon house section (Turgut Yılmazipek Silk Factory, Bursa) (Prepared by the Author using plan drawings produced by Oral, 2004).

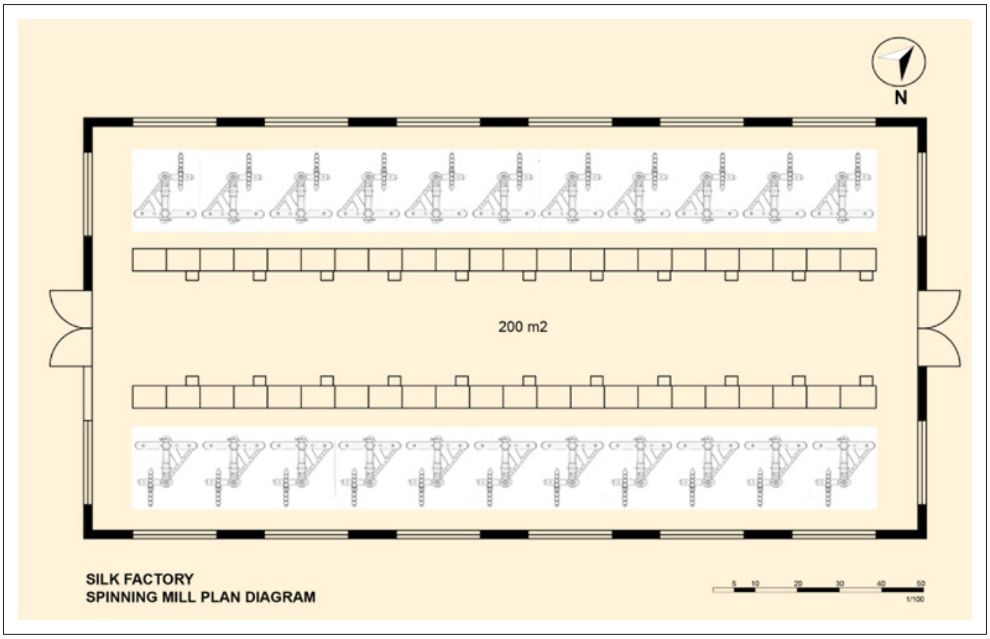

Figure 24. Spinning mill building plan (Turgut Yılmazipek Silk Factory, Bursa) (Prepared by the Author using plan drawings produced by Oral, 2004).

spinning the thread with a spinning wheel for silk thread. This stage, requiring wet areas and technical equipment, is carried out in service areas of the dwelling known as "stone cellars" or "storage areas" (Figure 20).

In workshops and silkworm cocoon drying buildings, production has become semi-industrial, separate from residential settings. These structures feature a drying rack system with numerous drying racks, equipment for spinning multiple yarns, and traditional weaving looms, thus increasing production capacity (Figure 20). Medium-sized production areas typically have 3-4 story silkworm cocoon drying buildings with attics. Cocoons are thinly arranged on these racks and dried for 3 months. Since a moisture-free environment is necessary for the drying process, wood with moisture-absorbing properties is preferred in the construction of these cocooning facilities. All windows have wooden shutters to prevent sunlight. In a medium-sized building, the volume of a single cocoon storage floor is approximately 900 m^3. 18-20 m^3 of volume is required for one ton of wet cocoons. Assuming a 15% volume loss for circulation, air gaps, and structural elements, this volume



Figure 25. Weaving unit plan (Turgut Yılmazipek Silk Factory, Bursa) (Prepared by the Author using plan drawings produced by Oral, 2004).

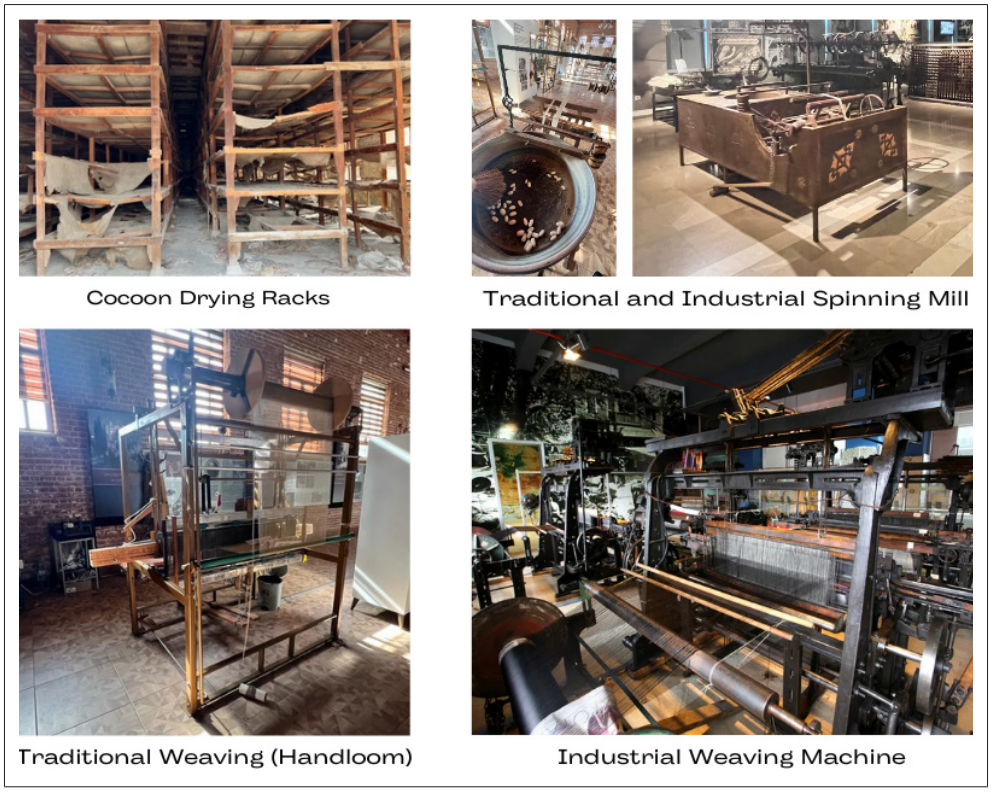

Figure 26. Traditional and industrial equipment (Prepared by the Author) (These photos have been documented through field work, 2024).

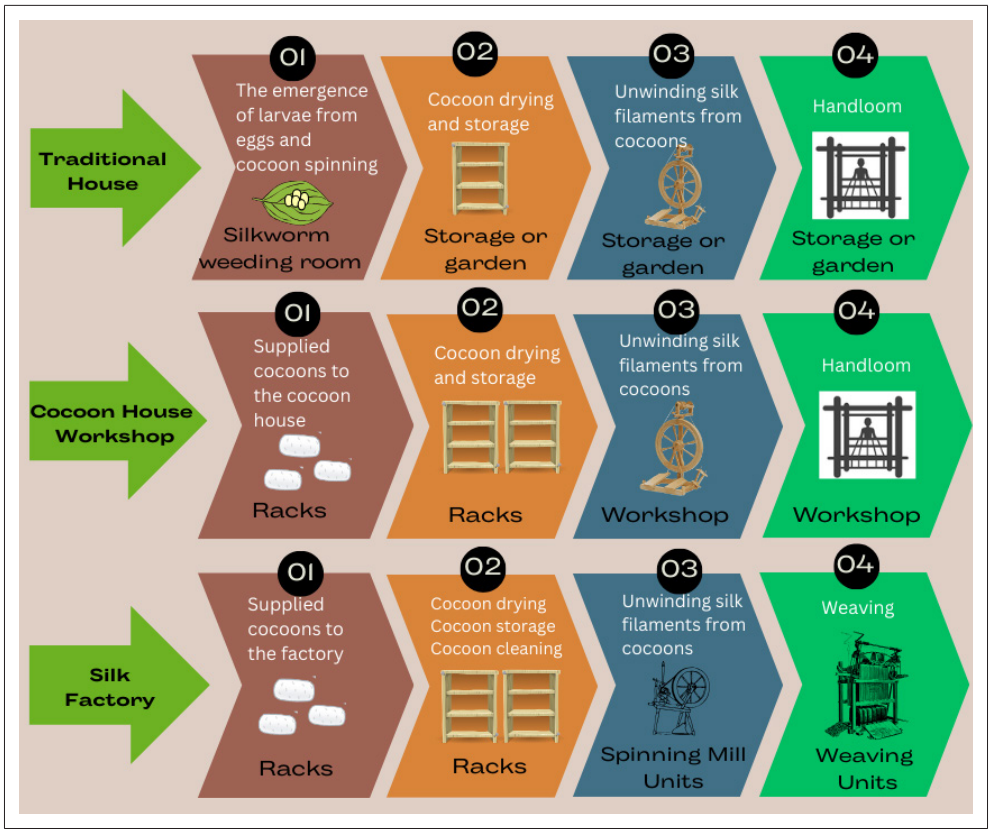

Figure 27. Diagram of silk production stages in buildings (Prepared by the Author based on fieldwork, 2026).

provides approximately 38-43 tons of wet cocoon storage capacity (Ministry of Agriculture and Forestry, 2023). Since the weight of cocoons decreases by 1/3 when dried, this results in approximately 26-30 tons of dry cocoon capacity. Therefore, cocoon storage capacity is directly dependent on the volume of the space. Being typically three-story, with the ground floor used for storage, there is approximately 1800 m^3 of drying space available. In total, a single building has 76-86 tons of wet cocoon storage space. The workshop structure located next to the cocooning area contains 4-6 spinning machines for the yarn spinning process. These structures, of this scale, have become regional centers where cocoons collected from surrounding villages are processed. The process of transforming the raw material into yarn using a "spinning machine" requires mechanical equipment, thus necessitating a special workshop area called the "Workshop".

Large-scale silk factories are designed to encompass the entire process, from raw material input to the final product: Fabric. These structures include cocoon drying and storage facilities, steam spinning machines, weaving and production sections; mechanical flow and division of labor are ensured between production units. In large-scale factories built after the 1920s, silkworm cocoon drying buildings are separate from the main production facilities and featured interior wooden racks for the drying process. They generally consist of 2-3 floors, with an average area of 300-380 m2 and a volume of 900-1100 m3 per floor. In this case, they have the same wet cocoon drying volume as medium-sized structures. That is, an average of 76-86 tons of wet cocoon storage space is available in a single building. While cocoon production capacities are similar in large-scale and medium-scale production structures, there are differences in the production process. Medium-scale structures provide seasonal and short-term storage, while large-scale structures are used continuously throughout the year. In medium-sized buildings, they are located independently or near residences or workshops, while in large-scale buildings, they are directly connected to the factory production line. The most fundamental difference is that factory-scale structures contain multiple silkworm cocoon drying buildings; in addition to having the same production capacity as medium-scale facilities, the number of these structures has been increased (Figure 27). In large-scale facilities, cocoons dried in the silkworm cocoon drying buildings are successively sent to the cocoon drying unit, spinning mill units, twist mill and warp mill. The equipment within these units determines the production capacity of the facilities. In large-scale facilities, silk is spun in spinning mill units. Spinning machine operating with steam power and a mechanical system provide better standards in the spun yarns compared to those using hand spinners. The production chain begins with preparatory processes such as drying, sorting, and storing the cocoons; these processes are carried out in "Silkworm Cocoon Drying Buildings". The process continues with the "Spinning Machine Unit" for silk reeling, the "Warping/Twisting Unit" for yarn processing (warping/twisting), and the "Weaving Units" for the final textile product (Oral, 2004).

For the sake of methodological transparency, the numerical estimates and volumetric capacity calculations presented in this section were obtained through a triple analysis of comprehensive fieldwork, archival records, and official technical data. The physical dimensions and spatial volumes of the documented cocoon houses were determined through direct on-site measurements and architectural documentation during the field research. To convert this volumetric spatial data into accurate production capacities, data from the Ministry of Agriculture and Forestry's (2023) official technical report containing standard spatial parameters for cocoon storage areas were integrated.

According to field observations and archival records, the silk production process began on a residential scale, and later, as production volume increased, silkworm cocoon drying buildings and workshop structures emerged. In the subsequent period, silk factories were established to meet the growing demand and needs. The biological process continued at a residential scale. Workshops and silkworm cocoon drying buildings served as a bridge between residential and factory settings. Factories enabled the industrialization of silk production (Table 2).

CONCLUSION

This study reveals the morphological and spatial transformation in the traditional sericulture and silk production heritage of the Southern Marmara Region through a holistic architectural reading, ranging from rural housing scale

Table 2. Building scale-production capacity relationship (Prepared by the Author based on archival records, fieldwork and technical reports, 2026)

Type of Structure	Number of Cocoon Houses	Capacity of Cocoon Strage	Type of Steam Boiler	Number of Spinning Machine	Number of Weaving Loom
Traditional Houses	Unavailable	50-60 M2	Small Hot Boiler	1	Unavailable
Workshop and Silkworm Cocoon Drying Buildings	1	900 M2	Small Scale Steam Boiler	3-4	1
Silk Factories	2-3	1800-2700 M2	Big Scale Steam Boiler	8-12	8-10

to industrial factory scale in urban centers. The original findings of the research demonstrate that all biological and technical stages of silk production processes are directly reflected in architecture as spatial counterparts, shaping building forms. In the traditional houses of Tuzaklı village in Söğüt, micro-scale production intertwined with family life has been transferred to cocoon drying houses and workshops in Söğüt as production has evolved into a semi-industrial intermediate form through commercialization. In this context, the frequent ventilation openings, wooden shutters, and functional floor organizations that ensure continuous air circulation in the cocoon houses are the most concrete evidence of how production directly designs the architectural shell and spatial typology. From the 19th century onwards, large-scale silk factories in Bursa, which emerged with the integration of steam technology, represent the highest scale of production, where the linear production flow completely standardized the architecture, consisting of modular and high-ceilinged halls. The case studies documented and analyzed in this study are now cramped within the urban fabric and face the threat of becoming derelict. Preserving these structures as tangible cultural heritage for the future is possible not only through the preservation of their physical integrity but also through their integration into the contemporary socio-economic ecosystem. In this regard, adaptive reuse models should be developed that do not harm the architectural identities and spatial dimensions of the original structures examined. These models include living silk museums, art studios, creative industry centers, or the transformation of factory courtyards into public squares, thus keeping the region's traditional production culture alive. In conclusion, this research fills a significant gap in the literature by clearly defining the spatial counterparts of silk production processes and the evolutionary trajectory of architectural spatial analysis. The data and methodological documentation obtained provide a scientific basis and reference source for future conservation, restoration, and repurposing interventions for sericulture heritage in the Southern Marmara Region.

ETHICS: This study did not require approval from an institutional ethics committee because it involved no clinical procedures, personal data collection, or intervention with human participants.

PEER-REVIEW: Externally peer-reviewed.

CONFLICT OF INTEREST: The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Article

From the "Principle of Dressing" to the "Law of Dressing": The contentious relation between Gottfried Semper and Adolf Loos

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ABSTRACT

Two architects—Gottfried Semper in Altona, in 1834, and Adolf Loos in Vienna, in 1897—started a radical battle against the prevalent order of the theory and practice of fine art and architecture. This paper aims to discuss the theoretical approaches and practical conditions which generated both Semper's and Loos' critical positions and to rethink the correlation of their ideas (i.e. Semper's principle of dressing and Loos' interpretation of Semper's principle)—both in terms of agreement and conflict. To illuminate the contentious nature of this correlation, first, two key methodological approaches in Semper's thinking—primordial history [*Urgeschichte*] and relational analysis—and Loos' dualistic stance towards these approaches will be examined. Second, the act of dressing will be discussed as a reconciliation in which the contention between Semper's and Loos' thinking is resolved on two levels: The theoretical contention between relational analysis and primordial history, and the practical contention between the subject and the material. The analysis is based on Semper's two treatises which are the 1851 treatise *The Four Elements of Architecture* and the 1861 treatise *Style in the Technical and Tectonic Arts or Practical Aesthetics: A Handbook for Technicians, Artists, and the Patrons of Art* translated by Mallgrave and Hermann, and on three articles written by Adolf Loos, "Das Prinzip der Bekleidung" [The Principle of Dressing] and "Glas und Ton" [Glass and Clay] published in 1898 and "Architektur" [Architecture] published in 1909.

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INTRODUCTION

Having received extensive criticism from August Schmarsow (1893) and Peter Behrens (Behrens, 1910), Semper's principle of *dressing* [*Bekleidung*] and *spatial enclosure* rather found its most remarkable realization in the works and writings of three architects: Otto Wagner, Hendrik Berlage and Adolf Loos. Semper's criticism of architecture not only provided them with an exemplary retort against the "dead categories" in both arts and philosophy, but more importantly with the primordial conditions [*Urzustände*][1] of modern architecture allowing them to generate their own positions within the crisis of architecture.

[1] At the risk of falling into the same error that I criticize, I see myself forced to go back to the primitive conditions (*Urzustände*) of human society in order to come to that which I actually propose to set forth" (Semper, 1851, p. 102).

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Compared to Wagner and Berlage, Loos' stance on Semper's principle of dressing is the most ambitious. Loos could challenge Semper's principle into a "law of dressing" [*ein Gesetz der Bekleidung*] as a guideline for architects how to avoid imitation in practice and how to achieve truth while dressing materials. Loos' adaptation of Semper's principle of dressing, however, did not imply that he completely agreed with Semper. Two articles written by Loos in 1898—"Glas und Ton" and "Das Prinzip der Bekleidung"— explicitly draw on Semper's ideas from the 1861 treatise, *Der Stil in den technischen und tektonischen Künsten oder praktische Äesthetik: Ein Handbuch für Techniker, Künstler und Kunstfreude*, but also make clear Loos' *conditional* reception of the practical application of these ideas.

The relation between Semper's and Loos' theoretical thinking has been widely discussed in recent studies, which rely on Loos' two articles to claim a connection between Semper's principle of dressing and Loos' concept of *Raumplan*. None of these studies, however, addresses the contentious nature of this relation in general and Loos' conditional acceptance of the principle of dressing. Rykwert's study is an exception: Rykwert (1998, p. 21) discusses Loos' "ambiguous attitude to Semper" with regard to historicism, and brings out one remarkable detail about the contentious nature of their relation apropos Semper's contribution to the *Ringstraßenarchitektur* of Vienna in the last years of his life. Semper, in collaboration with Carl von Hasenauer, was the architect of the Art History Museum (1869-1891) and the Hofburg Theater (1871-1888) during Vienna's so-called *Ringstraße* era. In his article "Das Prinzip der Bekleidung," Loos (1898c) describes this period as "a sorrowful era for art"[2] and explicitly condemns its architects en masse without mentioning Semper's or any others by name. What Rkywert overlooks in his discussion, however, is that the contention between Semper and Loos was not only limited to historicism but also pertained specifically to the principle of dressing.

My purpose in this paper is to revisit the theoretical and practical conditions which generated both Semper's and Loos' critical positions to their own times and to rethink the correlation of their ideas (i.e. Semper's principle of dressing and Loos' interpretation of Semper's principle of dressing)—both in terms of agreement and conflict. Moreover, this correlation must be seen as a process of transformation—moving from the principle of dressing to the law of dressing—rather than as a matter of fact in itself.

To illuminate the contentious nature of this correlation, I will first examine two key methodological approaches in Semper's thinking—primordial history [*Urgeschichte*] and relational analysis—and explore Loos' dualistic stance towards these approaches. Second, I will re-examine the act of dressing as a reconciliation in which the contention between Semper's and Loos' thinking is resolved on two levels: The theoretical contention between relational analysis and primordial history, and also the practical contention between the subject and the material.

In addition to some notes on secondary literature, this study is primarily an analysis of the following original texts: The 1851 treatise *The Four Elements of Architecture* and the 1861 treatise *Style in the Technical and Tectonic Arts or Practical Aesthetics: A Handbook for Technicians, Artists, and the Patrons of Art* both by Gottfried Semper (as translated by Mallgrave and Hermann), the 1898 articles "Das Prinzip der Bekleidung" and "Glas und Ton" by Adolf Loos, as well as his 1909 article, "Architektur."

URGESCHICHTE: AS A GUIDE TO THE TRUTH OF PRACTICAL AESTHETICS

The writings of both Semper and Loos express their awareness of contemporary polemics and the respective crises in the fine arts and architecture out of which they developed their own theories, as mere criticisms of their times. In other words, their theories were not simply aphorisms or abstractions, but parries directed to specific scholars or practitioners: Agents of real conflicts in the fine arts and architecture.

Semper's first treatise *The Four Elements of Architecture* (1851) focused on the genealogical history of architecture [*Urgeschichte*] by attacking the approach of contemporary scholars in the theory of art—i.e. in the Academia. The second treatise *Style in the Technical and Tectonic Arts or Practical Aesthetics: A Handbook for Technicians, Artists, and the Patrons of Art* (1861), on the other hand, shifted its direction from theory to practice, from to the academy of arts to "the art industry"—in Semper's words—and finally from the scholars of art to the producers of art—i.e. technicians, artists and patrons of art, as it is clear from the subtitle title.

The decay of ethics in architectural practice is at the center of Loos' criticisms, which illustrate how the natural truth to materiality in the work of craftsmen was degenerated by architects into imitation, forgery and ungracious dressing of construction with redundant ornamentation. Indeed, imitation was the main subject of his article "Das Prinzip der Bekleidung," in which Loos (1898c) sharply attacked both the Viennese architects of the *Ringstraße* era and those of his own time who executed their profession in the name of *art of building*, but thereby lost the *essence of building* (pp. 140-141).

In response to the degeneration of art and aesthetics in everyday life, both authors returned to societies other than their own—Semper to the ancients and Loos to English and the Americans—in the search of truth in the act of making.

[2] Loos, 1898c, p. 140. "…eine traurige zeit für die kunst…"

The reason Semper sought to dissect the habits and techniques of production in everyday life in ancient time was to extrapolate a model—both theoretical and practical—for the present. The crisis within fine arts and architecture forced him to take lessons from "the wealth of information on ancient conditions" (Semper, 1851, p. 107) for contemporary use. For Semper (1861), the source of truth did not exist in the abstract propositions of Greek philosophy, but in the material reality and practical aesthetics of Assyrian, Egyptian, Persian and Chinese cultures (p. 233).

Before defining his four new elements of architecture in his book, Semper confronts recent theories of art and proposes a return to the very origins of history—the primordial history [*Urgeschichte*]:[3]

> At the risk of falling into the same error that I criticize, I see myself forced to go back to the primitive conditions [*Urzustände*] of human society in order to come to that which I actually propose to set forth. (Semper, 1851, p. 102)

Thus, Semper's theoretical approach is to write a primordial history of architecture, looking at ancient cultures in Assyria, Persia, Egypt and Greece not only to explore how they were building, but how they were combining arts and techniques of construction with those of handicrafts such as wickerwork, painting, needlework and others while creating and producing their everyday objects.

In the two articles written by Loos, "Glas und Ton" (1898b) and "Das Prinzip der Bekleidung" (1898c), Loos' thinking on the distortion of meaning within the theory and practice of art and architecture is analogous to Semper's understanding of primordial history. In "Glas und Ton," Loos makes extensive reference to Semper's study of ancient household utensils from the section on ceramics in the book *The Style*. Remarkably, this is the only article where Loos (1989b) directly quotes from Semper the detailed explanation of how the difference between an Egyptian *situla* and a Greek *hydria* does not depend on formalistic codes—as it was claimed and taught by the academy of fine arts—but on practical and cultural ones. The form of a pail, Semper illustrates, is primarily derived from the relation of the artifact to the women who carry it on their heads and to the source of water—i.e., a river, a spring or a fountain.

Semper's comprehension of primordial history [*Urgeschichte*] as a way of decoding not only genealogical properties of household objects or commodities, but their power of manifestation [*Offenbarungskraft*] to inform on the traditions of the nation or the character of the topography and cultural habits, as well, fascinated Loos. Adding to Semper, Loos (1898b) claimed that this power of manifestation is not only embedded in pots but in every material commodity (p. 89).

For Loos, the primordial history [*Urgeschichte*] of architecture is connected to the principle of dressing. In his article "Das Prinzip der Bekleidung," Loos (1898c) proclaims that cover [*Decke*] is the primordial architectural detail—i.e., the primordial form of architecture—made of a pelt or a woven textile. The idea of dressing and the need for enclosure emerged first, and then the need for a constructional framework and walls behind the cover. Loos (1898c) finds this sequential evolution of needs fundamental for the development of the idea of building, which is moreover a universal process experienced by all human beings in the same sequence (p. 139). It is also this process within which Loos notices the transformation of the use of the carpet as a primordial form of spatial enclosure in its truest sense in ancient architecture into an imitation of dressing in contemporary architecture.

According to Semper (1861), the transformation of materials happens through artistic motives and technical treatments within the course of history. Within the process of this "metamorphosis," neither the artistic motive nor the primordial type [*Urtypus*] remains the same. They both go through "a new material transformation" [*Stoffwechsel*] the multiple phases of which are recorded as a genealogical memory on the ultimate form of the *Urtypus* (pp. 258-259). In that sense, only a search for the primordial history [*Urgeschichte*] of both everyday and monumental materials would purify architectural history of its chauvinism and barbarism to ancient arts, restore the overlooked relationships among the various arts including architecture, sculpture and textile, and finally, bring their appreciation in ancient times back to the present (pp. 260-261).

Here, at a glance, the notion of "metamorphosis" as well as the primordial type [*Urtypus*] in Semper's use recalls Goethe's notion of the primordial plant [*Urpflanze*]. Malgrave (1996) notes that, with the primordial plant, Goethe wanted to identify "the oldest, archetypal plant species from which all other plants evolved" who made an extensive use of primordial forms [*Urformen*], primordial shapes [*Urbilden*] and primordial phenomona [*Urphänomene*] in his scientific and poetic writings after 1790 (p. 158). Goethe's concepts were well-known to Semper who used them in his London lecture in 1853 along with the evolutionary concepts of Georges Cuvier and Alexander von Humboldt (Mallgrave, 1989, p. 30). As early as 1848, in a manuscript of a lecture, Semper put forward two forms as the primordial forms [*Urformen*] of architectural creation: First, the "vertical enclosure" [*Umfriedigung*] which was a wall motif used as a spatial boundary for security against enemies in the courtyards of the southern climate; and second, the "gabled roof" which was a commonly used motif in the huts of the northern climate (Mallgrave, 1996, p. 163).

[3] In his writings, Semper (1861) uses this term not in "The Four Elements," but in "The Style": "Presently, we shall discuss the predilection of the Chinese and the Indians for wickerwork and its importance for the primordial history (*Urgeschichte*) of architecture and style." [Semper's italics], (p.

It is remarkable to recall here that Goethe's concept of the primordial phenomenon [*Urphänomen*] was also borrowed by Walter Benjamin in his *Passagenwerk*, where he wrote the primordial history [*Urgeschichte*] of modernity by looking at moments of the nineteenth century Paris as "ur-forms of the present" (Buck-Morss, 1991, p. 77). In 1918, Benjamin argued "what Goethe called ur-phenomona were not symbols in the sense of poetic analogies, but, rather, 'ideal symbols' in which the ideal essences of which Plato spoke appeared in sensual forms" (Buck-Morss, 1991, p. 71).

In *Passagenwerk*, for Benjamin, the architectural primordial type of the nineteenth century Paris was "the arcade" built out of iron- and glasswork. If for Semper, the "vertical enclosure" and the "gabled roof" were two primordial forms of architectural creation, then for Benjamin, the "iron gate" of the arcade was the "vertical enclosure" to secure the goods in the shops in the evenings, and the "glass roof" of the arcade the "gabled roof" to let the daylight, but not rain, flow through the whole arcade. While Benjamin was working on *Passagenwerk* from 1927 to 1940, however, the glory days of the Paris arcades in the nineteenth century were in the past: most of the arcades were in poor shape and did not survive the economic decline of the late 1920s, neither economically in terms of the type of small shops they contained nor structurally in terms of the primordial forms of architecture.

This dialectical juxtaposition of the primordial history [*Urgeschichte*] and the present quietly incarnates both Semper and Loos in Benjamin's work: Semper through his genealogical approach to the world of artifacts and Loos through his dialectical thinking of modernity.[4] By questioning imitation and tastelessness in modern living of his time, Loos captured symbolic contradictions of the material transformation within the primordial history of architecture in two artifacts (to which he came via Semper's understanding of practical aesthetics and the principle of dressing): The ceramics/the pail and the textile/the carpet. Thus, what Loos illustrates to his readers in 1898 is the encapsulation of the material transformation by the symbolic one—in other words, the encapsulation of the practical by the beautiful, of truth by imitation and of dressing by decorating. This was the crucial decline of architecture that urged Loos to look at the primordial phenomena of the present—as Benjamin was to do—and to capture moments of modern living in a revolutionary way he never actually named—the *Urgeschichte* of modernity.

RELATIONAL ANALYSIS AS A GUIDE TO A GENEALOGY OF ARCHITECTURE

In his critique of Franz Kugler's arguments on polychrome architecture, Semper (1851) puts emphasis on the decontextualization and the sublimation of works of art with reference to Kugler's book entitled *On the Polychromy of Greek Architecture and Sculpture and Its Limits*. Although the Greek temple had always been "a part of a greater whole for which it was the center of relations," in academia it was taken out of its context with a total disregard of relations between various materials and their meanings (p. 89). Here, Semper (1861) brings out a particular stress on *relations* for the first time and puts architecture as well as his theory "in the center of relations" (p. 203). Thus, according to Semper, the substance of architecture is not concealed in the material creations themselves—i.e., buildings—but in the relations between arts, objects and techniques, and further, in the relations between concepts and laws, as well.

Although Semper's relational thinking is at the center of his theories, none of the recent studies on Semper gives much attention to the analysis of this aspect. The common emphasis, instead, is generally put on the relation between ethnography and architecture rather than specifically Semper's relational thinking.[5] In his challenging study of the tectonic, Frampton (1995) is no exception in this regard. He argues that, as a response to the degeneration of his time, Semper reappraised "the ethnographic origins of the various manufacturing procedures, together with their material references and corresponding forms" (p. 87). But following this point, he does not call attention to Semper's fundamental belief on relational thinking.

In his study of Semper, Mallgrave (1996) emphasizes Semper's theoretical affinity towards anthropology and his awareness of archeological findings resulting from the significant unearthing of Assyrian cities during the 1840s (pp. 161-163). Yet, he pays scant attention to the "genealogical link" observed by Semper (1851) between societies and their influences on each other—including building practices and types (p. 121).

Before positing his four new elements of architecture, to oppose Vitruvius' elements of architecture—the *hearth*, the *roof*, the *enclosure* and the *mound*/the *terrace*—Semper (1851) starts the section "The Four Elements" with the following: "Hellenic culture could only have arisen on the humus of many past traditions long since dead and decayed and from alien motives brought over from without and no longer intelligible in their original meaning" (p. 101).

Semper (1851) did not view Hellenic culture "out of context" (p. 102), just as he would refuse to view the Greek temple itself. Although anthropologists were uncertain of the specifics of how these lands were settled and how the peoples interacted, Semper (1851) had no doubts about ancient Greece, "that the most varied constituent parts of older civilizations were deposited here and intermingled and in

[4] Worbs (1995) notes that this destructive nature of Loos' architecture is praised by Benjamin in his article "Karl Kraus" and "Der destruktive Character" published in *Illuminationen. Ausgewählte Schriften*. See Worbs, 1995, p. 520.

[5] For two interpretations of Semper's anthropological approach, see van Eck, 2021 and Payne, 2021.

a great metamorphosis of people shot together (like Parian marble) from sedimentary conditions into a crystal-clear independence" (p. 102).

Recognizing "a genealogical link" between Greek and ancient cultures which was manifest in the Doric tribe itself, Semper (1851) refers to ethnology to depict the primordial forms of Greek architecture. "Ethnology, in considering pre-Hellenic social man, offers four noteworthy and singular developments of the building instinct: The *Chinese*, the *Egyptian*, the *Assyrian*, and the *Phoenician*" (p. 113). What Semper describes in his text are not only singular developments within each culture, but also their relations to each other. Social and economic relations between societies cause a kinship among them as well as their building forms and practices:

> From time immemorial the Phoenicians had trade links with the Greeks, who borrowed their written language and many useful inventions, and it should not be surprising that the idea that received its fullest and clearest expression in the Greek temple can be already discerned in the layout of the Phoenician-Jewish temple, certainly less developed but decidedly enough. (Semper, 1851, p. 113)

The genealogical reading of history allows Semper (1851) to draw a morphological relation between the Assyrian tower and the Greek temple, and between the Asiatic enclosed court and the primordial hut (pp. 124-125). Pairing similar types together, Semper achieves a matrix in which identical types form various groups or veritable *block models*[6] ("Egyptian-Doric" or "Oriental-Attic") for further analysis. He attributes these block models to *systems* (the "Egyptian system" or the "Oriental system") that comply or conflict with each other. What comes out of the interactions between these systems is then legible in works of art themselves, for which Semper (1851) gives the example of the wall paintings of Pompeii (pp. 125-126).

Semper's relational thinking, which I try to uncover and emphasize, is not deterministic but intuitive from the start. His interest is not to draw a concrete chart in which types are classified, but instead, to draw an *imaginative* map where a host of possible combinations could be pointed out. In that sense, Semper never thought of writing a history of works of art classified by periods, regions or nations. Instead, taking "events *developing* as it were" within the history of art and archeology, Semper (1861) traced the genealogy of materials involved in these events back to the primordial history [*Urgeschichte*] and turned these specific materials, then, into generic types that constitute the substance of architecture (p. 183).

Semper's proposal of the four elements of architecture, which he materialized in the example of the Caribbean hut, was an outcome of this relational thinking. He defined the four elements of architecture—the *hearth*, the *roof*, the *enclosure*, the *mound*/the *terrace*—in relation to their materials—clay, wood, textile, stone—and the technical arts which produce them—ceramics, carpentry (tectonics), weaving, masonry (stereotomy). Semper (1851) did not conceive of the relations between these elements, materials and technical arts as static, but as open and varied under different geographical and climatic conditions (p. 110).

If one takes Semper's relational thinking at its early stage in *The Four Elements of Architecture*—i.e. before it is further developed and unified with primordial history in *The Style*—and tries to extricate Loos' stance towards it, certain contentions between the two theoreticians appear. First, it must be made clear that the question of style is not seen by both Semper and Loos as specific to architecture, but as an outcome of its relation to various arts including textile arts, ceramics, painting and others. By underlining the relation between textile arts, ceramics and architecture, Semper observed "how textile patterns that had developed in wall hangings were retained or applied to Assyrian bas-reliefs executed in stone" and "how geometric patterns originating in baskets might be transposed into conventional geometric designs on ceramic vases or even applied to column capitals" (Mallgrave, 1996, pp. 284-285). Whereas Semper used the relation as an *analytical* tool to prove that, in ancient cultures, the character of imitation is not conscious but purely traditional, Loos used it as a *dialectical* tool to criticize the degeneration of imitation in Austrian culture, showing how geometric patterns are turned into solitary motifs—such as a lion's head, a column, a knob or a balustrade. The same motif with arbitrary alterations made to it—sometimes extended or shortened, sometimes thickened or thinned—as Loos points out, was then embossed *into* every piece of furniture in the effort to create a "stylish" house.[7] In his article "Glas und Ton," Loos (1898b) argues that the Austrian architects in fact made use of only two motifs in their creations which he likens to the "verses" of a song—the profile and the ornament, which are repeated and applied onto every possible surface (p. 91).

What becomes problematic in terms of Loos' stance towards relational thinking is the fact that he seems to fall into the very categorization of the history of art which had so strongly been rejected by Semper in the investigation into the relations between ancient and Greek cultures in *The Four Elements of Architecture*. Semper did not consider the regional differences between the four societies he investigated—the *Chinese*, the *Egyptian*, the *Assyrian*, and the *Phoenician*—to be determinants for re-constructing a superior/inferior dichotomy in the relation of ancient arts

[6] I am using here the term *block model* with a reference to the structural analysis in social sciences, the main idea of which is based on relational analysis in a social framework.

[7] For Loos' critique to the decoration of a "stylish" room, see Loos, 1898a, p. 75.

to the Greek art (which had, in fact, been Semper's main criticism of the academic history of art). In his observation of differences between the Austrian culture and the Other [*das Andere*], Loos, however, does not problematize this dichotomy and even re-constructs it by signifying the classical antiquity (the Greeks and the Romans), the Americans and English as the *superior* Other or the West, and the Balkanizes, Chinese, Ottomans and Papua New Guineans as the *inferior* Other—the East. Whereas the superior provides Austria with a model of modern conditions for living, the inferior illustrates primitive conditions to avoid.[8]

In that sense, relational thinking is the key theoretical contention between Semper's and Loos' positions within the history of art, casting doubt on several other all to easily correlated meanings in their texts. Consider just the example of the architecture of China, which Loos despises when compared with West, but Semper (1851) praises, proposing to take lessons from their "ancient use of stucco and rich general polychromy" for his own time (p. 107).

DRESSING, TRUTH AND IMITATION

Having discussed two key methodological approaches in Semper's thinking— primordial history and relational analysis—and the ways in which the former approach is appropriated in Loos' thinking while the latter reflects the conflict between them, we must reconsider Semper's principle of dressing at the intersection of Loos' dualistic attitude towards it. Recent studies have masked this attitude, subsuming it under the principle of dressing itself. On the contrary, I argue that the act of dressing itself reveals the contentious nature of the relation between the two architects and is the point of reconciliation for Loos' ambivalent attitude toward Semper on theoretical and practical levels. It reveals both the theoretical contention between relational analysis and primordial history, and the practical one between the material and the subject. What begins the reconciliation within Loos' own theory, in fact, is his conditional reception of the principle of dressing in terms of its practical applications, on the one hand, and the theoretical soundness of Semper's definition of dressing [*Bekleidung*] which is an immanent phenomenon to Loos' "law of dressing," on the other.

In the section "The Principle of Dressing Has Greatly Influenced Style in Architecture and in the Other Arts in All Periods and in All Nations" of *The Style*, Semper evokes the most common connotation of dressing. For Semper (1851), the primordial technique for creating *enclosure* comes from "the art of the *wall fitter* [*Wandbereiter*], that is, the weaver of mats and carpets" (p. 103). Thus, "the carpet in its capacity as a *wall*" creates the primordial spatial enclosure. According to Semper, the weaving of mats and covers out of various materials—such as tree branches, plant fibers and others—and, consequently, the use of wickerwork precede masonry. "Wickerwork was the *essence of the wall*," Semper (1851) writes with implicit reference to the "truth" of building (p. 104). Following this statement, Semper (1851) addresses the etymological relation between the words *Wand* [wall] and *Gewand* [dress] in a footnote, with an emphasis on the same act of weaving these two share: "The German word *Wand* [wall], *paries*, acknowledges its origin. The terms *Wand* and *Gewand* [dress] derive from a single root. They indicate the woven material that formed the wall" (p. 104). [Semper's italics.][9]

Although solid walls had to be built for reasons of security and rigidity, carpets were still hung in front of solid walls and were the primary creators of the spatial enclosure in ancient arts. According to Semper (1851), the essential meaning of covering the walls with carpets did not change even after the carpets themselves disappeared and were replaced with various "substitutes"— stucco or bitumen plaster as the first substitute, followed later in time by glazed terra cotta, metal plates, and panels of sandstone, granite, alabaster and marble (p. 104).

At this point, it is noteworthy that Semper designates the transformation of the original, functional meaning of dressing into a symbolic one with the word "substitute." By emphasizing the fact that the same patterns and decorations were transferred from a woven domain to a painted one, he ascertains that imitation in ancient arts neither undermined the existence of truth nor implied any intentional forgery. Instead, he reminds us of the means of industrial production whereby copying a pattern—as it is still done today in dressmaking—is a mere technique:

> For a long time the character of the copy followed that of the prototype. The artists who created the painted and sculptured decorations on wood, stucco, fired clay, metal, or stone traditionally though not consciously imitated the colorful embroideries and trellis works of the age-old carpet walls (Semper, 1851, p. 104).

To avoid any contemporary misappropriation of his notion of imitation in ancient arts, Semper acknowledges a concern about altering the meaning of dressing—no less forcefully than Loos. Truth in its primordial applications, he feared, inevitably transforms into conscious imitation in

[8] In her study of Loos' cultural criticism, Stewart (2000) points out that "the signifiers of the Other as cultural renewal" come from the Western culture, while "those which signify the Other as cultural threat" are from the East (p. 65). Although she recognizes the dialectical thinking of Loos and writes on the relation between Benjamin and Loos, there is no discussion in her study about the relation between Semper and Loos. In fact, the influence of Semper on Loos is totally ignored where Semper's name surprisingly appears just in a single footnote.

[9] While writing the section "The Principle of Dressing," in *The Style*, Semper (1861) again points out this etymological relation between *Wand* and *Gewand*, and adds the following statement: "Likewise, *Decke*, *Bekleidung*, *Schranke*, *Zaun* (similar to *Saum*), and many other technical expressions are not somewhat late linguistic symbols applied to the building trade, but reliable indications of the textile origin of these building parts" (p. 255).

the contemporary practice of art. By the time Loos (1898c) uses the words "imitation" and "surrogatkunst" [substitute art] in his article "Das Prinzip der Bekleidung," neither connotes truth in dressing (p. 141). The innocence of imitation in ancient arts has long since turned into purposeful forgery, to which Semper's "substitutes" are mere accomplices.

If this is the case, then, where is this turning point in the history—the moment where imitation becomes degenerated? Though acknowledging the difference between traditional and conscious imitation, Semper does not mention any certain moment in time where a change begins to take place.[10] Nevertheless, he points out a turning point in the Roman era when the artistic creation started to put more emphasis on materiality and construction of the wall than its dressing. In that sense, the order of meanings attributed by Semper to four elements of architecture started to shift. Through its form, the wall overtook the dominant meaning of the roof (Semper, 1851, p. 126).

Loos, however, is more explicit than Semper in defining a moment of rupture between truth and imitation. Imitation, he says, is an outcome of being uncultivated. When Loos (1909) criticizes the architect for having no culture "like nearly every other city inhabitant" (p. 91), he dates his present Vienna as the highpoint of a cultural degeneration that started to evolve in the second half of the nineteenth century.[11] What generates this moment of rupture in human history is precisely a change in the perception of time: "Bis dahin blieb die entwicklung unserer kultur in schönem gleichmäßigen fluß. Man gehorchte der stunde und sah nicht vorwärts und nicht rückwärts" (Loos, 1909, p. 91). Although Loos makes no direct link to architecture, one can follow this assumption and argue that the change in the perception of time is also crucial to understanding the rupture in architectural history and its outcomes: That is, historicism and monumental architecture.

In a chapter of *The Style* entitled "The Principle of Dressing," Semper points out the current interest of the history of art on monumental architecture as opposed to the "prearchitectural conditions" which he venerated in his theory of dressing. Nevertheless, he does not view monumental architecture and the theory of dressing as opposed to one another. The architectural primordial type—the dwelling or the Caribbean hut—is, in fact, the prototype to the "monumental form" (Semper, 1861, p. 255).

For Semper (1861), monumental architecture is the exception for truth in dressing and artistic creation becomes an issue for the legitimization of "exterior adornment" and the "dressing" of structure through "masking of reality" (p. 257). In that sense, only the theatrical and the celebrative nature of architecture, such as dressed scaffoldings, are allowed to mask the materials of the construction underneath and gird the bare structural body with paint, textiles, etc. according to the principle of dressing. Semper (1861) writes in a footnote:

> The denial of reality, of the material, is necessary if form is to emerge as a meaningful symbol, as an autonomous creation of man. Let us make forgotten the means that need be used for the desired artistic effect and not proclaim them loudly, thus missing our part miserably. The untainted feeling led primitive man to the denial of reality in all early artistic endeavors; the great, true masters of art in every field returned to it—only these men in times of high artistic development also *masked the material of the mask*… Masking does not help, however, when *behind* the mask the thing is false or the mask is no good (p. 257). [Semper's italics.]

THE MATERIALITY OF THE DRESSING

Both Semper and Loos are concerned with the idea of dressing and its materiality on two levels: First, the relation of the subject—i.e., the architect—to the material, and second, the relation of one material [*das bekleidete Material*] to another [*das bekleidendes Material*]. Indeed, the principle of dressing offers the possibility of revealing both the analytical and the critical in these reciprocal relations.

The advice given by Semper (1851) to his readers in the first of his five principals for artistic painting "to remain mindful of the carpet as the earliest spatial enclosure," leans arguably toward the analytical end of the spectrum (p. 127). In his article "Das Prinzip der Bekleidung," Loos (1898c), on the other hand, illustrates how acts of misuse and imitation—such as creating wall masses [*Mauerkörper*] instead of spatial enclosures, selecting any kind of dressing that *fits* on these walls, substituting one material for another and being indifferent to the material's pattern language [*Formensprache*]—derive from the relation of the architect to the material (p. 140).

For Loos, the untruthful relation of the architect to the material distorts the relation of one material [*das bekleidete Materia*l] to another [*das bekleidendes Material*], as well. Even though a living room may be dressed with carpets covering the walls and the floor, he would be skeptical about the deceitfulness of such an act of dressing in a contemporary situation. In that situation, not only is the room imitated, but also the act of dressing. What remains independent of this

[10] "For a long time the character of the copy followed that of the prototype. ..." (Semper, 1851, p. 104). "… carpets were also the models for the art of mosaic, which remained for the longest time true to its origin." (Semper, 1851, p. 106) Although Semper (1851) implies in the following sentence that ancient arts came to an end with the Byzantine, there is no explicit reference to the end of truth in the practice of art: "Antique art completed its cycle, having run the full circle back to its origins, and became extinct with Byzantine embroideries. Its swaddling clothes became its burial shroud" (p. 110).

[11] "Als die materialien, die zur bekleidung verwendet werden, noch nicht imitiert wurden, hat man keine gesetze ausgetüftelt. Nun aber scheint es mir hoch an der zeit zu sein." (Loos, 1898c, p. 142.)

cornucopia of imitation, however, is the dressing material [*das bekleidendes Material*] itself—the carpet.[12]

One can argue that in this scene of counterfeit dressing, Loos justifies the autonomy of the dressing material and, consequently, Semper's principle of dressing. In his article "Das Prinzip der Bekleidung," Loos (1898c) proposes to transform the "principle of dressing" into a "law of dressing" [*Gesetz der Bekleidung*][13] and reveals two purposes of a "law of dressing." First, to prevent false application of the principle of dressing in practice, and second, to bring Semper's proposals for the practical application of dressing up to date, and in this way, to remove the potential confusion between an act of dressing and the principle of dressing. Giving examples of applications with three constructive materials—brick, iron and wood—Loos (1898c) illustrates the various modes of building to which the principle of dressing can be applied (p. 144). He expects not only the architect to be obliged by his law, but workers and artists, as well.

What becomes evident here is the relation of one material—that is *dressed* [das bekleidete Material]—to another one—that is *dressing* [das bekleidendes Material]. To reconstruct this relation within the general principle, Loos proposes that the constructive framework—such as brick walls, iron columns and wooden pillars—and the dressing materials—such as paint, stucco, wallpapers, oil clothes, textiles and carpets—be interrelated in a controlled manner. As the act of dressing always involves two materials—the *dressed* and the *dressing*—he pairs these in various ways following from the most basic of the principles of dressing—that is, the *dressing* is not permitted to imitate the *dressed* material.

Thus, Loos pairs a dressed metal with a dressing metal or with oil paint, but not with a metal-color; and similarly, a dressed wood with a dressing wood or oil paint, but not with a wood-color. He thereby proposes the formation of certain blocks of relational material characteristics—such as metal, wood, colors, techniques. What comes out of this formation can be construed as a matrix of four hypothetical block models in which the intersections of various materials are represented.[14]

CONCLUSION

It is Loos's declaration on dressing and its connection to the spatial enclosure that makes him the most Semperian theoretician and architect. In his article "Das Prinzip der Bekleidung," Loos (1898c) writes: "*Im anfange war die bekleidung*" ["In the beginning, there was dressing"] (p. 139). Then came the cover [*Decke*]; after that, the walls. However, if one also recognizes here the implicit references to *when* and *how* the dressing started, then Loos' affirmation of Semper's principle of dressing must be considered in light of two methodological approaches—*Urgeschichte* and relational analysis.

Primordial history [*Urgeschichte*] and relational analysis suggest not only similarities but also contradictions and reveal the contentious relation between Semper's and Loos's understanding of dressing. Whereas Semper sets the origin of the principle of dressing at the history of antiquity and investigates truth in ancient arts, Loos locates his law of dressing directly against the imitations of dressing from the mid-nineteenth century up to his present time. Thus, it is the primordial history of modernity where Loos confronts symbolic contradictions of the material transformation. Relational analysis, on the other hand, serves as a guide to a genealogy of architecture for both Semper and Loos. They explore the relations between societies, technical arts, buildings, objects, materials, techniques and procedures, and then pair the most identical types by creating groups, associations, blocks in an imaginary matrix. By tracing the genealogy of materials, they illustrate the process of this "metamorphosis," that is "a new material transformation (*Stoffwechsel*)" and a new understanding of "architecture as procedure," as Deamer (2000, p. 109) points out. According to Semper, it is the ultimate form of the *Urtypus* where multiple phases of this process are recorded as a genealogical memory. Where primordial history [*Urgeschichte*] and relational analysis link to each, the theoretical contention between Semper and Loos becomes apparent. Openness, variety and multiplicity are precisely the sound values of Semper's principle of dressing which allow it to be transformed under new conditions of architectural practice—as Loos was to do—without losing any of its basic ideas. Loos' conditional adoption of the principle of dressing in terms of its practical applications, on the other hand, is evidence of an attempt to bring a highly theoretical discussion into the domain of practice and to make it available to architects and builders.

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[12] In his article "Das Prinzip der Bekleidung," Loos (1898c) explicitly illustrates the act of dressing by the use of carpets: "Aber ist der wohnraum, der ganz mit teppichen ausgelegt ist, keine imitation? Die wände sind ja nicht aus teppichen gebaut! Gewiß nicht. Aber diese teppiche wollen nur teppiche sein und keine mauersteine, sie wollen nie für solche gehalten werden, zeigen dies weder durch farbe noch muster, sondern bringen ihre bedeutung als bekleidung der mauerfläche klar zutage. Sie erfüllen ihren zwecke nach dem prinzipe der bekleidung" (p. 141).

[13] "Dieses gesetz lautet also: Die möglichkeit, das bekleidete material mit der bekleidung verwechseln zu können, soll auf alle fälle ausgeschlossen sein. Auf einzelne fälle angewendet, würde dieser satz lauten: Holz darf mit jeder farbe angestrichen werden, nur mit einer nicht – der holzfarbe" (Loos, 1898c, p. 141).

[14] A further discussion of cladding and the materiality of dressing in Loos's interiors is needed; yet, it exceeds the limits of this paper. For an analysis of the American Bar (or Loos-Bar) in Vienna and the dressing materials Loos used, see Moravánsky, 1996, p. 43.

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Article

Climate-responsive roof design: phase-change materials and cool-roof coatings across Türkiye's six climate zones

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ABSTRACT

Roof material and coating decisions are typically finalized early in design, yet climate-specific evidence for choosing among roof-integrated phase-change materials (PCMs), high-reflectance cool roofs (CR), and their combination remains limited. This study evaluates all three strategies via annual EnergyPlus simulations of a standardized office model across Türkiye's six TS 825 climate zones (Mersin, Şanlıurfa, İstanbul, Ankara, Van, and Erzurum). Five inorganic PCM products with nominal melting temperatures of 21, 23, 25, 27, and 29 °C were tested individually before the best-performing temperature in each city was paired with the cool-roof finish. Performance was assessed from annual ideal-load heating and cooling demand, with total demand defined as their sum. The optimal PCM reduced total demand by 4.24–10.15%, with the preferred melting temperature shifting from 25 °C in cooling-dominated Mersin to 21 °C in cold Erzurum; 23 °C was optimal in the other four cities. The cool roof reduced cooling demand in every city but increased heating demand, producing net annual savings of only 0.22% in Erzurum and up to 5.86% in Mersin. The combined strategy achieved the lowest total demand in five cities, with savings of 8.00–11.92%. Van was the exception: its optimal PCM alone saved 10.01%, whereas the combined case saved 6.33%, indicating that the coating and PCM were not universally additive. The findings show that PCM transition temperature should be matched to local operating conditions and that cool roofs require an annual heating–cooling assessment rather than a cooling-only evaluation.

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INTRODUCTION

Reducing the heating and cooling requirements of buildings is an important component of improving operational energy performance. Because the building envelope controls heat exchange between indoor and outdoor environments, modifications to walls and roofs can reduce thermal loads and improve indoor conditions. Phase-change materials (PCMs) have received considerable attention in this context because they can store and release latent heat within

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a limited temperature range (Faraj et al., 2021). Cool-roof materials represent another passive strategy, using high solar reflectance and thermal emissivity to reduce the solar energy absorbed by the roof (Saber, 2021).

Roofs are particularly exposed to solar radiation and fluctuations in outdoor temperature. When incorporated into a roof, a PCM can absorb heat during melting and release the stored energy during solidification, thereby attenuating and delaying heat transfer. However, its effectiveness depends on factors such as melting temperature, latent-heat capacity, thickness, position within the construction and local climatic conditions (Rathore et al., 2022). Seasonal analyses have also demonstrated that PCM performance can vary substantially with phase-transition temperature and environmental conditions (Tunçbilek et al., 2020).

Cool-roof performance is similarly climate-dependent. Increasing roof solar reflectance generally decreases roof-surface temperature and cooling demand, but the annual benefit varies according to climatic conditions and the balance between heating and cooling requirements (Rincón et al., 2024). During winter, a reflective roof may reduce beneficial solar heat gains and consequently increase heating demand (Ascione et al., 2018). Therefore, evaluating cooling demand alone may overestimate the annual benefit of a cool roof, particularly in heating-dominated climates.

Previous studies have investigated radiative-cooling roofs and PCM-integrated roof systems under different environmental conditions (Kim et al., 2020; Tang et al., 2024). Other studies have specifically evaluated combined PCM–cool-roof configurations through experimental and numerical approaches (Yang et al., 2019). A review by Rawat et al. further demonstrated the growing interest in integrating latent-heat storage with reflective roof technologies (Rawat et al., 2022). Nevertheless, direct comparisons using an identical building model, a common roof construction and the same range of PCM melting temperatures across multiple climate zones remain limited.

Furthermore, the energy benefits of PCM and cool-roof technologies should not automatically be assumed to be additive when the two measures are applied together. A reflective exterior finish changes the thermal conditions experienced by the underlying roof layers and may therefore influence PCM melting and solidification. The combined configuration must consequently be simulated as a coupled system and compared directly with the individual strategies.

Roof material and coating decisions are generally finalized during the early design phase, before the mechanical systems are sized or optimized. Architects therefore need climate-specific, comparative evidence for choosing between passive envelope strategies such as PCM integration and cool-roof coatings. Without such evidence roof specifications tend to default to convention rather than to tested climate performance, particularly in a country as climatically diverse as Türkiye.

Accordingly, the present study investigates one flat-roof office model in six representative Turkish cities, each corresponding to one of the six climate zones defined by the Turkish Standard for Thermal Insulation Requirements in Buildings, TS 825 (TSE, 2024). Five nominal PCM melting temperatures, 21, 23, 25, 27 and 29 °C, were initially evaluated for each city. The city-specific optimal PCM was subsequently compared with a TiO_2–SiO_2 cool-roof coating and a combined PCM–cool-roof configuration. The objectives were to: (i) identify the preferred PCM melting temperature for each climate, (ii) quantify the annual heating–cooling trade-off associated with the cool roof, and (iii) determine whether the combined measures exhibit synergistic, additive or antagonistic behavior.

BACKGROUND

Roof-integrated phase-change Materials

PCMs provide thermal storage by absorbing energy during melting and releasing it during solidification. This process increases the effective heat-storage capacity of a building component within the material's phase-transition range (Faraj et al., 2021). When incorporated into roofs, walls or other envelope elements, PCMs can reduce temperature fluctuations, delay peak heat transfer and potentially reduce space-conditioning demand.

The thermal performance of a PCM-integrated envelope depends on the relationship between the phase-transition temperature and the temperature cycle experienced by the material. PCM performance is also affected by latent-heat capacity, thermal conductivity, layer thickness, position, envelope construction and local climatic conditions (Rathore et al., 2022). If the transition range is unsuitable, the PCM may remain predominantly solid or liquid, restricting effective melting and solidification and limiting the use of its latent-heat capacity.

Tunçbilek et al. showed that the seasonal and annual performance of PCM-integrated building components is strongly affected by climatic conditions and the selected phase-transition temperature (Tunçbilek et al., 2020). Azimi et al. similarly demonstrated the importance of optimizing PCM selection and application parameters for the specific building and climate under investigation (Azimi et al., 2025). Tokuç et al., evaluated a flat roof containing a single PCM layer across Türkiye's four climatic zones for only cooling season and reported substantial reductions in cooling load (Tokuç et al., 2017). These findings indicate that selecting a PCM solely according to peak summer outdoor temperature may not produce the lowest annual heating and cooling demand.

Recent research has also examined more advanced PCM roof configurations. Tang et al. experimentally investigat-

ed a radiative-cooling roof incorporating dual PCMs under hot-summer and warm-winter climatic conditions (Tang et al., 2024). Kim et al. evaluated PCM-containing materials for cool-roof applications and reported reductions in roof-surface and indoor temperatures (Kim et al., 2020). Although these studies demonstrate the potential of PCM roof systems, their findings also emphasize that performance is closely related to material selection and operating conditions.

In addition to material selection and operating conditions, the PCM configuration and integration method can influence envelope performance. Experimental evidence indicates that changing the position of the PCM layer and the associated thermal resistance can improve latent-heat utilization compared with a fixed PCM arrangement (Li et al., 2024). EnergyPlus simulations of PCM-integrated façades have also shown that PCM composition and melting characteristics can substantially affect annual heating and cooling loads (Azadani & Ardekani, 2025). In Türkiye specifically, Arıcı et al. found that the optimum position of PCM within a wall assembly shifted from an inner to an outer layer between milder and colder cities (Arıcı et al., 2020). These findings demonstrate that PCM performance depends not only on transition temperature but also on material composition, position within the envelope, and interaction with the surrounding construction.

Cool Roofs and Combined Systems

Cool roofs employ exterior materials with high solar reflectance and thermal emissivity. These optical properties reduce the proportion of incident solar radiation absorbed by the roof and facilitate heat rejection to the outdoor environment (Saber, 2021). As a result, cool roofs generally reduce daytime roof-surface temperatures, inward heat transfer and cooling demand.

The magnitude of this benefit depends on climate, roof insulation and building operation. Studies of office buildings across different Spanish climate zones have demonstrated that the effects of cool roofs on cooling demand, annual energy demand and thermal comfort vary with climatic conditions (Rincón et al., 2024). Ascione et al. specifically investigated the winter energy penalty of reflective roofs and showed that reduced solar absorption can increase heating requirements (Ascione et al., 2018). Therefore, both heating and cooling demands must be considered when evaluating annual cool-roof performance.

Recent reviews have further emphasized that cool-roof performance depends on more than solar reflectance and thermal emittance. Roof material selection, insulation level, coating durability, weathering, construction thickness, cost, and local climate can influence the practical energy benefit (Basyouni & Mahmoud, 2024). These factors reinforce the need to evaluate cool-roof configurations under the climatic and construction conditions in which they will be applied.

Other studies have reported similar heating–cooling trade-offs. Yazdani and Baneshi compared dynamic cool roofs and green roofs under different climatic conditions, demonstrating the importance of climate-responsive roof selection (Yazdani & Baneshi, 2021). Application of a cool coating to a laboratory building reduced cooling demand but increased heating demand (Kolokotsa et al., 2012). These findings confirm that a cool roof's annual performance cannot be determined solely from its cooling-season benefit.

Combining a cool roof with PCM introduces two thermal-control mechanisms: solar-gain reduction at the exterior surface and latent-heat storage within the roof construction. Yang et al. experimentally and numerically investigated a PCM cool-roof system and reported reductions in roof-surface temperature (Yang et al., 2019). Rawat et al. reviewed combined PCM–cool-roof applications and reported potential improvements in thermal comfort and building energy performance (Rawat et al., 2022).

However, the two measures may not operate independently. A highly reflective coating can reduce the magnitude of the temperature variation transmitted through the roof, potentially changing the degree of PCM melting and solidification. Therefore, the performance of a combined PCM–cool-roof configuration should be determined directly rather than estimated by adding the savings obtained from the two individual measures. In the present study, this relationship is evaluated using an interaction indicator that distinguishes synergistic, additive and antagonistic behavior.

From a design perspective, TS 825 establishes minimum envelope insulation requirements for each climate zone but provides no guidance on complementary passive strategies such as PCM integration or cool-roof coatings. Consequently, climate-specific guidance for selecting or combining these measures remains limited. This study addresses this gap by evaluating both strategies, individually and in combination, across Türkiye's six TS 825 climate zones.

METHODOLOGY

Building and Simulation Model

A simple two-story office model was developed using DesignBuilder version 7.3.0.040 (DesignBuilder) and simulated with its integrated EnergyPlus version 9.4.0 (EnergyPlus) engine. Six timesteps per hour, corresponding to 10-minute intervals, were used. The rectangular building was aligned with the cardinal directions, with its 10 m façades facing north and south and its 9 m façades facing east and west. The same external geometry was used in all cities, including a gross flat-roof area of 90.00 m^2. The gross window-to-wall ratio was defined as the total exterior win-

dow-opening area divided by the total above-ground gross exterior wall area. Based on a window-opening area of 24.78 m^2 and a gross exterior wall area of 205.20 m^2, the resulting ratio was 12.08%. The roof construction, internal-gain densities, schedules, and HVAC settings were retained across the climate cases. The assigned DesignBuilder HVAC template was a four-pipe fan-coil unit with an air-cooled chiller.

The windows had a U-value of 1.8 W/(m^2·K), a solar heat gain coefficient of 0.691, a direct solar transmittance of 0.624, and a visible transmittance of 0.744. Infiltration was modelled at a constant rate of 0.50 air changes per hour. Mechanical ventilation supplied 10 L/s of outdoor air per person according to the occupancy schedule, while natural ventilation was disabled. The occupancy, lighting, and equipment densities were 0.111 people/m^2, 15 W/m^2, and 11.77 W/m^2, respectively. Table 1 summarizes the main geometric, operational, and simulation parameters of the reference office building.

Figure 1 shows the building developed in DesignBuilder and used for all climate simulations.

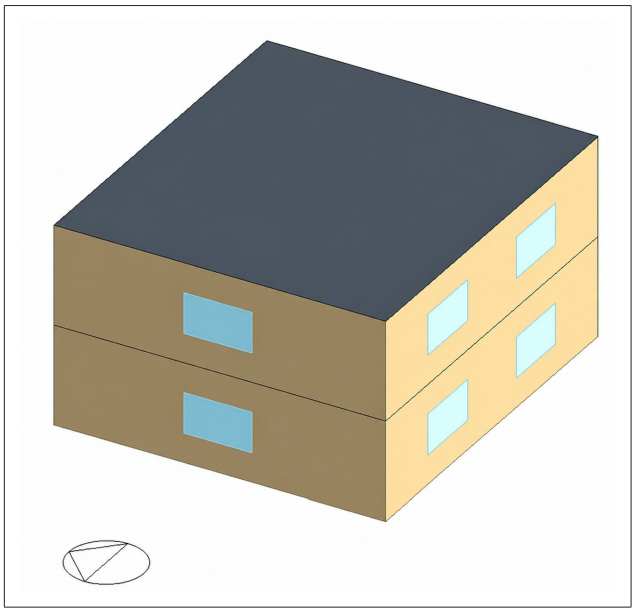

Figure 1. 3D model of the case study building.

Climate Locations and Weather Data

Six cities were selected to represent the six climate zones used in the current Turkish thermal-insulation framework (TSE, 2024). The corresponding EnergyPlus Weather (EPW) files were used for the simulations (Lawrie, 2026). Table 2 presents the selected cities, their TS 825 climate zones, and geographical information.

Table 3 summarizes the envelope constructions used in the simulations. To isolate the effects of climate and the investigated roof modifications, the roof construction and its U-factor were kept constant across all six cities. The wall and ground-floor insulation thicknesses were selected with reference to the recommendations for the corresponding TS 825 climate zones, while the remaining construction layers were kept consistent across the models (TSE, 2024).

Table 1. Main building and simulation parameters

Parameter	Value used in the model
Gross roof area	90.00 m^2
Window opening area	24.78 m^2
Gross window-to-wall ratio	12.08%
Activity template	Office
Operating schedule	Monday–Friday 09:00–17:00, Saturday–Sunday off
Heating setpoint / setback	22 °C / 12 °C
Cooling setpoint / setback	24 °C / 28 °C
Assigned HVAC template	Fan Coil Unit (4-Pipe), Air cooled Chiller
Simulation period	1 January–31 December

Roof Configurations

A flat-roof geometry was used in all simulations. The base roof had a U-factor of 0.24 W/(m^2·K) and consisted, from outside to inside, of a 4 mm bituminous membrane, 120 mm XPS insulation, 2 mm vapor-barrier membrane, 150 mm lightweight cast-concrete deck, and 15 mm gypsum plasterboard. The base case contained no PCM.

For the PCM cases, a 20 mm PCM layer was placed between the concrete deck and the gypsum plasterboard. PCM heat transfer was calculated using the finite-difference method with a fully implicit first-order scheme and the hysteresis model. The melting and freezing peaks were set 1 °C above and below each nominal transition temperature, respectively, with a 1 °C temperature difference on either side of each peak. Five PCMs, InfiniteRPCM21C, InfiniteRPCM23C, InfiniteRPCM25C, InfiniteRPCM27C, and InfiniteRPCM29C, with nominal transition temperatures of 21, 23, 25, 27, and 29 °C, respectively, were evaluated while all other model parameters remained unchanged. For each city, the PCM configuration with the lowest annual total thermal demand was selected for the combined PCM and cool-roof case. In this study, "optimal PCM" refers to the best-performing option among the five tested nominal transition temperatures.

For the cool-roof case, the roof geometry and construction were retained, and only the exterior surface properties were modified by applying a TiO_2–SiO_2 coating with a solar absorptance of 0.05 and thermal emittance of 0.91 (Benmoussa et al., 2023). The combined configuration incorporated

Table 2. Representative cities and weather-file locations

Zone	City	Latitude (°N)	Longitude (°E)	Elevation (m)
1	Mersin	36.78	34.60	3.0
2	Şanlıurfa	37.45	38.90	822.0
3	İstanbul	40.97	28.82	49.7
4	Ankara	39.97	32.86	891.0
5	Van	38.47	43.33	1670.3
6	Erzurum	39.95	41.19	1756.6

both the city-specific optimal 20 mm PCM layer and the cool-roof finish. The thermophysical and optical properties of the cool-roof coating are presented in Table 4.

The main thermophysical properties of the investigated PCMs are summarized in Table 5.

Table 6 summarizes the simulated roof configurations and their key modeling parameters.

Performance Indicators

Annual total thermal demand was calculated as the sum of annual heating and cooling demands:

$$Q_{total} = Q_{heating} + Q_{cooling}$$

The energy saving of each scenario relative to the base roof was calculated as:

$$S_i = 100 \times (Q_{base} - Q_i)/Q_{base}$$

where positive values indicate a reduction in annual thermal demand and negative values indicate an energy penalty.

For the combined PCM and cool-roof configuration, the interaction term was calculated as:

$$\Delta S_{int} = S_{PCM+CR} - (S_{PCM,\,opt} + S_{CR})$$

Positive values indicate a synergistic interaction, values close to zero indicate an approximately additive effect, and negative values indicate an antagonistic interaction.

RESULTS AND DISCUSSION

Sensitivity to PCM Melting Temperature

The annual heating, cooling, and total demands show a clear non-monotonic response to PCM melting temperature (Figure 2). The best temperature was 21 °C in Erzurum, 25 °C in Mersin, and 23 °C in Van, Ankara, İstanbul, and Şanlıurfa. These optima reduced annual total demand by 10.15%, 4.24%, 10.01%, 7.49%, 6.37%, and 7.23%, respectively. The result demonstrates that the warmest climate did not simply favor the highest tested transition temperature. Instead, useful performance depended on matching the PCM transition range to the roof's operating cycle.

Figure 3 shows that PCM performance strongly depended on the relationship between the melting temperature and the thermal conditions within the roof. Lower-temperature PCMs generally performed better in colder cities, where the temperature at the PCM layer was more likely

Table 3. Envelope constructions and calculated U-factors used in the simulations

Component	Applicable cities (TS 825 zone)	Construction / insulation	U-factor (W/(m²·K))
Flat roof	All six cities (Zones 1–6)	4 mm bituminous membrane, 120 mm XPS, 2 mm vapor barrier, 150 mm lightweight concrete, 15 mm gypsum plasterboard	0.24
External wall	Mersin (1)	20 mm cement plaster, 80 mm EPS, 200 mm concrete, 15 mm gypsum plaster	0.42
External wall	Şanlıurfa (2), İstanbul (3), Ankara (4)	20 mm cement plaster, 100 mm EPS, 200 mm concrete, 15 mm gypsum plaster	0.35
External wall	Van (5), Erzurum (6)	20 mm cement plaster, 150 mm EPS, 200 mm concrete, 15 mm gypsum plaster	0.24
Ground floor	Mersin (1), Şanlıurfa (2), İstanbul (3), Ankara (4)	30 mm floor finish, 40 mm lightweight concrete, 1.5 mm bituminous membrane, 100 mm XPS, 1 mm bituminous membrane, 75 mm lean concrete, 100 mm gravel fill	0.26
Ground floor	Van (5), Erzurum (6)	30 mm floor finish, 40 mm lightweight concrete, 1.5 mm bituminous membrane, 120 mm XPS, 1 mm bituminous membrane, 75 mm lean concrete, 100 mm gravel fill	0.22

Table 4. Properties of the TiO_2–SiO_2 cool-roof coating (Benmoussa et al., 2023)

Material	Thermal conductivity (W/(m·K))	Density (kg/m³)	Specific Heat (J/(kg·K))	Thermal emissivity	Solar absorptance	Solar reflectance
TiO_2–SiO_2 coating	4.80	3,970	683	0.91	0.05	0.956

Table 5. Thermophysical properties of the investigated PCM (Terhan & Ilgar, 2023)

Material	Nominal transition temperatures (°C)	Density (kg/m³)	Thermal conductivity, liquid/solid (W/(m·K))	Latent heat (kJ/kg)	Specific heat (J/(kg·K))
InfiniteRPCM	21, 23, 25, 27, 29	1,540	0.54/1.09	200	3,140

Table 6. Simulated roof configurations

Case	Roof modification	Key modeled variable
Base	Flat roof	U=0.241 W/(m²·K)
PCM21–PCM29	20 mm PCM between concrete and gypsum	Nominal melting temperature 21, 23, 25, 27, or 29 °C
CR	High-reflectance exterior coating	Solar absorptance 0.05, emittance 0.91
PCMopt + CR	City-specific optimal PCM plus coating	Both modifications applied

PCM: phase-change material; CR: cool roofs

to enter the 21–23 °C transition range and subsequently decrease below it, favoring repeated melting and solidification. Accordingly, PCM21 achieved the highest energy saving in Erzurum (10.15%), while PCM23 was optimal in Van (10.01%), Ankara (7.49%), İstanbul (6.37%), and Şanlıurfa (7.23%). In cooling-dominated Mersin, the optimum shifted to PCM25, although the resulting saving was lower (4.24%). This may be related to the relatively high roof insulation level and the cooling control strategy, which reduced the contribution of the PCM to the total building energy demand.

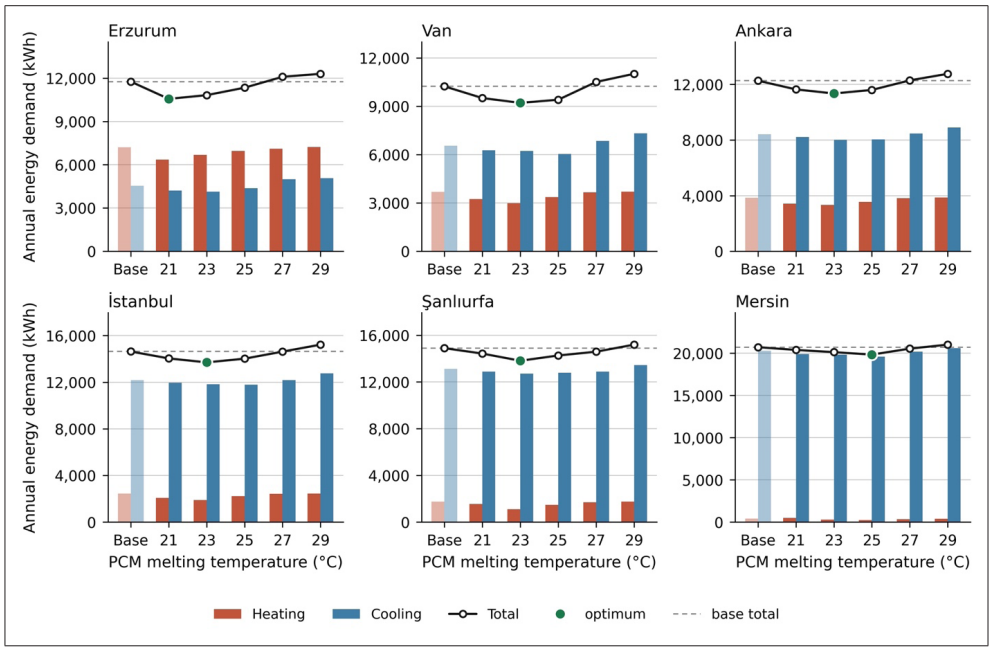

Figure 2. Annual heating, cooling, and total thermal demand for the base roof and the five PCM melting temperatures. Green markers identify the minimum-total-demand PCM in each city.

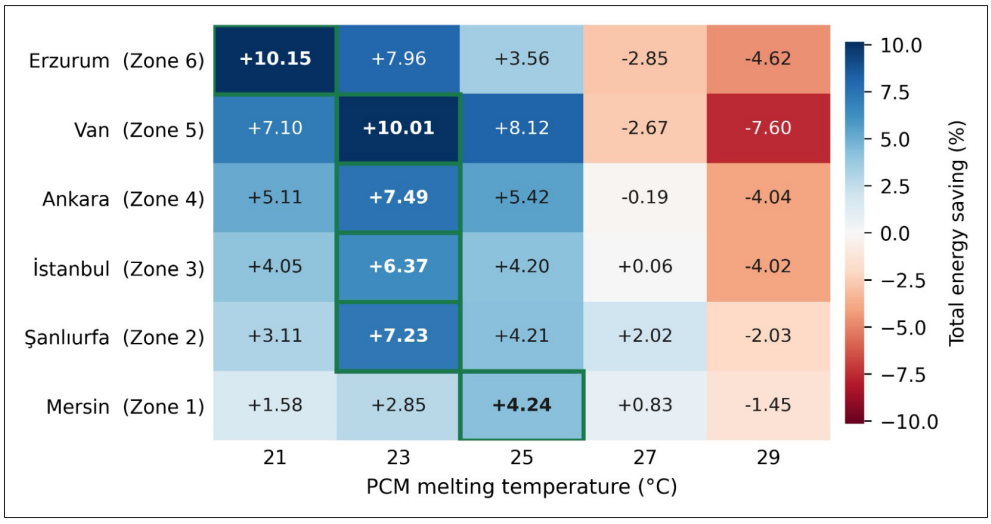

Figure 3. Total annual thermal-demand saving relative to the base roof for each PCM melting temperature. Green outlines identify the city-specific optimum, negative values denote an energy penalty.

In contrast, the effectiveness decreased as the melting temperature increased. PCM27 provided only limited benefits in Mersin, İstanbul, and Şanlıurfa and increased energy demand in Ankara, Van, and Erzurum. PCM29 increased total energy demand in all cities, with penalties ranging from 1.45% in Mersin to 7.60% in Van. A possible explanation is that the temperature at the PCM layer did not remain within the higher transition ranges sufficiently often to allow effective melting and solidification. Consequently, the latent heat storage capacity may have been only partially activated, while sensible heat storage and changes in heat-transfer timing could have reduced the overall benefit. These findings indicate that PCM selection should consider the annual thermal conditions at the PCM location and the balance between heating and cooling demand rather than relying solely on peak outdoor summer temperatures.

The climate-dependent optimum identified here is consistent with previous studies emphasizing that the phase-transition temperature must be matched to the PCM's operating conditions. For example, the transition temperature of an internal PCM layer should be selected according to the air-conditioning schedule and indoor thermal conditions (Tang et al., 2024). In contrast, a substantially higher transition temperature of 44 °C was selected for a PCM installed near the exterior roof surface in Seoul (Yang et al., 2019). This difference can be attributed to the different PCM locations and the thermal conditions experienced by the material. In the present study, the PCM was placed between the concrete deck and gypsum plasterboard, where its operating temperature was more closely influenced by indoor conditions. The poor performance of PCM27 and PCM29 therefore suggests that a higher transition temperature is not necessarily advantageous, even in warmer climates, if the PCM cannot complete effective melting and solidification cycles.

Optimal PCM, Cool Roof, and Combined Strategy

Table 7 compares the city-specific optimal PCM, cool-roof, and combined configurations. The optimal PCM produced annual thermal-demand savings in all six cities, whereas the cool roof created a trade-off between reduced cooling demand and increased heating demand. Consequently, the effectiveness of each strategy varied according to the local balance between heating and cooling requirements.

Table 7. Annual total thermal-demand savings relative to the base roof

City	Optimal PCM	PCM-saving (%)	CR-saving (%)	PCM + CR saving (%)	Lowest-demand strategy
Erzurum	21 °C	10.15	0.22	11.92	PCM + CR
Van	23 °C	10.01	3.44	6.33	PCM alone
Ankara	23 °C	7.49	4.14	11.53	PCM + CR
İstanbul	23 °C	6.37	2.76	9.55	PCM + CR
Şanlıurfa	23 °C	7.23	4.24	11.48	PCM + CR
Mersin	25 °C	4.24	5.86	8.00	PCM + CR

PCM: phase-change material; CR: cool roofs

The cool roof was most effective in cooling-dominated Mersin, where the cooling reduction clearly exceeded the associated heating penalty. Its net benefit was generally lower in colder climates. In Erzurum, for example, the cool roof increased heating demand by approximately 529 kWh while reducing cooling demand by approximately 555 kWh, resulting in a net annual saving of only 0.22%. This near balance illustrates why considering cooling demand alone can overestimate the annual effectiveness of a reflective roof in heating-dominated locations.

Figure 4 presents the corresponding annual heating and cooling demands in absolute terms. The combined strategy achieved the lowest total demand in five of the six cities. Van was the exception: the optimal PCM alone achieved a saving of 10.01%, compared with 6.33% for the combined configuration. Therefore, adding a reflective coating to a successful PCM roof does not necessarily provide an additional benefit, demonstrating the importance of evaluating the two measures as a coupled system.

A component-level comparison provides further insight into the performance of the three strategies. For the city-specific optimal PCM, both heating and cooling demand decrease in every city, although their relative contributions vary with climate. Heating reduction constitutes a substantial share of the benefit in colder locations, whereas cooling reduction becomes increasingly important in warmer climates (Figure 5a).

A different pattern is observed for the cool roof. Its high solar reflectance reduces absorbed solar radiation and lowers cooling demand in all cities. However, it also limits beneficial solar gains during the heating season, resulting in higher heating demand. The net annual benefit therefore depends on whether the cooling reduction is sufficient to compensate for the heating penalty (Figure 5b).

This heating and cooling trade-off is consistent with previous studies showing that reflective roof coatings can increase winter heating requirements despite providing substantial cooling-season benefits (Ascione et al., 2018). Conversely, considerable reductions in roof heat gain have been reported under tropical, cooling-dominated conditions (Yang et al., 2018). These contrasting findings support the present results: cool roofs provide their greatest annual benefit where cooling demand dominates, whereas their winter penalty can offset much of the cooling benefit in colder climates.

When the two measures are combined, the cooling reduction is greater than that achieved by either strategy individually in every city. Nevertheless, the reflective coating diminishes part of the heating benefit obtained with PCM alone and, in Van, causes heating demand to exceed the base-case value. The results indicate that the two technologies have complementary thermal functions, but their combined benefits are not necessarily additive and remain climate-dependent (Figure 5c).

Interaction Between PCM and Cool Roof

For the combined configuration, the interaction between the two measures was quantified. Because PCM and the cool-roof coating both act on the same roof heat flux, they

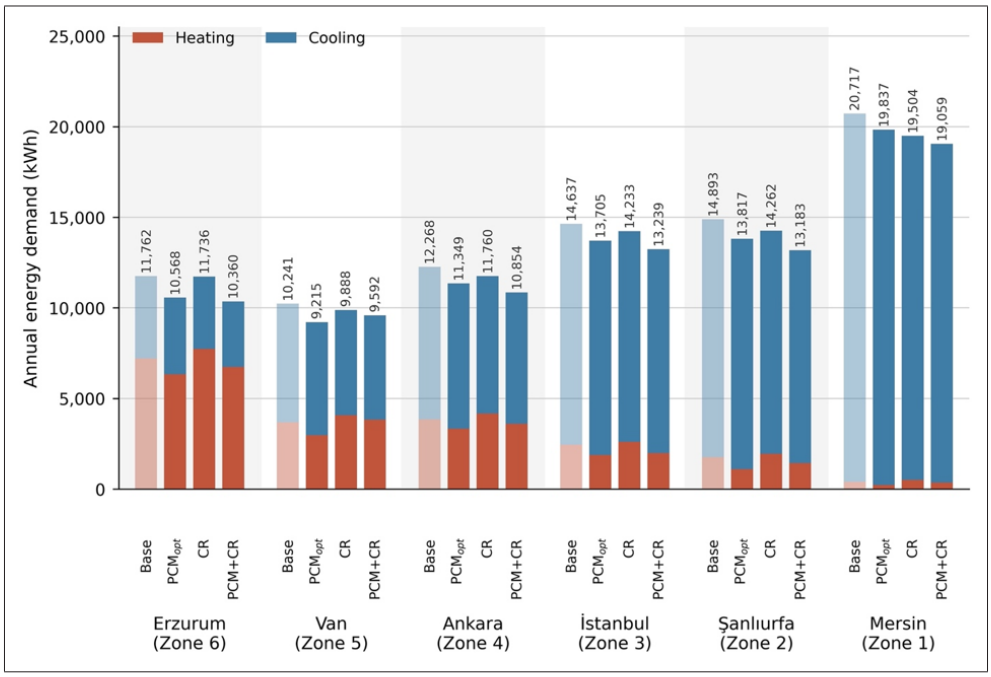

Figure 4. Annual heating and cooling demand for the base roof, city-specific optimal PCM, cool roof, and combined PCM–cool-roof cases. Labels show total annual thermal demand.

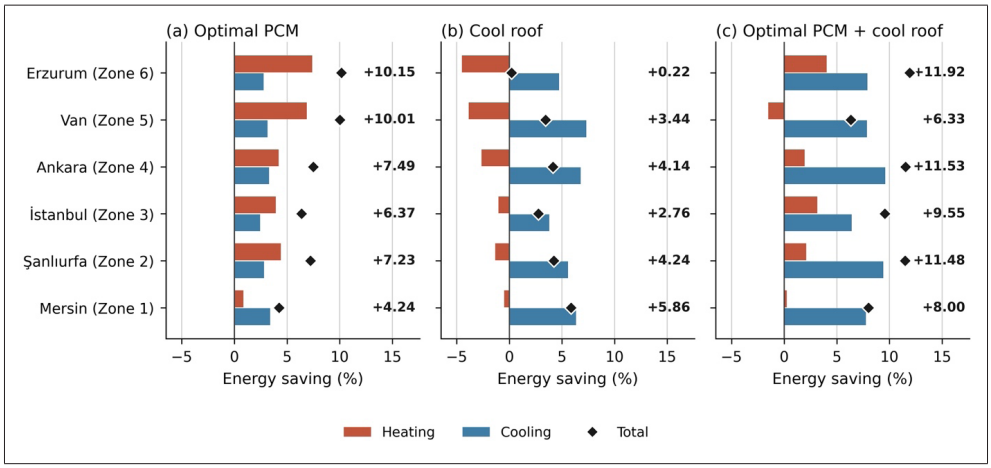

Figure 5. Contributions of heating and cooling to the annual thermal-demand savings achieved by **(a)** the optimal PCM, **(b)** the cool roof, and **(c)** the combined PCM and cool-roof system. The black diamonds show the total saving for each city.

interact with each other. Therefore, their individual savings cannot be simply added. This deviation from additivity was quantified as an interaction effect, calculated as:

$$\Delta S_{int} = S_{PCM+CR} - (S_{PCM,\,opt} + S_{CR})$$

where S_{PCM+CR} is the total annual saving of the combined PCM-and-cool-roof configuration, $S_{PCM,\,opt}$ is the saving achieved by the city-specific optimal PCM alone, and S_{CR} is the saving achieved by the cool-roof coating alone, each expressed in percent relative to the base roof of the same city, so that ΔS_{int} is reported in percentage points. Positive values indicate a synergistic interaction, values near zero indicate an additive effect, and negative values indicate an antagonistic interaction.

The interaction effect was calculated for each city (Figure 6). Erzurum showed a positive interaction of approximately +1.54 percentage points, while İstanbul and Şanlıurfa were nearly additive (+0.42 and +0.02 points). Ankara was also close to additive (−0.11 points). By contrast, Mersin (−2.10 points) and especially Van (−7.13 points) showed antagonistic interaction.

A plausible explanation is that the cool roof lowers the temperature amplitude at the PCM layer and thereby changes the frequency or completeness of melting and solidification. This interpretation is consistent with the direction of the results but cannot be confirmed from annual load totals alone. Direct analysis of PCM phase fraction, enthalpy, or layer temperature would be needed to establish the mechanism. For design purposes, the practical implication is already clear: the PCM should be re-optimized after the exterior optical properties are changed rather than assuming the independently optimal PCM remains optimal in the combined roof.

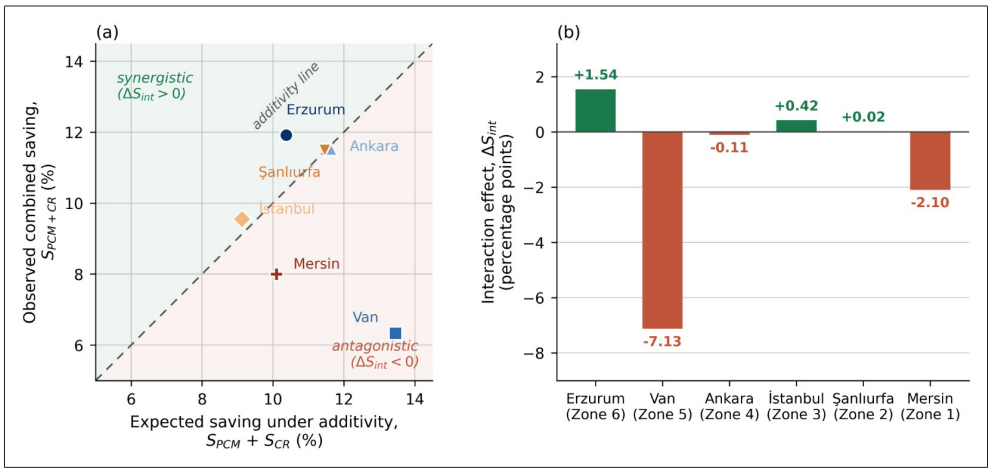

Figure 6. Interaction between the city-specific optimal PCM and cool roof. **(a)** Observed combined saving versus the sum of individual savings; points above the additivity line indicate synergy. **(b)** Interaction term ΔSint in percentage points.

Previous investigations of combined PCM and reflective-roof systems reported reductions in roof-surface temperature, indoor temperature, or cooling load under predominantly cooling-season conditions (Tang et al., 2024) (Yang et al., 2019). However, these studies did not quantify whether the annual benefit of the combined system equaled the sum of the benefits obtained from the individual measures. The present results extend this evidence by showing that the interaction may be synergistic, approximately additive, or antagonistic depending on climate. Therefore, cooling improvements observed over short monitoring periods should not automatically be interpreted as evidence of an additive annual energy benefit.

Implications for Climate-responsive Roof Design

The results support a climate-responsive roof selection procedure. A cool roof is attractive in cooling-dominated Mersin, whereas a lower-temperature PCM is more important in cold Erzurum. In the intermediate zones, a 23 °C PCM gave the best individual PCM result, but the value of adding the cool roof depended on the heating–cooling balance and interaction with the PCM. Reporting only cooling savings would therefore overstate annual benefits, particularly in heating-dominated locations. These results translate into practical, climate-zone specific guidance for architects specifying flat roof systems in Türkiye:

- Zone 1 (Mersin): The cool-roof coating alone achieved a saving of 5.86%, while the combined configuration increased the saving to 8.00%. Although the combined configuration produced the lowest thermal demand, its additional benefit over the cool roof alone was 2.14 percentage points.
- Zone 2 (Şanlıurfa) and Zone 4 (Ankara): PCM (23 °C) combined with the cool roof is recommended, with the two measures behaving near-additively (11.48% and 11.53% combined, respectively).
- Zone 3 (İstanbul): The combined strategy produced the lowest thermal demand and showed an approximately additive interaction, with a combined saving of 9.55%.
- Zone 5 (Van): PCM (23 °C) alone is recommended; adding cool-roof coating here is counterproductive, reducing realized savings from 10.01% to 6.33% due to an antagonistic interaction.
- Zone 6 (Erzurum): The combined strategy produced the lowest thermal demand, with a positive synergistic interaction and a combined saving of 11.92%.

These recommendations are intended as a starting point for schematic-design decision-making rather than a substitute for project specific simulation, and should be revisited when the roof construction, glazing ratio, or the occupancy pattern differs from the reference model described in Section 3.1.

Study Limitations

The study is comparative rather than a calibrated prediction of a specific occupied building. It uses ideal thermal loads, a single office geometry, one PCM thickness and position, and an initially clean high-reflectance surface. Aging, moisture, cost, embodied impacts, equipment efficiencies, demand peaks, and PCM state variables were outside the present scope. These limitations should be addressed before translating thermal-demand savings directly into operational energy, emissions, or economic savings.

CONCLUSION

The study demonstrated that PCM melting temperature and cool-roof application are climate dependent choices rather than fixed specifications. The evaluations were performed across six selected cities from Türkiye's six TS 825 climate zones and the results have revealed significant differences. The optimal PCM melting temperature ranged from 21 °C in Erzurum to 25 °C in Mersin, with 23 °C optimal in the four intermediate zones, and reduced annual heating plus cooling demand by 4.24-10.15%. A poorly matching 29 °C PCM produced an energy penalty in every city, underscoring that melting temperature must be carefully selected according to climate rather than assumed.

The cool-roof coating consistently reduced cooling demand but increased heating demand, so its net annual benefit was far more climate-dependent than a cooling-season assessment alone would suggest. Its annual saving ranged from 0.22% in Erzurum to 5.86% in Mersin. Combining PCM with the cool roof achieved the lowest overall demand in five of the six cities, with savings of up to 11.92%. Van is the only city where the combined system underperformed the PCM-only case, confirming that the two measures cannot be assumed additive and must instead be evaluated, and where necessary re-optimized as a coupled system.

These findings support a climate-responsive approach to roof design in Türkiye, in which PCM melting temperature and cool-roof applications are evaluated together for each climate zone rather than applied as a single national specification. Future work should examine PCM phase fraction and layer temperatures, optimize the PCM within the combined roof, assess peak-load and comfort effects, and include coating aging, system efficiency, life-cycle cost, and embodied impacts.

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Article

The heat preparedness gap: Bridging urban heat risk and municipal heat governance

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ABSTRACT

Extreme heat is emerging as one of the most critical climate-related challenges facing cities, yet whether municipal planning systems are adequately prepared for local heat risks remains poorly understood. Existing studies predominantly assess either urban heat risk or climate adaptation planning, while the relationship between heat risk and municipal preparedness has received limited attention. To address this gap, this study introduces the Heat Preparedness Gap (HPG), defined as the mismatch between urban heat risk and the preparedness capacity of municipal planning systems. An integrated assessment framework was applied to 21 metropolitan municipalities with publicly available strategic climate plans in Türkiye. A Heat Preparedness Index (HPI) was developed through the evaluation of six preparedness domains, while a multidimensional Heat Risk Index (HRI) was constructed by integrating indicators of heat exposure, sensitivity, and adaptive capacity. The relationship between HPI and HRI was subsequently evaluated through the HPG and a Heat Risk–Preparedness Matrix. The analysis identified four distinct preparedness profiles, demonstrating that municipalities facing comparable levels of heat risk often exhibit markedly different preparedness capacities. The findings further reveal that preparedness is not closely aligned with climatic exposure alone and varies substantially across different planning and governance contexts. Although heat-related issues are increasingly incorporated into municipal planning, operational heat management—including Heat Action Plans, heat-health early warning systems, and targeted protection for vulnerable populations—remains consistently underdeveloped. The proposed framework provides a transferable approach for benchmarking municipal preparedness, identifying adaptation priorities, and strengthening operational heat governance.

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INTRODUCTION

Cities are increasingly recognised as critical arenas for climate change, concentrating populations, infrastructure, economic activities, and environmental vulnerabilities within highly modified landscapes. Among the many climate-related hazards affecting urban areas, extreme heat has emerged as one of the rapidly intensifying threats, driven by rising global temperatures and accelerating urbanisation (Cheval et al., 2024; Khanh et al., 2023; Y. Ren et al., 2023). These processes are increasing the frequency, duration, and intensity of heatwaves, tropical nights, and

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prolonged thermal stress across almost all climatic regions (IPCC, 2022). Their impacts are further amplified by the Urban Heat Island (UHI) effect, whereby dense urban morphology, extensive impervious surfaces, limited vegetation, and anthropogenic heat emissions elevate urban temperatures beyond those of surrounding rural areas (Erdem Okumus & Terzi, 2021; Oke et al., 2017; Santamouris, 2020).

Extreme heat is now recognised as one of the deadliest climate-related hazards, contributing to excess mortality, cardiovascular and respiratory diseases, declining labour productivity, increasing energy demand, and widening social inequalities (Hondula et al., 2015; Mora et al., 2017; Romanello et al., 2024). Unlike floods, storms, or wildfires, heat often develops gradually and leaves little visible physical damage, leading it to be characterised as a "silent killer" (Hughes et al., 2016; United Nations, 2024). Its impacts are also unevenly distributed, with heightened vulnerability among older and younger populations, individuals with chronic illnesses, outdoor workers, and socially and economically disadvantaged groups (Ebi et al., 2021; Erdem Okumus, 2025; WHO, 2026). Consequently, extreme heat is not only a climatic hazard but also a multidimensional urban governance challenge encompassing public health, social equity, infrastructure resilience, emergency management, and spatial planning.

Urban planning plays a central role in shaping both the causes and consequences of urban heat through land-use patterns, urban morphology, building density, transport systems, and green and blue infrastructure (Erdem Okumus & Akay, 2025; Erdem Okumus & Terzi, 2021, 2023; Oke et al., 2017; Yu et al., 2024). At the same time, municipalities are expected to coordinate public health responses, emergency management, social assistance, and risk communication during extreme heat events. Urban heat resilience therefore depends not only on the physical characteristics of cities but also on the local governments' capacity to anticipate, prepare for, and respond to heat-related risks.

Urban heat research has expanded rapidly, with a focus on assessing risk through climatic exposure, demographic sensitivity, socioeconomic vulnerability, and adaptive capacity (Chakraborty et al., 2019; Harlan et al., 2006; Xiang et al., 2022; Xu et al., 2024; Yang et al., 2025). Building upon the IPCC risk framework (IPCC, 2014, 2022), numerous composite indicator approaches have been developed to identify vulnerable populations and support evidence-based adaptation planning (Erdem Okumus, 2025; Li et al., 2022; Qian & Liu, 2025). However, most heat risk assessments remain fundamentally diagnostic, identifying where risks are concentrated rather than whether municipalities possess the institutional capacity to manage them.

In parallel, a growing body of research has examined climate adaptation planning, urban resilience, and local climate governance (Gori Nocentini, 2024; Holtan et al., 2026; Zhang et al., 2024). Municipalities worldwide have increasingly adopted climate adaptation strategies and local planning instruments (Aylett, 2015; Rogers et al., 2023), whose evaluations typically focus on plan quality, policy integration, implementation capacity, or governance arrangements (Berke & Godschalk, 2009; Grafakos et al., 2020; Rose & Göçmen, 2025; Yu et al., 2024). Yet these studies rarely assess whether municipal preparedness is commensurate with local heat risk.

This disconnect also reflects a distinction between heat mitigation and heat management (Keith et al., 2023; Rose & Göçmen, 2025). Heat mitigation seeks to reduce long-term exposure through interventions such as urban greening, blue infrastructure, cool materials, and climate-sensitive urban form (Cui et al., 2024; S. Ren et al., 2025; Srivastava et al., 2026). Heat management, by contrast, protects populations during extreme heat events through operational measures including Heat Action Plans (HAPs), heat-health early warning systems, cooling centres, public communication, and targeted support for vulnerable groups (Singh et al., 2024; WHO, 2026). While complementary, municipal planning has generally prioritised long-term mitigation over operational preparedness.

Accordingly, urban heat governance extends beyond physical cooling strategies to encompass institutional coordination, public health preparedness, emergency management, and implementation capacity (Keith et al., 2023; Yazar & York, 2021). Despite advances in both research traditions, heat risk studies rarely evaluate governance capacity, while planning evaluations seldom examine whether such capacity is proportionate to local climatic risk. Municipalities facing similar heat risks may exhibit markedly different preparedness levels, while those with comparable planning capacities may confront substantially different risks. A fundamental planning question therefore remains: Are cities prepared for the level of heat risk they face? Addressing this question requires moving beyond separate assessments of heat risk and planning quality towards evaluating their alignment.

Although the proposed framework is broadly applicable, Türkiye provides a particularly suitable empirical setting. Located within the Mediterranean Basin—one of the world's most prominent climate change hotspots—the country is projected to experience rising temperatures, more frequent heatwaves, and increasing tropical nights (IPCC, 2022). Its metropolitan municipalities (MMs) span diverse climatic regions while operating within a shared national governance context. Municipalities have increasingly prepared Sustainable Energy and Climate Action Plans (SECAPs), Provincial Climate Change Action Plans (IDEPs), and Provincial Disaster Risk Reduction Plans (IRAPs). More recently, the Regulation on Local Climate Change Action Plans (YİDEPs) and Provincial Climate Change Coordination Boards established YİDEPs as a formal instrument integrating climate risk assessment,

adaptation, responsible institutions, implementation, and monitoring into provincial climate planning (Regulation on Local Climate Change Action Plans (YİDEP) and Provincial Climate Change Coordination Boards, 2026). This combination of climatic diversity and a shared national governance context enables comparison across different heat risk contexts. However, despite growing research on urban heat in Türkiye (Akay & Erdem Okumus, 2026; Birinci et al., 2026; Erdem Okumus & Terzi, 2022), little is known about whether municipalities facing greater heat risk are better prepared to manage it.

To address this gap, this study introduces the Heat Preparedness Gap (HPG) framework for evaluating the alignment between municipal preparedness and urban heat risk. A Heat Preparedness Index (HPI) comprising six preparedness domains is compared with a multidimensional Heat Risk Index (HRI) to identify preparedness gaps and classify municipalities into distinct Heat Risk–Preparedness profiles. Accordingly, the study addresses three research questions: (1) To what extent are MMs prepared to address extreme heat through existing planning and policy frameworks? (2) How does municipal preparedness compare with urban heat risk across metropolitan contexts? (3) Which preparedness dimensions are most consistently underdeveloped across municipalities? By linking municipal preparedness with urban heat risk, this study moves beyond conventional heat risk mapping and plan quality assessment to evaluate whether preparedness is commensurate with local heat risk. It provides a transferable approach for benchmarking municipal preparedness, identifying governance gaps, and supporting evidence-based heat adaptation planning.

MATERIALS AND METHODS

This study develops an integrated framework to evaluate whether municipal preparedness is proportionate to urban heat risk across MMs. The framework combines two complementary assessment components: (i) an HPI, derived from a structured plan evaluation framework encompassing six preparedness domains, and (ii) a multidimensional HRI, integrating indicators of heat exposure, population sensitivity, and adaptive capacity. The relationship between these indices was subsequently assessed through the HPG, which measures the alignment between municipal preparedness and estimated heat risk. The methodological workflow comprises five sequential stages: municipality selection and data collection; construction of the HRI; assessment of municipal preparedness using the HPI framework; calculation of the HPG; and classification of municipalities using the Heat Risk–Preparedness Matrix to identify preparedness profiles and adaptation priorities.

Study Area

The study included the 21 municipalities for which at least one strategic climate planning document—SECAP or IDEP—was publicly available at the time of data collection (Figure 1). All selected municipalities were also covered by IRAPs (AFAD, n.d.), while Istanbul was the only municipality possessing all three planning instruments (SECAP, IDEP, and IRAP). Municipalities without either a SECAP or an IDEP were excluded because municipal heat preparedness could not be evaluated in the absence of strategic planning documents. Plan type itself was not used as an indicator of preparedness; all eligible documents were instead evaluated using the same heat-specific HPI assessment framework. Consequently, the assessment focuses on planning-active municipalities rather than all MMs in Türkiye. The selected municipalities represent approximately 71% of Türkiye's population and encompass diverse climatic, geographical, and urbanisation conditions, providing a suitable basis for evaluating the proposed framework across contrasting heat risk and planning contexts (Table 1).

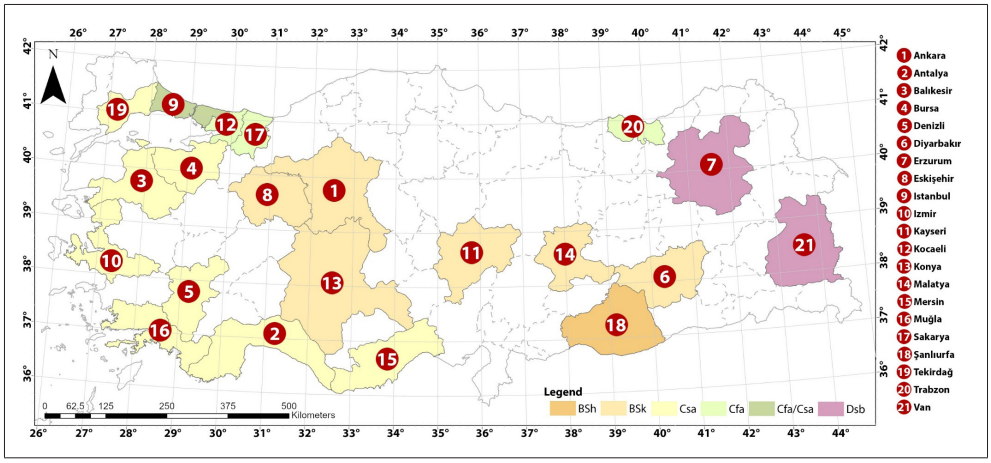

Figure 1. Locations and dominant Köppen–Geiger climate types of the 21 MMs included in the study.

Heat Risk Assessment

Urban heat risk (HR) was conceptualised as the interaction of climatic conditions, exposed populations, and their capacity to cope with impacts (IPCC, 2014, 2022). For comparative assessment, hazard and exposure were operationalised as a unified Heat Exposure (HE) dimension incorporating elevated temperatures, heatwave occurrence, tropical nights, and cumulative thermal stress. Accordingly, the HRI was constructed from three complementary dimensions: HE, Heat Sensitivity (HS), and Adaptive Capacity (AC) (Table 2).

The HR framework assumes that heat risk reflects the combined effect of climatic exposure and population sensitivity, moderated by the capacity to adapt to heat-related impacts. Accordingly, the overall HRI was calculated by integrating the three component indices—Heat Exposure Index (HEI), Heat Sensitivity Index (HSI), and Adaptive Capacity Index (ACI)—using an equal-weighting approach (Equation 1). Because higher AC reduces heat-related risk, the inverse form of the ACI (1 − ACI) was incorporated into the index construction. Consequently, higher HRI values indicate greater heat-related risk, whereas lower values represent comparatively lower levels of risk. The HRI should be interpreted as a comparative measure of heat risk at the metropolitan scale rather than as a measure of intra-urban thermal heterogeneity.

$$HRI = \frac{HEI + HSI + (1 - ACI)}{3} \qquad \text{Equation 1}$$

Equal weighting was adopted because the selected indicators represent complementary dimensions of HE, HS, and AC, and were therefore assumed to contribute equally to the composite index. This approach provides a transparent and reproducible framework for comparative assessment while avoiding subjective weighting decisions.

Table 1. Description of case MMs

Cities	Total Area (km^2)[1]	Built-up Area (km^2-%)[2]	Population (2025)[3]	Climate Type[4]	Planning Documents[5]	Plan Source
Ankara	25602.57	1627.79 (~6.36%)	5,910,320	BSk	IDEP	(AMM, 2022a)
Antalya	20162.43	2279.62 (~11.31%)	2,777,677	Csa	SECAP	(AMM, 2022b)
Balıkesir	14376.22	759.89 (~5.29%)	1,284,517	Csa	SECAP	(BMM, 2025)
Bursa	10791.94	866.08 (~8.03%)	3,263,011	Csa	SECAP	(BMM, 2017)
Denizli	12119.21	667.25 (~5.51%)	1,060,975	Csa	IDEP	(DMM, 2019)
Diyarbakır	15146.15	691.94 (~4.57%)	1,852,356	BSk	SECAP	(DMM, 2025)
Erzurum	24981.95	401.98 (~1.61%)	736,877	Dsb	SECAP	(EMM, 2023a)
Eskişehir	13941.05	378.73 (~2.72%)	927,956	BSk	SECAP	(EMM, 2023b)
Istanbul	5452.18	1536.57 (~28.18%)	15,754,053	Cfa/Csa	SECAP	(IMM, 2024)
Izmir	11831.76	1419.98 (~12.00%)	4,504,185	Csa	SECAP	(IMM, 2020)
Kayseri	16945.56	718.19 (~4.24%)	1,458,991	BSk	IDEP	(KMM, 2022a)
Kocaeli	3395.91	649.66 (~19.13%)	2,161,171	Cfa	IDEP	(KMM, 2022b)
Konya	40785.85	1472.17 (~3.61%)	2,343,409	BSk	SECAP	(KMM, 2024)
Malatya	12240.64	454.75 (~3.72%)	755,854	BSk	IDEP	(MMM, 2017)
Mersin	16004.1	1059.96 (~6.62%)	1,956,428	Csa	SECAP	(MMM, 2023)
Muğla	12614.96	975.97 (~7.74%)	1,099,547	Csa	SECAP	(MMM, 2025)
Sakarya	4822.27	620.58 (~12.87%)	1,123,693	Cfa	SECAP	(SMM, 2020)
Şanlıurfa	19230.48	980.74 (~5.10%)	2,265,800	BSh	IDEP	(SMM, 2022)
Tekirdağ	6213.02	411.67 (~6.63%)	1,208,441	Csa	SECAP	(TMM, 2023)
Trabzon	4627.16	419.97 (~9.08%)	823,323	Cfa	SECAP	(TMM, 2019)
Van	20897.87	554.21 (~2.65%)	1,112,013	Dsb	SECAP	(VMM, 2022)

[1] Total area was calculated directly from the metropolitan boundary.

[2] Built-up area was derived from the ESRI Land Cover 2025 dataset (ESRI, n.d.).

[3] Population data were obtained from the Turkish Statistical Institute (TÜİK) Address-Based Population Registration System (Turkish Statistical Institute [TÜİK], n.d.).

[4] Dominant climate types were assigned according to the Köppen–Geiger climate classification (BSk: Cold semi-arid; Csa: Mediterranean; Dsb: Continental; Cfa: Humid subtropical; BSh: Hot semi-arid).

[5] Provincial Disaster Risk Reduction Plans (IRAPs) for all provinces were additionally examined (AFAD, n.d.).

Table 2. Indicators used to construct the HRI

Dimension	Indicator	Definition	Data Source	Unit	Year
Heat Exposure (HE)[1]	HE1. Mean summer temperature	June–August mean 2m air temperature	ERA5-Land Daily mean	°C	2020-2025
	HE2. Heatwave days	Number of days within ≥3 consecutive days above local 95th percentile Tmax	ERA5-Land Daily maximum	days/year	
	HE3. Tropical nights	Number of nights with Tmin >20°C	ERA5-Land Daily minimum	nights/year	
	HE4. Very hot days	Number of days with Tmax > 35°C	ERA5-Land Daily maximum	days/year	
	HE5. Maximum summer temperature	June–August max 2m air temperature	ERA5-Land Daily maximum	°C	
	HE6. Cooling degree days (CDD)	Annual sum of Tmean above 22°C	ERA5-Land Daily mean	CDD/year	
Heat Sensitivity (HS)[1]	HS1. Population density	Resident population density	TUIK	persons/km²	2025
	HS2. Elderly dependency ratio	Population aged 65 years and over relative to the working-age population			
	HS3. Child dependency ratio	Population aged 0–14 years relative to the working-age population			
	HS4. Unemployment rate	Unemployed population as a percentage of the labour force			
	HS5. Foreign population ratio	Foreign nationals as a percentage of the total population			
	HS6. Low educational attainment	Population aged 6 years and over with less than upper secondary education (below high school level) as a percentage of the population aged 6 years and over			2024
	HS7. Socioeconomic disadvantage index (SEDI)[2]	Composite index	Endeksa socioeconomic segmentation (SES) data	Index (1–5)	2025
	HS8. Single-person household ratio	Single-person households as a percentage of all households	TUIK	%	
	HS9. Lone-parent household ratio	Lone-parent households with children as a percentage of all households			
	HS10. Crude suicide rate	Number of suicides		per 100,000 population	2024
	HS11. Crude death rate	Number of deaths			
	HS12. Infant mortality rate	Number of infant deaths		per 1,000 live births	
Adaptive Capacity (AC)[1]	AC1. Normalized Difference Vegetation Index	Mean annual NDVI	Sentinel-2 Level-2A	Index (-1 to 1)	2025
	AC2. Modified Normalized Difference Water Index	Mean annual MNDWI			

Table 2. Continued

Dimension	Indicator	Definition	Data Source	Unit	Year
Adaptive Capacity (AC)[1]	AC3. High education attainment	Population aged 6 years and over with a bachelor's degree or higher as a percentage of the population aged 6 years and over	TUIK	%	2024
	AC4. Healthcare capacity	Number of physicians		per 1,000 population	
	AC5. Hospital bed capacity	Number of hospital beds			
	AC6. Municipal financial capacity (MFC)	Mean per capita municipal revenue and expenditure.	Official metropolitan municipal budget documents	TL/person	2025

[1] Higher HE and HS values increase HRI, whereas higher AC values decrease HRI. [2] SEDI was calculated from the proportional distribution of Endeksa (Endeksa, n.d.) socioeconomic segments (A+, A, B, C and D) using ordinal weights ranging from 1 (A+) to 5 (D) (SEDI=1(A+)+2A+3B+4C+5D). Higher values indicate greater socioeconomic disadvantage.

Heat Exposure Assessment

HE was characterised using six complementary indicators representing different dimensions of climatic heat stress (Table 2). The indicator set captures background summer thermal conditions (HE1), the frequency and persistence of extreme heat events (HE2, HE4), night-time thermal stress (HE3), peak summer heat (HE5), and cumulative thermal stress and cooling demand (HE6) (Table A1), providing a comprehensive representation of chronic and acute heat (IPCC, 2014, 2022).

All indicators were derived from the ERA5-Land dataset, which provides spatially continuous estimates of near-surface meteorological conditions at approximately 9 km spatial resolution and is widely used in climate assessments because of its spatial consistency and long-term coverage (Muñoz-Sabater et al., 2021). Indicators were calculated for the 2020–2025 period to characterise recent heat exposure while reducing the influence of year-to-year variability. This period was selected to align the exposure assessment with the contemporary planning context represented by the municipal plans evaluated in the HPI, rather than to characterise long-term climatological normals. For event-based indicators (HE2–HE4 and HE6), annual values were calculated by averaging the six-year totals over the 2020–2025 period, whereas HE1 and HE5 were derived directly from the multi-year temperature observations. All indicators were min–max normalised to a 0–1 scale and averaged with equal weights to derive the HEI.

Heat Sensitivity Assessment

HS was represented using twelve demographic, socioeconomic, household, and health-related indicators (Table 2). The indicators were selected to capture complementary pathways through which population characteristics may increase susceptibility to heat-related impacts (Ebi et al., 2021; Erdem Okumus, 2025; Harlan et al., 2006; Wolf & McGregor, 2013). Population density (HS1) represents the concentration of potentially exposed populations, while elderly and child dependency (HS2–HS3) capture age-related physiological and functional susceptibility to heat (Li et al., 2022). Unemployment, foreign population, low educational attainment, and socioeconomic disadvantage (HS4–HS7) represent socioeconomic conditions that may constrain access to information, healthcare, adequate housing, cooling, and other protective resources (Niu et al., 2021). In particular, foreign populations may face additional linguistic, institutional, and socioeconomic barriers that can limit access to heat risk information and protective resources (Li et al., 2022). Household structure (HS8–HS9) captures potential limitations in social support, financial resources, and household-level coping capacity; for example, people living alone may be less likely to receive timely assistance during extreme heat events (Reid et al., 2009). These demographic and socioeconomic characteristics are widely recognised as important components of population-level heat vulnerability.

Health-related indicators (HS10–HS12) were included to represent broader underlying population health vulnerability (Niu et al., 2021). Crude suicide, crude death, and infant mortality rates were used as population-level proxies for adverse health and social conditions that may reflect underlying population vulnerability, rather than as direct measures of heat-related health outcomes. This distinction is important because these indicators characterise pre-existing sensitivity within the metropolitan population and are not interpreted as outcomes attributable to heat exposure. All indicators were min–max normalised to a 0–1 scale and equally weighted to derive the HSI. Higher HSI values indicate greater sensitivity to heat-related impacts and a higher contribution to overall heat-related risk.

Adaptive Capacity Assessment

AC was characterised using six indicators representing four complementary dimensions: environmental resources, human capital, healthcare capacity, and institutional capacity

(Table 2). Environmental AC was represented by NDVI and MNDWI, reflecting the cooling potential of urban vegetation and surface water. Human AC was represented by higher educational attainment as a proxy for adaptive awareness and access to information. Healthcare capacity was represented by physician and hospital bed availability, while institutional capacity was represented by municipal financial capacity (MFC). MFC was calculated as the arithmetic mean of per capita approved annual municipal revenue and expenditure budgets for 2025. Higher MFC values indicate greater financial capacity to plan, implement, and sustain heat adaptation measures. All indicators were min–max normalised to a 0–1 scale. ACI was calculated as the arithmetic mean of the six standardised indicators, assuming equal weighting.

Heat Preparedness Assessment

Municipal heat preparedness (HP) was evaluated using a structured plan evaluation framework developed to assess how existing planning documents address extreme heat. The framework builds on established plan quality approaches that evaluate the progression from problem identification and evidence generation to policy formulation, implementation, and monitoring (Berke & Godschalk, 2009; Grafakos et al., 2020). These principles were adapted to the specific context of urban heat governance, where preparedness encompasses both long-term heat mitigation and short-term heat management responses (Keith et al., 2023; Rose & Göçmen, 2025). Accordingly, the framework comprises six complementary preparedness domains: (HP1) Problem Definition and Risk Awareness, (HP2) Evidence Base and Vulnerability Assessment, (HP3) Heat Mitigation Policies, (HP4) Heat Management Policies, (HP5) Implementation Capacity, and (HP6) Monitoring, Evaluation and Updating (Table 3). Together, these domains capture the progression from recognising and assessing heat-related risks to developing policy responses and establishing the institutional mechanisms required for implementation, monitoring, and updating. All planning documents were assessed using the same protocol and scoring rubric.

Criterion-based scoring was applied to HP1, HP2, HP5, and HP6, whereas HP3 and HP4 were evaluated according to policy maturity, ranging from policy absence or general recognition to increasingly detailed and operationally specified measures. Within the proposed HPI framework, greater weight is allocated to the two policy domains, consistent with heat-preparedness plan evaluation approaches that place particular emphasis on the breadth and strength of heat mitigation and management measures (Rose & Göçmen, 2025). Heat Mitigation Policies (HP3) and Heat Management Policies (HP4) together account for 50% of the total score,

Table 3. HP assessment protocol and scoring rubric

Domain	Assessment Criteria	Score[3]
HP1. Problem Definition and Risk Awareness	Climate change is explicitly identified as a challenge for the city	2
	Extreme heat and/or heatwaves are explicitly identified as an urban planning and public health issue	2
	UHI effects, LST, and/or thermal comfort are addressed	2
	The health impacts of extreme heat are identified	2
	Vulnerable population groups are explicitly identified	2
	Maximum domain score (A)	10 points
HP2. Evidence Base and Vulnerability Assessment	Local temperature and/or meteorological data are used	3
	LST, UHI, heat mapping, or hotspot analysis is included	3
	Population and socioeconomic vulnerability assessments are included	3
	Data on green spaces, impervious surfaces, and/or urban development are used	2
	Spatial prioritisation at neighbourhood or district level is undertaken	2
	Climate projections or future scenarios are incorporated	2
	Maximum domain score (B)	15 points
HP3. Heat Mitigation Policies[1]	Policy absent	0
	General statement only	1
	Policy described in detail and/or accompanied by measurable targets	2
	Policy described in detail, with measurable targets and designated responsible institutions and/or implementation timelines	3
	Maximum domain score (C)	20 points

Table 3. Continued

Domain	Assessment Criteria	Score[3]
HP4. Heat Management Policies[2]	Policy absent	0
	General statement only	1
	Policy proposed, but implementation details are limited	2
	Implementation details, target groups, responsible institutions and/or protocols are specified	3
	Maximum domain score (D)	30 points
HP5. Implementation Capacity	Responsible departments and/or institutions are identified	3
	Inter-institutional coordination mechanisms are defined	3
	Budget and/or funding sources are specified	3
	Short-, medium-, and long-term implementation timelines are provided	3
	Mechanisms for prioritising vulnerable groups are included	3
	Maximum domain score (E)	15 points
HP6. Monitoring, Evaluation and Updating	Measurable indicators are provided	2
	Monitoring responsibilities are assigned	2
	Reporting frequency is specified	2
	A plan revision/update schedule is included	2
	Performance indicators related to heat and/or health outcomes are provided	2
	Maximum domain score (F)	10 points
TOTAL (HP score)=HP1+HP2+HP3+HP4+HP5+HP6		100 points
Heat Preparedness Index (HPI)=HP score/100		1

[1] Heat mitigation policies included urban greening, blue-green infrastructure, cool materials, building energy efficiency, sustainable mobility, climate-sensitive urban design, and heat-responsive urban regeneration. [2] Heat management policies included heat-health early warning systems, cooling centres, protection of vulnerable populations, health response protocols, public risk communication, occupational heat measures, public cooling infrastructure, energy assistance, and inter-agency emergency coordination during heatwave events. [3] For HP1, HP2, HP5, and HP6, criterion scores were summed directly to obtain the domain score. For HP3 and HP4, each policy was evaluated separately using the corresponding 0–3 policy-maturity scale. The resulting raw scores were standardised to the maximum score assigned to each domain (20 points for HP3 and 30 points for HP4) using the ratio of the observed raw score to the maximum possible raw score.

reflecting their role in translating identified heat risks into long-term preventive measures and operational responses during extreme heat events. The remaining domains capture supporting components of preparedness, including risk recognition, evidence generation, implementation capacity, and monitoring. To minimise interpretive subjectivity, the assessment was conducted using a predefined scoring rubric and consistent decision rules across all municipalities, with scores assigned only to explicitly documented evidence. The HPI reflected the level of heat preparedness embedded within planning documents rather than the implementation or effectiveness of municipal heat policies.

Heat Preparedness Gap Analysis

To evaluate the alignment between municipal preparedness and estimated heat-related risk, HPG analysis was conducted by comparing the HPI and the HRI. As both indices were normalised to a common 0–1 scale, the HPG was calculated as their difference (Equation 2). Positive HPG values indicate higher preparedness relative to estimated heat-related risk, whereas negative values indicate comparatively lower preparedness relative to risk. The HPG should therefore be interpreted as a relative index-based measure of risk–preparedness alignment rather than as an absolute measure of whether preparedness is sufficient to offset heat risk.

$$\mathrm{HPG} = HPI - HRI \qquad \text{Equation 2}$$

To further assess the relationship, municipalities were positioned within a Risk–Preparedness Matrix (Table 4) according to their HRI and HPI values. Median HRI and HPI values were used as thresholds to classify municipalities into four strategic profiles: Critical Priority (high risk–low preparedness), Adaptation Leaders (high risk–high preparedness), Emerging Concern (low risk–low preparedness), and Preparedness Leaders (low risk–high preparedness). This classification enabled balanced comparisons among municipalities while also supporting domain-level analyses to identify priority areas for improving municipal heat preparedness.

Table 4. Heat Risk–Preparedness Matrix and strategic municipal profiles

Heat Risk	Heat Preparedness: Low	Heat Preparedness: High
High	Critical Priority	Adaptation Leaders
Low	Emerging Concern	Preparedness Leaders

RESULTS

Heat Risk Profiles

The results revealed substantial spatial variation in urban heat risk across the 21 MMs (Table A2, Table A3, Table 5, Figure A1, Figure A2). The HEI exhibited the greatest variability, ranging from 0.01 in Trabzon to 0.94 in Şanlıurfa. The highest exposure levels were recorded in Şanlıurfa (0.94), Diyarbakır (0.74), İzmir (0.57), Muğla (0.54), and Denizli (0.51), whereas Trabzon (0.01), Erzurum (0.18), Sakarya (0.19), and Van (0.23) recorded the lowest values.

Compared with HEI, the HSI showed relatively limited variation (0.28 to 0.47). The highest HSI values were observed in Şanlıurfa (0.47), Malatya (0.45), İzmir (0.43), and Mersin (0.43), whereas Ankara, Erzurum, Kocaeli, and Sakarya recorded the lowest values. The ACI ranged from 0.12 in Şanlıurfa to 0.68 in Ankara. The highest ACI values were recorded in Ankara (0.68), Istanbul (0.63), İzmir (0.56), Erzurum (0.56), and Trabzon (0.54), while Şanlıurfa (0.12), Diyarbakır (0.24), and Tekirdağ (0.27) exhibited the lowest adaptive capacity. The integrated HRI ranged from 0.28 to 0.76. Şanlıurfa recorded the highest overall heat risk (0.76), followed by Diyarbakır (0.63), Denizli (0.51), Mersin (0.49), İzmir (0.48), Muğla (0.48), and Tekirdağ (0.48). Trabzon (0.28) and Erzurum (0.30) exhibited the lowest HRI values.

Heat Preparedness of Municipalities

HP levels varied considerably across municipalities, with HPI values ranging from 0.57 to 0.89 (mean=0.70), indicating an overall moderate level of preparedness (Table 6, Figure A1). Only two municipalities—Istanbul (0.89) and Mersin (0.86)—achieved Very High preparedness category, while Malatya, Eskişehir, and Konya were classified as High. Eleven municipalities exhibited Moderate preparedness, whereas Ankara, Balıkesir, Denizli, Erzurum, and Trabzon were classified as Low.

A comparison of the six preparedness domains revealed notable differences in municipal performance. The highest

Table 5. Comparative HPG profiles

Cities	HEI	HSI	ACI	HRI	HPI	HPG
Ankara	0.34	0.28	0.68	0.31	0.57	0.26
Antalya	0.44	0.33	0.47	0.43	0.69	0.26
Balıkesir	0.35	0.38	0.40	0.44	0.64	0.20
Bursa	0.29	0.31	0.39	0.41	0.70	0.29
Denizli	0.51	0.38	0.38	0.51	0.58	0.07
Diyarbakır	0.74	0.39	0.24	0.63	0.73	0.10
Erzurum	0.18	0.28	0.56	0.30	0.60	0.30
Eskişehir	0.30	0.39	0.50	0.40	0.77	0.37
Istanbul	0.39	0.41	0.63	0.39	0.89	0.50
Izmir	0.57	0.43	0.56	0.48	0.72	0.24
Kayseri	0.25	0.35	0.39	0.40	0.68	0.28
Kocaeli	0.26	0.28	0.50	0.34	0.73	0.39
Konya	0.34	0.36	0.45	0.42	0.76	0.34
Malatya	0.36	0.45	0.51	0.43	0.80	0.37
Mersin	0.41	0.43	0.37	0.49	0.86	0.37
Muğla	0.54	0.31	0.42	0.48	0.69	0.21
Sakarya	0.19	0.28	0.30	0.39	0.66	0.27
Şanlıurfa	0.94	0.47	0.12	0.76	0.69	-0.07
Tekirdağ	0.43	0.30	0.27	0.48	0.69	0.21
Trabzon	0.01	0.36	0.54	0.28	0.64	0.36
Van	0.23	0.37	0.33	0.42	0.71	0.29

Table 6. Comparative HP scores of municipalities

	City	HP1	HP2	HP3	HP4	HP5	HP6	HPI	Preparedness Level*
1	Ankara	7	11	14	6	12	7	0.57	Low
2	Antalya	8	12	15	13	13	8	0.69	Moderate
3	Balıkesir	7	11	14	12	13	7	0.64	Low
4	Bursa	8	12	15	13	14	8	0.70	Moderate
5	Denizli	7	10	13	8	13	7	0.58	Low
6	Diyarbakır	8	13	15	15	14	8	0.73	Moderate
7	Erzurum	6	11	13	10	13	7	0.60	Low
8	Eskişehir	8	14	17	15	14	9	0.77	High
9	Istanbul	10	15	18	21	15	10	0.89	Very High
10	Izmir	8	13	16	13	14	8	0.72	Moderate
11	Kayseri	7	12	14	13	14	8	0.68	Moderate
12	Kocaeli	7	13	16	14	15	8	0.73	Moderate
13	Konya	8	13	16	15	15	9	0.76	High
14	Malatya	9	14	17	17	14	9	0.80	High
15	Mersin	10	15	18	19	15	9	0.86	Very High
16	Muğla	8	12	15	13	13	8	0.69	Moderate
17	Sakarya	7	11	14	12	14	8	0.66	Moderate
18	Şanlıurfa	9	13	14	11	14	8	0.69	Moderate
19	Tekirdağ	7	12	15	13	14	8	0.69	Moderate
20	Trabzon	8	13	15	10	12	6	0.64	Low
21	Van	7	13	15	14	14	8	0.71	Moderate
Average scores		8	13	15	13	14	8	0.70	

* Preparedness levels were defined for descriptive interpretation using rounded thresholds aligned with the natural breaks observed in the HPI distribution: Very High (HPI ≥ 0.85), High (0.75 ≤ HPI < 0.85), Moderate (0.65 ≤ HPI < 0.75), and Low (HPI < 0.65).

average scores were recorded for Evidence Base and Vulnerability Assessment (HP2; mean=13/15), Heat Mitigation Policies (HP3; mean=15/20), and Implementation Capacity (HP5; 14/15). In contrast, Heat Management Policies (HP4) received the lowest average score (13/30), indicating comparatively limited attention to operational heat response measures within municipal plans. Substantial inter-city variation was also observed. Istanbul and Mersin demonstrated consistently high performance across all domains, whereas municipalities classified as having Low preparedness generally achieved lower scores in the Heat Management Policies domain, resulting in lower overall HPI values.

Heat Risk–Preparedness Gap

The HPG ranged from −0.07 to 0.50 (Table 5, Figure A1). Positive values indicate comparatively higher preparedness relative to estimated heat risk, whereas negative values indicate a preparedness deficit relative to risk. Istanbul exhibited the largest positive gap (0.50), followed by Kocaeli (0.39), Eskişehir (0.37), Malatya (0.37) and Mersin (0.37). Şanlıurfa was the only municipality with a negative HPG (−0.07). Heat Risk–Preparedness Matrix (Figure 2) classified municipalities into four strategic profiles. Four municipalities (Bursa, Eskişehir, Istanbul, and Kocaeli) were classified as Preparedness Leaders, while Diyarbakır, İzmir, Konya, Malatya, Mersin, and Van were identified as Adaptation Leaders. The Emerging Concern profile included Ankara, Erzurum, Kayseri, Sakarya, and Trabzon, whereas Antalya, Balıkesir, Denizli, Muğla, Şanlıurfa, and Tekirdağ were classified as Critical Priority municipalities.

DISCUSSION

Distinct Heat Preparedness Pathways

MMs in Türkiye do not follow a single pathway of heat preparedness. Although 20 of the 21 municipalities had positive HPG values, indicating relatively higher preparedness scores in relation to the comparative risk index, the degree of risk–preparedness alignment varied considerably across cities. Municipalities experiencing comparable levels of heat risk often exhibited markedly different preparedness

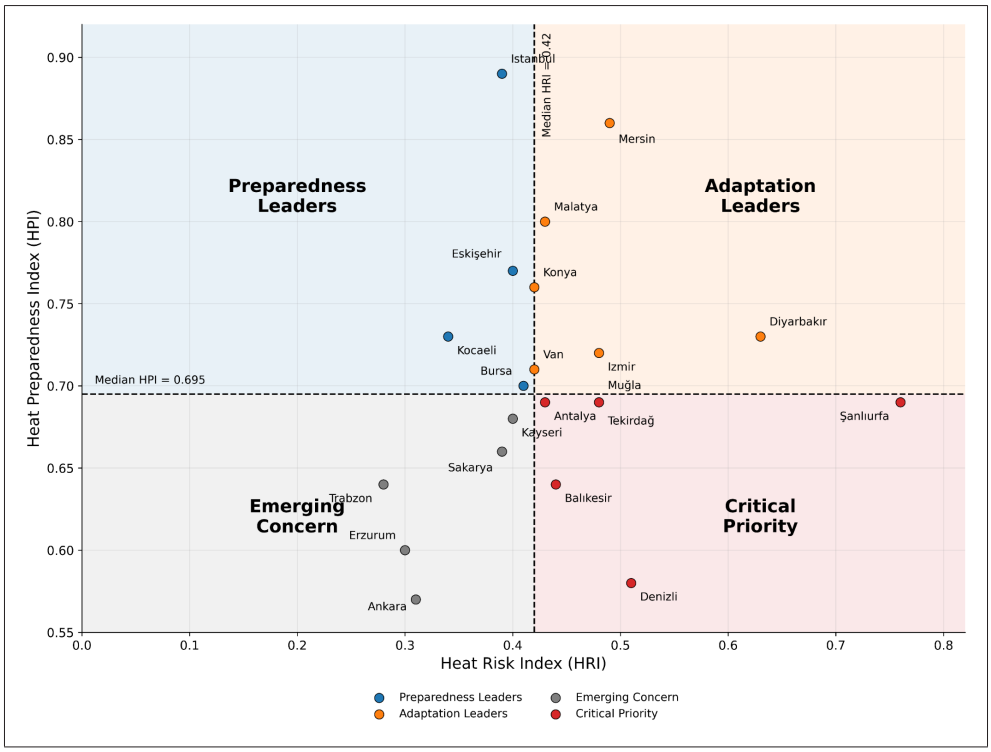

Figure 2. Heat Risk–Preparedness Matrix of municipalities classified using median HRI and HPI values, resulting in four strategic municipal profiles.

capacities, indicating that preparedness is shaped not only by climatic conditions but also by differences in planning approaches, documented governance arrangements, and the integration of heat adaptation into local policy frameworks. This finding is consistent with the broader climate adaptation literature, which emphasises that local adaptive capacity is shaped by institutional arrangements, governance structures, resource availability, and the extent to which climate considerations are mainstreamed into municipal planning (Gori Nocentini, 2024; Grafakos et al., 2020; Rogers et al., 2023).

The institutional context of the planning instruments evaluated also warrants consideration when interpreting differences in documented preparedness. SECAPs follow the standardised methodology, including baseline emission inventories, climate risk and vulnerability assessments, mitigation and adaptation actions, and periodic monitoring (Bertoldi, 2018; Davide et al., 2025). IDEPs, by contrast, have developed within Türkiye's evolving national and local climate governance context, which has recently been formalised through the YİDEP regulatory framework (Regulation on Local Climate Change Action Plans (YİDEP) and Provincial Climate Change Coordination Boards, 2026). Nevertheless, the two instruments can substantially overlap in their substantive scope, particularly in incorporating greenhouse gas inventories, climate risk and vulnerability assessments, and mitigation and adaptation actions. The distinction between plan types should therefore not be interpreted as an inherent hierarchy of preparedness. Rather than assigning preparedness on the basis of plan type, the HPI evaluates the heat-specific content documented within each plan, including risk assessment, mitigation and management measures, implementation capacity, and monitoring. At the same time, differences in institutional context, methodological guidance, and reporting requirements may influence how these components are articulated within individual plans. These differences should therefore be considered as contextual factors when interpreting cross-municipal variation in HPI scores.

The four preparedness profiles further illustrate these divergent pathways. Preparedness Leaders and Adaptation Leaders exhibited very similar average preparedness levels (HPI ≈ 0.77 and 0.76, respectively), despite markedly different risk profiles. Adaptation Leaders combined higher climatic exposure and demographic sensitivity with lower adaptive capacity, resulting in higher overall heat risk despite comparable preparedness. A complementary pattern emerged for Emerging Concern and Critical Priority municipalities: although both exhibited comparatively limited preparedness, Critical Priority municipalities were characterised by substantially higher heat exposure and lower adaptive capacity. These contrasts demonstrate that the observed profiles reflect different configurations of exposure, sensitivity, adaptive capacity, and preparedness rather than climatic exposure alone.

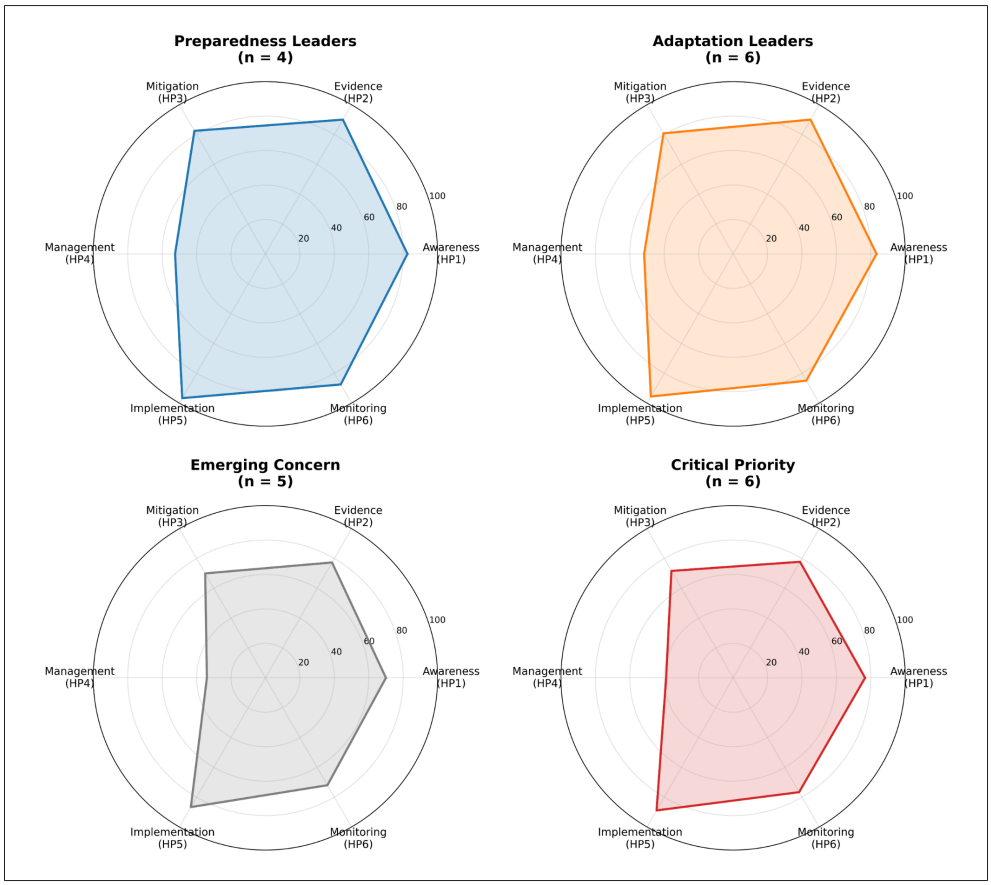

Figure 3. Domain-specific preparedness patterns across the four profiles identified through the Heat Risk–Preparedness Matrix. Radar charts present the mean normalised preparedness scores (%) for the six HPI domains within each profile. Domain scores were normalised by the maximum possible score of each domain before averaging across municipalities.

Among municipalities on the high-risk side of the matrix, preparedness further differentiated Adaptation Leaders from Critical Priority municipalities, with the former showing stronger performance particularly in evidence and vulnerability assessment and operational heat management. Şanlıurfa illustrates the most pronounced mismatch, combining the highest heat exposure, highest sensitivity, and lowest adaptive capacity with only moderate preparedness, resulting in the only negative HPG. Strengthening operational heat governance, including HAPs, heat-health early warning systems, and targeted protection for vulnerable populations, is therefore particularly important for municipalities where high risk coincides with limited preparedness. Despite marked differences in heat risk between Preparedness Leaders and Adaptation Leaders, their domain-specific preparedness profiles (Figure 3) are remarkably similar. Together, these patterns reinforce the importance of institutional and governance capacities in shaping how municipalities prepare for and respond to heat risk (Keith et al., 2023; Rogers et al., 2025; Zhang et al., 2024).

Beyond differences in overall preparedness, the domain-specific preparedness profiles (Figure 3) reveal a remarkably consistent structural pattern: operational heat management was consistently the lowest-scoring preparedness domain across all four profiles, while substantially higher scores were observed for awareness, evidence generation, mitigation, implementation, and monitoring. Climate plans commonly recognised heat-related risks and proposed broad mitigation strategies, yet comparatively few incorporated dedicated HAPs, heat-health early warning systems, cooling centres, protocols for vulnerable populations, or heat-specific emergency response procedures. The consistency of this structural imbalance across profiles suggests that this domain represents a systemic gap in municipal preparedness rather than an isolated weakness confined to specific municipalities. This operational gap may also reflect broader implementation constraints. Municipalities in Türkiye differ in their fiscal capacity and rely to varying degrees on intergovernmental transfers, a substantial component of which is linked to population size (Kiziltan & Yereli, 2023; Neyapti & Oluk, 2021). These structural conditions may affect the resources available for translating

strategic commitments into operational heat-management measures. However, as these relationships were not directly tested in the study, they should be interpreted as contextual factors rather than as demonstrated drivers of HP4 performance. This pattern is consistent with international evidence showing that, despite growing recognition of extreme heat in climate adaptation planning, the translation of strategic commitments into operational heat-response mechanisms remains uneven across cities (Boehnke, 2025; Holtan et al., 2026; Rose & Göçmen, 2025).

From Climate Adaptation to Heat Governance

The findings suggest that a fundamental shift is required in the way municipalities conceptualise and operationalise urban heat adaptation. Although most municipalities have incorporated heat-related issues into broader climate adaptation agendas, preparedness remains primarily framed within long-term environmental planning rather than as an operational public health and emergency management challenge. This pattern is consistent with the higher preparedness scores observed for evidence generation, heat mitigation, and implementation capacity, compared with the consistently lower performance of operational heat management. Consequently, municipalities appear to be more effective at identifying heat risks and proposing urban cooling strategies than at establishing governance mechanisms capable of protecting populations during extreme heat events.

This reflects an important distinction between climate adaptation and heat governance. Climate adaptation primarily aims to enhance the long-term resilience of urban systems through measures such as urban greening, ecosystem-based adaptation, energy-efficient buildings, sustainable mobility, and climate-sensitive spatial planning (Cui et al., 2024; S. Ren et al., 2025; Santamouris, 2020). While these interventions reduce future heat exposure, they do not necessarily ensure protection during individual heatwave events. By contrast, heat governance integrates urban planning with public health, emergency management, meteorological services, and social welfare to establish coordinated operational responses to acute heat-related risks (Keith et al., 2023; WHO, 2026).

Within this broader landscape of heat action planning, Heat–Health Action Plans (HHAPs), as promoted by the World Health Organization, place particular emphasis on protecting population health through coordinated preparedness and response (WHO, 2008, 2026). International experience demonstrates that effective heat governance depends not only on reducing urban temperatures but also on operational measures such as heat-health early warning systems, cooling centres, surveillance of heat-related illness, targeted risk communication, occupational heat protection, and clearly defined institutional responsibilities. The comparatively low scores for the Heat Management Policies domain indicate that these operational components remain underdeveloped across Turkish MMs, regardless of their overall preparedness level.

The findings suggest that municipalities in Türkiye have made substantial progress in the first phase of heat adaptation by recognising heat as a climate-related planning issue. The next phase should focus on institutionalising operational heat governance, where preparedness is assessed not only by the existence of adaptation strategies but also by the capacity to anticipate, coordinate, and respond effectively to extreme heat events. The recently adopted YİDEP Regulation (Regulation on Local Climate Change Action Plans (YİDEP) and Provincial Climate Change Coordination Boards, 2026) represents an important institutional step in this direction by establishing a more systematic framework for climate risk assessment, implementation, monitoring, and cross-sectoral coordination at the provincial level. However, these provisions do not in themselves guarantee heat-specific operational preparedness. The emerging YİDEP framework therefore provides an important opportunity to translate strategic climate planning into operational heat governance through stronger integration of spatial planning, public health, emergency management, and social protection.

Policy Implications

The Heat Risk–Preparedness Matrix provides a practical framework for prioritising municipal interventions according to both existing heat risk and preparedness capacity. Rather than applying uniform adaptation strategies, the findings support a differentiated policy approach tailored to each preparedness profile. For Critical Priority municipalities, the immediate priority should be establishing the core components of operational heat governance, including HHAPs, heat-health early warning systems, cooling centres, targeted communication for vulnerable populations, and stronger integration of public health agencies within municipal emergency management systems (WHO, 2026). Given their comparatively high heat risk, delays in implementing these measures may leave vulnerable populations insufficiently protected during extreme heat events.

Municipalities classified as Emerging Concern should prioritise anticipatory adaptation by strengthening institutional coordination, incorporating heat considerations into urban planning, and developing operational response protocols before heat risk intensifies. In contrast, Adaptation Leaders should build on their existing planning capacity by reinforcing cross-sectoral coordination among planning, public health, meteorological, and emergency management agencies, with greater emphasis on protecting vulnerable populations during extreme heat events. Preparedness Leaders are well positioned to focus on continuous improvement and innovation through initiatives such as digital heat risk dashboards, neighbourhood-scale heat monitoring, AI-supported early warning systems, and systematic evaluation of adaptation effectiveness. They may also play an important

role in disseminating good practices and supporting capacity building across municipalities with lower preparedness.

Notably, the governance requirements introduced by the YİDEP Regulation closely correspond to several dimensions of the HPI developed in this study—particularly evidence-based risk assessment (HP2), implementation capacity (HP5), and monitoring and updating (HP6). This correspondence suggests that the proposed framework may also provide a useful benchmark for evaluating the heat-specific preparedness of future YİDEPs. However, the Regulation does not explicitly require heat-specific operational mechanisms such as HAPs, cooling centres, or dedicated protocols for heat-vulnerable populations. This is particularly important given that Heat Management Policies (HP4) emerged as the weakest preparedness domain across all four municipal profiles. The effectiveness of the emerging YİDEP framework for extreme heat will therefore depend on whether its broader climate-governance requirements are translated into heat-specific operational mechanisms linking spatial planning, public health, disaster risk reduction, and emergency management. More fundamentally, municipal heat preparedness should be evaluated not by the existence of climate adaptation plans alone, but by the operational capacity to anticipate, coordinate, and respond effectively to extreme heat events.

Limitations and Future Research

The analysis covered 21 MMs for which relevant climate planning instruments were publicly available, and the HPI captures preparedness as documented in these plans rather than their actual implementation or effectiveness. Although the HPI applies a common heat-specific assessment framework across planning instruments, differences in the institutional contexts, methodological guidance, and reporting structures of SECAPs and IDEPs may influence how preparedness components are documented and should therefore be considered when interpreting cross-municipal comparisons. The HRI provides a comparative assessment at the metropolitan scale and therefore does not represent intra-urban variations in heat risk. Although the use of standardised indicators, equal weighting, and median-based thresholds provides a transparent basis for comparison, alternative indicator selections, weighting schemes, or classification thresholds may influence relative municipal positions. Future research could extend the framework to incorporate evidence on policy implementation and outcomes, examine the influence of different planning frameworks on documented heat preparedness, and test the sensitivity of municipal classifications to alternative weighting and threshold specifications.

CONCLUSION

Extreme heat is emerging as one of the most significant climate-related threats to cities, yet whether municipal preparedness is commensurate with local heat risk remains poorly understood. This study addressed this gap by developing an HPI and applying it to 21 MMs in Türkiye through a systematic evaluation of municipal climate-related planning documents across six preparedness domains. By integrating the HPI with a multidimensional HRI, the study provides a novel framework for assessing the alignment between urban heat risk and municipal preparedness. Unlike conventional assessments of heat risk or adaptation planning in isolation, the HPG framework integrates these dimensions to identify relative mismatches between municipal preparedness and heat risk.

The findings demonstrate considerable variation in municipal preparedness across Türkiye, reflecting different configurations of heat risk, planning capacity, and documented governance arrangements. The Heat Risk–Preparedness Matrix identified four distinct preparedness profiles, demonstrating that municipalities follow multiple pathways towards heat resilience rather than a single adaptation trajectory. A key finding is that Turkish MMs have largely succeeded in integrating heat into climate adaptation planning but have made less progress in developing operational heat governance. Across all preparedness profiles, Heat Management Policies consistently represented the weakest preparedness domain, indicating that operational measures remain underdeveloped regardless of overall preparedness level. This suggests that the principal challenge is no longer recognising heat as a climate adaptation issue but translating strategic planning into operational systems capable of protecting populations during extreme heat events.

In Türkiye, the newly introduced YİDEP framework provides an immediate institutional context in which the proposed approach could be applied to assess whether emerging local climate plans translate broader climate-governance requirements into heat-specific preparedness. Beyond the Turkish context, the proposed framework provides a transferable approach for evaluating municipal heat preparedness using existing planning documents and identifying mismatches between heat risk and preparedness across different institutional and climatic contexts. As climate change continues to amplify extreme heat, future urban resilience will depend not only on reducing long-term heat exposure but also on strengthening the governance capacity to anticipate, coordinate, and respond effectively to heat-related emergencies.

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APPENDICES

Table A1. Operational definitions of heat exposure indicators

Mathematical definition	Variable definitions
$HE1 = \frac{1}{N}\sum_{i=1}^{N} T_{mean,i}$	=hourly near-surface air temperature. =the total number of summer observations.
$T_{95} = P_{95}(T_{max})$ $HE2 = \sum HW_d$	=the 95th percentile of the daily maximum temperature distribution for the 2020–2025 period. =The local threshold for each grid cell. if day belonged to a heatwave sequence and otherwise.
$HE3 = \sum I(T_{min} > 20℃)$	=an indicator function equal to one when the condition is satisfied and zero otherwise.
$HE4 = \sum I(T_{max} > 35℃)$	=indicator function equal to one when Tmax > 35°C, otherwise zero.
$HE5 = \max(T_{\max})$	Maximum daily maximum air temperature recorded during the summer period.
$CDD_d = \max(T_{mean,d} - 22)$ $HE6 = \sum_{d=1}^{n} CDD_d$	=for each day. HE6=total Cooling Degree Days

Table A2. Normalised values of heat exposure and adaptive capacity indicators

Cities	HE1	HE2	HE3	HE4	HE5	HE6	AC1	AC2	AC3	AC4	AC5	AC6
Ankara	0.39	0.72	0.07	0.07	0.60	0.16	0.15	0.65	1.00	1.00	0.77	0.52
Antalya	0.50	0.84	0.40	0.12	0.47	0.30	0.52	0.39	0.62	0.48	0.48	0.33
Balıkesir	0.44	0.58	0.23	0.05	0.61	0.18	0.68	0.20	0.55	0.24	0.24	0.49
Bursa	0.38	0.45	0.20	0.03	0.56	0.14	0.71	0.35	0.52	0.30	0.23	0.23
Denizli	0.58	0.94	0.34	0.24	0.61	0.36	0.42	0.40	0.48	0.36	0.39	0.21
Diyarbakır	0.85	0.58	0.68	0.75	0.85	0.71	0.13	0.55	0.22	0.21	0.26	0.06
Erzurum	0.00	0.94	0.00	0.00	0.16	0.01	0.26	0.42	0.40	0.52	1.00	0.79
Eskişehir	0.39	0.47	0.05	0.09	0.66	0.15	0.25	0.47	0.74	0.48	0.65	0.42
Istanbul	0.48	0.42	0.68	0.01	0.54	0.21	0.70	0.35	0.76	0.58	0.35	1.00
Izmir	0.65	0.77	0.62	0.29	0.68	0.43	0.59	0.32	0.74	0.67	0.43	0.63
Kayseri	0.21	0.80	0.02	0.02	0.40	0.06	0.10	0.63	0.48	0.42	0.46	0.24
Kocaeli	0.39	0.23	0.26	0.01	0.55	0.12	0.84	0.13	0.60	0.24	0.24	0.98
Konya	0.41	0.72	0.12	0.06	0.54	0.18	0.11	0.70	0.40	0.42	0.62	0.44
Malatya	0.46	0.63	0.16	0.13	0.54	0.24	0.14	0.60	0.48	0.39	0.84	0.60
Mersin	0.47	0.81	0.40	0.07	0.48	0.26	0.36	0.44	0.50	0.24	0.26	0.39
Muğla	0.63	0.70	0.67	0.21	0.62	0.43	0.67	0.29	0.73	0.33	0.21	0.27
Sakarya	0.31	0.21	0.13	0.01	0.42	0.07	0.88	0.11	0.43	0.21	0.10	0.06
Şanlıurfa	1.00	0.61	1.00	1.00	1.00	1.00	0.11	0.58	0.00	0.00	0.00	0.00
Tekirdağ	0.53	0.67	0.50	0.05	0.56	0.25	0.38	0.27	0.42	0.12	0.26	0.19
Trabzon	0.00	0.00	0.05	0.00	0.00	0.00	1.00	0.00	0.58	0.52	0.68	0.47
Van	0.14	1.00	0.05	0.00	0.16	0.03	0.00	1.00	0.15	0.18	0.27	0.36

Table A3. Normalised values of heat sensitivity indicators

Cities	HS1	HS2	HS3	HS4	HS5	HS6	HS7	HS8	HS9	HS10	HS11	HS12
Ankara	0.07	0.39	0.06	0.41	0.21	0.00	0.00	0.51	0.76	0.51	0.32	0.16
Antalya	0.04	0.37	0.09	0.04	0.22	0.25	0.29	0.66	0.65	0.82	0.32	0.20
Balıkesir	0.02	1.00	0.00	0.00	0.02	0.39	0.37	0.87	0.00	0.75	1.00	0.13
Bursa	0.10	0.45	0.13	0.46	0.09	0.36	0.30	0.40	0.33	0.50	0.47	0.19
Denizli	0.02	0.61	0.07	0.08	0.02	0.43	0.46	0.68	0.66	0.77	0.60	0.18
Diyarbakır	0.03	0.06	0.58	0.55	0.00	0.71	0.85	0.00	0.99	0.34	0.07	0.47
Erzurum	0.00	0.40	0.27	0.17	0.00	0.49	0.56	0.41	0.12	0.11	0.40	0.39
Eskişehir	0.01	0.61	0.00	0.39	0.04	0.13	0.13	1.00	0.79	0.95	0.63	0.06
Istanbul	1.00	0.22	0.07	0.49	1.00	0.19	0.14	0.50	0.67	0.19	0.24	0.16
Izmir	0.12	0.63	0.02	0.71	0.07	0.21	0.23	0.74	0.95	0.74	0.60	0.20
Kayseri	0.02	0.43	0.19	0.16	0.02	0.41	0.37	0.33	0.56	0.88	0.40	0.42
Kocaeli	0.21	0.27	0.18	0.44	0.03	0.25	0.24	0.29	0.55	0.38	0.28	0.21
Konya	0.01	0.46	0.22	0.18	0.04	0.57	0.52	0.33	0.36	0.93	0.40	0.32
Malatya	0.01	0.55	0.15	0.31	0.00	0.39	0.56	0.63	0.96	1.00	0.44	0.43
Mersin	0.03	0.47	0.19	0.30	0.07	0.43	0.49	0.51	1.00	0.91	0.46	0.33
Muğla	0.02	0.69	0.01	0.14	0.04	0.21	0.35	0.90	0.10	0.72	0.56	0.00
Sakarya	0.07	0.49	0.13	0.33	0.04	0.36	0.38	0.43	0.47	0.00	0.50	0.19
Şanlıurfa	0.03	0.00	1.00	0.37	0.01	1.00	1.00	0.00	0.63	0.53	0.06	1.00
Tekirdağ	0.06	0.39	0.13	0.31	0.01	0.42	0.37	0.46	0.11	0.67	0.44	0.19
Trabzon	0.05	0.79	0.08	0.15	0.02	0.27	0.36	0.78	0.94	0.05	0.57	0.24
Van	0.01	0.03	0.54	1.00	0.00	0.79	0.90	0.00	0.16	0.42	0.00	0.56

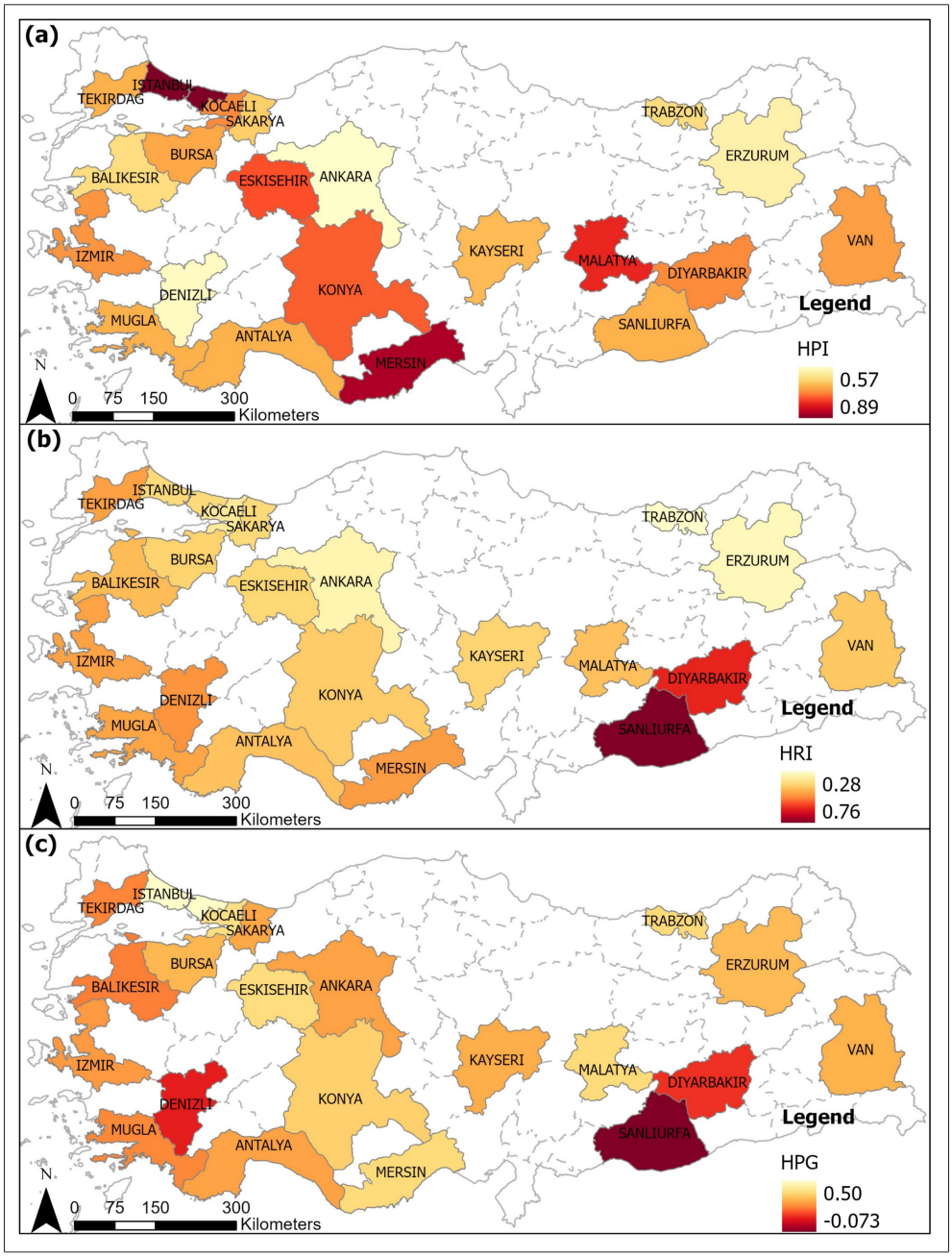

Figure A1. Heat preparedness, risk and gap profiles of MMs.

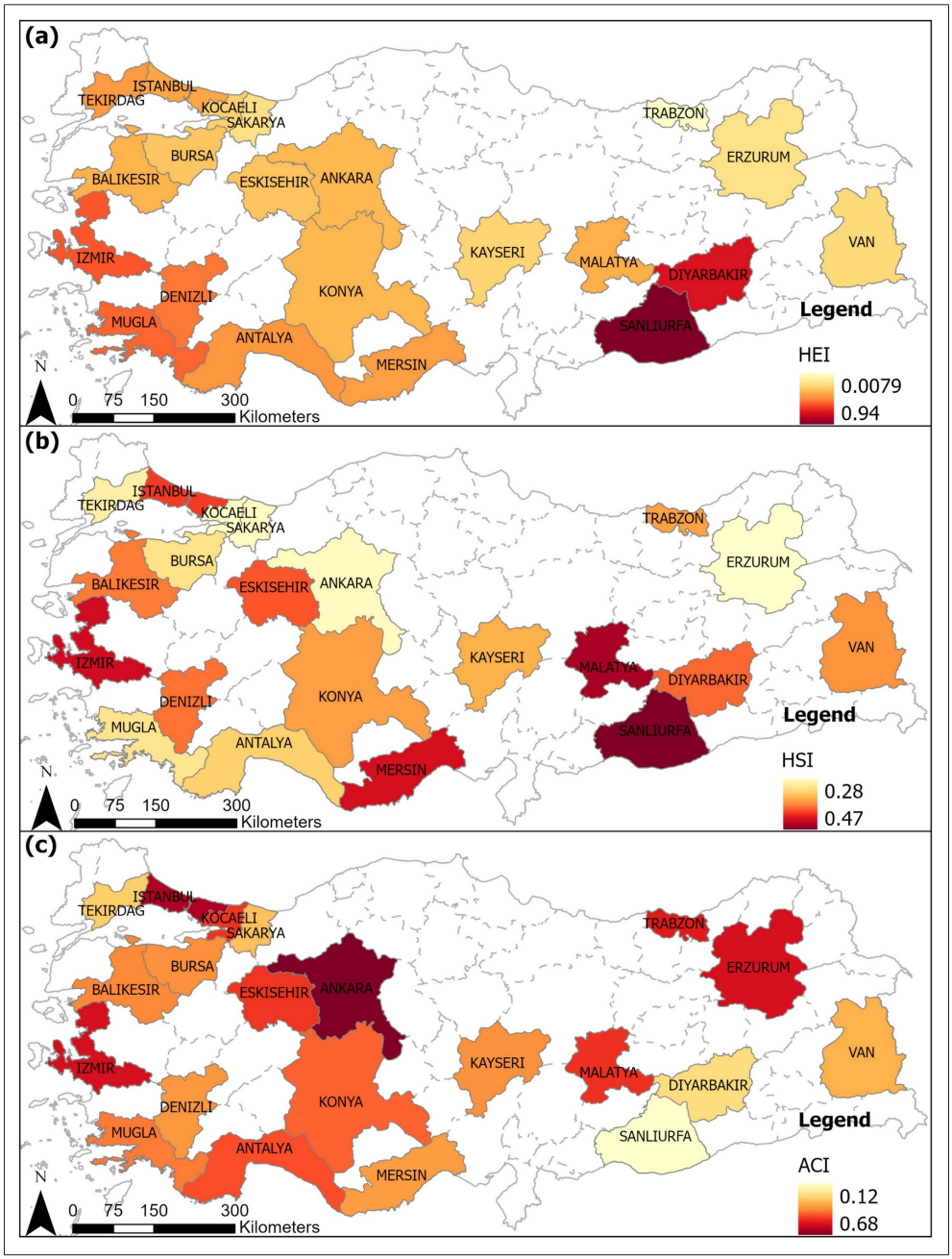

Figure A2. Heat exposure, sensitivity and adaptive capacity profiles of MMs.

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Article

Material-led design research through biomaterial transformation: Temporality, participation, and spatial production

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ABSTRACT

This article investigates how biomaterials can act as active drivers in material-led design research through time-dependent transformation. While biomaterials are often framed as sustainable alternatives, their role in generating spatial and experiential conditions remains underexplored. Addressing this gap, the study develops a practice-based research approach examining food-waste-derived biomaterials as surface-forming agents. The research is structured around Sta!ned, a participatory installation operating as a design research medium. Biomaterials are produced and applied through pouring protocols, while environmental conditions and participant interaction, observed qualitatively, act as sources of variation in material behavior. Longitudinal observation and structured analysis enable the systematic examination of transformation processes. Findings show that surface formation emerges through accumulation, diffusion, and decay, producing temporally evolving spatial conditions rather than fixed outcomes. The study proposes a transferable methodological framework integrating material agency, temporality, and participation, positioning material transformation as a generative component of design knowledge.

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INTRODUCTION

In material ecology, computational material culture, and material-driven design, architectural systems are defined as a set of configurations in which material performance, environment, and space interact as a set of interdependent variables, and architectural form is only partially determinable via the mediation of material systems and atmospheric forces (Menges, 2012; Oxman, 2016). In this regard, bio-based materials go beyond replacing traditional materials and incorporate temporality, heterogeneity, and transformation as inherent architectural features that require new modes of representation and performance (Thomsen & Tamke, 2022). Simultaneous advancements in architectural theory continue to redefine living and bio-based systems from design materials to co-design participants in architectural design and production. New paradigms of ecology highlight spatial creation as a result of the interplay between biological behavior, interior space, and design intention, diverting attention from form-making in architecture and focusing on spatial formation as a process of architecture (Chayaamor-Heil et al., 2024).

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Under this paradigm, experimental installations are made to function as architectural research tools capable of analyzing the interaction between materials and the environment at the interior scale. The experimental installations are made to function not as representational objects but as space apparatuses through which the behavior of materials may be analyzed at the interior scale. Research on responsive environments illustrates that the presence of the body may function as a controlled input capable of modulating architectural systems through participation that is structured and constrained (Achten, 2019; Costa Maia & Meyboom, 2015). Accordingly, in this research, participation is understood as an operative condition of the system rather than a symbolic act.

Critical discourse on bio-design further supports this approach by cautioning against reducing living systems to representational materials and encouraging their use within architecture based on performative and operational abilities, such as surface creation and organizational behavior (Collet, 2017). According to this perspective, installation practices are situated within architecture as a form of knowledge creation within architecture studies rather than being a form of artistic representation (Rendell, 2006). At the same time, biomaterials also take on a significant position in architectural research for their ability to act as adaptive systems that are responsive to their environment. The study of engineered living materials and biological composites illustrates that these materials maintain their functional integrity while also displaying adaptive, time-dependent behavior, causing biomaterials to be viewed not simply as reactive architectural options but dynamic architectural systems in their own right (Geng et al., 2024; Quijano et al., 2025). The study of bio-based building materials, such as engineered mycelium systems, illustrates the ability of biological growth to achieve material properties relevant to architectural surface creation and performance (Jones et al., 2020).

Despite advances, existing research largely focuses on material engineering or design concepts, revealing a gap in protocol-based architectural analysis that systematically integrates biomaterial properties into interior surface formation. While responsive architecture addresses interaction and environmental feedback, few studies establish structured procedures for biomaterial formulation, exposure, observation, and structured participation. Moreover, temporality—manifested through drying, cracking, diffusion, sedimentation, and growth—remains underdeveloped as an architectural variable despite its recognized significance (Thrift, 2008). Through biomaterial formulation, exposure, temporal recording, and protocol-guided participation, "Sta!ned" provides a transferable architectural research process for analyzing temporal surface formation on the interior scale. The practice of installation is here considered not only a type of exhibition design but also a spatial research tool that generates knowledge within a particular disciplinary field. This stance corresponds with practice-led interior research that conceives of installation-based thinking as a knowledge-generating tool, where interior space itself is understood not as a representation but rather a site of knowledge (Roes & Snowdon, 2018).

This study addresses the following research questions:

1. How can the properties and behaviors of biomaterials under interior atmospheric conditions be operationalized as active surface-forming agents rather than treated as representational or decorative layers in interior environments?
2. To what extent can practice-based architectural installation generate transferable knowledge on time-dependent surface production, interior atmospheric interaction, and material–environment relationships at the interior scale?

In response, the project Sta!ned is presented as a practice-based architectural research installation investigating surface formation generated through biomaterial behavior in interior environments. Biomaterials are applied through repeated, gravity-driven pouring actions, while participation follows a pouring protocol and is treated as an observed, but not quantitatively tracked, source of variability in flow paths, deposition height, and drying. Through this configuration, bodily presence and human participation become part of the system rather than external to it (Beesley, 2010).

METHOD

Research data were collected through a longitudinal observation protocol documenting drying rate, crack formation, flow behavior, layer overlap, detachment, chromatic change, olfactory response, and microbial indicators. Photographic and time-lapse recordings were captured immediately after deposition, and at 24-hour and 7-day intervals, with all data time-stamped for chronological analysis of surface evolution. Conducted at the interior scale, the study enables direct interaction between material behavior and atmospheric conditions such as humidity, airflow, and bodily proximity. While the single-site setup limits climatic generalization, the protocol is replicable and adaptable across interior contexts. The research positions the investigator as an embedded practitioner, integrating spatial, material, and environmental variables within a practice-based design research framework.

Research Design

The study adopts a practice-based architectural research methodology integrating material experimentation, spatial configuration, and environmental conditions. The installation is framed not as an artwork but as a research

device for examining biomaterial-driven surface and environmental formation at the interior scale. Conducted over six months, the research follows iterative cycles of material development and controlled activation within a single-case embedded design. Within this framework, the interior site functions as an environmental field, biomaterial formulations as experimental variables, surface evolution over time as the primary unit of analysis, and human presence as an observed source of variability in material behavior that was not quantitatively tracked. However, there was no controlled laboratory comparison setup because the aim was to test the materials under real atmospheric conditions rather than stabilized conditions. This reflects the architectural research viewpoint on space that considers space as a product of the intersection of material, environmental, and social factors rather than a self-contained form system (Till, 2009).

Biomaterial Formulation Protocol

Biomaterials were produced from food-waste-derived pigments, a cellulose-based binder, and plant plasticizers, with all mixtures standardized by weight-to-volume ratios (g/mL) to ensure traceability. Mixing, heating, and pause durations were controlled, following bioplastic and bio-fabrication prototyping principles that balance replicability and variation (Dunne, 2018). Each formulation was prepared in triplicate and evaluated for viscosity, flow behavior, adhesion to textile substrates, opacity, chromatic stability, and sensitivity to humidity and temperature. All tests were systematically documented through photographic and written records for comparative analysis. Moving beyond the classification of biomaterials as sustainable substitutes, the study adopts a material-agency perspective, positioning material behavior as constitutive of architectural knowledge and practice. Drawing on socio-material approaches, architectural outcomes are understood as emerging from intertwined social and material relations (Salama & Patil, 2025), where phenomena such as flow, adhesion, cracking, pigment migration, stratification, and early biodegradation operate as active agents in interior surface formation.

Spatial Application Protocol

Biomaterials were applied exclusively through gravity-driven pouring onto vertically suspended textile surfaces integrated into the installation. Application parameters were standardized as follows:

- pouring height: approximately 120–150 cm,
- pour volume: approximately 20–25 mL per action,
- resulting layer thickness: approximately 1–3 mm, depending on viscosity.

No corrective manipulation—such as brushing, smoothing, or mechanical spreading was permitted. Each deposition was applied directly onto previous layers without surface cleaning, enabling cumulative stratification, interlayer interaction, and emergent temporal behavior. This protocol ensured that surface formation resulted from material agency and environmental conditions, rather than external formal control, allowing spatial effects to emerge through process rather than representation.

Interior Environmental Conditions

All experiments were conducted under ambient interior conditions representative of a public indoor environment:

- temperature: 18–24 °C,
- relative humidity: 60–75%,
- indoor light exposure: approximately 9–11 hours per day,
- ventilation: passive airflow supported by an HVAC-equipped interior space.

Environmental variability was treated as an operative architectural parameter rather than a disturbance to be minimized. Rather, it is sought to explore how interior atmospheric conditions affect the development of materials and surfaces. In this research on interior atmospheres, these are not understood to provide the stable setting in which other phenomena unfold but are understood to be active environments that co-create surfaces in relation to moisture, air currents, light, and physical proximity. At the same time, research on cross-modal congruence (for instance, smell-color-language congruence) confirms that atmospheric experience is the result of organized relationships between sensory modalities and design parameters rather than by-products of these parameters (Tonin & Ferrara, 2025). Accordingly, the stratified biomaterial surfaces developed here operate as atmospheric registers: they capture and externalize time-dependent material–environment interactions, enabling interior atmospheres to be approached as measurable and designable conditions rather than purely experiential descriptors (Tonin & Ferrara, 2025; Treacy, 2025).

Analytical Framework

Analysis combined deductive structural coding and inductive thematic interpretation to translate observable material behavior into architectural outcomes. A structured coding matrix categorized behaviors including adhesion, crack development, detachment, stratification density, temporal instability, chromatic change, and olfactory/biological indicators, enabling comparative analysis across formulations and substrates. Inductive analysis proceeded through open coding (identifying recurring transformations), axial coding (establishing relationships between material behavior, substrate response, and environmental conditions), and selective coding. Material agency is used here in an operational sense, to refer to observable behaviors such as flow,

adhesion, cracking, and stratification under interior atmospheric conditions; the four categories organize these behaviors. In the axial step, the coded behaviors were grouped by the relationship they describe: between poured material and gravity (how far a deposit travels before it sets), material and substrate (whether it remains attached), material and time (how long it remains stable before cracking or biological activity), and successive deposits (whether earlier layers remain visible). Selective coding consolidated these groupings into Flow and Retention, Adhesion and Separation, Temporal Durability, and Layered Surface Formation, respectively, each tied to recorded indicators: lateral spread and drying time; adhesion and detachment; crack onset, first mold growth, and temporal stability; and layer overlap and previous-layer visibility (Table 1; Supplementary Table S2). These categories inform the interpretation of how biomaterial behavior generates evolving spatial conditions. Architectural outcomes were evaluated as spatial effects emerging from the interaction of controlled pouring, material response, environmental modulation, and cumulative temporal change, demonstrating that practice-based processes can operate as knowledge-producing systems rather than representational installations.

Participant Interaction Protocol

The installation was situated in a public interior space and enabled non-intrusive participation guided by a pouring protocol. Interaction occurred through:

- spatial proximity,
- bodily movement around suspended surfaces,
- localized atmospheric disturbance.

Comparable interior-scale constructs have been documented as 'interior skins' that register bodily presence and spatial interaction through controlled responsiveness (Wu,

Table 1. Biomaterial Recipes, Production Methods, and Qualitative Behavioral Evaluation

No	Material	Image	Results & Observations	Material Behavior Category	Epistemic Effect on the Surface	Layer Overlap Intensity	Lateral Spread Width
1	Turmeric		Gel-like, matte, slippery, layered surface	Flow retention + layered stratification	Slow temporal accumulation	High	Medium–High
2	Beetroot		Matte, grainy, detaches easily	Weak adhesion + surface separation	Fragmented traces	Low	Low–Medium
3	Purple Cabbage (Peel)		Thick, rigid, difficult to pour	Material resistance + rigidity	Restricted temporal agency	Very Low	Very Low
4	Purple Cabbage (Juice)		Soft, pourable, chromatic diffusion	High fluidity + pigment migration	Visible temporal color displacement	Medium	High
5	Coffee Grounds I		Dark, matte, strong pigmentation	Pigment dominance + surface saturation	Dense epistemic deposition	High	Low
6	Coffee Grounds II		Water-dependent firmness	Moisture-modulated agency	Variable temporal inscription	Medium–High	Medium
7	Coffee Grounds III		Thin, fragile surface	Structural fragility	Transient epistemic traces	Low	Medium
8	Banana Purée & Peel		Soft, light color	Diluted material agency	Low epistemic density	Low–Medium	High
9	Banana Peel Powder		Grainy, detaches easily	Granular fragmentation	Dispersed micro traces	Very Low	Medium–High
10	Spinach		Dark green, stains, fades	Chromatic migration + oxidative decay	Temporally legible color erosion	Medium	High

2018). In this study, participants poured within a restricted spatial setting and according to the application protocol described above. Because individual pours nevertheless differed, participation is treated as an observed source of variability in deposit thickness, flow path, and drying, not as a controlled variable. Participation was not quantitatively tracked; its effects were evaluated qualitatively by comparing the time-stamped photographic records of the surfaces, and no causal relationship between participant movement and specific surface changes is claimed. This reading resonates with participatory scholarship in architecture, which emphasizes what participation produces within experimental practices (e.g., new relations, new artifacts, new spatial arrangements) instead of treating participation as a representational add-on (Royer, 2022), and with longitudinal accounts in which participation is evaluated through experience and its impact on social interaction and spatial use (Loiseau et al., 2022). Accordingly, the pouring gestures are treated as a repeatable participatory protocol whose effects on the surface are reported descriptively (Bennett, 2025; Loiseau et al., 2022; Robson, 2023; Royer, 2022).

RESULTS

This section reports the empirical results of Sta!ned as a practice-based architectural research project investigating the formation of surfaces through biomaterials in a public indoor environment. These results have been obtained through cycles of biomaterial preparation, pouring, observation, and participation. These observations have been recorded in photographs, time-lapse recordings, as well as comparisons of surface characteristics.

Biomaterial Research, Experimental Tests, and Formulation Development

The screening phase evaluated the suitability of pigments and residues obtained from food waste for gravity-based applications in interior settings. This was based on the following criteria for which the materials would be disqualified: (i) the production of pungent smells and instability for interior applications, (ii) inability to pour the material uniformly in a standard manner, and (iii) the rate of color degradation leading to reduced legibility of the surface. The residues evaluated in the screening phase included those obtained from tomatoes, spinach, citrus fruits, beetroot, purple cabbage, coffee ground residues, tea leaf residues, plum residues, cumin seed residues, banana peel residues, and eggshell residues (Figure 1). Based on the results of the screening phase, the next phase evaluated the following ten biomaterial compositions for various applications in four principal color ranges and varied physical properties: turmeric, beetroot, purple cabbage (peel and juice), coffee ground residues (I-III), banana purée, banana peel powder, and spinach.



Figure 1. Biomaterial Research Process and Experimental Samples.

Table 1 identifies four recurring biomaterial behavior patterns based on layer overlap and lateral spread: (1) flow retention with stratification, (2) weak adhesion with surface separation, (3) high fluidity with pigment migration, and (4) pigment-dominant yet structurally variable compositions. The four analytical categories cut across these formulation-level patterns, as set out below. These results demonstrate that biomaterials actively generate differentiated surface conditions through their flow, adhesion, and temporal transformation, rather than functioning as passive finishes. Biomaterials have existed at the nexus of material culture studies and the production of knowledge in architecture and biotechnology (De Mol & Vandamme, 2024). All selected formulations were biodegradable, coming from renewable or recovered sources. The criteria included characteristics relevant to architectural surface layer formation, such as viscosity suitable for controlled pouring, binding ability to textile support, possibility of layer stratification, color stability, and migration, or changes over time under indoor humidity flow and air currents (Figure 2).

Within contemporary architectural research, biomaterials have moved beyond their initial framing as sustainable alternatives toward being understood as operative architectural systems whose material behavior actively contributes to spatial production. Bio-digital architectural studies have articulated how living and bio-based materials can act as generative agents, embedding metabolic processes, growth, and decay directly into architectural logic rather than treating biological activity as an external constraint (Pasquero & Poletto, 2020; Valenti & Pasquero, 2021). Parallel experimental research on bacterial cellulose and biologically active composites has demonstrated how such materials can be deployed as performative surface and skin systems, where flexibility, environmental responsiveness, and temporal transformation constitute design-relevant parameters (Massoud et al., 2024; Turhan-Haskara et al., 2024). Within the built environment discourse, engineered living materials further establish a methodological bridge between biological activity and architectural performance, positioning biomaterials as a legitimate subject of architectural research rather than material novelty (Proksch, 2024). At the interior scale, studies on mycelium-based composites and digitally fabricated bio-based components show how biomaterials



Figure 2. Experimental Material Responses, Biomaterial Samples and Formulations Mock-up.

can be systematically integrated into architectural assemblies through controlled fabrication protocols and spatial testing (Özkan & Güzelci, 2025). Taken together, these contributions consolidate biomaterials as architectural agents mediating form, surface behavior, and environmental interaction, providing the conceptual and methodological foundation upon which the present study builds.

In all the formulations, the successive layering was cumulative in its contribution to the deposition, but the degree of layering, adhesion, and diffusion differed among the formulations. This was helpful in making comparisons of the readings of surface formation (Table 1). The compositional ratios are shown in detail in Supplementary Table S1, whereas the comparative physical, temporal, and epistemic properties are shown in Supplementary Table S2.

Read against the four analytical categories (Table 1; Supplementary Table S2): in Flow and Retention, purple cabbage juice, banana purée and peel, and spinach spread widely, whereas Coffee Grounds I and purple cabbage peel stayed close to the point of deposition; in Adhesion and Separation, the same three formulations adhered strongly, while beetroot and banana peel powder detached easily after drying; in Temporal Durability, only purple cabbage juice and Coffee Grounds I were rated high in stability; and in Layered Surface Formation, earlier layers remained most visible under turmeric and Coffee Grounds I and least under purple cabbage peel and banana peel powder.

Throughout the observation period, all formulations showed time-dependent variation that was readable on the textile substrate. The most frequent patterns of transformation were:

- Drying and setting properties: Drying rate differences appeared as early setting (fast-setting) and delayed flow and diffusion (slow-setting).
- Cracking patterns were varied, ranging from fine, diffused micro-cracking to larger, discontinuous fracture patterns, depending on viscosity, pigment content, and binder ratio.
- Surface Detachment: The detachment process mostly occurred where the formulation had lower adhesive strength, which resulted in patchy deposits.
- Chromatic variation: there was chromatic variation in several formulations, in the form of pigment migration, fading, or oxidative tone changes.
- Biodegradation markers: odor formation and the growth of microorganisms were monitored in test formulations.

These results were recorded by means of timed photographic shots and time-lapse photography done at immediate, 24-hour, and 7-day intervals in order to facilitate comparisons regarding transformation sequences. Before their usage during the installation phase, the samples were kept for observation for three weeks, during which the outcomes of stability, such as the change in viscosity, color, smell, and growth of molds, could be marked, as follows:

- Class I: low fluidity, high density, slow drying rate, lower pigment retention.
- Class II: Has high fluidity, low density, and translucency characteristic of thin fabrics.
- Class III: Viscosity and flexibility are well balanced; chromatic saturation and operational stability are increased.

As a result, that Class III findings were most consistent with controlled pouring and layering under interior conditions. These observations played a role in the last modification to formulations prior to application.

Textile Material Research

This section explains how different types of fabric affect dripping, flow, and fixation of biomaterials in order to control visualizations of depth, stratification, and temporal unfolding in the installation setting.

Five fabrics of three major types, namely tulle, chiffon, and canvas, were chosen for their differences in permeability and flow properties (Figure 3). Thus, tulle facilitated fast dripping and heavy fixation, chiffon allowed for light-

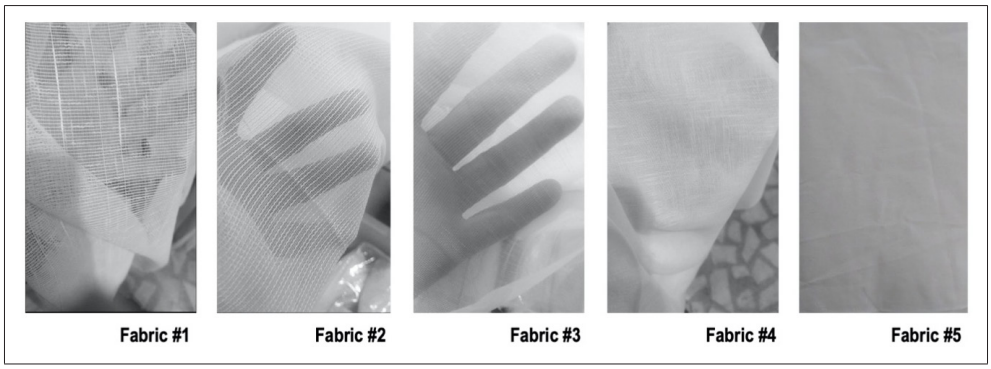

Figure 3. Fabric Tests and Material–Textile Interaction.

er and continuous flow, and canvas served as a support for the eventual fixation of pigments, enabling transient processes to be translated into permanence. Under all experimental scenarios, marked differences in biomaterial flow were found, depending upon viscosity, setting in a dynamic relation between biomaterial properties and textile properties. Biomaterial properties were found to display life-like qualities, in terms of odor, mold, viscosity, and pigments, reinforcing that production as a continuous investigational process represents a series of processes rather than a recipe. Across the five fabrics, different regimes of dripping were identified, from flow traces and rhythmic dripping to sedimentation, pigment deposition, and permanent fixation. The analysis of the relationship between textile permeability and biomaterials behavior shows that textile surface porosity plays a direct role in staining, layer formation, and material sedimentation. Compact textile surfaces enhance fixation and accumulation, whereas relatively permeable textile surfaces facilitate diffusion and the dispersal of pigments. Such negotiations in materials, as a result of absorption, resistance, and flow, form a textile register where the "palimpsestical" order of the work appears.

Project Implementation Process

The project, whose visual identity is shown in Figure 4, unfolded as a non-linear research process in which material experimentation, spatial configuration, and participant interaction occurred simultaneously. Rather than following a sequential workflow, spatial definition emerged through iterative testing of viscosity, color diffusion, and drying behavior. The Sta!ned installation employs a modular, vertical, and lightweight structure that enables stratification, where overlapping, semi-transparent layers regulate diffusion and accumulation.



Figure 4. Visual Identity of the Project.

The sacks above serve as the release points for dripping, and variations in textile properties manage exposure, absorption, and pigment retention at different spatial planes (Figures 5 and 6).

Structural Assembly Process

The structure was built as a digitally coordinated modular system of five dismantlable wooden units (M1-M5) (Figures 6-8). Metal grids in the upper levels and semi-permeable platforms regulated the vertical flow of biomaterial between layers (Figure 9), while the textile components defined different permeability thresholds. The reversible construction allowed the structure to be dismantled and reassembled across successive exhibitions.

The structural assembly was conceived not as a neutral exhibition support but as part of the research method. Pouring height, vertical sequencing, permeability gradients, and deposition areas were fixed by the structure, which provided a stable spatial setting within which material and environmental processes could be observed systematically.

Pigment layers accumulated through successive applications, each activating prior deposits. Weekly dripping sessions

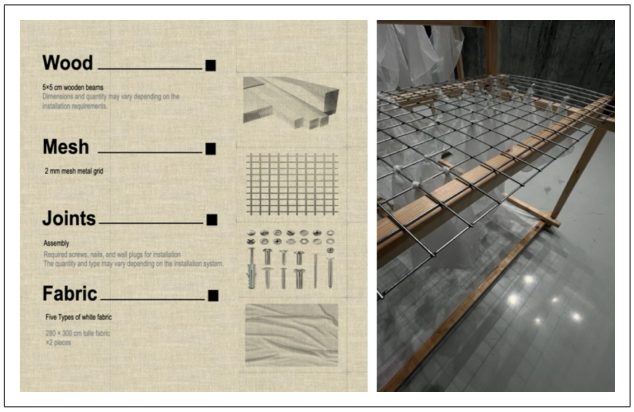

Figure 5. Prototype Development and Early Material Applications.

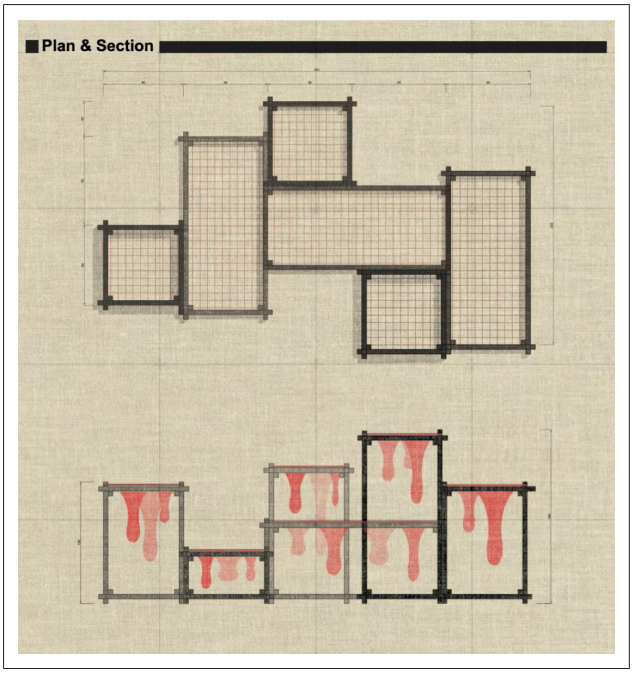

Figure 6. Spatial Arrangement and Layered Structure Formation.

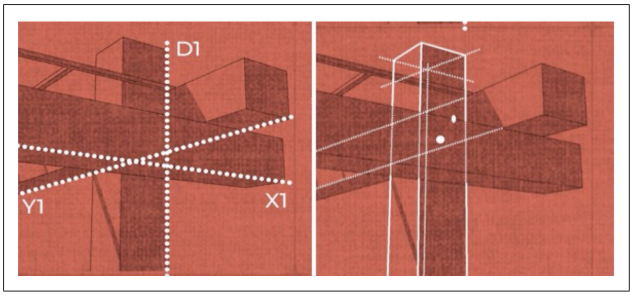

Figure 7. Structural Assembly Process: Modular Wooden Framework.

introduced participation and further variability, while drying, cracking, and coloration produced a palimpsest shaped by material behavior, time, and environment. Over three months, the system remained in continuous transformation, forming a temporally adaptive interface defined by deposition, erosion, and change. A time-based release system using biomaterial cartridges generated variations in viscosity, flow, and color, directly affecting surface formation. Participation was thus registered materially in the evolving surface.

Figures 10 and 11 present the final structure during the exhibition, with material deposited at multiple levels and flowing toward the canvas surfaces.

These results address RQ2 by demonstrating that spatial configuration itself can be operationalized as a methodological variable, stabilizing experimental conditions while allowing material behavior to remain dynamic and comparable across time.

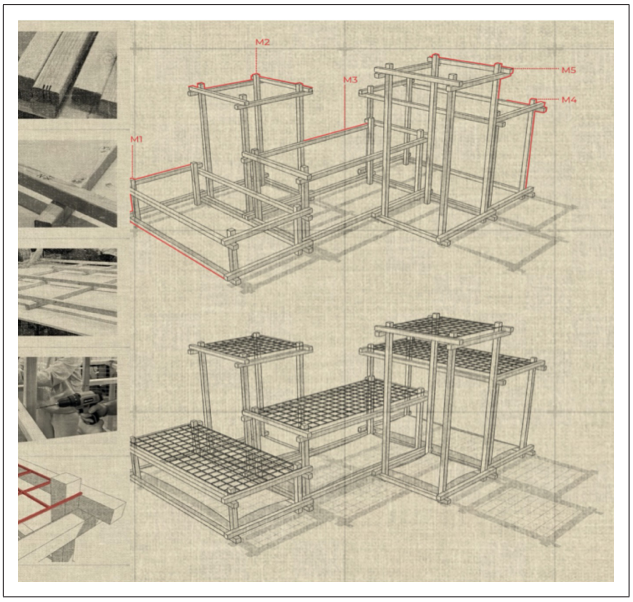

Figure 8. Installation Process: Material Application onto Textile Layers.

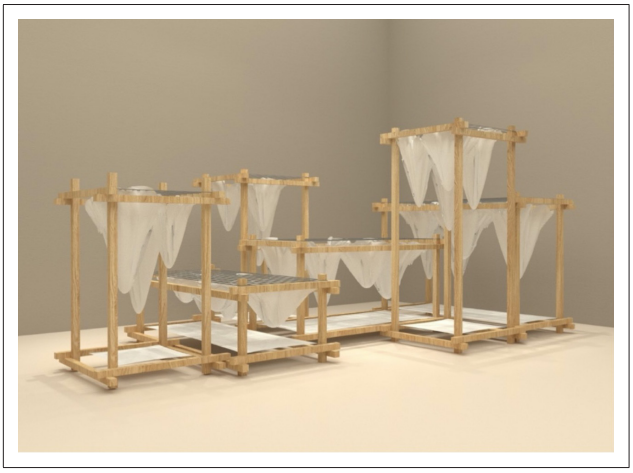

Figure 9. Render Image - Grid System and Textile Suspension.

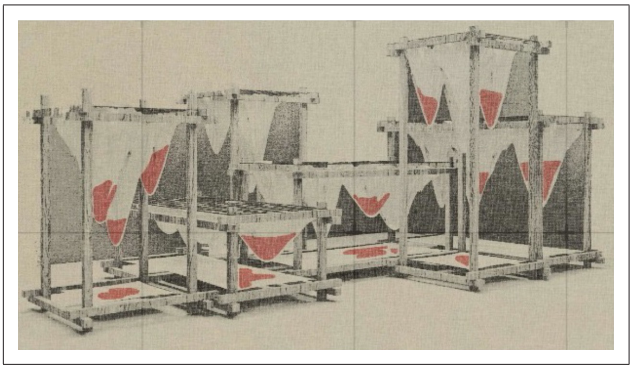

Figure 10. Surfaces Demonstrating Layer Formation.



Figure 11. Assembly and Exhibition: Day One of Dripping Cycles and Layer Accumulation.

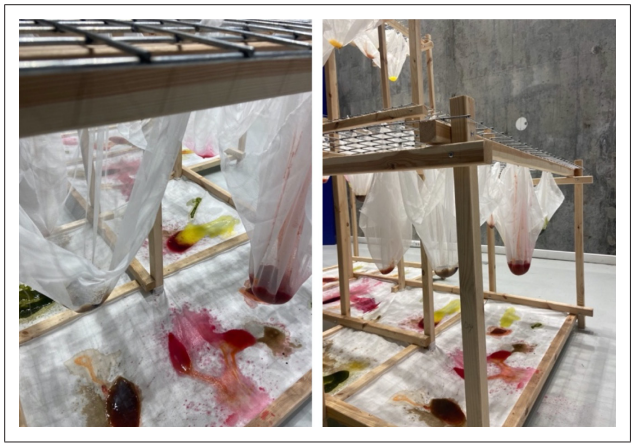

Figure 12. Collective Layer Formation.



Figure 13. Participant Interaction.

Participatory Process During Exhibition of the Spatial Installation

The participatory drip actions are documented in Figures 12 and 13, which show visitors' pours being added to the cumulative stratification. Each pour produced its own local flow pattern and deposit, which was then incorporated into the stratified surface. Participation is hence recorded not as a symbolic trace but as material deposited under gravity and ambient conditions.

With each iteration of observation and operation, the system demonstrated recursive transformation, where each new deposit interacted in some way with the pre-existing layers, whether it be by blending, occluding, cracking, and/or detaching. The surface developed here is a temporally layered material archive, recording traces of interaction rather than individual marks. It is through such a process that the installation receives the ability to become an interior-scale architecture, where collective activity is continually worked back into the material processes, and the formation of the surface becomes understood as an effect of procedural development and situated activity. Figure 13 shows participants dripping material onto the surfaces. Individual pouring actions differed, and the resulting deposits varied in flow, layer thickness, and drying; these differences contributed to stratification rather than producing symbolic traces. The installation constitutes an interior-scale environment in which spatial conditions are continuously produced through the interaction of material properties and human presence, with layered surfaces acting as records of these processes. Participation was not quantitatively measured: its effects were assessed only qualitatively, through photographic comparison of deposition, flow, and drying, and they cannot be separated from those of formulation, substrate, and environmental conditions. Participation is therefore reported as an observed source of variability rather than as a controlled variable, which is a limitation of the study.

DISCUSSION

The results of Sta!ned show that installations realized using biomaterials can become architectural research devices, within which the process of material transformation becomes a dynamic factor for space generation, rather than a secondary or representative result.

The internal environment factors, which include humidity, temperature, air current, and light, have a direct effect on

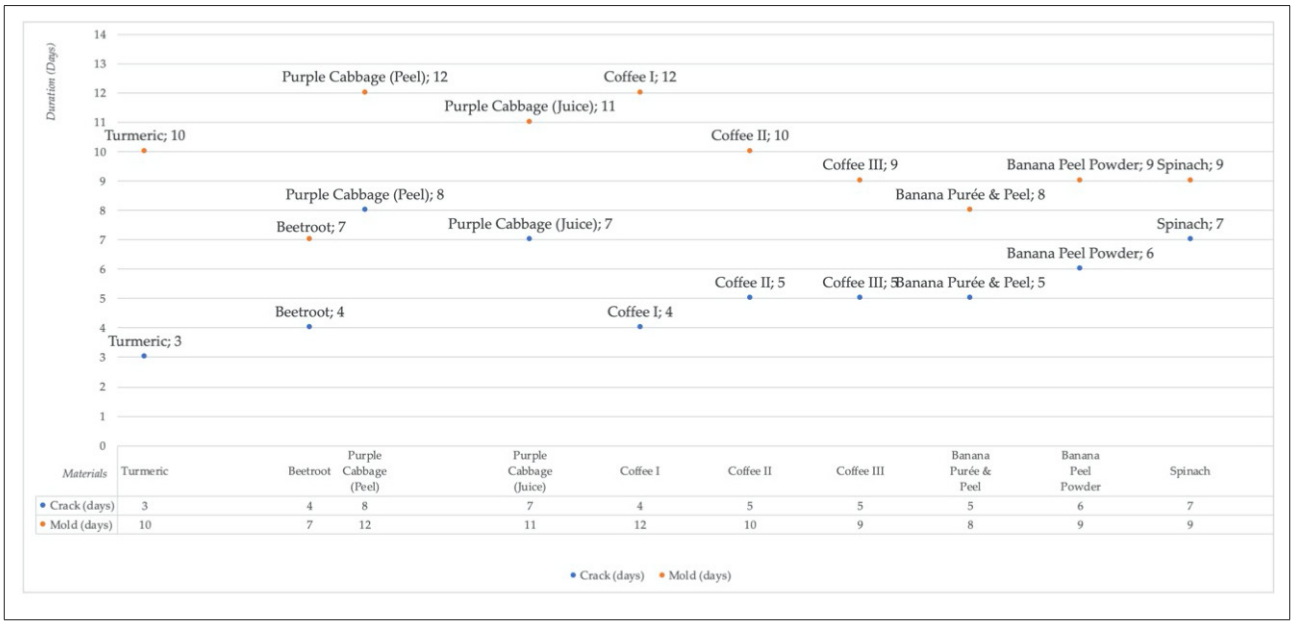

Figure 14. Temporal distribution of crack formation and first visible mold growth across ten biomaterials.

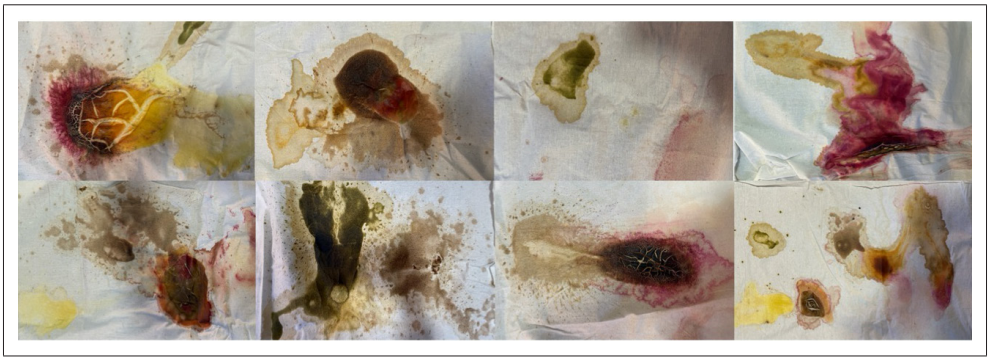

Figure 15. Surface Samples Showing Layer Formation and Material Transformation.

drying rate, pigment migration, formation of cracks, and sedimentation processes. Instead, the role of these environmental factors as external modifiers that act on the preformed object shifts to becoming an internal factor within the spatial system, thus placing the site in the role of a participant as an environment factor.

Moreover, in this model, time is conceptualized not as something that is externally applied from without upon space, but as a functional space dimension that continuously regulates surface behavior and spatial effects. The value of this study lies not within a singular installation, as it offers a repeatable and protocol-driven architectural research system that formalizes material formation, exposure, protocol-guided participation, and documentation as a systemizable whole. Accordingly, this study is pertinent within a methodological architectural research paradigm, wherein systematic procedures, such as simulation-informed evaluative procedures, are employed as a means of producing commensurable evidence and informing architectural practices (Balafoutis, 2025). In the present research, repeatability is secured through (i) explicit formulation ratios and deposition rules, (ii) controlled environmental observation intervals, (iii) standardized photographic documentation enabling temporal comparison, and (iv) a bounded participatory input, where pouring gestures follow a common protocol. While the proposed protocol does not seek to generalize biomaterial behavior across all interior contexts, it establishes a comparative architectural framework through which material-driven surface formation can be systematically observed, documented, and evaluated under varying interior atmospheric conditions. From such a point of view, sustainability is conceptualized as a design logic immanent in material cycles of use and re-entry, rather than in ethical assertions and symbolic statements external to design itself (McDonough & Braungart, 2002). This kind of design logic is in line with process-based philosophies of spatial production that emphasize material change and practices rather than representational outcomes (Thrift, 2008). The interior

space, therefore, can be understood not merely in terms of geometry and enclosure but in terms related to atmospheres arising out of material properties and bodily perceptions—stopping short of architectural theories which define atmosphere as medium rather than effect (Böhme, 2017).

Throughout the three-month period of observation, the deposition processes caused the formation of stratified surfaces, which were simultaneously sites of accumulation, erosion, and reactivation. The occurrence of cracking, which made known the layers of the stratified surface before the deposition, represents the non-linear logic of the formation of the surface itself, which did not follow the logic of progress but rather the logics of accumulation and cracking. In various studies using engineered living materials and biomaterial composites, the ability of biologically active systems to maintain integrity amidst environmental changes, which attest to the notion of biomaterial systems having performative potential rather than being passive material substrates, has been observed and described (Geng et al., 2024; Quijano et al., 2025).

Three mechanisms link these material processes to spatial production. First, sedimentation and retention: on canvas, pigment settled and fixed, so that successive pours thickened the surface, whereas on tulle and chiffon the material passed through or diffused and the layer remained thin. Because the textiles hung as overlapping, semi-transparent layers, these differences changed how much of the layers behind remained visible, and therefore the perceived depth of the installation. Second, cracking and detachment exposed earlier deposits, so that the surface showed several stages of its formation at once. Third, biodegradation—odor, chromatic change, and visible mold growth (Figure 14)—altered the olfactory and visual character of the interior beyond the plane of the surface. In each case a material process changed a spatial property (visual depth, legibility of layers, atmosphere) without any change in the geometry of the structure. These links rest on photographic documentation and direct observation; they were not measured instrumentally.

Surface and 'skin' systems have been theorized as performative interfaces that mediate environmental and experiential conditions, rather than as static finishes—an approach that frames interior surface behavior as an operative design parameter (Addington & Schodek, 2005; Wigginton & Harris, 2002; Wu, 2018). Reading interior surface formation through a performative lens positions material behavior and environmental mediation as design drivers rather than representational effects (Kolarevic & Malkawi, 2005).

Positioned within established accounts of practice-led inquiry, the Sta!ned installation is advanced here as a mode of architectural research in which making and observing are treated as primary knowledge-producing operations rather than as representational outputs (Frayling, 1993). By structuring the work as a protocol-led, single-case, longitudinal investigation—where the "case" is the interior-scale surface system and its time-variant behavior—the study aligns with architectural research method frameworks that legitimize systematic observation, documentation, and comparative interpretation as valid architectural evidence (Groat & Wang, 2013). Read through performance-oriented architectural discourse, the findings further support the claim that spatial outcomes can be understood as emergent effects of coupled material–environment processes, where performance is generated through interaction and temporal transformation rather than fixed form (Hensel, 2010).

Figure 14 plots two events for each of the ten formulations on a common time axis, counted in days from pouring (day 0): the first visible crack and the first visible mold growth, under ambient interior conditions (18–24°C; 60–75% relative humidity). Each formulation first dried (average drying time 10–36 hours) and then cracked, between day 3 (turmeric) and day 8 (purple cabbage peel). Visible mold followed between day 7 (beetroot) and day 12 (purple cabbage peel and Coffee Grounds I). The interval between cracking and mold ranged from two days for spinach (days 7 and 9) to seven days for turmeric (days 3 and 10) and eight days for Coffee Grounds I (days 4 and 12); for the remaining formulations it was three to five days. The sequence of drying, cracking, and biological activity was therefore common to all formulations, while its pace was formulation-specific; the interval marks the threshold at which physical transformation passes into biochemical change. Staining, cracking, and degradation thus operate as readable indicators of material response, allowing time to be encoded within the surface as an observable and comparable condition rather than as a symbolic construct.

The use of biomaterials from food waste situates the formation of surfaces into the larger metabolic processes of consumption, transformation, and decay. Far from being a symbol of sustainability, this installation actualizes it through material processes that are visibly reactive to environmental and human inputs. The engagement of the public through pouring introduces a further, observed source of variation in deposition thickness, flow pathways, and rates of drying. Because this variation was not quantitatively tracked, human presence is considered here a contributing condition of the system rather than a controlled parameter.

Figure 15 presents representative surface samples resulting from prolonged deposition and transformation cycles. Variations in viscosity, evaporation rate, substrate permeability, and environmental exposure produced differentiated patterns of diffusion, discoloration, fiber penetration, and crystallization. These outcomes confirm that layered surface formation emerges from the interaction of material properties, atmospheric conditions, and repeated application, generating quantifiable patterns of temporal stratification. Such patterns enable comparative evaluation across

formulations and substrates, reinforcing the role of biomaterials as analytical tools for studying time-based surface processes in interior architectural contexts.

However, this research deviates from experiments conducted in material science as it neither isolates variables within a controlled lab setting nor aims to normalize variables such as expression or symbolism, as is the case with art installations. The novelty of this research is based on creating a research environment within architecture that utilizes formulation, atmospheric exposure, and configuration as interconnected variables, together with protocol-guided participation. In this case, architectural knowledge is derived from making as well as observation at the interior level, which allows for the translation of time-related material properties into transferable insights at the interior level. As these effects are registered by bodily experience—the proximity, movement, and atmospheric change—the installation comes to be conceived as an interior architectural condition rather than a visual object per se (Pallasmaa, 2009). Architecturally speaking, the fragility and temporal flux of biomaterials pose a problem to the assumptions about the production and display of space in general. Instability, degradation, and transformation are no longer problems to be solved but conditions to be accommodated in architectural terms. Thus, the installation becomes a temporal architectural environment in which the surfaces are always receptive to change rather than being fixed in completion. In this way, stratification becomes an effect of the interaction between material agency, environment, and human action, which provides a model for architectural research in which process, temporality, and materiality take center stage.

CONCLUSION

This research establishes the potential of biomaterials to act as active architectural material systems capable of directly engaging with the production of space through time-variant processes of transformation, rather than merely acting as sustainable materials or representational surfaces. Through a systematic observation of the phenomena of flow, drying, cracking, pigment diffusion, sedimentation, degradation, and microbiology in interior climatic conditions, the project establishes these phenomena to be operative in a way that the resultant surface properties are measurable and comparable. In other words, time is introduced in material systems as an internal architectural variable to facilitate the creation of stratified surfaces with inherent spatial properties.

Methodologically, the work establishes a formal procedure for practice-led architectural research that combines the formulation of biomaterials, exposure to the environment, observation over time, and protocol-guided participation. The demountable and modular structure allows for the repetition of experiments under fluctuating interior conditions, and the photographic documentation allows for the observation of the material transformation. Accordingly, the proposed procedure can be applied to other architectural experiments that include material reactivity, environmental response, and timescale as relevant parameters at the interior scale.

Aside from the specificity of the case study, the results indicate an architectural model in which spatial outcomes emerge through the interaction of three interrelated factors:

Biomaterials Performance × *Temporal Process* × *Participatory Spatial Input*

With material agency understood in this operational sense, spatial memory is described not as a fixed entity, but as the material condition produced by the interaction between biological matter and activity, and the geological forces of the natural environment and constructed architecture. The stratified surfaces achieved in the installation can thereby be seen as material registers, signifying the process of accumulation, erosion, and activation, as an architectural reading of stratification.

Participation in the system is organized through a pouring protocol rather than as expressive or symbolic involvement. Pouring gestures were observed to vary the paths and drying of the deposits, but this effect was not quantitatively tracked: the study does not establish a causal relationship between participant movement and surface change, and this is acknowledged as a limitation. Human involvement is thus part of the logic of formation in the system, and measuring its contribution remains a task for future work.

The contributions of this research can be outlined as follows:

(1) Conceptual Contribution

- Repositions biomaterial transformation as an operative architectural parameter, rather than a secondary or representational surface condition, in the production of interior architectural space.
- Frames stratification as an empirically identifiable, time-dependent architectural condition, shaped by environmental and operational factors rather than symbolic intent.

(2) Methodological Contribution

- Establishes a replicable, practice-based architectural research protocol that integrates biomaterial formulation, longitudinal observation, environmental exposure, and protocol-guided participation.
- Proposes an analytical framework that systematically relates material-level behavior to temporal surface formation at the interior architectural scale.

(3) Practical Contribution

- Demonstrates the architectural viability of food-waste-derived biomaterials for responsive interior surface systems.

- Provides transferable insights into material durability, substrate interaction, and assembly logics relevant to temporally adaptive architectural systems.
- Offers actionable perspectives for architects and designers seeking to integrate process-oriented and environmentally responsive biomaterials into interior architectural practice.

Taken collectively, the results of this research indicate that the installations utilizing biomaterials, viewed through the lens of an architectural framework, represent an environment where the process of space formation occurs through the interaction of behavior, environment, and the intervention of human factors. This work, therefore, offers an important contribution to the literature in the realm of architecture.

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Supplementary Table S1. Detailed Biomaterial Recipes and Preparation Protocols

No	Material	Recipe Composition	Preparation Protocol	Drying / Setting Characteristics
1	Turmeric	70 ml water; 5 tsp corn starch; 2 tsp glycerin; 2 tsp gelatin; 20 g turmeric powder	Turmeric powder is mixed with water; starch, glycerin, and gelatin are added. The mixture is heated while stirred for 1 minute until homogeneous. Poured onto flat surface.	Dries to gel-like, matte, slippery layered surface
2	Beetroot	50 ml water; 5 tsp corn starch; 2 tsp glycerin; 2 tsp gelatin; 1 beetroot	Beetroot scraps washed, chopped, blended into purée. Other ingredients heated; purée added. Mixed for 1–2 minutes and poured onto surface.	Matte, grainy surface; easily separable after drying
3	Purple Cabbage (Peel Mix)	400 ml water; 30 g starch; 25 g glycerol; 60 ml vinegar; purple cabbage peels	All ingredients mixed; cabbage peels added and boiled for 1 minute.	Thick, rigid, low pourability due to low water content
4	Purple Cabbage (Juice Mix)	300 ml cabbage juice; 30 g starch; 25 g glycerol; 60 ml vinegar	Cabbage juice strained. All ingredients boiled for 10 minutes under continuous stirring.	Soft, pourable consistency; light magenta tone
5	Coffee Grounds I	100 ml water; 3 tbsp starch; 1 tsp glycerin; 1 tsp vinegar; 3 tbsp coffee grounds	Coffee grounds added to homogenized mixture. Heated for 10 minutes and dried.	Dark brown, matte, strong pigmentation
6	Coffee Grounds II	50 ml water; 3 tbsp starch; 1 tsp glycerin; 1 tsp vinegar; 1 tbsp coffee grounds	All ingredients homogenized and heated for 10 minutes.	Increased firmness with lower water content
7	Coffee Grounds III	100 ml water; 1 tbsp starch; 1 tsp glycerin; 1 tsp vinegar; 1 tbsp coffee grounds	Ingredients mixed and heated for 10 minutes, then dried on flat textile surface.	Thin, fragile texture; reduced structural cohesion
8	Banana Purée & Peel	100 ml water; 1 tbsp starch; 1 tsp glycerin; 1 tsp vinegar; 3 tbsp banana peel purée	Banana and peel blended into purée, mixed with other ingredients, heated for 10 minutes.	Soft consistency, light coloration
9	Banana Peel (Powder)	70 ml water; 5 tsp starch; 2 tsp glycerin; 2 tsp gelatin; 20 g banana peel powder	Banana peels dried and ground to powder; all ingredients heated and mixed for 1 minute.	Matte, grainy texture; dark yellow tone
10	Spinach	70 ml water; 5 tsp starch; 2 tsp glycerin; 2 tsp gelatin; 20–25 g spinach leaves	Spinach blended into purée; mixed with base ingredients and heated for 1–2 minutes.	Dark green wet tone; lightens as it dries

These biomaterial formulations were developed through iterative experimentation to achieve varying viscosity, chromatic intensity, and temporal transformation behaviors under changing environmental conditions.

Supplementary Table S2. Comparative behavioral characteristics of biomaterial formulations under interior atmospheric conditions

Material	Surface Adhesion Level	Avg. Drying Time	Crack Onset	First Visible Mold Growth	Smell	Temporal Stability	Previous Layer Visibility	Key Epistemic Effect	Material Behavior Category
Criteria	**(Low / Medium / High)**	**(hours)**	**(Day)**	**(Day)**	**(None/ Natural/ Moderate/ High)**	**(Low / Medium / High)**	**(Low / Medium / High)**		
Turmeric	Medium–High	12h	3	10	Natural	Medium	High	Gel-like, matte, slippery, layered surface	Flow retention + layered stratification
Beetroot	Low–Medium	24h	4	7	Moderate	Low	Low	Matte, grainy, detaches easily	Weak adhesion + surface separation
Purple Cabbage (Peel)	Very Low	36h	8	12	High	Low	Very Low	Thick, rigid, difficult to pour	Material resistance + rigidity
Purple Cabbage (Juice)	High	24h	7	11	Moderate	High	Medium	Soft, pourable, chromatic diffusion	High fluidity + pigment migration
Coffee Grounds I	Low	12h	4	12	Natural (low)	High	High	Dark, matte, strong pigmentation	Pigment dominance + surface saturation
Coffee Grounds II	Medium	10h	5	10	Natural	Medium	Medium–High	Water-dependent firmness	Moisture-modulated agency
Coffee Grounds III	Medium	10h	5	9	Natural	Low	Low	Thin, fragile surface	Structural fragility
Banana Purée & Peel	High	16h	5	8	Natural	Low	Low–Medium	Soft, light color	Diluted material agency
Banana Peel Powder	Medium–High	16h	6	9	Natural	Low	Very Low	Grainy, detaches easily	Granular fragmentation
Spinach	High	18h	7	9	Moderate	Medium	Medium	Dark green, stains, fades	Chromatic migration + oxidative decay

Comparative physical, temporal, and epistemic characteristics of ten biomaterials under uniform interior ambient conditions. The table summarizes surface adhesion, average drying time, crack onset, first visible mold growth, olfactory response, temporal stability, previous layer visibility, and associated epistemic effects for each biomaterial. All samples were exposed to uniform interior ambient conditions corresponding to Istanbul spring climate (18–24 °C, 60–75% relative humidity), and all interventions were performed exclusively through pouring.

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Article

Integrating social resilience into the sustainable management of Edirne's historic city center

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ABSTRACT

In recent years, the concept of social/community resilience has gained increasing attention in resilience discussions and is becoming more prominent in planning and conservation literature. This study examines the historical city center of Edirne, selected for its unique historical fabric, multi-layered cultural heritage, and diverse dimensions of vulnerability. Within this area, the Selimiye Mosque and its complex were inscribed on UNESCO's World Heritage List in 2011. Current interventions focus mainly on physical preservation, integrating social, cultural, and environmental dimensions is essential for sustainable outcomes. In this context, the study aims to identify the determinants of social resilience in the Historic Urban Landscape of Edirne and to examine the relationship between these determinants, management and planning processes. This study is designed as mixed-methods research and employed multiple data collection methods, including literature review, on-site observation, surveys, and semi-structured interviews. Participants were purposively sampled from groups directly involved with the historical city center. The survey was structured based on indicators of urban vulnerability, resilience, and social resilience, covering physical/environmental, social, economic, and administrative dimensions. This study was prepared to demonstrate that indicators of social resilience not only produce data describing the current social situation, but also offer a concrete information infrastructure that can be used in spatial planning processes. In this context, the study theoretically aims to operationalize social resilience in historic city centers through measurable indicators based on the integration of conservation and planning processes. Findings indicate that social resilience is critical for effective management, with community engagement, sense of belonging, and social awareness as key factors. Urban vulnerabilities are multidimensional, emphasizing the need for a holistic HUL approach. Edirne demonstrates how social resilience can be integrated into historic urban landscape management, providing a framework to balance conservation and contemporary urban use in historic environments.

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INTRODUCTION

Contemporary historic cities face vulnerabilities in the face of rapidly changing social, spatial, and environmental conditions. These vulnerabilities are particularly acutely felt in historic city centers. Protecting, ensuring the sustainability, and maintaining the resilience of historic city centers in the face of urban development dynamics is becoming increasingly important. There is a mutually beneficial interaction between the resilience of the city and the preservation of historical environments.

Current interventions focus mainly on physical preservation, integrating social, cultural, and environmental dimensions is essential for sustainable outcomes.

However, in order to ensure the sustainability of these areas through conservation, not only physical resilience but also the dimension of social resilience has gained increasing importance.

This study proposes a theoretical framework that considers social resilience in historic city centers as a mediating capacity between urban vulnerability and spatial planning decision-making processes. Within this framework, urban vulnerabilities (physical, social, economic, and administrative dimensions) are shaped by the social resilience components of local communities (belonging, participation, social solidarity, perception of security and demographic continuity, satisfaction with public services, satisfaction with social and cultural life, satisfaction with urban life and economy); the strength or weakness of these components directly affects the effectiveness of planning decisions. Therefore, social resilience is not considered a passive consequence of vulnerabilities, but rather a dynamic intermediary layer that determines the quality of the planning process. This approach reveals that resilience in historic city centers should be addressed not only through physical interventions but also through administrative and participatory mechanisms that strengthen community capacity, considering the city as a whole.

In this context, the study aims to identify the determinants of social resilience in the Historic Urban Landscape of Edirne and to examine the relationship between these determinants, management and planning processes. The research seeks to answer the following questions:

1. What are the key components that determine social resilience?
2. How are these components related to dimensions of urban vulnerability?
3. How can social resilience indicators be integrated into planning processes?

The Edirne Historical City Center (Urban Conservation Area) was chosen as the study area due to its unique historical fabric, multi-layered cultural heritage, and diverse dimensions of vulnerability. The Kaleiçi district, located within the historical city center, is the first settlement area of Edirne. As part of the Historical City Center, the Kaleiçi settlement, with its old and historical building stock, aging and inadequate facilities, and urban fabric largely preserved through individual rather than holistic conservation efforts, struggles to maintain its existence.

Edirne, which served as the capital of the Ottoman Empire for 92 years, has adapted to physical, social, and economic changes brought about by wars and migrations, and has reached the present day. The Edirne Historic City Center carries the living traces of the past into the present with its old city fabric and distinctive architectural works, playing a role in the spatial and social life practices of Edirne's residents.

Located in the historical city center of Edirne, the Selimiye Mosque and its complex were included in UNESCO's World Heritage list in 2011 (UNESCO, 2025). The city center's historical and cultural fabric is one of the most important elements of the city's identity. Built by Mimar Sinan and included in the World Heritage list, the Edirne Selimiye Mosque is located in the most visible and central point of the city. Many other historical and cultural heritage elements (such as the Old Mosque, the Three-Domed Mosque, the Ali Pasha Bazaar, the Bedesten, the Rüstem Pasha Caravanserai, the Municipal Building, and the Governor's Office) and public service buildings are also located in the historical city center of Edirne. (Figures 1-2)

The Historic Urban Landscape (HUL) approach, defined by UNESCO in 2011, emphasizes the holistic consideration of urban areas, integrating heritage conservation with social, cultural, economic, and environmental aspects while promoting participatory governance and sustainable development.

In this context, ensuring social resilience has become increasingly important for the holistic planning and sustainable management of Edirne's historic urban landscape, representing an innovative planning approach.

While the social resilience of a city holds a significant place in the urban conservation literature, it has been addressed primarily in relation to the historical city center of Edirne.

METHODOLOGY

This study is designed as mixed-methods research and utilized multiple data collection techniques, including literature review, on-site observation, survey application, and semi-structured interviews. Face-to-face surveys and interviews were conducted with 72 participants who experienced the city and its historic city center between May and July 2024. Participants consisted of real estate agents (14 people), neighborhood heads (16 people), and residents of



Figure 1. Selimiye Mosque (Top left), Old Mosque and Edirne Municipality (Bottom left), Saraçlar Street (Top right), National Education Directorate and Edirne Governorship (Bottom right). (July, 2024).

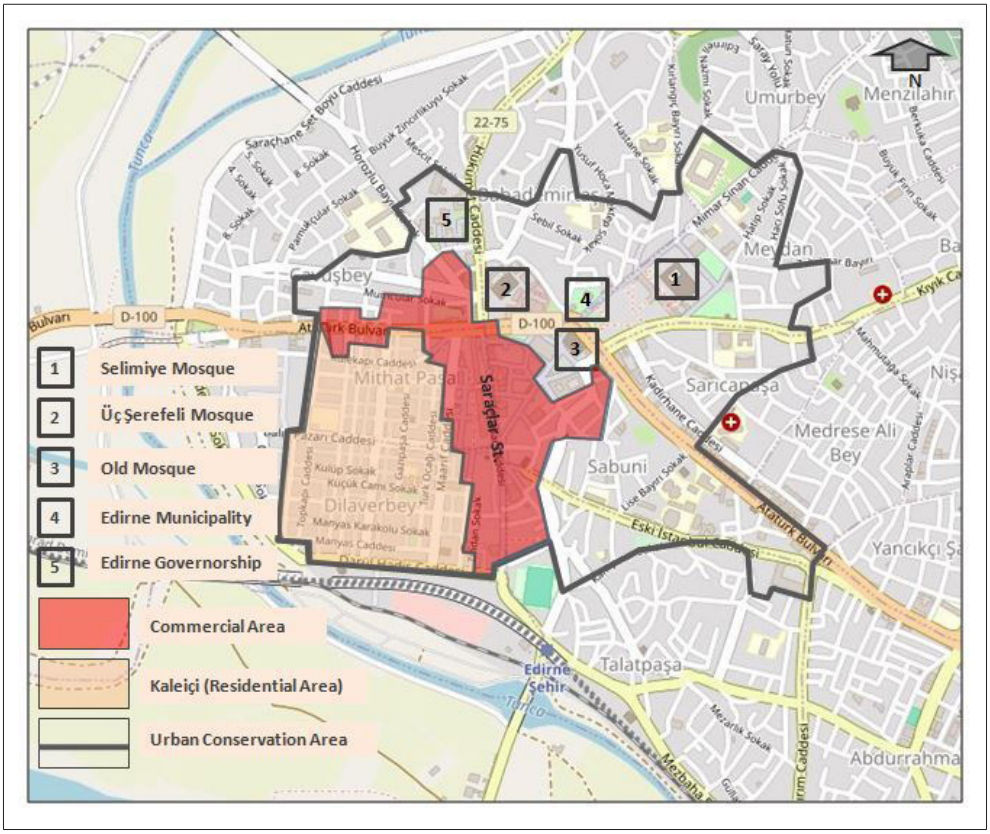

Figure 2. Edirne Central District Urban Site Area.
Source: (Map base) Googlemap.com, March 2024; KAIP, 2007; Yenigün Ölmez, 2021.

the city center, selected from groups directly involved with and experiencing the city and its historic city center.

The general flow of the research process consists of the following stages: literature review, preparation of survey and interview questions, pilot study, data collection, data cleaning, reliability analysis, thematic analysis of interviews, and integration of findings.(Table 1)

Sampling Strategy and Participant Selection

A purposive sampling strategy was used because the research aimed to collect information from individuals who have direct experience and knowledge of the study area. Participants were selected according to the following criteria: (i) being at least 18 years old, (ii) living, working, or regularly using the historical city center, and (iii) being sufficiently familiar with the social and spatial characteristics of the area. A total of 72 questionnaires were included in the analysis. For the qualitative component, interviews were also conducted with neighborhood heads, real estate agents, and residents of Edirne Central District during the survey.

Survey Structure

The survey consists of three sections. The first section collected demographic information including age, gender, educational background, occupation, and length of residence in the work area. The second section (participation in physical and social propositions) included statements measuring different dimensions of urban resilience such as spatial/physical resilience, social resilience, economic resilience, and institutional/administrative resilience. The third section focused on participants' perceptions of the historic city center; these included attitudes related to belonging to the city, urban participation, and social solidarity.

Data Analysis Procedure

Quantitative data were analyzed using statistical software.

Tablo 1. The general flow of the research process

Literature review
↓
Preparation of survey and interview questions
↓
Pilot study
↓
Data collection
↓
Data cleaning
↓
Reliability analysis
↓
Thematic analysis of interviews
↓
Integration of findings
↓
Results and conclusion

Table 2. Quantitative data-Qualitative data

Quantitative data		Qualitative data
Participation in Physical and Social Propositions: *Physical/spatial *Social *Economic *Institutional	⇔	*Belonging to the City *Participation *Social Solidarity

Descriptive statistics were then used to summarize participant characteristics and response distributions.

The internal consistency of the scale was assessed using Cronbach's Alpha coefficients. Qualitative interview data were analyzed using thematic analysis.

Finally, the findings from both quantitative and qualitative analyses were integrated to develop a planning strategy framework and a decision support framework to enhance the resilience of the historic city center. (Table 2)

The questions regarding participation in physical and social issues were prepared using a Likert scale and evaluated together with the results obtained regarding belonging to the city, urban participation, and social solidarity.

Interviews were conducted in a semi-structured format, and participants' experiences with the space, perceptions of belonging to the city, and solidarity practices were examined in depth. The responses to the survey questions were analyzed using SPSS (Statistical Package for Social Science) to create frequency tables. Quantitative data were evaluated using descriptive statistics, while qualitative data were analyzed using thematic analysis.

The emerging themes were linked to the study's research questions. The themes identified through the qualitative analysis were considered alongside the key findings from the quantitative analyses.

During the analysis process, the data were first coded and then classified under the themes of vulnerability and resilience. Rather than establishing a definitive resilience threshold, the results were defined based on participant perceptions; in this context, a participation rate of 50% or higher was considered "high resilience potential." The data obtained based on participant perceptions are important for providing insights into enhancing the city's social resilience.

The limitations of the study are that the sample size remained at the local level and the findings were evaluated within the context of the Edirne Historical City Center. Nevertheless, the study offers significant qualitative contributions in terms of revealing site-specific indicators of social resilience.

LITERATURE

Urban Vulnerability and Resilience

According to UNDRR[1] (2017), vulnerability is "conditions determined by physical, social, economic, and environmental factors or processes that increase the susceptibility of an individual, community, entity, or system to the effects of hazards." Vulnerability differs from risk in that it corresponds to a situation encountered suddenly and unpredictably. The concept of risk includes predictability. According to Sarewitz et al. (2003), what distinguishes vulnerability from risk is the difference in policies for dealing with extreme events.

The concept of urban vulnerability refers to the level at which a system can be damaged by external shocks (Cutter et al., 2003). Resilience, on the other hand, is defined as a system's capacity to resist, adapt to, and recover from these shocks. In historical environments, vulnerability is not limited to physical structures but also encompasses social, economic, and administrative dimensions. In the literature, the role of local communities, spatial planning tools, and governance models stand out as important elements in strengthening resilience. However, the number of studies that address these approaches within a holistic framework in historical environments is limited. The vulnerabilities of a city can stem from both structural (natural disasters, climate change, etc.) and non-structural (social, economic, etc.) impacts. A city's resilience means that its physical, social, economic, and institutional components can continue to function against unexpected negative threats at any moment. For this to happen, these characteristics must have a robust, sustainable, harmonious, and adaptable potential.

Urban vulnerability can manifest in physical, social, economic, environmental, and governance dimensions (Davoudi, 2012; Meerow et al., 2016). Resilience is crucial for the long-term sustainability and adaptation to crises of historical environments. Studies on resilience in the literature began in the 1970s, primarily focusing on the balance between urban and ecological systems. Research on the resilience of cities has been developed to address the potential consequences of disasters, risks, and hazards, primarily aiming to reduce and prevent physical damage.

Satisfaction with urban services and urban resilience are interrelated concepts. Satisfaction with urban services refers to indicators that reflect individuals' evaluations of public services provided by local governments. Urban resilience is not merely a concept encompassing satisfaction with urban services; it describes the capacity of an urban system to prepare for, adapt to, recover from, and adjust to uncertainties. While satisfaction with public services may be a factor in a city's resilience in the face of uncertainties and crises, it is not sufficient on its own. Satisfaction with urban services is not a substitute for urban resilience, but rather a crucial component of a city's social resilience. The main themes of urban resilience are the city's environmental-physical resilience, its social resilience, its economic resilience, and its institutional resilience (Table 3).

The Physical Resilience

The physical resilience of a city refers to the ability of its infrastructure and superstructure to maintain their functionality in the face of any threat. Infrastructure is paramount among basic public services. Roads, bridges, airports; housing, commercial, and recreational areas; clean water infrastructure, and waste recycling or disposal are all important aspects of urban infrastructure (OECD, 2016; UN-Habitat, 2018). The continuity of infrastructure services is crucial in the face of crises and unexpected shocks. The usability of information and communication networks is as important as the robustness of urban infrastructure. A systematic, holistic approach to urban infrastructure is effective in building public trust. Ensuring equal access to infrastructure and basic services is vital for meeting the vital needs of the urban population and for a city to function and develop properly. Given the increasing number of shocks and stresses affecting cities worldwide in recent years, fully integrating the design and management of infrastructure and basic services into the concept of resilience is becoming a crucial issue. Therefore, taking measures related to the physical robustness and sustainability of the city is important in ensuring its social resilience.

Economic Resilience

Economic resilience refers to the processes, mechanisms, and activities that enable cities to become the driving force of socio-economic development in a country or region by creating job opportunities, increasing household income, generating investment, reducing social tensions and crime, increasing public equality and participation, promoting social solidarity, and improving security and safety (UN-Habitat, 2018).Ensuring economic resilience is essential for the social resilience of the city. The economic resilience of a city is also related to the effectiveness of its current and potential economy. Economic resilience reveals which sectors have development potential within the city. In times of crisis and shock, an effective, proactive planning strategy is needed to quickly assess the before, present, and after situ-

Table 3. Key Themes in Urban Resilience

Key themes in urban resilience.	- Environmental and physical resilience. - Social resilience. - Economic resilience. - Institutional resilience.

[1] United Nations Office for Disaster Risk Reduction

ations and ensure the continuation of economic activities in these sectors. Therefore, the city should have integrated management mechanisms in its risk management and disaster planning processes to ensure the continuity of economic activities.

The Institutional Resilience

According to Kasperson and Kasperson (2001), if institutions cannot plan for hazards or changing social conditions and risks, the vulnerability of the system may increase. Therefore, a comprehensive vulnerability theory to global change should take into account a range of risks, thresholds, and institutional responses and resources (given that vulnerability will manifest itself differently at different scales).

In a rapidly changing and increasingly complex world, individuals, institutions, and societies need to be resilient—structured in a way that allows them to cope with, adapt to, and shape change.

To increase institutional resilience, it is necessary to raise awareness, adopt a participatory governance approach, regulate the legal framework, strengthen institutions and policies, ensure coordination between institutions/organizations, and increase information sharing between official and private institutions. According to Eren (2019), the three most important issues that local governments should focus on during crises are: public support, self-help (individuals protecting themselves), and mutual assistance/support. This may require practice and training. The most dynamic relationship between institutions and society in a city's institutional resilience is their ability to possess the necessary tools to help each other and themselves in unexpected times of crisis.

The Growing Importance of Social Resilience in Ensuring Urban Resilience

Resilient cities are those that, both in their physical and social structures, can maintain their functionality against all kinds of risks (natural, technological, social, etc.) that may arise in their sphere of influence, and can survive by rapidly adapting to new conditions (Godschalk, 2003). A resilient city should be adaptable, inclusive, capable of responding quickly, able to change and transform, open to cooperation, and possess mechanisms that can generate creative solution processes(Lewis, 2020).

Wardekker (2023a) points out that there are two important frameworks of urban resilience: the 'System Resilience' framework, which focuses on maintaining functions and processes, and the 'Community Resilience' framework, which emphasizes urban life and community capacity and self-sufficiency.

In ensuring the social resilience of a city, Cutter et al. (2008) emphasize that factors such as "demographic structure, social networks and social inclusion, social values and commitment, risk awareness, healthy and good living conditions, quality of life-high satisfaction" are important. In studies that examine the resilience of historical city centers from a social perspective, urban participation (Wardekker 2023a; Cao, 2023; Keck&Sakdapolrak, 2013; Castro, 2021) is an important parameter. In historical environments, preserving the city's identity (Wardekker, 2023a; Walidonna et al., 2024) is seen as an important element for the resilience of the city (See Table 4). The Resiliage project, a UNESCO and European Union project, examines the resilience of the city through the concepts of social cohesion, social ties, collective action, collective memory, and sense of belonging. (Pavlova, 2024)

The social resilience of a city is defined as the capacity of communities within the city to adapt and change in the face of crises and transformation processes. One of the important characteristics of a city's social resilience is the concept of "belonging to the city." Belonging to the city is considered an indicator of the relationship individuals establish with the space they live in.

For the social resilience of the city, it is the ability of citizens to organize themselves (to form organizations) as a result of the combination of a sense of belonging to the city, urban participation, and social solidarity (Keck & Sakdapolrak, 2013; Zeng et al., 2022). In the literature, within the context of the city's social resilience, emphasis is placed on its relationship with a sense of belonging to the city, social solidarity, and urban participation. (Table 4)

There is a reinforcing relationship between urban resilience/social resilience and the preservation of historic environments, whereby each positively influences the other. (Wardekker et al., 2023b, Walidonna, 2024). Cutter et al. (2008), through their studies prioritizing the social dimension of cities, established indicators and sub-categories of social resilience that will ensure urban resilience. The main headings of these indicators are ecological, social, economic, institutional, infrastructure, and societal indicator dimensions. According to their social and societal dimensions, the relevant indicators are listed as: demographic structure (age, gender, occupation, class, salary), social networks and social inclusion, social values-loyalty, faith-based organizations, local risk awareness, guidance services, presence of pathophysiological diseases (alcohol, drugs, various addictions), healthy and good living conditions (mental health status, stress-related conditions), and quality of life (high satisfaction). (Table 4)

According to Zeng et al. (2022), parameters and appropriate indicators for social resilience include demographic changes (population flows, migrants), income level (household income, poverty level, GINI coefficient), security (crime rate, perception of security), social networks of communities (number of civil society organizations), and access to services (access to public services, public transport). Ac-

Table 4. Social resilience parameters for the historic city center

Studies on historical and cultural heritage, urban resilience, and the social resilience of the city.	Social resilience parameters for the historic city center.
Cutter et al. 2008.	Demographic structure, social networks and social inclusion, community values and commitment, risk awareness, healthy living conditions, quality of life, high satisfaction.
Zeng et al. 2022.	Demographic changes, income level (household income, poverty level, GINI coefficient), social networks of communities (number of NGOs), access to services (access to public services, etc.)
Wardekker, 2023a.	Public participation, quality of life, focus on local initiatives, increasing the resilience of vulnerable groups, developing social support networks, strengthening urban identity, improving people's skills and education, and ensuring social equality.
Walidonna, 2024.	Urban identity, management of physical and cultural heritage, social development, economic development, a multidimensional and collaborative approach.
Cao, 2023. (urban resilience)	Community participation, social cohesion, inclusion, economic diversity, sustainable infrastructure, environmental sustainability, effective governance, stakeholder collaboration, integrated risk management, conducting risk assessments, incorporating resilience into urban planning, proactive planning, and leveraging technology and innovation.
Castro, 2021.	Encouraging and integrating social participation, robust participation tools, social connections, and strong links to cultural heritage assets into the institutional framework.
Keck&Sakdapolrak, 2013.	Social learning, participatory decision-making, collective transformation.
UNESCO and the European Union (Resiliage project)	Social cohesion, social bonds, collective action, collective memory, sense of belonging.

cording to Wardekker (2023a), public participation, quality of life, focusing on local initiatives, increasing the resilience of vulnerable groups, developing social support networks, strengthening urban identity, improving people's skills and education, and ensuring social equality are important for the social resilience of the city. (See Table 4) Education, awareness, and individual skills are important tools when facing potential urban hazards (Azad & Pritchard, 2023).

In historic city centers, the vulnerabilities of the city may lie in its environmental/physical, social, economic, and institutional characteristics, which are components of the city. Data obtained from qualitative research for identifying vulnerabilities can be applied at the local level and can make significant contributions to holistic urban resilience. According to Stolte et. al. (2024), knowing the vulnerabilities of the city is important in understanding its potential resilience characteristics.

The social resilience of a city is a characteristic that, along with the physical resilience of the city and its historic city center, should possess against unexpected and uncertain threats. The social resilience of a city against structural or non-structural threats encompasses the entirety of relationships involving human interaction, which is a crucial part of urban life. This includes all human relationships with space, with each other, and with institutions.

According to the literature that examines historical cities within the framework of resilience, the heritage, identity, and cultural values of the historical environment possess characteristics that encourage increased resilience. Understanding the relationship between the city and society/individuals, both physically and environmentally, and socially, economically, culturally, and institutionally, is crucial for understanding vulnerabilities and resilience. Research aimed at understanding this relationship will significantly contribute to planning processes that will produce solutions. The environmental, social, economic, and spatial resilience of contemporary cities are beginning to be considered together, and studies are being conducted in this direction. (Table 5)

For an urban system to be resilient, it must incorporate features such as being adaptable, robust, having redundant capacity, flexible, inclusive, and integrated.

The concept of resilience has provided ideas for systems with many components and intense interrelationships, such as cities, that can ensure the system's ability to sustain itself in times of uncertainty and sudden danger (Walker & Salt, 2006; Davoudi, 2012).

The Historic City Center of Edirne within the Spatial Development Process

The Kaleiçi district, where traces of civil architecture and traditional residential fabric are still present, has developed in a grid-like urban structure and houses residential func-

Table 5. Key sources and topics examining historical cities from a resilience perspective

References	Topics
Chen&Bian&; Wang, 2024	Urban resilience guides historic and cultural cities in resisting the impacts and pressures they face.
Jigyasu et al., 2013 (UNSDR)	Heritage preservation promotes resilience.
Castro, 2021	In disasters, community resilience ensures the preservation of cultural heritage.
Wardekker et al., 2023(b)	The interaction between cultural heritage and societal resilience in volcanic regions affected by disasters.
Walidonna et al., 2024	To provide an analysis of the factors contributing to the resilience of urban heritage sites.

tions. The Kaleiçi settlement is part of the Historic City Center. The old and historical building stock, along with aging and inadequate facilities, attempts to maintain its existence through mostly individual rather than holistic preservation efforts within the urban fabric.

Saraçlar Street, the main street of the historical city center, is a street where the service sector and retail trade (shops, restaurants, cafes, etc.) are predominantly located. (Edirne Municipality, 2007) Today, Saraçlar Street, which is located in an urban protected area, has been pedestrianized and is an axis where commercial functions are concentrated. The historical city center is still important for the city dwellers. (Figure 2)

According to the 2007 approved KAIP report, the analysis shows that 62% of the project area consists of residential areas, 10% of outbuildings, and 9% of commercial areas. One-story buildings constitute 55%, two-story buildings 22%, and three-story buildings 13%. (Figure 2) The current population in the historical city center, within the project area, is 26,105 (KAIP,2007, pp. 113-114; KAIP, 2007).

Throughout the spatial development process of Edirne, the historical city center has maintained its central character. From the Kaleiçi (Castle District) Development Plan, commissioned by Mayor Dilaver Bey in 1905 after the 1903 fire, to the development plans made after the Republic, Kaleiçi has predominantly retained its residential function, while Saraçlar Street has retained its commercial function. (Figures 2)Public service facilities are still present in the historical city center. A Conservation Development Plan for the Historic City Center was prepared in 1991. Plans made after 2000 had limited effects on the historic city center, and it was subsequently regulated by the 2007 Conservation-Oriented Development Plan. The 2007 approved Conservation-Oriented Development Plan aimed to improve the deterioration of the historical fabric.

Currently, the Ministry of Culture and Tourism and the Edirne Governorship are jointly working on the renovation and restoration of Saraçlar Street, which is 1500 meters long. Restoration and conservation efforts related to the historical environment are being carried out under the coordination of the Edirne Governorship. It is stated that in the future, the area where the 25 November Stadium is located will be transformed into a city square, thus supporting the holistic conservation policies of the historical city center and the work of the Edirne Municipality. (Devrim Newspaper, 2025) As of 2025, within the scope of the ongoing street revitalization project, 376 buildings have been intervened in, and 195 of them are being restored to their original form. Work continues in many areas, primarily in Saraçlar, Balıkpazarı, Çilingirler, and Terziler streets. Efforts are being made to revive the historical fabric of the streets and make them compatible with the city's identity (Batı Ekspres, 2025). The Conservation-Oriented Revision Zoning Plan is still in the approval process. Consistency of decisions and policies is crucial for ensuring the holistic/social resilience of the historical city.

In the historical city center of Edirne, the plans that organized the historical macro form between 1930 and 1960, namely the Plan of Prof. Earnst Arnold Egli and the Plan of Gündüz Özdeş, were implemented. With the increase in urban population, in 1956, the Zoning Law No. 6785 was enacted for the purpose of urban planning, followed by the Master Zoning Plan in 1963 and the Zoning Plan in 1966. The State Planning Organization was established in 1961, and with the five-year development plan covering the years 1968-1972, Edirne was included in the list of priority development regions. With the encouragement of industry in the 1970s, urban development activities increased in the city. Between 1960 and 1980, the 1966 Development Plan and the 1975 Supplementary Development Plan, which was added to this plan, were implemented. The 1975 plan designated areas for mass housing and industrial zones, and Trakya University was opened. With the 1984 plan, the area around the Selimiye Mosque, the Üç Şerefeli Mosque, and the Old Mosque became a protected historical site, and the activities of housing cooperatives accelerated (Edirne Municipality, 2003; Solmaz, 2021). Edirne was removed from the list of priority development provinces in 1976.

In the historic city center, the deterioration of the urban fabric intensified with construction activities following the urban development plans of 1966 and 1984.Tourism is one of the important sectors that provides significant economic input to the city. The presence of many monumental works in the central district has ensured that historical and cultural tourism remains vibrant. Edirne's central district offers religious, cultural, and shopping tourism. Kaleiçi, located in the historical city center, is the first settlement area of Ed-

irne. Due to the inadequacies of the aging urban fabric and the political decisions made regarding the city in the 1970s and 1980s, the old city residents living in the historical city center mostly began to prefer the developing areas of the city (Figure 3).

Trakya University was established by a Decree Law in 1982 in Edirne. The campuses of Trakya University, located in the Central District of Edirne, are shown in Figure 3. The Balkan campus is the largest campus, located on the Istanbul road in the southeastern part of the city. To the west of the city, in Karaağaç, the Faculty of Fine Arts is located alongside the Old Karaağaç Train Station and the Lausanne Monument.Due to the increasing population, proximity to the university, and the fact that students also reside in these areas, the Fatih, Kocasinan, Şükrüpaşa, and Atatürk neighborhoods have become preferred, and the city has expanded in this direction.

Changes in the Social Structure of Edirne City

Edirne, which has been home to many civilizations, has shown demographic differences during the Ottoman and Republican periods. While settlement existed within the city walls (Kaleiçi) until the 14th century, its population increased during the Ottoman period in the 16th century (Diktaş, 2008, p. 43). The population consists of Muslims and non-Muslims (Greeks, Armenians, Bulgarians, Catholics, Jews, Protestants) (Yurt Encyclopedia, 1981). Furthermore, Romani culture holds an important place in its multicultural structure. In the late Ottoman period, there were Romani migrations from Greece and Bulgaria (Historical Background, 2025). Although people of Romani origin mostly live in the Menzilahir neighborhood, they also partially reside in Kaleiçi and other neighborhoods.

The population of Edirne Province was 150,889 in 1927, while in 2023 it was 419,913. The population of Edirne Central district increased from 68,279 in 1927 to 194,991 in 2023. Approximately 195,000 people live in Edirne city center (DIE, 2002, TUIK, 2024, 2026a; Population of the city center by year, 2026). According to Turkish Statistical Institute (TUIK) data, Edirne province have a population of 421,247 in 2024. In 2024, Edirne received 17,332 migrants from other provinces and 16,323 migrants to other provinces, resulting in a net migration of 1,009 people and a net migration rate of 2.4. Migration from other countries was 1,361, while migration to other countries was 881. (TUIK, 2026b).

Looking at the population of immigrants who underwent citizenship procedures in Edirne until 1993, by year, those who came from Bulgaria were the most numerous between 1950-1986 (Edirne Municipality, 2007). The year with the highest net migration in Edirne was 2023 (TUIK, 2026b). It can be considered that the Kahramanmaraş earthquakes of February 6, 2023 affected Edirne as well as the entire country. The increase in net migration in 2021 and 2022 is thought to be due to the influx of people from other provinces and Istanbul during the Covid Pandemic (March

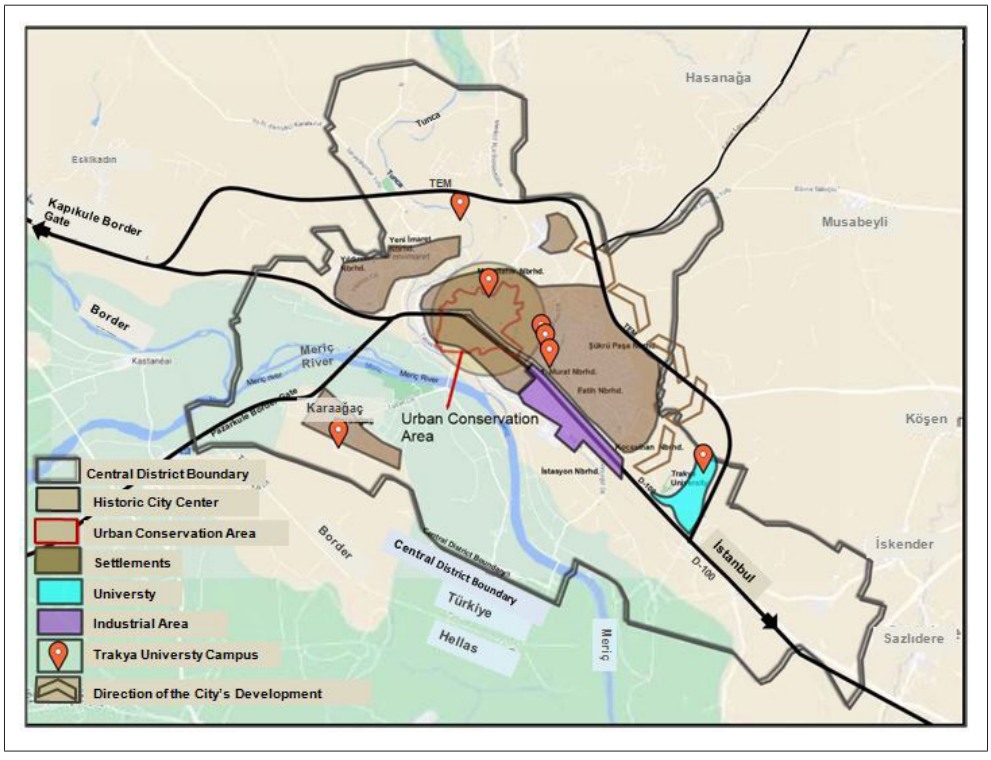

Figure 3. Diagram showing the location of existing functions in Edirne Central District.

2020-2021-2022-May 2023) (BBC Türkçe, 2023). Edirne and its historical city center are affected by irregular migration movements due to its location as a border city. The establishment of Thrace University and industrial areas has caused changes in the city's population. With the outbreak of the Syrian civil war in 2011, Edirne became a transit point and sometimes a stopping point for Syrian refugees who wanted to go to Europe from Edirne.

Today, the multicultural structure that forms the social fabric of Edirne includes Romani people, refugees from other countries, and those who have come from within and outside the country, all of whom are located partly in the central district of Edirne, particularly in Kaleiçi, which is a part of the historical city center.Edirne's status as a tourism, university, and transfer hub causes seasonal population movements, increasing the instability of its demographic structure, which is a significant vulnerability.

RESULTS

The survey and interviews were conducted in May and July 2024 with individuals over the age of 18 residing in the central district of Edirne, as well as with neighborhood headmenand real estate agents.

65% of the participants are between 35-55 years old, and 61% are male. 88% have completed high school or higher education. (Figure 4) 38% of the participants are private sector employees and tradespeople, 29% are civil servants, and 23% are retirees. (Figure 5) 76.4% of participants have lived in Edirne for 21 years or more. (Table 6) 65.3% of participants were born in Edirne, and 34.7% were born outside of Edirne.

In the section measuring participation in physical and social propositions, a Likert scale was used, Cronbach's Alpha reliability analysis were performed to measure validity. According to the analysis performed using SPSS software, the 20-item scale has a reliability of 87%.

This study proceeded with a descriptive research approach to analyze the established model and hypotheses. SPSS IBM version 25 statistical analysis program was used for data analysis. Reliability Analysis and Normality Test were applied. In these analyses, the acceptable margin of error (statistical significance level/p-value) was set at 5%.

Ho: The participation values regarding physical and social propositions related to Edirne satisfy the assumption of normal distribution.

H1: The participation values regarding physical and social propositions related to Edirne do not satisfy the assumption of a normal distribution.

Since the p-value is 0.295 > 0.05, the Ho hypothesis cannot be rejected at the 0.05 significance level. This means that

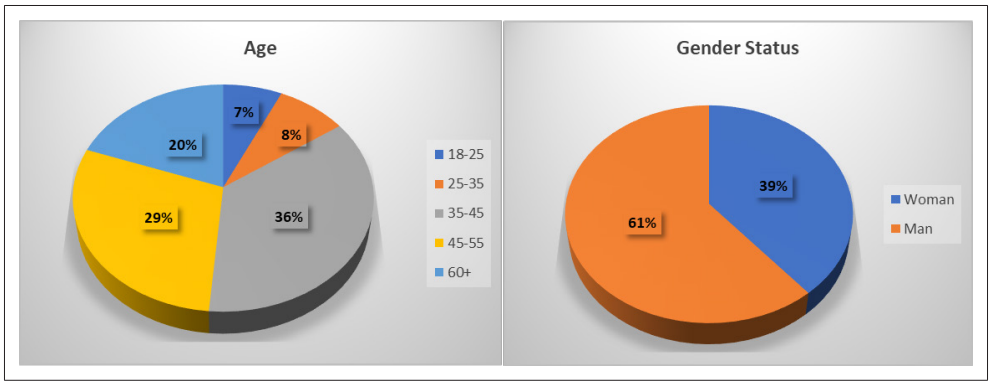

Figure 4. Age and Gender Distribution.

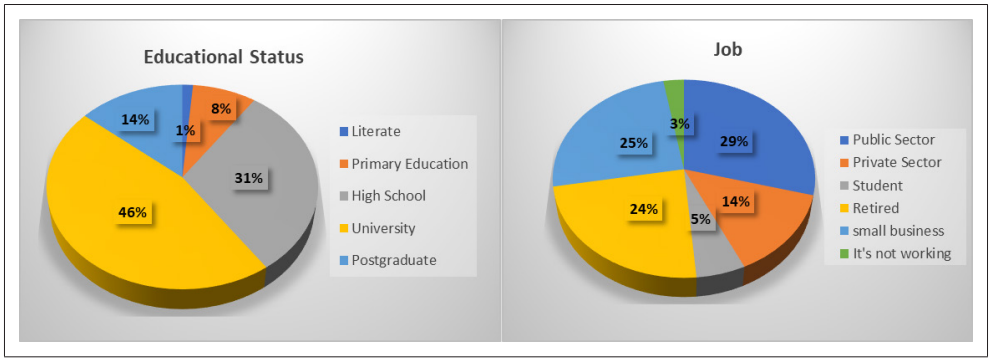

Figure 5. Education and Occupational Status.

Table 6. How long have you been living in Edirne?

	Frequency of answer	%
Less than 1 year	1	1.4%
1-5 years	8	11.1%
6-10 years	1	1.4%
11-15 years	3	4.2%
16-20 years	4	5.6%
21+	55	76.4%
Total	72	100

the participation values regarding the physical and social statements about Edirne satisfy the assumption of a normal distribution. (Table 7, Figure 6)

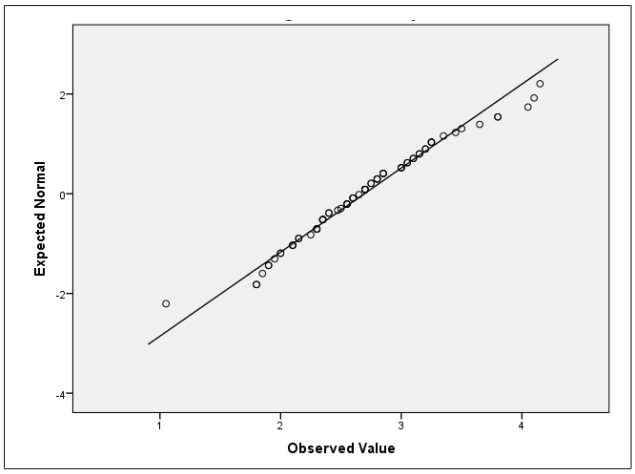

Figure 6. Normality distribution of participation in physical and social propositions related to Edirne.

Graphical Assessment of Normality

The normality of the data was evaluated using graphical methods, including a normal Q–Q plot. The graph indicated that the data were approximately normally distributed.

The frequency and percentage table regarding participation in physical and social proposals related to Edirne is shown in Appendix 1.

Participation questions and responses to physical and social propositions prepared under the headings of environmental/physical, social/societal, economic, and institutional were analyzed with the themes of vulnerability and resilience. (See Table 8)

The results regarding participation in the physical and social propositions about Edirne are shown in Table 8. A participation rate of 50% or higher is considered high potential for resilience. As a definitive resilience threshold and instead describe the results more as participant perceptions. Since the number of undecided respondents was approximately 20% and the percentages of those participating and those not participating were close, the proposition "natural values are being preserved" was marked as both fragile and resilient.

- Environmental/Physical (Infrastructure): Participants' evaluations regarding environmental and physical proposals related to Edirne indicate that historical and natural values are mostly preserved, they are partially satisfied with infrastructure services, transportation facilities, and the adequacy of green spaces, and public transportation is mostly inefficient.
- When participants evaluated the city from a social perspective, they stated that there were not many opportunities to spend their leisure time. They were partially satisfied with the variety of social activities and the existence of cultural events. They considered the city to be safe, and the quality of life was generally deemed good.
- The vast majority of participants believe that Edirne is generally a safe city. However, in interviews with participants, it was mostly stated that the Kaleiçi area, which is part of the Historical City Center, had a more respectable and livable spatial and social structure before the 1980s. While there are concerns about nighttime street safety in Kaleiçi, it is currently considered an option for those whose economic level does not allow them to afford new and comfortable housing in developing areas, due to the more affordable rental and sale prices of housing there.
- According to the participants, the attitude of Edirne residents towards foreigners (refugees or those from other places) is partially positive, and there is a general belief that urban solidarity can be easily achieved during difficult times.

Table 7. Tests of normality

	Kolmogorov-Smirnova			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Participation in physical and social proposals regarding Edirne	0.077	72	0.200*	0.980	72	0.296

*A Sig. value of 0.20 indicates that the data are normally distributed.

Table 8. Questions on participation in physical and social propositions (Evaluated based on survey and interview questions from May-July 2024.)

CATEGORY /SIZE	PARTICIPATION IN PHYSICAL AND SOCIAL PROPOSALS	PERCENTAGE OF AGREEMENT	PERCENTAGE OF DISAGREEMENT	VULNERABLE (LESS THAN 50%)	RESILIENce potential (HIGHER than 50%)
ENVIRONMENTAL /PHYSICAL (INFRASTRUCTURE)	Natural values are being protected.	37.5% *(Undecided: 20.8%, therefore both)	41.7%	X	X
	I am satisfied with the infrastructure services in the city.	12.5%, *(Undecided: 13.9%)	73.6%	X	
	I am satisfied with the transportation options in the city.	18.1%, *(Undecided: % 18.1)	63.8%	X	
	Public transportation is efficient.	25%, *(Undecided: 20,8%)	54.2%	X	
	Historical values are being preserved.	51.4% *(Undecided: % 25)	23.6%		X
	I am satisfied with the adequacy of green spaces in the city.	15.3%, *(Undecided: 25%)	59.7%	X	
SOCIAL / COMMUNITY	There are many opportunities to make the most of my free time.	25%, *(Undecided:27.8%)	47.2%	X	
	I am pleased with the variety of social activities.	27.8%, *(Undecided:22.2%)	50%	X	
	There are numerous cultural activities.	25%,*Undecided:26.4%	48.6%	X	
	It is a safe city.	86.1%, *Undecided:4.2%	9.7%		X
	I find the quality of life in the city to be good.	56.9%, *Undecided:27.8	15.3%		X
	People in Edirne have a positive attitude towards foreigners (non-tourists - refugees or those from other places).	27.8%, *Undecided:25	47.2%	X	
	The people of Edirne can easily demonstrate urban solidarity during difficult times.	44.5% *Undecided:34.7%	20.8%		X
	People in Edirne can easily demonstrate social solidarity during difficult times.	55.6%, *Undecided:27.8%	16.6%		X
ECONOMIC	It's not considered an expensive city to live in.	9.7%, *Undecided:15.3%	75%	X	
	I am satisfied with the job opportunities in the city.	20.8%, *Undecided:20.8%	58.4%	X	
	Rental housing prices in the city are affordable.	4.2%, *Undecided:6.9%	88.9%	X	
	Housing prices in the city are affordable.	8.3%, *Undecided:11.1%	80.6%	X	
	The city center will meet all your needs.	48.6% *Undecided:27.8%	23. 6%		X
INSTITUTIONAL/ ADMINISTRATIVE	I am satisfied with the city administration's services.	22.2%, *Undecided:30.6%	47.2%	X	

- Economically, the city is considered to be relatively expensive to live in, and job opportunities are generally unsatisfactory. According to participants, rental/sale prices for housing in the city are not sufficiently affordable. However, it is generally believed that the city center meets all needs. According to real estate agents, religious tourism is mostly in the form of day trips rather than overnight stays.
- Administrative: The response received indicated partial satisfaction with the services of the city administration.

Belonging to the city, participation and social solidarity

In this section, the data obtained from surveys and interviews are grouped under three main themes: These are; (1) belonging to the city, (2) urban participation and (3) social solidarity.

To assess the social resilience of the city, responses to survey and interview questions related to belonging, participation, and social solidarity were analyzed (See Tables 9, 10, 11).

Regarding questions about belonging to the city, participants mostly gave positive answers. 94.4% of participants thought they knew the city, 93.1% followed the city's development process, and 73.6% had a means or opportunity to be informed about decisions made regarding the city. 72.2% followed local newspapers. While 68.1% knew about the Edirne City Council, 58.3% were unaware of the Edirne City Council's activities. (Table 9) They stated that the first thing that comes to mind when Edirne is mentioned is the Selimiye Mosque, and that the most important features of Edirne are primarily its history and culture.

When we examine the participants' answers to questions about the participatory environment, we see that 73.6% are not members of civil society organizations. 72.2% do not participate in the work of local newspapers. 55.6% do not follow the process of making planning decisions for the city. 70.8% want to participate in decisions related to the city. 76.4% are not active in the decision-making processes in the city where they live. (Table 10) According to the participants' answers regarding the participatory environment, although they want to participate in decisions related to the city, they are not active in this regard.

According to the survey and interview results:

Resilient characteristics associated with belonging to the city are that participants mostly follow the city's development process. It is having an environment and tools to

Table 9. Belonging to the city

Belonging to the city	Yes	No
Do you think you know this city?	94.40%	5.60%
Are you following the city's development process?	93.10%	6.90%
Do you have any means or channels to stay informed about decisions regarding the city?	73.60%	26.40%
Do you follow local newspapers?	72.20%	27.80%
Are you familiar with the Edirne City Council?	68.10%	31.90%
Are you aware of the work of the Edirne City Council?	41.70%	58.30%

Table 10. Participation environment

Participation Environment	Yes	No
Are you a member of any NGOs?	26.40%	73.60%
Do you participate in the work of local newspapers?	27.80%	72.20%
Are you following the process of making urban planning decisions?	44.4%	55.60%
Do you have a desire to participate in the decisions made regarding this city?	70.8%	29.2%
Are you actively involved in the decision-making processes in the city where you live?	23.6%	76.4%

Table 11. Social solidarity

Social Solidarity	Yes	Undecided / Neutral	No
Is the attitude of the people of Edirne towards foreigners (refugees or those from other places) positive?	27.8%	25%	47.2%
Can the people of Edirne easily provide urban solidarity during difficult times?	44.5%	34.7%	20.8%
Can the people of Edirne easily provide social solidarity during difficult times?	55.6%	27.8%	16.6%

be informed about decisions made regarding the city. The process of making city planning decisions is followed by 44.4% of the participants. The resilient characteristics of a participatory environment include the participants' general willingness to engage in decisions related to the city. In interviews with participants, it was mostly stated that they were able to learn about decisions made about the city through social media, local newspapers, and Edirne television. Their desire to participate in decisions made about the city shows that they have a positive attitude towards urban participation. The existence of a participatory environment is an important element in the preservation of the historical urban heritage, along with a sense of belonging to the city. (Table 10)

Regarding the participatory environment, insufficient active participation in decision-making processes within the city has been identified as a vulnerability. The desire to participate in decisions concerning the city, and having access to a platform or means to be informed about these decisions, are resilient characteristics of a participatory environment. Being involved in matters concerning the city of Edirne, and having a desire to participate in urban public decisions related to the city, is an important part of a sense of belonging to the city. Although participants are willing to participate in decisions concerning the city, they often do not follow the decision-making process for urban planning decisions.

The survey results show that 55.6% of participants believe that social solidarity is strong. Looking at the participants' answers to questions about social solidarity, it is seen that the percentage of those who were undecided is not small. According to the participants, the people of Edirne believe that they can more easily provide social solidarity in difficult times. According to the participants, the attitude of the people of Edirne towards foreigners (refugees or those from other places) is partially positive, and the belief that urban solidarity can be easily provided in difficult times is partially held by 44.5% of the participants. Positive attitudes regarding urban and social solidarity do not vary significantly depending on the length of time spent living in Edirne. The majority of participants believe that urban and social solidarity can be provided in Edirne in difficult times (Table 11).

DISCUSSION

The data obtained within the scope of the research shows that social resilience in Edirne does not exhibit a one-sided structure. The strong sense of belonging to the city among the majority of participants, their willingness to participate in decision-making processes, and their belief that solidarity is possible in difficult times can be seen as an important foundation of social capacity. However, the insufficient support of this desire through institutional mechanisms prevents its full potential from being realized. In this context, it is understood that social resilience is not only a societal capacity but also a structure directly related to administrative and political processes.

Edirne's status as a border city, coupled with seasonal migration movements and population fluctuations stemming from the university, creates discontinuities in its demographic structure. This mobility generates certain risks in terms of social cohesion and continuity at the neighborhood level in the historical city center. Therefore, the conservation approach in historical environments should not be limited solely to physical rehabilitation projects; it must be addressed together with social policies that support the established community structure. Otherwise,spatial improvements may not produce the expected effect if community continuityis not ensured.

In the field of historical and cultural heritage, while the concept of conservation is considered holistically with environmental/physical, social, and economic development, an interdisciplinary approach in the preparation of urban plans and policies can yield positive results (Hosagrahar et al., 2016). In this context, this study aims to identify the determinants of social resilience in the historical city center of Edirne and to examine the relationship between these determinants and management and planning processes.

The research seeks to answer the following questions:

What are the key components that determine social resilience?
The social resilience criteria for Edirne and its Historical City Center have been determined as follows: demographic situation, satisfaction with social and cultural life, satisfaction with urban life and economy, social solidarity, sense of belonging to the city, participatory environment, and satisfaction with public services.

How are these components related to the dimensions of urban vulnerability?
When explaining vulnerabilities related to the components of the city's social resilience, important findings are made regarding the areas in which the city's resilience can be ensured.

Satisfaction with social and cultural life: The lack of diversity in social and cultural activities and insufficient opportunities for leisure activities are among the vulnerabilities indicated by the participants.

Satisfaction with urban life and economy: Being an expensive city to live in, insufficient job opportunities, and the low prices of houses for sale/rent are among the problems encountered in urban life in Edirne and its historical city center.

Social solidarity: According to the participants, the people

of Edirne can provide social solidarity in difficult times.

Belonging to the city: In this context, the partial lack of social inclusion is among the vulnerabilities obtained from the interview analyses.

Participation environment: Survey and interview questions revealed that participants were only partially members of NGOs, mostly did not participate in the work of local newspapers, were mostly unaware of the work of the Edirne City Council, mostly did not follow the decision-making process for urban planning, and were mostly not actively involved in decision-making processes in their city. Their lack of active participation in city-related decisions, despite their desire to do so, is a vulnerability related to this component.

Satisfaction with public services: According to the results of surveys and interviews conducted in Edirne and its historical city center, dissatisfaction with infrastructure services, transportation facilities, public transport services, and the adequacy of green spaces in the city, and partial satisfaction with the services of the city administration, are among the vulnerabilities in this context.

How can indicators of social resilience be integrated into planning processes?

This study, using the example of Edirne's Historical City Center, demonstrates that social resilience is not merely a complementary concept in the preservation of historical environments and planning processes; rather, by following the Historical Urban Landscape (HUL) approach, it provides a decisive framework for understanding vulnerabilities and identifying areas of intervention.

The research findings revealed the key factors affecting the resilience capacity of the historic city center and formed the basis for developing the proposed planning framework. Accordingly, the findings were translated into spatial, social, economic, and institutional intervention areas, and priority strategies were developed for decision-makers.

Infrastructure/Spatial

Vulnerabilities related to satisfaction with public services are mostly related to the physical environment and infrastructure.

In the study area, which also includes the Kaleiçi settlement, in addition to physical preservation efforts, the integration of the city's general/social resilience characteristics/policies into processes that positively influence physical spatial decisions can be evaluated, thereby creating a historically integrated environment with the city.

Social

According to the statements obtained from the interviews, it was revealed that spatial identity is mostly associated with the Edirne Historical City Center and the Selimiye Mosque. The study shows that those living in Edirne and in the historical city center have a sense of belonging to the city.

The fact that the participants in the research were knowledgeable and mostly engaged about their living environments/cities in the interviews can contribute to increasing the overall resilience capacity of the city and making it less affected by vulnerabilities.

In Edirne, which has a historical city center, it was assessed that the participants have the social capacity to ensure the holistic/social resilience of the city in times of crisis and danger, and that they are open to education, awareness and sensitivity studies, as well as cooperation with other social and institutional actors.

Participants' positive attitudes towards belonging are positive attributes in terms of their ability to organize and participate (Keck & Sakdapolrak, 2013). It is thought that these attributes will have positive effects in creating a participatory approach environment in the city's public policies. Having data on belonging to the city, urban participation, and social solidarity has the potential to contribute to processes that will generate solutions for the social/holistic resilience of the city.

While the vast majority of participants believe that Edirne is a safe city, interviews with participants revealed that the Kaleiçi region, which is part of the Historic City Center, has lost its more refined and livable spatial and social structure since the 1980s, leading to increasing concerns about nighttime street safety. This is considered a social vulnerability. The decrease in the sense of social security in the historic city center may also reduce the tendency towards social solidarity.

According to the responses given by the participants in the study, the fact that the majority of participants in Edirne and its Historical City Center have a university or higher education level, find the city safe, were born in Edirne, and believe that the historical and natural values of the city are largely preserved, that the city center can meet all their needs, and their general perception of satisfaction are factors that may contribute to the social resilience of the city.

Economic

Cities create processes, mechanisms, and activities that enable them to be the driving force of socio-economic development in a country or region by creating job opportunities, increasing household income, attracting investment, reducing social tensions and crime, increasing equality and participation, promoting social cohesion, and improving security and safety (UN-Habitat, 2018, p. 9).

The fact that most participants perceive the city as an expensive place to live and that job opportunities are generally seen as limited underlines the need to increase the resilience of the city's economy. The city's economic development policies can be evaluated in relation to its spatial and social policies.

Institutional
Partial satisfaction with the city's municipal services is among the issues to be considered in order to increase the overall/social resilience of the city. When the vulnerabilities and resilience of the city of Edirne and its historical city center are evaluated together with qualitative data, it can facilitate the production of protection and planning policies that will increase the social resilience of the city.

CONCLUSION

The social resilience of a city is not only a relational and dynamic process, but also a political process encompassing urban and public policies. While Edirne has large-scale Strategic Plans and Environmental Planning Plans, it also has smaller-scale Implementation Zoning Plans and Conservation Zoning Plans. Although the issue of participation is addressed in the plans, improving the public's active participation in the implementation process could enhance the quality and feasibility of the plans. For this, appropriate practices supported by education and awareness-raising aimed at developing practices that will increase participation in the planning process can be tried. İncreasing stakeholder awareness, and making collaborations more effective are important for the resilience of the city.

In the current situation, it is observed that Conservation Zoning Plans largely focus on spatial arrangements; legal and administrative tools that address social resilience in a holistic way are limited. This situation can be considered one of the factors that reduce the effectiveness of plan decisions in practice. Updating the Management Plan emerges as an important necessity in this context.

While Law No. 2863 (Law on the Protection of Cultural and Natural Heritage) mentions participation by stating that Master and Implementation Development Plans should be prepared "within a specific vision and theme, including participatory area management models," there is insufficient effective activity related to this issue in practice. The legal and administrative framework can make it mandatory to plan and implement processes aimed at increasing the social resilience of the city.

The current approach to cultural heritage site management requires not only the spatial preservation of cultural assets but also a systematic assessment of the attitudes of residents in historical city centers regarding belonging to the city, urban participation, and social solidarity, as well as the vulnerabilities of the city. In this context, integrating social resilience indicators into site management and spatial planning processes supports not only the preservation of historical city centers but also their sustainability as living and evolving urban systems.

Adding social resilience indicators as an "analysis" to the current "Cultural Heritage Site Management" legislation in Türkiye will enhance the overall resilience of the city.

The stages for developing a Planning Decision Support Framework based on the social resilience of the city can be structured as follows: identifying the city's vulnerabilities, determining indicators of social resilience, analyzing the relationship between vulnerability and resilience, developing priorities for urban planning and conservation policies, integration into the area management plan, participatory decision-making and its integration into planning decisions, monitoring and feedback. (Table 12)

In the proposed Planning Decision Support Framework—which is grounded in the city's social resilience—practices that actively involve residents in the process (such as identifying urban vulnerabilities and social resilience indicators, as well as participatory decision-making) could be expanded. Thus, alongside data derived from participants' perceptions, positive urban relationships—such as social solidarity and a sense of belonging to the city (as demonstrated in this study)—can play an effective role in fostering resilience, and specifically social resilience.

The management of the historic city center should focus on the social resilience of the city, as this is necessary to reduce vulnerabilities and increase social endurance. Furthermore, the social resilience of the city should be considered not merely as an abstract conceptual discussion, but as an analytical layer that can be used in decision-making processes.

It is crucial for civil society organizations, Trakya University, the Ministry of National Education, local and central governments, and other public and private institutions to inform each other about their work on policies aimed at ensuring the social resilience of the city and to utilize today's technological and communication opportunities. The importance of the issue of the city's social resilience and the planning processes that enable institutions and society to work together can be emphasized in policies and urban planning at all scales.

Table 12. Planning Decision Support Framework Based on the Social Resilience of the City

1.	Identifying the city's vulnerabilities. (Physical, social, economic, and administrative vulnerabilities)
2.	Determining indicators of social resilience.
3.	Analysis of the relationship between vulnerability and resilience.
4.	Developing priorities for urban planning and conservation policies.
5.	Integration into the area management plan.
6.	Participatory decision-making (Local people, Municipality, Central government, NGOs, University, Local economic actors, etc.)
7.	Integration of this into planning decisions. (Coordination between area management, conservation plan and urban planning policies)
8.	Monitoring and feedback.

Although this study relies on a limited sample size in terms of evaluating the social resilience of the city through the perceptions of local actors, it offers a framework for including local indicators in the planning process.

In conclusion, ensuring the sustainability of historical city centers in environments of uncertainty and multiple vulnerabilities depends not only on spatial interventions but also on strengthening social capacity. The Edirne example shows that social resilience offers an important basis for re-examining the relationship between conservation and planning in cities with historical city centers.

In conclusion, the sustainability of the city of Edirne and its Historical City Center is possible through ensuring the social resilience of the city and supporting physical conservation efforts through participatory channels that foster a sense of belonging.

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A*ppendix 1.* The table below shows the frequency and percentages of participation in physical and social proposals related to Edirne

		Gender			
		Female		Male	
		Column N %	Count	Column N %	Count
I am satisfied with the infrastructure services in the city.	I strongly disagree	60.7%	17	36.4%	16
	I disagree	14.3%	4	36.4%	16
	I'm undecided	21.4%	6	9.1%	4
	I agree	3.6%	1	13.6%	6
	I strongly agree	0.0%	0	4.5%	2
I am satisfied with the transportation options in the city.	I strongly disagree	32.1%	9	22.7%	10
	I disagree	32.1%	9	40.9%	18
	I'm undecided	17.9%	5	18.2%	8
	I agree	14.3%	4	18.2%	8
	I strongly agree	3.6%	1	0.0%	0
Public transport efficient.	I strongly disagree	32.1%	9	22.7%	10
	I disagree	21.4%	6	31.8%	14
	I'm undecided	25.0%	7	18.2%	8
	I agree	17.9%	5	22.7%	10
	I strongly agree	3.6%	1	4.5%	2
There are many opportunities to make the most of my free time.	I strongly disagree	28.6%	8	20.5%	9
	I disagree	14.3%	4	29.5%	13
	I'm undecided	46.4%	13	15.9%	7
	I agree	10.7%	3	27,3%	12
	I strongly agree	0.0%	0	6.8%	3
I am pleased with the variety of social activities.	I strongly disagree	25.0%	7	15.9%	7
	I disagree	21.4%	6	36.4%	16
	I'm undecided	35.7%	10	13.6%	6
	I agree	17.9%	5	22.7%	10
	I strongly agree	0.0%	0	11.4%	5
Cultural activities are numerous.	I strongly disagree	21.4%	6	15.9%	7
	I disagree	32.1%	9	29.5%	13
	I'm undecided	32.1%	9	22.7%	10
	I agree	14.3%	4	20.5%	9
	I strongly agree	0.0%	0	11.4%	5
Historical values are being preserved.	I strongly disagree	3.6%	1	9,1%	4
	I disagree	21.4%	6	13.6%	6
	I'm undecided	17.9%	5	29.5%	13
	I agree	39.3%	11	40.9%	18
	I strongly agree	17.9%	5	6.8%	3
Natural values are being protected.	I strongly disagree	10.7%	3	6.8%	3
	I disagree	32.1%	9	34.1%	15
	I'm undecided	17.9%	5	22.7%	10
	I agree	39.3%	11	34.1%	15
	I strongly agree	0.0%	0	2.3%	1

Ap*pendix 1.* Continued

		Gender			
		Female		Male	
		Column N %	Count	Column N %	Count
It's not considered an expensive city to live in.	I strongly disagree	35.7%	10	54.5%	24
	I disagree	28.6%	8	27.3%	12
	I'm undecided	25.0%	7	9.1%	4
	I agree	10.7%	3	4.5%	2
	I strongly agree	0.0%	0	4.5%	2
I am satisfied with the job opportunities in the city.	I strongly disagree	35.7%	10	34.1%	15
	I disagree	14.3%	4	29.5%	13
	I'm undecided	32.1%	9	13.6%	6
	I agree	17.9%	5	20.5%	9
	I strongly agree	0.0%	0	2.3%	1
Rental housing prices in the city are affordable.	I strongly disagree	53.6%	15	47.7%	21
	I disagree	32.1%	9	43.2%	19
	I'm undecided	10.7%	3	4.5%	2
	I agree	3.6%	1	2.3%	1
	I strongly agree	0.0%	0	2.3%	1
Housing prices in the city are affordable.	I strongly disagree	50.0%	14	52.3%	23
	I disagree	28.6%	8	29.5%	13
	I'm undecided	14.3%	4	9.1%	4
	I agree	7.1%	2	9.1%	4
	I strongly agree	0.0%	0	0.0%	0
It is a safe city.	I strongly disagree	3,6%	1	4,5%	2
	I disagree	0,0%	0	9,1%	4
	I'm undecided	7.1%	2	2.3%	1
	I agree	28.6%	8	40.9%	18
	I strongly agree	60,7%	17	43.2%	19
I find the quality of life in the city to be good.	I strongly disagree	3,6%	1	4.5%	2
	I disagree	10.7%	3	11.4%	5
	I'm undecided	39.3%	11	20.5%	9
	I agree	39.3%	11	47,7%	21
	I strongly agree	7.1%	2	15.9%	7
I am satisfied with the adequacy of green spaces in the city.	I strongly disagree	25,0%	7	15,9%	7
	I disagree	46,4%	13	36,4%	16
	I'm undecided	17.9%	5	29.5%	13
	I agree	10.7%	3	11.4%	5
	I strongly agree	0.0%	0	6.8%	3
People in Edirne have a positive attitude towards foreigners (refugees or those from other places).	I strongly disagree	21.4%	6	29.5%	13
	I disagree	10,7%	3	27,3%	12
	I'm undecided	35,7%	10	18.2%	8
	I agree	28,6%	8	20.5%	9
	I strongly agree	3.6%	1	4.5%	2

A*ppendix 1.* Continued

		Gender			
		Female		Male	
		Column N %	Count	Column N %	Count
The people of Edirne can easily demonstrate urban solidarity during difficult times.	I strongly disagree	0,0%	0	13,6%	6
	I disagree	10.7%	3	13.6%	6
	I'm undecided	46.4%	13	27.3%	12
	I agree	21.4%	6	36.4%	16
	I strongly agree	21.4%	6	9,1%	4
People in Edirne can easily provide social solidarity during difficult times.	I strongly disagree	0,0%	0	7.0%	3
	I disagree	10.7%	3	14.0%	6
	I'm undecided	28.6%	8	27.9%	12
	I agree	39.3%	11	34.9%	15
	I strongly agree	21.4%	6	16.3%	7
The city center meets all your needs.	I strongly disagree	3.6%	1	9.1%	4
	I disagree	10.7%	3	20.5%	9
	I'm undecided	32.1%	9	25.0%	11
	I agree	42.9%	12	34.1%	15
	I strongly agree	10.7%	3	11.4%	5
I am satisfied with the city administration's services.	I strongly disagree	10.7%	3	15.9%	7
	I disagree	35.7%	10	31.8%	14
	I'm undecided	35.7%	10	27.3%	12
	I agree	17.9%	5	20.5%	9
	I strongly agree	0.0%	0	4.5%	2

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Article

From lived house to personality house museum: A spatial and ınstitutional comparison of Türkiye and the United Kingdom

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ABSTRACT

This article examines personality house museums in Türkiye as spatial and institutional constructs formed through the transformation of lived domestic interiors into curated environments of representation. Positioned at the intersection of architectural history, conservation, and museum studies, the study approaches the house museum as a distinct typology in which space itself functions as a primary medium of narrative production. Focusing on Türkiye while using the United Kingdom as a reference context, it investigates how biographical narratives are shaped through spatial organization, exhibition language, and operational structures. The article employs the DEMHIST classification, particularly the category of the personality house, to establish a comparative analytical framework. Within this framework, Barış Manço House Museum and İsmet İnönü House Museum are examined as two different modes of biographical representation. The Charles Dickens Museum in London is added as a British reference case, offering institutional and archival depth that grounds the UK comparison in concrete terms. The comparison clarifies how governance models, accreditation systems, and funding structures shape conservation, visitor management, and curatorial interpretation. The study argues that house museums should be understood as reconstructed interiors in which authenticity, memory, and representation are produced through selective spatial and curatorial decisions. In doing so, it contributes to the Turkish literature by strengthening the architectural and spatial dimension of house museum analysis and by making visible the institutional conditions that shape their formation and sustainability.

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INTRODUCTION, METHOD, AND COMPARATIVE APPROACH

House museums form a distinct spatial category between the domestic space and the public museum, linking architectural history, conservation theory, and museum studies. Unlike museums built for exhibition from the outset, they emerge when a once-inhabited interior is incorporated into public display, interpretive narrative, and institutional structure — a layered transformation in which the domestic space is read, arranged, and reconstructed through specific representational strategies (Günhan, 2011; Uz, 2010). Traces assumed to have been preserved are often reordered through curatorial and managerial decisions, so the past is

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structured within a representational order shaped for public narration. House museums therefore need to be examined through both the representational capacity of architectural space and the mechanisms that activate it.

International scholarship links the conversion of the house into a museum to spatial arrangement, exhibition language, and institutional frameworks (Pavoni, 2001). Decisions about which rooms are preserved and opened, which objects are displayed, and which are withheld establish a representational order that fixes the past to a particular moment; this order is often justified through claims of authenticity, yet authenticity is frequently produced through selection and reconstruction (Nora, 1989; Lowenthal, 1998). House museums retain value as documents of domestic typologies and interior culture, while musealization reshapes that documentary quality and produces a new narrative framework (Bakır, 2023; Özdirir, 2022).

In Türkiye, house museums remain a relatively new and fragmented field, with much existing work focused on individual cases (Uz, 2010; Aslan, 2019). This article outlines the general condition of house museums in Türkiye, examines the selected examples' transformation through spatial organization, curation, and operation in relation to the tension between house and museum, and proposes an analytical framework that may help address a gap in the Turkish literature. The study focuses on "personality houses" within the DEMHIST classification[1] developed by the ICOM International Committee for Historic House Museums. Such museums' main concern is how biographical narrative is constructed through spatial arrangement and exhibition language.

The United Kingdom serves as a comparative reference context: the earlier institutionalization of its house museum tradition offers a basis for clarifying the operating conditions and limitations of Turkish examples, and the Charles Dickens Museum grounds this comparison in concrete curatorial and spatial terms. DEMHIST offers a classificatory logic beyond the label of "historic house," making it possible to discuss examples from different national contexts through a shared conceptual language (ICOM, 2001). The case readings examine spatial organization, curatorial decisions, and operational structures together, asking how institutional affiliation and management converge with exhibition language, and how this becomes visible in the domestic interior through room hierarchy, circulation, thresholds, and display elements.

The main research problem concerns how house museums in different national contexts construct architectural space as an instrument of representation, and through which institutional and spatial mechanisms this process operates. The study addresses three questions: How is domestic circulation transformed into a museum route? Which rooms and thresholds become focal points of biographical representation? How do governance and access conditions affect the spatial and curatorial organization of the house? Each case is examined through a common set of criteria — original domestic organization, current spatial use, room hierarchy, thresholds, visual axes, visitor circulation, exhibition interventions, access restrictions, and institutional governance — first identifying former domestic functions, then examining how these were retained, altered, or replaced during musealization.

THE CONCEPT OF THE HOUSE MUSEUM AND THEORETICAL FRAMEWORK

A house museum emerges when a former residence associated with a person, family, way of life, or historical event is preserved and opened to visitors. The building no longer functions as a neutral container for objects; through its layout, room hierarchy, circulation, and traces of everyday use, it becomes a direct carrier of exhibition meaning (Butcher-Younghans, 1993; Pavoni, 2001). Narrative is embedded in the space itself: interior atmosphere, object arrangement, and the proximity created by domestic scale become key elements of visitor experience (Günhan, 2011).

House museums do not preserve the past unchanged; they construct it through selection. Collective memory is socially produced, and arrangements in house museums are likewise shaped by social and cultural frameworks (Halbwachs, 1992). The house museum turns an individual life story or family history into an object of cultural memory through public visitation and interpretation; the reconstruction of domestic order, the emphasis on particular rooms, and the concealment of selected traces produce a representational economy based on selective remembrance (Assmann, 2011).

A museum does more than display objects: it establishes relations between them and directs visitors toward a particular reading, and in house museums this narrative production works through the interaction of text, object, and space (Hooper-Greenhill, 2000). These narratives are constructed rather than neutral, since new circulation routes, safety requirements, and exhibition practices reorganize the interior (Bennett, 1995); the house museum thus retains documentary value while producing a new narrative framework (Günhan, 2011).

Authenticity depends on the preservation of original objects, but also on which historical moment is chosen as a reference point and how that moment is fixed in space (Nora, 1989). House museums rarely show the full flow of life; usually one period is selected and the interior orga-

[1] Categorisation Project - ICOM DEMHIST

nized around it, which may push the house's transformations and internal tensions into the background (Özdirir, 2022). Authenticity should therefore be understood as a representational strategy, shaped directly by restoration decisions, display design, lighting, signage, and visitor routes.

Typology debates within ICOM seek a common basis for examples appearing under different names in different national contexts. Pavoni's typology shows how house museums diverge between the "historic house" and the "museum house," through association with a person, the building's architectural value, or the way of life it represents (Pavoni, 2001); Pinna similarly argues that house museums are a museological field shaping visitor experience as well as a preservation practice (Pinna, 2001). In Türkiye, the concept of the house museum is produced through different institutions and scales, while the typology itself often remains unclear (Uz, 2010).

DEMHIST is used here to reduce this conceptual fragmentation. Rather than limiting house museums to the label of "historic house," it offers a classificatory logic based on the represented person or way of life, institutional structure, and preservation practices; since house museums can be distinguished by narrative focus, DEMHIST's categories (Table 1) serve as a practical tool for making those differences visible.

In sum, house museums matter for architectural history because of their close relation to domestic space: memory and authenticity are produced through spatial organization and curatorial decisions, and representation emerges through the interaction of text, object, and space (Hooper-Greenhill, 2000; Nora, 1989). ICOM's typology debates and the DEMHIST classification provide the analytical basis used here to classify and compare these structures across contexts.

HOUSE MUSEUMS IN TÜRKİYE AND ISTANBUL: GENERAL TENDENCIES AND SELECTED EXAMPLES

A singular, standardized house museum system cannot readily be identified in Türkiye. House museums emerge within broader museology and heritage management practices and are shaped by the operating logics of different institutions, so definitions, operational standards, funding, and supervision vary across cases (Uz, 2015). Even within the same city, municipal management, foundation or association administration, ministry-related structures, and private ownership produce differences in exhibition language, display practices, and maintenance rhythms (Günhan, 2011; Özdirir, 2022). House museums in Türkiye should therefore be understood as a spatial type in which the balance between preservation and public access is shaped case by case through ownership, governance, funding, and representation.

Turkish museums operate through a multilayered system: state museums affiliated with the Ministry of Culture and Tourism exist alongside private museums operating under the Ministry's permission and supervision. Under Law No. 2863 and related legislation, Ministry-affiliated museums are governed centrally, while private museums remain subject to ministerial approval for establishment, oversight, and inspection. Museums housed in historic buildings add a further layer of complexity, as decisions must also account for conservation provisions and regional conservation board rulings. A house museum's institutional structure therefore cannot be explained through formal affiliation alone; ownership, operating body, the relationship with the Ministry, and conservation obligations must all be considered together (Ministry of Culture and Tourism, 1990, 2005; Law on the Protection of Cultural and Natural Assets, 1983).

To understand the general condition of house museums in Türkiye, an inventory was compiled and mapped. As no sin-

Table 1. DEMHIST Categorization of House Museums, (DEMHIST, n.d.)

DEMHIST Category	Description
Personality houses	Writers, artists, musicians, politicians, military heroes, etc.
Collection houses	The former home of a collector or a house now used to display a collection.
Houses of beauty	Houses valued primarily as works of art.
Historic event houses	Houses commemorating an event associated with the house.
Local society houses	House museums established by a local community, usually as a social and cultural facility reflecting local identity rather than for a historic reason.
Ancestral homes	Country houses and small castles open to the public.
Power houses	Palaces and large castles open to the public.
Clergy houses	Monasteries, abbots' houses, and other ecclesiastical buildings with former or current residential use, open to the public.
Humble homes	Vernacular buildings such as modest farms, valued as reflections of a lost way of life and/or building tradition.

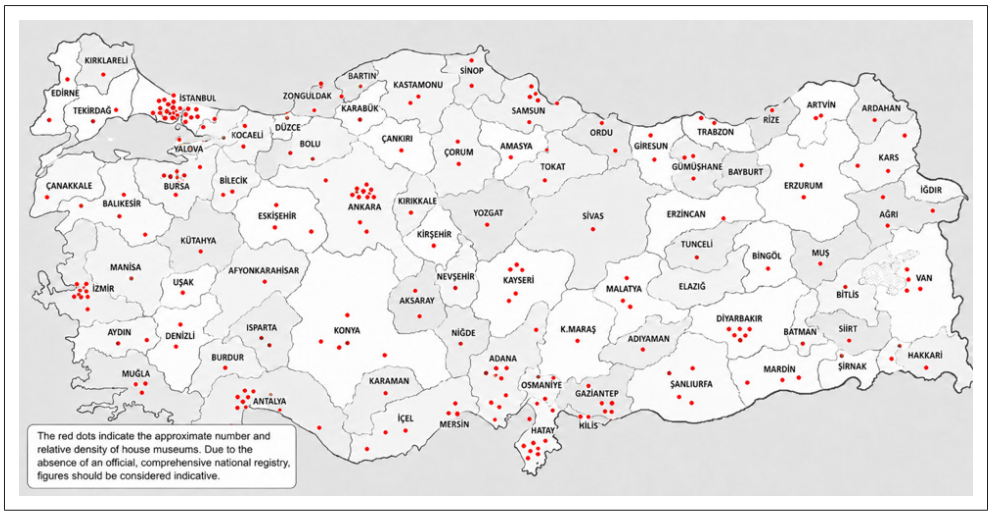

Figure 1. Distribution of identified house museums across Türkiye (prepared by the author, 2026, based on Uz, 2010 and the museum inventories of the Republic of Türkiye Ministry of Culture and Tourism). Each point indicates the approximate number and density of identified house museums, as no official national source provides an exact count.

gle national database exists for this purpose, the inventory was built by cross-checking the literature with official museum lists from the Ministry of Culture and Tourism (Uz, 2010; Republic of Türkiye Ministry of Culture and Tourism, n.d.-a, n.d.-b), and the identified examples were mapped by the author according to location.

The map shows that most house museums in Türkiye are located in Istanbul, likely reflecting the city's central role in cultural production and intellectual life since the late Ottoman and early Republican periods, alongside stronger local governance, foundation networks, and tourism demand (Figure 1). Istanbul stands out not only in number but as a setting where different combinations of ownership, governance, funding, and representation become visible; house museums cluster along particular routes, with thematic diversity higher in some districts than others. The inventory table (Table 2), presenting theme, management type, and brief notes together, clarifies the multi-actor framework within which the selected examples are situated.

The empirical corpus consists of two formally operating personality house museums, Barış Manço House Museum and İnönü House Museum, selected through purposive sampling from Table 2 because they belong to the same DEMHIST category while representing contrasting biographical fields and governance models: popular culture under municipal administration, and political history under foundation administration. Both retain the legibility of their former domestic organization and are regularly accessible, allowing the study to examine how represented identity and institutional structure jointly shape room hierarchy, circulation, exhibition language, and public access.

This institutional contrast also shapes the depth of material available: the two museums offer a comparable density of well-documented sources — photographic records, institutional statements, and press coverage — that several other examples in Table 2 lack. This documentary richness, together with their contrasting governance structures, makes a sustained comparative reading of curatorial decisions, access conditions, and archival depth possible across the two cases.

BARIŞ MANÇO HOUSE MUSEUM

Barış Manço, one of the most widely recognized figures in Turkish popular music and television culture, is regarded as one of the founding names of Anatolian rock. As a musician, composer, lyricist, and television presenter, he reached different generations and secured a lasting place in collective memory, especially through his TV program *7'den 77'ye*[2]. He may therefore be considered one of the most visible cultural figures in the history of popular culture in Türkiye (Kadıköy Municipality, n.d.).

Barış Manço House Museum was created when Manço's house in Moda (Figure 2) was opened to visitors by Kadıköy Municipality as a museum. Institutional narratives emphasize the contribution of the Manço family and the support of Halkbank, pointing to a model shaped by municipal initiative together with family and corporate support (Anadolu Ajansı, 2022). Originally built in the nineteenth century by the Whittall family, prominent Levantine residents of

[2] Barış Manço's television program 7'den 77'ye ("From 7 to 77"), broadcast in Türkiye between 1988 and 1998, was a highly popular cultural and educational program addressing audiences of all ages. The title became closely associated with Manço's public persona and his broad intergenerational appeal. (Kadıköy Municipality Barış Manço House, 2020)

Moda, the house was purchased by Manço from the family's last remaining members in 1984 for its Victorian character (ARTtv, 2020). The transformation from private residence to public museum did not require major structural intervention: the house retains its original massing and room configuration, though individual rooms were reassigned new functions — the room once used to serve meals from the dining room, for instance, was later redesigned as a costume display room (ARTtv, 2020).

As a personality house devoted to a popular cultural figure, the museum builds its biographical narrative through objects and interior atmosphere. Its municipal framework shapes public access, while maintenance and updating depend on the continuity of local administrative capacity and institutional support.

Table 2. Selected personality house museums in Istanbul (prepared by the author, 2026)

Museum Name	Year of Construction	Year the Person Began Living There	Year Opened to Visitors	Associated Figure (significance)	Governing Institution	Neighbourhood / District	Open to Visitors	Source(s)
Istanbul Atatürk Museum	1910	1918	1942	Mustafa Kemal Atatürk (Founder and the first President of the Turkish Republic)	Istanbul Metropolitan Municipality	Şişli (Halaskargazi Avenue)	Yes	İlgürel, M. (2021), Şişli Atatürk Evi, Atatürk Ansiklopedisi
Aşiyan Museum (Tevfik Fikret House)	1906	1906	1945	Tevfik Fikret (poet)	Istanbul Metropolitan Municipality	Beşiktaş (Aşiyan)	Yes	Demirgüç (2023); Istanbul Metropolitan Municipality (n.d.)
Adam Mickiewicz Museum	1870 (rebuilt)	1855	1955	Adam Mickiewicz (Polish poet)	Ministry of Culture and Tourism	Beyoğlu (Bostan Mahallesi)	Yes	Bektaş & Yalçınkaya (2020)
Sait Faik Abasıyanık Museum	19th century	1938	1959-2013 (Reopened)	Sait Faik Abasıyanık (writer)	Darüşşafaka Society	Adalar (Burgazada)	Yes	Aslan (2019); Darüşşafaka Society (n.d.)
Kazım Karabekir Paşa Museum	Late 19th century	1930	2005	Kazım Karabekir Paşa (commander in the War of Independence)	Kazım Karabekir Foundation	Kadıköy (Erenköy)	Yes	Özdökmeciler (2020); Kâzım Karabekir Foundation (n.d.); Anadolu Agency (2011)
Hüseyin Rahmi Gürpınar Museum	1911	1912	2000	Hüseyin Rahmi Gürpınar (writer)	Ministry of Culture and Tourism	Adalar (Heybeliada)	No	Çalışlar (2022); Adalar District Governorship (n.d.)
Barış Manço House Museum	1895–1900	1984	2010	Barış Manço (musician)	Kadıköy Municipality	Kadıköy (Moda)	Yes	Kadıköy Municipality (n.d.)
İnönü House Museum	1920	1924	1994	İsmet İnönü (Former President of the Turkish Republic)	İnönü Foundation	Adalar (Heybeliada)	Yes	İnönü Foundation (n.d.); Erkurt (2025)
Aziz Nesin Museum	1974	1981	1995	Aziz Nesin (writer and humorist)	Nesin Foundation	Çatalca (Gökçeali)	Yes	Nesin Foundation (n.d.); Cumhuriyet (1995)



Figure 2. Barış Manço House Museum: Exterior façade, Moda/Kadıköy. (Kadıköy Municipality Barış Manço House, 2020).

In the basement, the summer garden displays Manço's instruments, stage equipment, and concert memorabilia together, so that guitars, drums, and concert posters gain representational value through their selective placement within a biographical sequence (Anadolu Ajansı, 2022) (Figure 3).

The authenticity claimed by the museum is not tied to a single date but to the cumulative period of Manço's career, from his years as a performer to his death in 1999. Only objects directly linked to his own use — guitars, records, stage costumes, personal jewelry — carry the claim to originality (Anadolu Ajansı, 2022); didactic panels and thematic groupings, by contrast, are curatorial additions rather than inherited fragments of domestic life. This corresponds to what Lowenthal (1998) and Nora (1989) describe as the constructed nature of authenticity in memorial settings: the objects are original, yet their meaning is produced through their sequencing within the museum's narrative. A hierarchy emerges in which the basement summer garden functions as the primary node, anchoring the visitor's understanding of Manço as a musician, while the living room and main bedroom on the upper floors operate as secondary, background settings that humanise this public identity. Circulation reinforces this hierarchy: visitors move from the performance-oriented summer garden toward the more intimate domestic spaces above, staging the transition from



Figure 3. Summer garden, instrument display, basement. Photograph by the author, 2026.

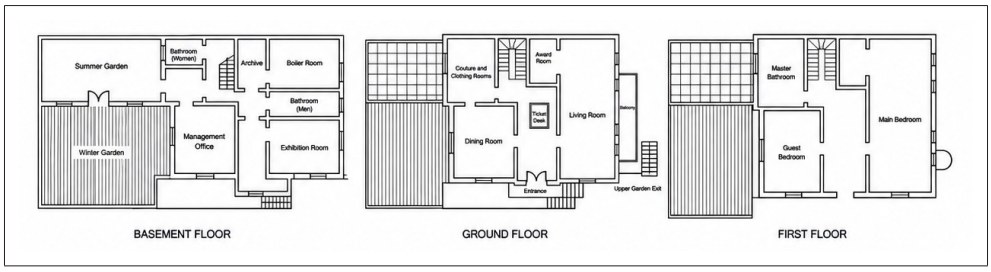

Figure 4. Basement, ground floor, and first floor plans of the Barış Manço House Museum, drawn to approximate proportions by the author (not to precise scale), 2026.

Manço's public persona to his private life. This hierarchy is legible in the combined floor plans (Figure 4), where the basement summer garden occupies the primary position along the visitor route and living Room and main bedroom on the upper floors appear as sequential, lower-emphasis stops.

The museum largely preserves the original domestic layout while reinterpreting selected rooms through thematic display: bedrooms remain legible as domestic interiors, yet are incorporated into the narrative through showcases and selected object groups. A small award room, accessed through the living room, displays Manço's prizes and honours alongside travel photographs, passports, and handwritten materials (Figure 5), making his identity as a musician, television figure, and public personality visible to visitors as they move through the house. This continuity between domestic and exhibition space means visitors experience the museum less as a conventional gallery sequence and more as an extension of lived domestic space, an effect reinforced by the retention of original room proportions and window placements, as in the main bedroom, where museum display sits directly alongside the room's original architecture (Figure 6).

İSMET İNÖNÜ HOUSE MUSEUM

İsmet İnönü was a leading figure of the Turkish War of Independence and the second President of the Republic, while his son Erdal İnönü sustained the family's public visibility in the next generation as an academic and a politician. İnönü House Museum in Heybeliada, formerly known as the Mavromatis Köşkü, was used as the family's summer house (Kaya, 2021) (Figure 7).

The site predates the İnönü family's residence: an earlier wooden mansion on the plot was destroyed in the 1894 earthquake, after which the current masonry structure was built in 1920 in a Neo-Classical style, on a basement, ground floor, two upper floors, and an attic (Kaya, 2021). The İnönü family rented the property in 1924 and purchased it in 1934. After İsmet İnönü's death in 1973, the house passed to the İnönü Foundation, underwent renovation in 1989–1990, and was later opened as a museum (Erkurt, 2025). The transition to museum use preserved the building's original room layout and proportions, with conversion limited mainly to interpretive material and controlled visiting arrangements rather than structural alteration (İnönü Foundation, n.d.).

As a personality house associated with a political figure, the İnönü House Museum connects his biography closely to



Figure 5. Award room displaying Manço's prizes and honours. Photograph by the author, 2026.



Figure 6. Main Bedroom interior alongside museum display. Photograph by the author, 2026.



Figure 7. İnönü House Museum: Exterior façade (İnönü Foundation, n.d.).

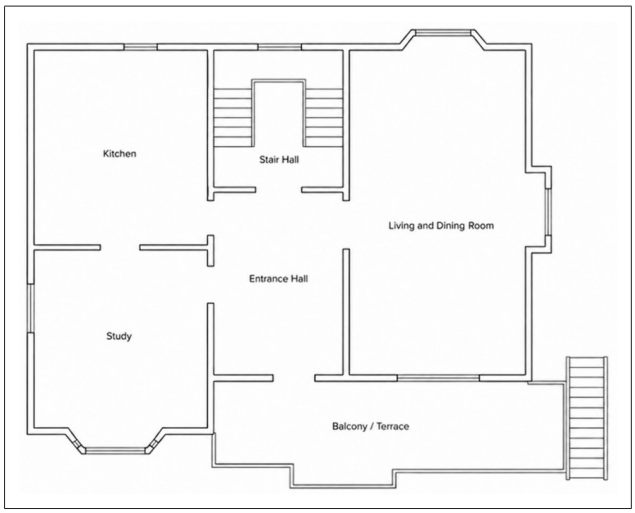

Figure 8. İnönü House Museum, ground floor plan, drawn to approximate proportions by the author (not to precise scale), 2026.

public history. The ground floor concentrates the semi-public register of the visit: living and dining room, kitchen, and İsmet İnönü's study open directly off the entrance, and nearly all furniture and objects in these rooms are original, with only a small number of pieces reupholstered. The stairwell walls extend this register vertically, displaying correspondence, family photographs, and paintings. This spatial organization is legible in the ground floor plan (Figure 8), where the study and the entrance sequence are marked as the primary route for visitors.

The first floor shifts toward the private and familial: it holds the bedroom of İsmet and Mevhibe İnönü and, separately, that of their sons, alongside a bathroom fitted with a bell-pull device installed in İnönü's later years for medical reasons (Figure 9). Here, authenticity is constructed less through iconic performance objects than through the material traces

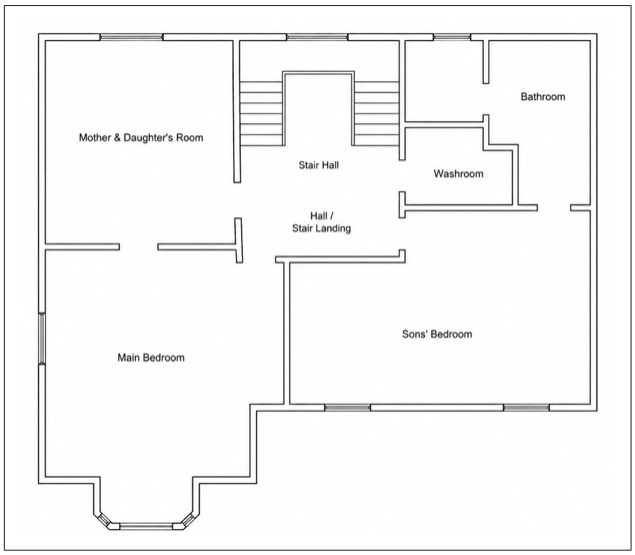

Figure 9. İnönü House Museum, first floor plan, drawn to approximate proportions by the author (not to precise scale), 2026.

of routine political labour: the desk, papers, and correspondence in the study are presented as evidence of continuous statesmanship rather than as isolated relics, aligning with Nora's (1989) argument that memory sites derive authority from implied continuity rather than singular events. The room hierarchy privileges the study and the balcony-adjacent sitting area as primary nodes, where political and familial narratives intersect, while the upstairs bedrooms recede into a supporting role — a distinction echoing how architectural representation in house museums organizes narrative through spatial hierarchy (Günhan, 2011).

The threshold between the ground floor's semi-public rooms and the first floor's private quarters is not merely spatial but symbolic, marking the boundary between İnönü's public political identity and his private family life. Original furniture placement and room proportions are retained throughout, so that museum display sits directly within the domestic setting rather than replacing it (Figure 10), a pattern also observed more broadly across house museums in Türkiye (Uz, 2015).

HOUSE MUSEUMS IN THE UNITED KINGDOM: HISTORICAL BACKGROUND AND PRACTICES

In the United Kingdom, house museums developed within institutional frameworks connecting the preservation of historic buildings with public access. These frameworks involve a range of charitable and statutory actors, among which the National Trust has played a prominent role. Established as a charity for the protection of "Places of Historic Interest or Natural Beauty" and supported by parliamentary authority through the National Trust Acts (1907–1971) and related legislation, it created a structure combining conservation and



Figure 10. Living and dining room, ground floor. Photograph by the author, 2026.

management (National Trust, 2024). Historic houses could thus be handled as properties where maintenance, access, and representation were managed together, with collection care, risk management, and visitor control becoming established parts of house museum practice.

Where ownership remains in state hands, a different model has operated since the 2015 division of English Heritage. On 1 April 2015, English Heritage split into two bodies: the new charity English Heritage, responsible for operating and presenting the state-owned National Heritage Collection, and Historic England, responsible for statutory and advisory functions (English Heritage, 2015). This keeps ownership public while assigning management to a charity with stronger capacity for presentation and revenue generation, making access, maintenance, and public representation more institutionally traceable.

The British model operates through a multi-channel funding structure rather than ticket income alone. The National Trust's 2023–2024 annual report, for example, records income from membership, donations and legacies, property-based commercial activity, and investments, showing how conservation and operation are funded together (National Trust, 2024). Large heritage institutions nevertheless remain vulnerable to financial pressure, which may lead to restructuring, staff reductions, and restricted access at some sites; the institutional framework does not remove this tension, but provides tools for managing it.

In exhibition and curatorial practice, interpretation design is treated as a core part of the house museum's representational structure. Narrative is shaped through object selection, decisions about which rooms are opened, how thresholds are marked, how routes are designed, and how visitor flow is controlled (Bennett, 1995; Hooper-Greenhill, 2000), including fixing the house to a particular historical moment through period-room logic and distinguishing public rooms from back-of-house areas such as storage and archives. The house museum thus works as both a spatial document carrying material traces and a planned representational order (Pavoni, 2001; Pinna, 2001).

One institutional basis of this standardization is the UK Museum Accreditation Scheme, administered by Arts Council England, which sets minimum criteria in governance, long-term collection care, and public access (Arts Council England, 2024). For house museums, this links curatorial decisions to collection policy, conservation planning, and institutional capacity. Independent charitable trusts such as the Charles Dickens Museum operate outside the National Trust and English Heritage structures but are held to the same accreditation standard, extending this framework to smaller, single-site personality houses.

To compare the number and variety of house museums in Türkiye and Istanbul with those in the United Kingdom and London, maps were prepared using data from the English Heritage website, identifying 438 examples in England, 78 in Scotland, 12 in Wales, and 6 in Northern Ireland (Figure 11 and Figure 12). These maps point to a far denser and more differentiated house museum landscape in the British context than in Türkiye, suggesting that, especially in London, house museums operate within a more established urban and institutional framework where different themes, scales, and modes of representation coexist in close proximity.

Within this landscape, the Charles Dickens Museum was chosen as the study's British reference case — not to match Manço's or İnönü's occupation, but for its institutional and archival depth, which grounds the UK comparison in concrete terms rather than national statistics. The museum operates under an independent charitable trust (Dickens House Fund, Charity No. 212172), differing from both the municipal administration of Barış Manço House Museum and the foundation-based administration of İnönü House Museum, and adding a further point of institutional contrast. Its documentation is extensive — an accredited collection of over 100,000 items, published guides, and detailed room-by-room curato-

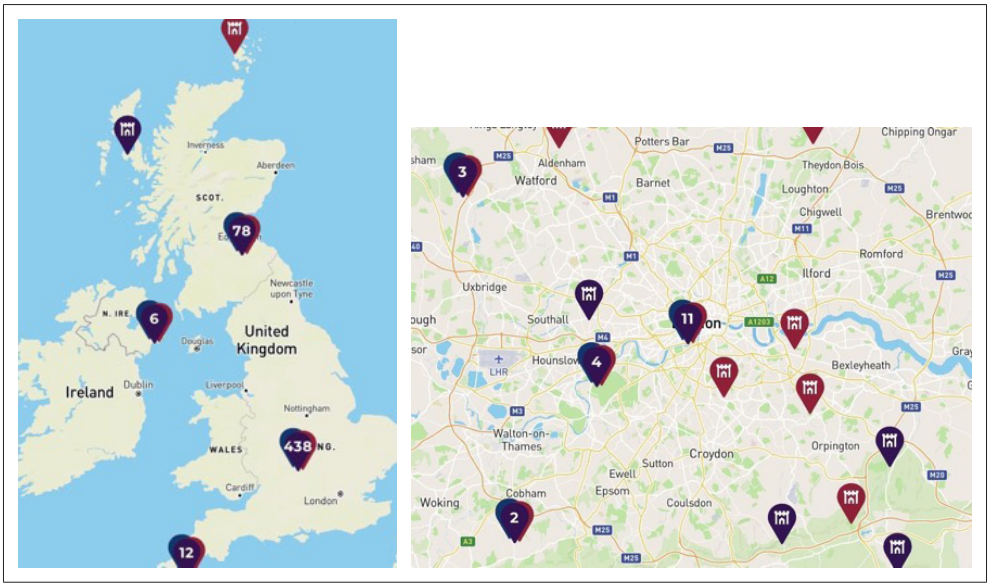

Figure 11, 12. Distribution of house museums across the United Kingdom and distribution of house museums in London (based on data from English Heritage).

rial records (Charles Dickens Museum, n.d.-d) — standing in clear contrast to the more limited archival infrastructure of the Turkish cases. This asymmetry is itself part of what the comparison is meant to reveal about the institutional conditions shaping house museum practice in each context.

CHARLES DICKENS MUSEUM

Charles Dickens, one of the most widely read novelists of the Victorian era, is regarded as a defining literary voice of nineteenth-century England. As a novelist, social critic, and public reader of his own works, he reached a broad readership and secured a lasting place in English literary culture, particularly through novels such as *Oliver Twist* and *Nicholas Nickleby*, both substantially written during his residence at 48 Doughty Street (Charles Dickens Museum, n.d.-a). He may therefore be considered one of the most visible literary figures in the history of English popular culture.

The Charles Dickens Museum was created when Dickens's house at 48 Doughty Street was opened to visitors by the Dick-



Figure 13. Charles Dickens Museum: Exterior façade, 48 Doughty Street, London. Photograph by the author, 2024.

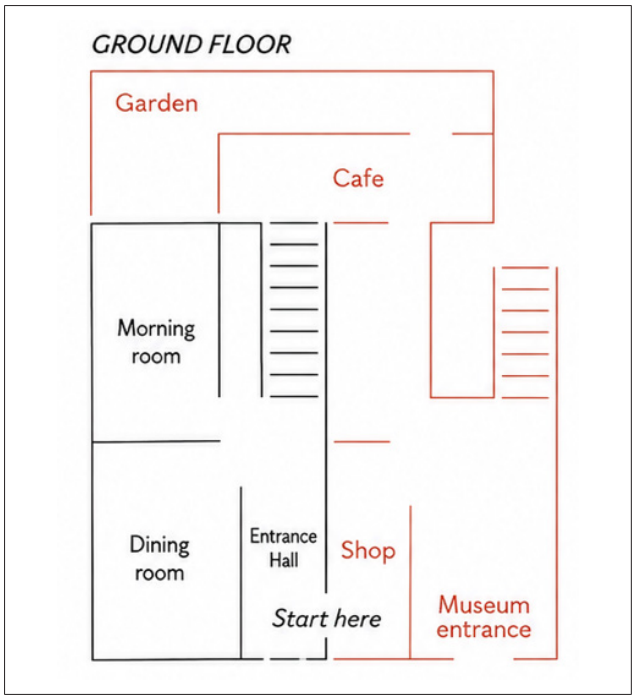

Figure 14. Charles Dickens Museum, ground floor plan, Adapted from the Charles Dickens Museum guide book (Charles Dickens Museum, n.d.-c).

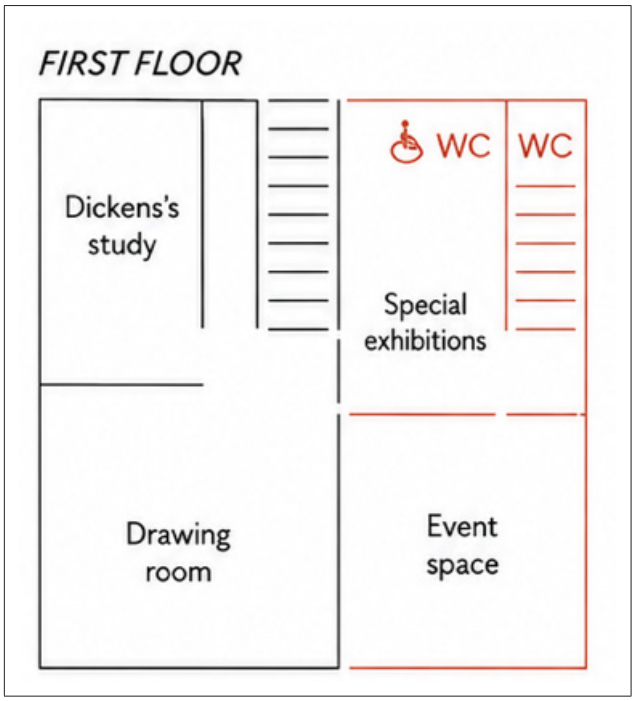

Figure 15. Charles Dickens Museum, first floor plan. Adapted from the Charles Dickens Museum guide book (Charles Dickens Museum, n.d.-c).

ens Fellowship in 1925 (Murray Birrell Chartered Surveyors, 2020), a model shaped by voluntary and philanthropic initiative rather than municipal or foundation-based administration (Art Fund, n.d.). The museum operates today under an independent charitable trust (Dickens House Fund, Charity No. 212172; Historic Houses, n.d.), and the 2012 refurbishment, which extended the museum into the neighbouring 49 Doughty Street, suggests that conservation decisions are reinforced through periodic institutional investment (Art Fund, n.d.) (Figure 13). The historic core at 48 Doughty Street, corresponding to Dickens's residence between 1837 and 1839, retains its original domestic rooms, while 49 Doughty Street houses the shop, café, and exhibition spaces added for the museum's contemporary operation (Charles Dickens Museum, n.d.-c).

As a personality house devoted to a literary figure, the museum builds its biographical narrative through domestic interiors reconstructed to evoke a specific historical moment. Its independent charitable governance shapes public access, while maintenance depends on the Fellowship's own resources rather than public subsidy. The ground floor holds the Entrance Hall, Dining Room, and Morning Room, opening directly onto the visitor route (Charles Dickens Museum, n.d.-c) (Figure 14).

The first floor concentrates the Drawing Room and Dickens's Study (Figure 15), the latter functioning as the visit's primary node. The authenticity claimed by the museum is fixed to this specific period rather than to Dickens's entire life: only objects directly tied to his own possession carry the claim to originality, while room-by-room thematic groupings and reconstructed period furnishings are visibly curatorial additions (Charles Dickens Museum, n.d.-a). Authenticity therefore operates on two registers: object-level authenticity (items Dickens owned or used) and setting-level authenticity (a staged historical moment), and the two do not always coincide.

This staging corresponds to what Lowenthal (1998) and Nora (1989) describe as the constructed nature of authenticity in memorial settings: the objects on display are genuinely associated with Dickens, yet their meaning is produced through their placement within a room-by-room narrative sequence. A hierarchy emerges in which the ground-floor rooms stage Dickens's social and family life, while Dickens's Study concentrates his literary identity as the visit's primary node (Charles Dickens Museum, n.d.-c). Circulation reinforces this hierarchy, moving visitors from shared domestic rooms toward the more private, authorial space of the Study, where original furnishings sit directly within the historic setting (Figure 16).

DISCUSSION

In house museums, representation extends beyond which objects are displayed or which rooms are opened. It also depends on ownership structure, management model, maintenance continuity, how interventions are decided, how



Figure 16. Dickens's Stud Room, first floor. Photograph by the author, 2024.

circulation is organized, and to which historical moment the building is fixed. In Türkiye, the absence of a standardized system causes these decisions to vary case by case; in the United Kingdom, similar tensions are addressed within more defined governance models, reporting practices, and conservation frameworks. The comparison is not meant to present Turkish house museums as deficient, but to clarify the conditions under which they take shape.

Ownership and governance form the first layer shaping what becomes possible in space. In Türkiye, house museums operate under municipal management, ministry-related institutions, foundations or associations, and private ownership, a multi-actor structure that strongly affects access regimes and the consistency of exhibition decisions (Günhan, 2011); the Barış Manço House Museum's municipal positioning, for instance, ties decisions directly to local administrative capacity. In the United Kingdom, membership-based charities such as the National Trust manage historic houses through long-term programs, while some state-owned properties are operated by charitable bodies with institutionalized structures (National Trust, 2024; English Heritage, 2015), making decision-making more traceable and systematic (Donnelly, 2002; Pustz, 2010). Independent charitable trusts such as the Dickens House Fund represent a third governance model, held to the same accreditation standards while operating outside these larger structures.

Funding forms a second layer shaping the continuity of spatial representation. In Türkiye, maintenance and exhibition updates are often sustained through fragmented resources — family budgets, municipal budgets, and limited partnerships — producing uneven sustainability from case to case (Uz, 2015; Bektaş & Yalçınkaya, 2020); in the Barış Manço House Museum, visible institutional support remains tied to shifting local priorities (Anadolu Ajansı, 2022), while continuity in the İnönü House Museum depends on the foundation's own resources and conservation approach, a more fragile model that can slow updating but preserve narrative within a more controlled framework. The main risk in both cases is that continuity depends on periodic budgets rather than long-term institutional guarantees. In the United Kingdom, multi-channel funding models — membership, donations and legacies, commercial income, and investment revenue — provide a stronger basis for long-term maintenance (National Trust, 2024), though financial pressure does not disappear and is instead managed through staff capacity, reservation systems, and maintenance cycles.

Exhibition language and spatial representation form the main plane through which the house museum operates as a reconstructed interior, reorganizing room hierarchy, redefining thresholds, and turning circulation into a narrative route (Butcher-Younghans, 1993; Günhan, 2011). In the Turkish examples, the interior is often fixed to a single historical moment: in the Barış Manço House Museum, this creates an intimate staging through the iconography of popular culture, while in the İnönü House Museum the same logic moves closer to a period-room model, concentrating biography within a stronger public-historical frame. In the British examples, this fixing is linked more explicitly to interpretation design — the interplay of text, object, and space produces a planned narrative architecture (Hooper-Greenhill, 2000; Bennett, 1995), including route design, display density, and the distinction

between public and back-of-house areas (Sparke et al., 2006; Pavoni, 2001). In the Charles Dickens Museum, this logic is vertical rather than horizontal: the ground floor concentrates semi-public, biographically anchored rooms, while upper floors stage an increasingly private, authorial identity along a numbered route.

The United Kingdom system has been used here as a reference rather than a model to be adopted directly. Its practice handles the balance between conservation and access within a more documentable decision structure, making visible institutional tools through which decision-making can become more traceable than in the more fragmented Turkish context (Donnelly, 2002; Pustz, 2010; Sparke et al., 2006). It also allows authenticity to be discussed through the structure of spatial experience as well as through original objects, since debates on staged and experience-based authenticity suggest that authenticity in house museums operates through selection and construction (ICOMOS, 1994; MacCannell, 1973; Wang, 1999).

CONCLUSION

This study set out to examine how house museums in different national contexts construct architectural space as an instrument of representation, through three questions posed in the introduction.

How is domestic circulation transformed into a museum route? Across the cases, circulation is redirected through the selective opening and closing of rooms and the introduction of directional cues that move visitors from public or semi-public space toward increasingly private space. This pattern holds in the Barış Manço House Museum, the İnönü House Museum, and the Charles Dickens Museum, though its formalization differs: in the British case it is planned as an explicit interpretive device, while in the Turkish cases it follows more directly from the building's own domestic logic.

Which rooms and thresholds become focal points of biographical representation? In each case, one room concentrates the represented figure's public identity — the summer garden for Manço's musicianship, the study and balcony-adjacent sitting area for İnönü's statesmanship, Dickens's Study for his authorship — while adjoining rooms recede into a supporting, humanising role. The threshold between these zones marks the boundary between a public persona and a private life, and its position is a curatorial choice as much as a spatial one.

How do governance and access conditions affect the spatial and curatorial organization of the house? Governance shapes not only funding continuity but which interventions become possible and visible. Municipal administration ties conservation decisions to local political priorities (Barış Manço House Museum); foundation-based governance preserves character within a more controlled, family-mediated framework (İnönü House Museum); and independent, accredited trusts allow interpretation to be planned more systematically, within institutional benchmarks largely absent from the Turkish context (Charles Dickens Museum).

Read together, these findings support a single comparative argument: the redefinition of room hierarchy, the conversion of circulation into a narrative route, and the selective opening or closure of thresholds are recurring mechanisms through which representation is produced — and the degree to which they are formally planned, rather than emerging informally from domestic use, tracks with the presence or absence of institutionalized interpretive practice (Smith, 2006). This is the study's main contribution: the Türkiye–UK comparison shows that these mechanisms are shared across contexts, but that their formalization is not — a distinction individual case studies, considered separately, cannot make visible. This strengthens the spatial line of analysis often secondary in the Turkish literature, approaching the house museum as an architectural regime of representation operating through the scale of the house. The transformation from house to museum should therefore be understood not simply as a change of function, but as a reorganization of visibility, movement, access, and meaning within the domestic interior.

Future research may expand this inquiry by producing a broader national inventory of house museums in Türkiye, developing comparative analyses of intervention levels, and examining house museum practices outside Istanbul in relation to local administrative capacity and heritage policy. Compared with the United Kingdom, such museums remain relatively limited in Türkiye; yet given the country's political, cultural, and social history, many residential buildings appear to hold potential for future transformation into house museums, realizing which depends on preserving buildings, assembling coherent collections, and establishing sustainable models of ownership and management.

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Article

Integration of climate adaptation into spatial planning in Turkish cities: A comparative evaluation

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ABSTRACT

Climate change adaptation is increasingly recognized as a core concern of spatial planning, yet the extent to which local adaptation priorities are reflected in statutory land-use decisions remains uncertain. This study evaluates climate-spatial integration at the local level in Türkiye and asks: To what extent are the thematic priorities in local climate adaptation plans reflected in the existing statutory spatial planning framework? A multi-source qualitative comparative research design was applied to four metropolitan municipalities—Sakarya, Konya, Muğla, and Samsun. Directed qualitative content analysis of the 2025 Local Climate Change Adaptation Strategy and Action Plans (LCCASPs) was conducted in NVivo 15 using five themes and fourteen sub-themes derived from the literature and international best practices. The results were then contextualized through qualitative document analysis of the corresponding macro-scale statutory spatial plans enacted between 2015 and 2018. The analysis identifies strong recognition of climate risks in the LCCASPs but limited explicit translation of these priorities into binding spatial plan provisions. The findings therefore indicate a baseline policy-implementation gap. Climate Law No. 7552 creates an emerging national framework for stronger coordination and local climate planning; however, effective integration will depend on operational mechanisms that connect climate-risk evidence, institutional coordination, and statutory plan-making.

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INTRODUCTION

Cities are increasingly on the front lines of the climate crisis. The density of population, infrastructure, and economic functions within urban areas amplifies their exposure to heat stress, extreme weather events, and various forms of environmental degradation. The role of spatial planning has transformed from guiding land-use decisions to anticipation of climate risks and supporting the creation of more resilient urban environments (Carter et al., 2015; Gradinaru & Hersperger, 2019; Mabon & Shih, 2021; Hurlimann et al., 2021).

AIM AND OBJECTIVES

This study examines how climate adaptation priorities can be translated into spatial planning at the local level. Its main aim is to develop and apply an analytical framework that

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distinguishes thematic recognition of climate risks from their spatial and regulatory operationalization. This distinction is important because identifying risks within strategic documents does not necessarily alter land-use designations, plan provisions, or development controls (Hurlimann et al., 2021; Berrang-Ford et al., 2019).

Accordingly, the study addresses the following main research question: "To what extent are the thematic priorities identified in the 2025 local climate adaptation plans of selected metropolitan municipalities reflected in their existing statutory spatial planning frameworks?"

Two sub-questions support the main research question:

- What thematic and operational indicators can be derived from the literature and international practice to evaluate climate-spatial integration?
- How do the distinct socio-ecological conditions and statutory planning priorities of the four cases shape the interpretation and potential spatial operationalization of adaptation themes?

SCOPE AND METHODOLOGY

The study focuses on local climate-policy integration in Türkiye. It examines the 2025 Local Climate Change Adaptation Strategy and Plan (LCCASP)s for Sakarya, Konya, Muğla, and Samsun together with the corresponding macro-scale statutory spatial plans enacted between 2015 and 2018. Because the statutory plans predate the LCCASPs, the comparison is not treated as a causal test of policy influence. Instead, it establishes a baseline assessment of whether and where the new adaptation priorities correspond to the existing spatial planning framework. The four cases were selected because they formed the metropolitan pilot set for which formal local adaptation plans were completed in 2025 and because they represent contrasting geographic, economic, and climate-risk contexts.

A multi-source qualitative comparative design was used. First, analytical indicators were derived from the literature and international planning examples. Second, the four LCCASPs were coded in NVivo 15 through directed qualitative content analysis. Third, the corresponding statutory spatial plans were reviewed through contextual qualitative document analysis to identify relevant land-use priorities, plan provisions, and legal-administrative constraints. The combined analysis enables a structured comparison between strategic adaptation intent and its potential spatial operationalization (Creswell & Poth, 2016; Santo-Tomás Muro et al., 2022).

Linking Climate Change Adaptation with Spatial Planning

Theoretical framework: climate-spatial integration

Climate-spatial integration is shaped by the relationship between strategic policy documents and statutory plans. Strategic or thematic documents organize cross-sectoral objectives—such as transport, water, energy, disaster risk, and climate action—whereas statutory spatial plans translate public objectives into territorially defined land-use decisions and development controls. Although this relationship varies among planning systems, integration depends on whether strategic priorities become spatially explicit and are embedded in instruments that guide or regulate development (Walmsley & George, 2005; Taşan-Kok & Gielen, 2010; Van den Hoek et al., 2020).

In Türkiye, environmental or territorial plans, master development plans, and implementation plans form the statutory spatial hierarchy under Zoning Law No. 3194 and the Spatial Plans Construction Regulation. Climate strategies operate as cross-sectoral policy documents that must be coordinated with this hierarchy rather than as a superior tier of spatial plan. This distinction is central to the present study because thematic consistency alone does not demonstrate spatial integration; integration requires translation into mapped decisions, plan provisions, implementation responsibilities, or development controls.

Climate-responsive planning relies on diagnostic and anticipatory tools. Vulnerability assessment identifies socio-spatial sensitivity and adaptive-capacity deficits; climate-risk mapping locates exposure and potential impacts; and scenario modelling enables planners to test alternative land-use and infrastructure pathways under uncertainty (Carter et al., 2015; Adams et al., 2017; IPCC, 2022). When these tools are linked to spatial data and statutory decision-making, they can support the prioritization of development boundaries, infrastructure investments, ecosystem protection, and risk-sensitive design (Füssel & Klein, 2006; Kruse & Pütz, 2014).

A climate-responsive planning framework therefore combines regulatory measures, technological and data-based tools, nature-based solutions, and participatory governance. Local knowledge and stakeholder participation are particularly important for identifying place-specific vulnerabilities and improving the legitimacy of adaptation priorities (Nalau et al., 2018). The analytical challenge is to determine whether these elements remain general policy commitments or are translated into spatially specific and implementable planning provisions.

International Best Practices

To translate the theoretical discussion into operational indicators, the study reviewed planning experience in Rotterdam, Liverpool, and Seattle. These cases were selected because they represent different geographic and governance contexts and were among the cities that progressively institutionalized climate adaptation between the mid-2000s and early 2010s. The review focused on how climate risks were connected to spatial visions, design guidance, infrastruc-

ture priorities, social equity, and implementation instruments rather than treating the cities as directly comparable models for Türkiye (Kazancı et al., 2026).

Rotterdam provides a prominent delta-city example in which sea-level rise, intense rainfall, drought, and flood risk have informed long-term resilience strategies. The Rotterdam Climate Change Adaptation Strategy emphasizes adaptive design, water-sensitive urban development, social resilience, and capacity building, while subsequent spatial strategies connect hydrological risk to area-based design and investment priorities (City of Rotterdam, 2013). This case informed the indicators for strategic visioning, spatial representation, climate-adaptive design, and water-sensitive planning.

Liverpool illustrates the relationship between post-industrial regeneration, green infrastructure, flood resilience, and the transition to a low-carbon economy. Its net-zero action framework and statutory Local Plan combine climate mitigation and adaptation objectives with development-management policies, infrastructure planning, and environmental protection (Liverpool City Council, 2020; 2022). The case informed the indicators related to nature-based planning, technological and analytical tools, sustainable urban systems, and the spatial implementation of climate objectives.

Seattle represents a multi-hazard West Coast context in which heat, flooding, water-resource pressure, infrastructure resilience, public health, and equity are addressed through climate preparedness and comprehensive planning. Its plans demonstrate how community health and social justice can be linked to spatial investment and land-use priorities (City of Seattle, 2018; 2022). The case informed the social-resilience indicators and the assessment of whether adaptation benefits and infrastructure are directed toward vulnerable communities.

Planning and legal context in Türkiye

The Turkish spatial planning system is principally governed by Zoning Law No. 3194 and the Spatial Plans Construction Regulation (Republic of Türkiye, 1985; 2014). Statutory plans operate at several scales, including environmental or territorial plans, master development plans, and implementation plans. The documents examined in this study are the relevant macro-scale statutory plans for each case; their formal scale varies according to the planning framework applicable to the province or planning region. National and local climate strategies have historically developed on a parallel policy track, creating a coordination challenge between sectoral climate objectives and legally binding land-use decisions.

Statutory spatial plans have binding regulatory effects on land use and development, whereas the 2025 LCCASPs were prepared as strategic policy documents and were not incorporated into the older plans examined in this study. The enactment of Climate Law No. 7552 in July 2025 changed this institutional setting. Article 7 requires public policy documents to take national climate strategies into account, establishes provincial climate coordination boards, and requires province-wide local climate action plans; the transitional provisions set 31 December 2027 as the initial deadline for their preparation and for the adaptation of relevant planning instruments. These provisions create an emerging legal basis for coordination, but the Law does not itself specify how adaptation priorities must be translated into zoning designations, plan notes, development controls, or building parameters. The study therefore evaluates the documentary gap as a baseline condition and distinguishes between a newly established legal mandate and its still-developing spatial operationalization (Republic of Türkiye, 2025).

Conceptual Synthesis

This study synthesizes the international planning lessons with the legal and administrative conditions of Türkiye. Its central proposition is that climate-spatial integration cannot be assessed through thematic similarity alone; it requires evidence of a bridge between strategic intent and spatial or statutory operationalization. The framework therefore evaluates both the presence of adaptation themes and the form in which they could influence mapped decisions, plan provisions, design standards, implementation responsibilities, or development controls.

The 'local level' is conceptualized as a scalar interface at which global climate agendas, national legislation, metropolitan governance, and place-specific spatial conditions intersect. Cities may act as important nodes of climate governance, but their capacity to translate policy into land-use outcomes is mediated by national legal hierarchies and institutional arrangements (Bulkeley & Betsill, 2005). Metropolitan municipalities are therefore examined as the arena in which broad adaptation objectives encounter locally specific risks and statutory planning instruments.

Focusing on this interface makes the policy-implementation gap analytically visible. The international cases demonstrate several ways of connecting climate knowledge to spatial instruments, whereas the Türkiye cases reveal whether comparable connections are identifiable within the documents examined. The comparison is not intended to transfer a single model, but to identify the operational conditions under which adaptation priorities can become spatially specific and implementable.

The analytical indicators were developed to assess 'operationalization': whether a strategic climate objective is expressed in a form capable of informing spatial decisions. Operationalization may be demonstrated through mapped risk zones, growth boundaries, land-use designations, plan

notes, design codes, infrastructure priorities, implementation responsibilities, or monitoring arrangements linked to spatial planning.

The framework comprises five themes and fourteen subthemes used as child codes in the NVivo analysis (Table 1). Table 1 also identifies the conceptual and case-based sources of each indicator and defines its expected form of spatial operationalization in the Türkiye context.

The indicators provide a common analytical lens for examining the four LCCASPs and for contextualizing their relationship with statutory spatial plans. They distinguish the identification of a climate issue from its translation into site-specific, implementable, or legally relevant planning provisions.

MATERIALS AND METHODS

Research Design

This study adopts a multi-source qualitative comparative research design. The design compares four metropolitan cases through a common analytical framework while retaining the contextual differences among their socio-eco-

Table 1. Climate-spatial adaptation indicators and their operational basis

Main theme	Sub-theme (child-codes)	Definition, Spatial Operationalization, and Source Basis
Risk Assessments	Risk assessments	Identification of socio-ecological vulnerabilities (e.g., floods, heatwaves, and drought) and their translation into spatial evidence or base maps for planning (Carter et al., 2015; IPCC, 2022).
Strategic Visioning	Detailed scenario	Use of climate projections and alternative futures to inform long-term growth boundaries, infrastructure choices, and land-use scenarios (Adams et al., 2017; City of Rotterdam, 2013).
Spatial & Design-Based Adaptation	Spatial representation	Explicit translation of climate risks into mapped boundaries, overlays, land-use designations, or plan provisions (Hurlimann et al., 2021; Liverpool City Council, 2022).
	Climate-adaptive design practices	Development of enforceable or implementable design guidance, such as permeable surfaces, green roofs, cooling measures, and water-sensitive urban design (City of Rotterdam, 2013; Hurlimann et al., 2021).
Social Resilience	Community health	Spatial interventions that protect public health from heat, flooding, and other climate extremes (City of Seattle, 2022; IPCC, 2022).
	Social justice	Equitable distribution of adaptation investment and priority protection for vulnerable communities and places (City of Seattle, 2018; Bulkeley & Betsill, 2005).
	Collaboration & participation	Institutionalized stakeholder and public participation in defining, locating, and implementing adaptation measures (Nalau et al., 2018; Bulkeley & Betsill, 2005).
Sustainable Urban Systems	Transportation	Resilient and low-carbon mobility networks, including the spatial coordination of public transport and active travel (Liverpool City Council, 2022; Hurlimann et al., 2021).
	Tourism	Land-use and design measures that reduce tourism-related climate exposure while protecting local economies and ecological assets (IPCC, 2022).
	Energy	Spatial provision for renewable or decentralized energy infrastructure and energy-efficient urban form (Liverpool City Council, 2020).
	Water resources	Blue-green infrastructure, watershed protection, sustainable drainage, and water-security provisions embedded in plans (City of Rotterdam, 2013; Carter et al., 2015).
	Agriculture & food	Protection of agricultural land and food systems from sprawl, drought, flooding, and other climate pressures through land-use controls (IPCC, 2022).
	Industry	Resilience measures and spatial controls for industrial areas, infrastructure, and vulnerable or emission-intensive activities (City of Rotterdam, 2013).
	Employment	Anticipation of spatial changes in employment and economic activity associated with climate adaptation and a just transition (Liverpool City Council, 2020; City of Seattle, 2022).

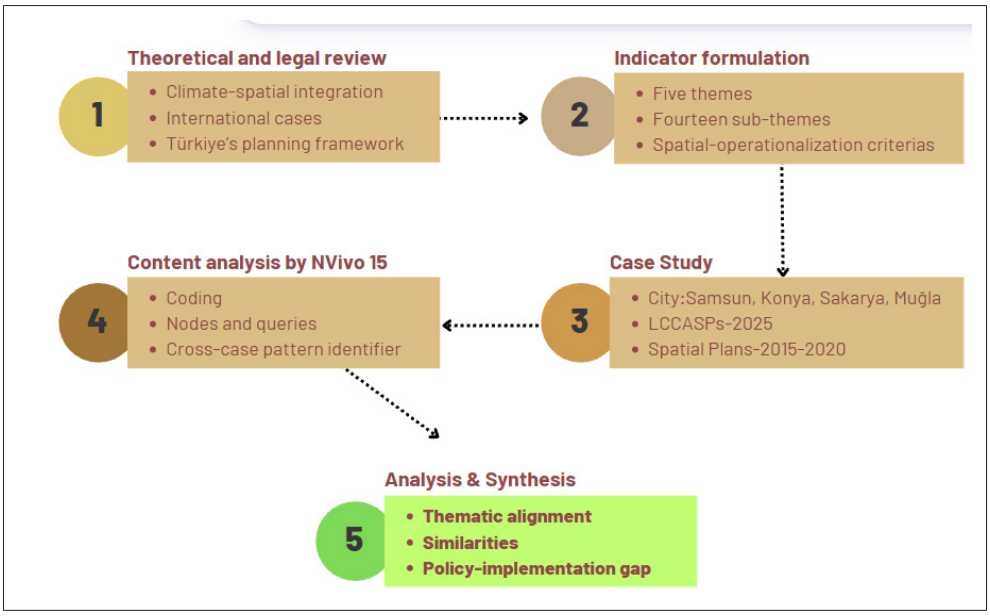


Figure 1. Research design and analytical workflow.

logical conditions and statutory planning systems. The research proceeded through six linked stages: (1) theoretical and legal review; (2) indicator formulation; (3) case and document selection; (4) directed qualitative content analysis of the LCCASPs in NVivo 15; (5) contextual qualitative analysis of the corresponding statutory spatial plans; and (6) cross-case synthesis. Figure 1 summarizes this workflow and clarifies the relationship between research design, data sources, and analytical techniques (Figure 1).

Case Study and Spatial Planning Context

The 2025 national pilot programme produced formal LCCASPs for Konya, Muğla, Sakarya, and Samsun (Figure 2). These metropolitan municipalities were selected as a complete pilot set rather than as a statistically representative sample. Their contrasting climatic, geographic, demographic, and economic characteristics provide a useful basis for comparative analysis.

Türkiye encompasses diverse climatic conditions, and the four cases represent inland semi-arid, Mediterranean coast-

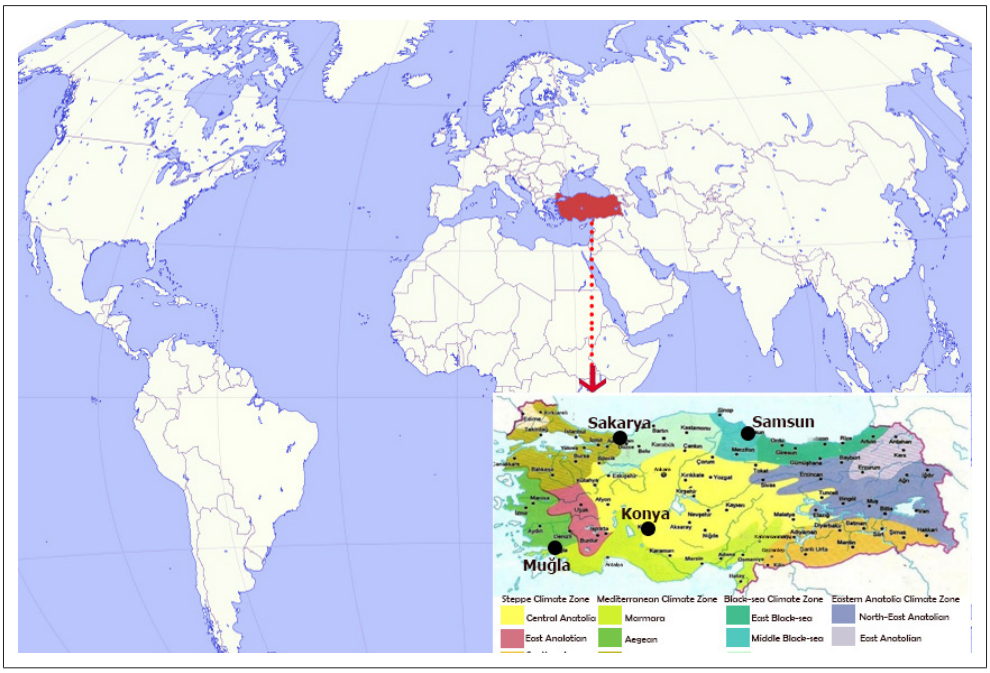


Figure 2. Location of Türkiye and case cities (Mızrak, 1983; Kazancı ve Tezer, 2023).

al, Marmara basin, and Black Sea coastal contexts (Mızrak, 1983; Peel et al., 2007). Their different hazard profiles and development pressures make it possible to examine whether a common national adaptation-planning framework is differentiated according to place-specific spatial conditions.

The cases therefore provide a comparative spectrum of socio-ecological conditions and spatial planning challenges rather than four interchangeable examples.

Because the LCCASPs were completed in 2025 while the principal statutory plans examined were enacted between 2015 and 2018, the statutory plans are treated as a pre-existing baseline. Table 2 juxtaposes the population, socio-ecological profile, climate vulnerabilities, adaptation priorities, and statutory spatial planning focus of each case. This temporal framing prevents causal claims and enables the study to identify the areas in which future plan revisions would need to operationalize the new adaptation priorities.

Although the four LCCASPs share a broadly comparable structure, their relevance to spatial planning depends on the distinct statutory priorities and development pressures of each case. The following summaries clarify the contextual basis used to interpret the NVivo results.

In Sakarya, the LCCASP prioritizes blue infrastructure, sustainable urban drainage, and land management in response to riverine flooding and extreme precipitation. The statutory spatial framework simultaneously addresses the protection of Sapanca Lake, agricultural land, and active fault zones while accommodating industrial development. The case therefore illustrates the challenge of connecting climate adaptation to basin protection, risk-sensitive growth, and industrial land-use decisions (MEU, 2015; MEUCC, 2025).

Muğla's LCCASP adopts a risk-governance approach and groups actions as policy and capacity measures, technological interventions, and nature-based solutions. Its Mediterranean coastal setting creates a combined exposure to forest fire, extreme heat, coastal hazards, and intense tourism-related development pressure. The statutory spatial framework emphasizes ecological protection and the management of tourism growth, providing a critical context for evaluating whether adaptation priorities can be translated into conservation, settlement, and design provisions (MBB, 2016; MEUCC, 2025).

Samsun combines regional logistics and agro-industrial functions with the ecological sensitivity of the Bafra and Çarşamba delta plains. Its statutory spatial framework addresses delta and agricultural-land protection, water basins, waste systems, and multimodal transport, while the LCCASP emphasizes green urbanization, local food security, and protection from flash floods and coastal storms. The case highlights the need to coordinate economic-corridor development with flood, coastal, and agricultural-land resilience (MEU, 2017; MEUCC, 2025).

Table 2. Population, socio-ecological characteristics, climate priorities, and statutory spatial planning context of the case municipalities

City	Population (TÜİK, 2025)	Socio-Ecological Profile & Main Economic Base (MEUCC, 2025)	Primary Climate Vulnerabilities (MEUCC, 2025)	LCCASP Focus (2025)	Statutory Macro-Scale Spatial Plan Focus
Konya	2.343.409	Inland semi-arid plateau Türkiye's primary agricultural hub and an expanding industrial center	Severe agricultural drought, water scarcity, heatwaves.	Agriculture, food security, drought resilience, and groundwater regulation.	Focuses on agricultural preservation and water management via the Konya Plain Project (KOP), while simultaneously establishing new logistics and industrial zones.
Muğla	1.099.547	Mediterranean coastal region; heavily reliant on seasonal tourism and rich in forest ecosystems.	Forest fires, sea-level rise, coastal erosion, extreme heat.	Risk-governance, resilient recovery, nature-based solutions, capacity building.	Aims to control tourism-driven rapid urbanization and protect ecologically sensitive areas through strict conservation zones.
Sakarya	1.123.693	Marmara river-basin context; a mixed economy of heavy industry and fertile agriculture.	Riverine flooding, extreme precipitation, urban heat islands.	Sustainable urban drainage, blue infrastructure expansion, land management.	Emphasizes protecting agricultural land, critical water basins like Sapanca Lake, and managing active fault lines.
Samsun	1.392.403	Black Sea coastal topography; a regional logistics and trade center with major agricultural delta plains.	Flash floods, landslides, coastal storms.	Green urbanization, hazard protection, local food security, institutional coordination.	Envisions the city as a macro-regional center for trade and agro-industry, prioritizing the absolute protection of delta plains from sprawl.

Konya's inland semi-arid geography produces a different planning context. The LCCASP emphasizes drought resilience, sustainable water supply, food security, and groundwater regulation, while the statutory spatial framework seeks to protect agricultural land and manage water resources alongside major industrial and logistics development. The case therefore tests whether climate and water constraints are reflected in long-term growth and land-allocation priorities (KMM, 2018; MEUCC, 2025).

These macro-scale statutory plans establish the principal conservation and development framework for the cases. Their comparison with the 2025 LCCASPs provides a baseline for identifying the spatial provisions, plan revisions, and lower-scale implementation instruments that would be required for climate priorities to affect future development decisions.

Analytical Method: Contextual Document and Content Analysis

The study combines two complementary qualitative techniques within a single comparative design. First, directed qualitative content analysis was used to identify and compare adaptation priorities in the four LCCASPs. NVivo 15 was selected for systematic data management, hierarchical coding, matrix queries, and cross-case comparison (Creswell & Poth, 2016; Santo-Tomás Muro et al., 2022). Second, contextual qualitative document analysis was applied to the corresponding statutory spatial plans to identify the land-use priorities, plan provisions, and legal-administrative conditions relevant to the coded adaptation themes. This is a multi-source qualitative design rather than a mixed-methods design because both components rely on qualitative documentary evidence.

The coding framework was derived from the conceptual synthesis and the indicators defined in Table 1. Four LCCASPs were imported into NVivo and coded through the following stages:

i. Initial coding: Relevant text was coded using the predefined indicators while allowing case-specific content to be recorded in analytical memos.

ii. Code structuring: Codes were organized as hierarchical nodes corresponding to the five themes and fourteen sub-themes.

iii. Matrix queries: NVivo matrix-coding queries were used to compare the presence, density, and co-occurrence of themes across the four cases.

iv. Comparative visualization: Cross-case relationships and thematic concentrations were visualized to support interpretation; visual outputs were treated as descriptive aids rather than independent evidence.

The statutory plans were not coded as if they were climate action plans. Instead, they were examined through a structured document-review matrix based on the same operational criteria: spatial representation, land-use provisions, design or development controls, infrastructure priorities, implementation responsibilities, and institutional coordination. The integration assessment was then produced by triangulating the NVivo findings with the case-context table and the statutory-plan review (Sembiring et al., 2025). This procedure improves transparency and reproducibility while avoiding the assumption that thematic frequency alone demonstrates spatial integration.

FINDINGS

The LCCASPs were coded through five themes and fourteen child codes (Figure 3).

Figure 3 maps the relationships between the four LCCASPs and the five principal indicator groups: risk assessment, strategic visioning, spatial and design-based adaptation, social resilience, and sustainable urban systems. The network visualizes thematic associations and supports cross-case comparison; it does not, by itself, demonstrate legal or spatial integration.

- Risk Assessments
- Strategic Visioning
- Spatial & Design-Based Adaptation
- Social Resilience
- Sustainable Urban Systems

The network indicates that the four plans contain multiple context-sensitive adaptation themes. However, comparison with the statutory-plan baseline identifies limited explicit correspondence between these themes and binding spatial provisions. The thematic density in Figure 3 is therefore interpreted as evidence of policy attention, whereas integration requires additional evidence in mapped decisions, plan provisions, development controls, or implementation mechanisms.

The codes were examined systematically within each LCCASP. Under spatial and design-based adaptation, for example, spatial representation is concentrated mainly in risk-assessment sections and generally takes the form of maps describing existing conditions. Strategic objectives and actions rarely extend this spatial evidence into plan amendments, mapped intervention zones, or enforceable development standards. This pattern is consistent with the interpretation that the LCCASPs function primarily as strategic guidance within the documentary period examined. Climate-adaptive design is likewise expressed mainly through proposals to prepare future guidelines, particularly for transport, tourism, green infrastructure, and the built environment.

Word-cloud visualizations summarize term frequencies in the four LCCASPs and support the identification of domi-

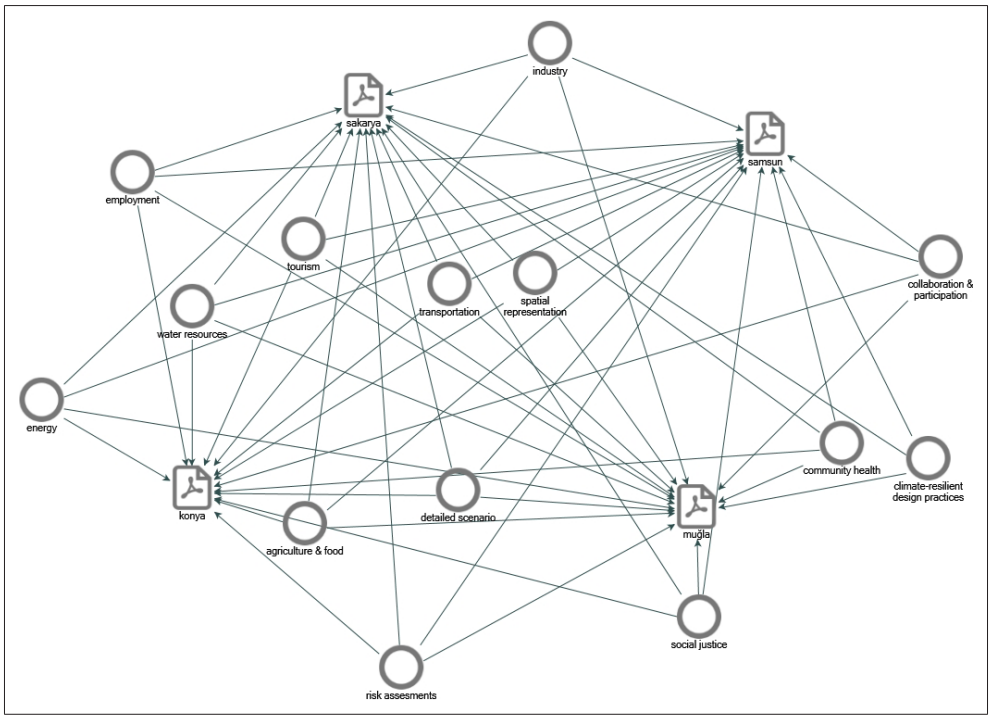
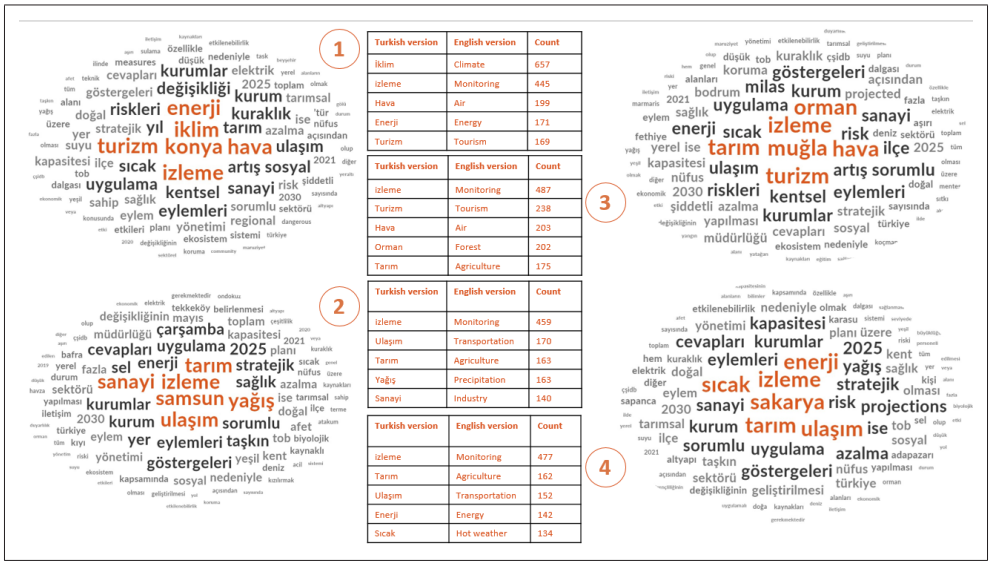


Figure 3. Relational mapping of climate adaptation priorities.

nant concepts (Figure 4). They are used as descriptive supplements to the coded analysis rather than as evidence of integration.

The word clouds reveal a shared vocabulary—particularly risk, climate, adaptation, monitoring, and implementation—alongside differences in sectoral emphasis. This standardized language coexists with the contrasting socio-ecological contexts summarized in Table 2. Themes such as water management in Konya, ecosystem protection in Muğla, drainage in Sakarya, and food or delta resilience in Samsun correspond to local vulnerabilities; however, the document comparison identifies limited explicit translation of these priorities into the pre-existing statutory spatial framework (Figure 4).

Differences in thematic distribution may reflect variations in local context, institutional experience, available evidence, and plan-preparation processes. Because these factors were not independently measured through interviews or organizational data, they are treated as plausible explanatory conditions rather than demonstrated causes. The results nev-



Turkish version	English version	Count
İklim	Climate	657
izleme	Monitoring	445
Hava	Air	199
Enerji	Energy	171
Turizm	Tourism	169

Turkish version	English version	Count
izleme	Monitoring	487
Turizm	Tourism	238
Hava	Air	203
Orman	Forest	202
Tarım	Agriculture	175

Turkish version	English version	Count
izleme	Monitoring	459
Ulaşım	Transportation	170
Tarım	Agriculture	163
Yağış	Precipitation	163
Sanayi	Industry	140

Turkish version	English version	Count
izleme	Monitoring	477
Tarım	Agriculture	162
Ulaşım	Transportation	152
Enerji	Energy	142
Sıcak	Hot weather	134

Figure 4. Word-cloud frequency visualizations for the four local climate adaptation plans.

ertheless show that place-based differentiation is necessary if a common national planning framework is to respond to distinct climate and spatial-development challenges.

Across the four cases, social justice, participation, monitoring, and institutional coordination are often expressed through similar formulations. This uniformity may indicate the influence of a common programme or planning template, but the documentary evidence does not establish the direction of policy transfer. More importantly, the statutory-plan comparison shows that frequently mentioned coordination objectives are not yet accompanied by clearly specified spatial-planning procedures, plan-revision triggers, or enforceable implementation responsibilities.

DISCUSSION AND CONCLUSION

This study assessed whether the thematic priorities of four 2025 LCCASPs are reflected in the existing statutory spatial planning framework. The results identify substantial attention to climate risks, strategic objectives, and sectoral actions within the adaptation plans, but limited explicit correspondence with mapped land-use decisions, binding plan provisions, or development controls in the older statutory plans. The central finding is therefore a baseline integration gap between strategic adaptation intent and spatial operationalization.

The LCCASPs share a broadly similar structure but differ in the emphasis placed on water, ecosystems, agriculture, tourism, transport, and other locally relevant systems. Some concepts—notably social resilience, participation, and employment—are repeated across the cases without always being connected to measurable spatial outcomes, green-economy transitions, or implementation responsibilities. This suggests that thematic completeness should not be treated as equivalent to context-sensitive or operational planning.

The comparison also clarifies the significance of temporal order. The statutory plans examined were enacted before the 2025 LCCASPs and therefore could not have incorporated those documents directly. The absence of correspondence should consequently be interpreted as evidence of the pre-existing planning baseline and of the scale of future integration required, rather than as proof that the new adaptation plans have already failed to influence subsequent plan revisions.

Two limitations should be noted. First, the study evaluates documentary alignment rather than implementation outcomes; interviews, institutional records, and project-level evidence would be required to test causal explanations concerning governance capacity or implementation performance. Second, the analysis captures a transitional legal moment: the statutory plans predate the 2025 LCCASPs, while Climate Law No. 7552 had only recently entered into force. Longitudinal research should therefore examine subsequent plan revisions and implementation decisions.

Climate Law No. 7552 introduces a new legal context by requiring climate strategies to be considered in public policy documents, establishing provincial coordination structures, and mandating local climate action plans. The Law strengthens the formal basis for integration, but the translation of climate priorities into spatial-plan designations, plan notes, development controls, financing, and monitoring procedures will depend on secondary regulation and implementation practice. Future statutory-plan revisions provide an important test of whether this emerging framework can close the documentary gap identified here.

The findings support three priorities for practice: a formal procedure linking LCCASP risk assessments to statutory-plan preparation and revision; spatial standards for converting risks and adaptation actions into mapped zones, plan provisions, and design requirements; and institutional arrangements that assign responsibilities, data-sharing protocols, monitoring indicators, and implementation resources. These mechanisms are necessary to move from thematic recognition to spatially accountable adaptation.

In conclusion, the four LCCASPs demonstrate increasing awareness of climate risk and provide a substantive strategic foundation for local adaptation. Their relationship with the existing statutory spatial framework remains limited, but the emerging legal context creates an opportunity for stronger integration. Realizing that opportunity will require explicit spatial-operationalization mechanisms and future empirical evaluation of how the new climate-planning obligations affect plan revisions and development decisions.

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Article

The Society of the Friends of İstanbul (İstanbul Şehri Muhipleri Cemiyeti) in light of new documents

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ABSTRACT

The Society of the Friends of Istanbul (İstanbul Şehri Muhipleri Cemiyeti/Société des Amis de Stamboul) (1911–1915), the first civil organization dedicated to preserving the natural and historical fabric of Istanbul during the Ottoman period, initiated pioneering efforts during its short period of activity. The emergence of the Society coincided with a period marked by both accelerated urban modernization initiatives and the widespread destruction of historical monuments in Istanbul. With a multinational membership, the Society was not only influenced by the social and political dynamics within the Ottoman Empire but was also positioned as a conduit for the expansionist cultural policies of European powers, particularly France. Through its publications, organized excursions, and conferences, the Society sought to cultivate public awareness among the Ottoman elite. By collaborating with state institutions, it prevented the demolition of numerous historical structures and facilitated their restoration. By encompassing both Byzantine and Ottoman legacies, the Society embraced Istanbul's multilayered cultural heritage. This research aims to illuminate the Society's activities, administrative structure, and unique position within the history of Ottoman preservation by utilizing primary documents obtained from contemporary newspapers, institutional archives, and personal archives that have received limited attention in the existing literature.

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INTRODUCTION

The modern consciousness of heritage emerged as a cultural byproduct of the French and Industrial Revolutions, where the destruction of monuments sparked a narrative of cultural awakening. With the establishment of the *Commission des Monuments Historiques* in 1837 and Eugène Viollet-le-Duc's conceptualization of restoration, France pioneered the state-centric preservation model, which spread across Continental Europe, the Americas, the Mediterranean, and East Asia. In 1877, with William Morris founding the Society for the Protection of Ancient Buildings (SPAB) and advocating anti-restoration and the honest preservation of historical layers[1], England's civic conservation model emerged as an alternative approach. Facilitated

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by advancing nineteenth-century communication networks, intellectuals, diplomats, and architects actively engaged in heritage protection through newly formed organizations (Swenson, 2013, p.56), with the SPAB directly influencing a broader network of Continental civic societies, most notably in Paris (1885), Rome (1890), and Dresden (1904).

Like other European nation-states and multinational empires, the inception of the modern preservation movement in the Ottoman Empire unfolded through state-centric initiatives. Although building maintenance prior to the 1839 Tanzimat Edict was sustained through endowments (*vakıflar*) driven primarily by religious, social, and economic imperatives, this traditional framework operated on a distinct philosophy of structural and functional continuity rather than a modern, secular heritage consciousness (Akbulut, 2020, p. 20). Following the *Tanzimat*, municipal interventions into Istanbul's urban fabric exacerbated tensions over its preservation. Throughout the nineteenth century, railway and bridge construction, port redevelopments, and the replanning of parcel and street networks following earthquakes and fires caused widespread destruction. While the capital faced this physical restructuring, concessions granted from the early nineteenth century exposed the Ottoman geography to large-scale looting and extraction by European actors. This extraction eventually compelled the state to take official countermeasures. In the 1840s, a circular prepared by the Sublime Porte *(Bâb-ı Âlî)* requested the provinces to identify ancient monuments and dispatch those of high value to the capital (Ortaylı, 1985, p. 1599). Although the Imperial Penal Law *(Cezâ Kanunnâme-i Hümâyûn)* of 1858 and the subsequent Regulations on Ancient Monuments *(Âsâr-ı Atîka Nizâmnâmeleri)* of 1874 and 1884 aimed to regulate antiquity ownership, prevent illicit export, and protect immovable properties, they offered a limited framework for safeguarding monuments (Açıkgöz, 2014, pp. 172–173).

As antiquities looting intensified, the Ottoman state gradually expanded its institutional preservation framework. Established in 1846, the Imperial Museum (Müze-i Hümâyûn) evolved into the principal authority for the protection of movable and immovable historical artifacts, operating under the Ministry of Education (Maârif Nezâreti), which subsequently supervised archaeological excavation permits, museum administration, and the control of antiquities exported abroad (Güngör, 2026, pp. 19, 22). Parallel to this public administrative oversight, the Imperial Buildings Depot *(Ebniyye-i Seniyye Anbarı)*, affiliated with the Privy Treasury Administration *(Hazine-i Hassa Nezâreti)*, oversaw the maintenance and restoration of dynastic assets (Yavuz, 2009, p. 28; Terzi, 2000, p. 66).

The proclamation of the Second Constitutional Era in 1908 and the rise of the Committee of Union and Progress *(İttihad ve Terakki Cemiyeti)* in national politics catalyzed the ascendancy of Turkism and cultural nationalism. This period initiated not only a political transformation within the Ottoman Empire but also radical shifts in municipal administration and urban development practices. Between 1908 and 1918, while grappling with consecutive conflicts, the Trablusgarp War (1911–1912), the Balkan Wars (1912–1913), and World War I (1914–1918), and severe economic crises, the Empire nonetheless sustained its infrastructural activities to restructure Istanbul through the lens of modern urban planning.

Within this constitutional framework, the institutional structure for monument protection took shape with the establishment of the Technical Committee for Construction and Restoration *(İnşâât ve Tâ'mirât Hey'et-i Fenniyyesi)* within the Ministry of Endowments *(Evkaf-ı Hümâyûn Nezâreti)* in 1908. In 1909, Architect Kemaleddin Bey, a prominent figure of the First National Architectural Movement, was appointed to lead the committee, subsequently pioneering Ottoman preservation by directing comprehensive restorations of major monumental complexes, including the Sultanahmet, Hagia Sophia, and Yeni Cami complexes (Yavuz, 2009, p.23). However, during the first decade of the twentieth century, the economic cycle of the endowment system was disrupted due to the financial crises, wars, and budget deficits experienced. Consequently, the 1911 Law on the Conversion of Ruined Endowed Buildings and Endowed Lands into Cash *(Harâb Mebânî-i Vakfiyye ile Vakıf Arsalarının Nakde Tahvili Hakkında Kanun)* came into force. Under this legislation, structures deemed unusable were demolished and their plots monetized, leaving certain historical buildings to disappear entirely, even though a portion was reconstructed under the same name and function using the generated revenue (Sıçrayık, 2019, pp. 32, 43).

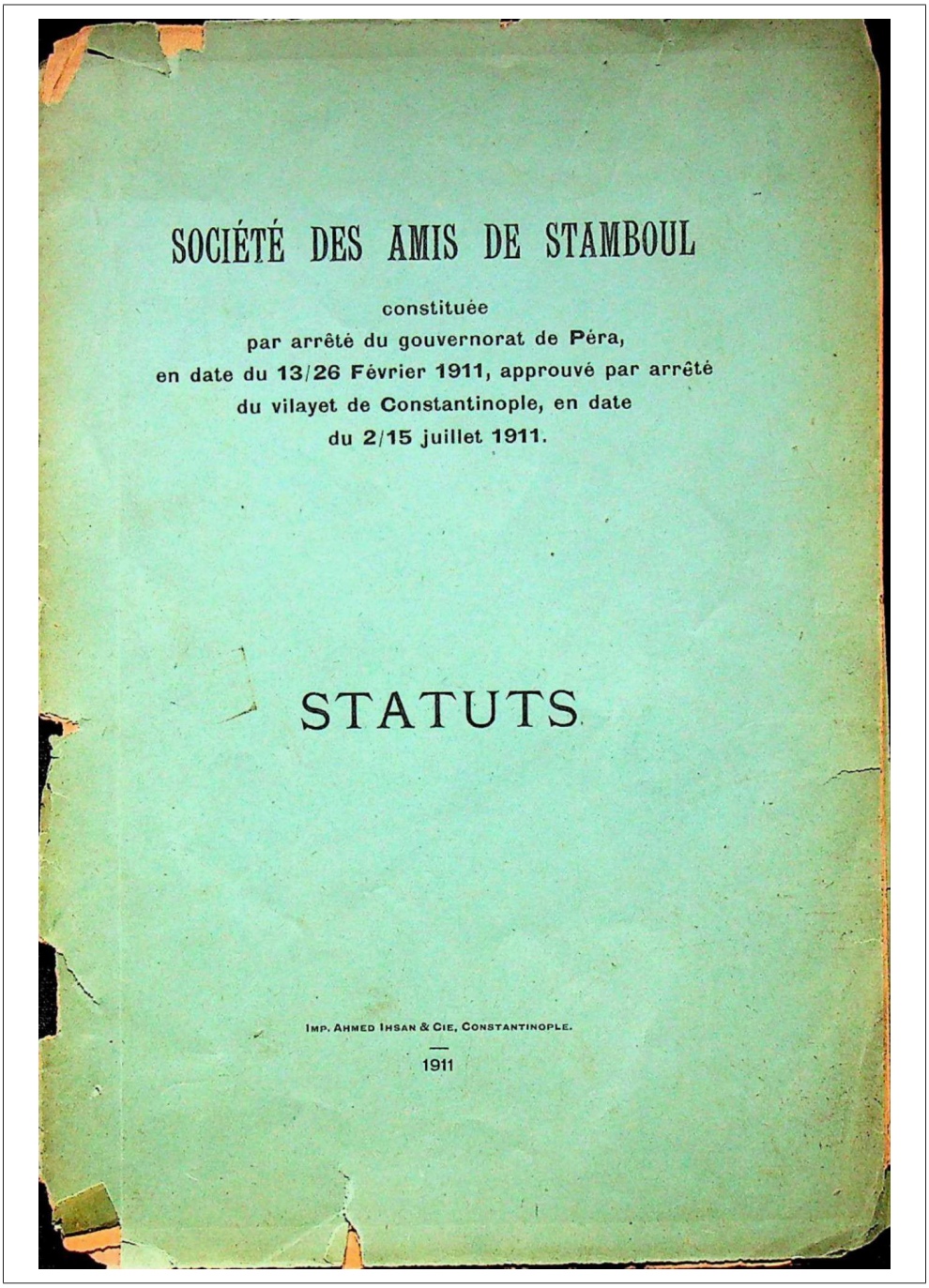
This systematic loss, compounded by the acceleration of modern urban development and the subsequent deterioration of Istanbul's historical fabric, gave rise to growing concern over the disappearance of the city's historical traces. Projects such as the reconstruction of the Galata Bridge *(cisr-i cedîd)*, the opening of Eminönü Square, and the widening of major arteries (Hagia Sophia Square–Karaköy, Şehzade Police Station–Fatih, Koska–Aksaray) inflicted significant damage to the historic built environment (Kanberoğlu, 2019, p. 164). In response to this destruction, however, the 1912 Regulation on the Preservation of Monuments (*Muhâfaza-i Âbidât Hakkında Nizâmnâme)* marked a significant step by introducing a formal approval system for demolitions and explicitly recognizing the heritage value of structures such as the city walls (Açıkgöz, 2014, pp. 172–173).

Simultaneously, a critical voice emerged against urban plans and practices that inadequately safeguarded Istanbul resulting in the establishment of the Society of the Friends of Istanbul *(İstanbul Şehri Muhipleri Cemiyeti/Société des*

[1] In the nineteenth century, *preservation* carried a meaning similar to its contemporary definition, implying the safeguarding of a structure from detrimental elements and executing only the necessary repairs to maintain its physical integrity. In contrast to modern practice, *restoration* during the same century often entailed the demolition of a building, either partially or entirely, to reconstruct it in a manner that frequently failed to reflect its authentic architectural style (Donovan, 2007, p. 2).

Amis de Stamboul). Formally initiated in 1911 upon the proposal of Madame Gabrielle Bompard de Blignières, wife of the French Ambassador Maurice Bompard, through a joint effort of the Ottoman bureaucratic elite and foreign diplomats, the Society stood as a pioneering civic organization. It collaborated with public institutions to document and preserve seventeenth- and eighteenth-century Ottoman monuments while safeguarding Byzantine heritage through excavations. Beyond technical preservation, the Society aimed to cultivate public awareness via excursions, conferences, and publications. However, its multinational composition hindered institutional continuity; the outbreak of World War I rendered its local operations untenable, leading to the Society's dissolution in 1915 despite short-lived efforts to maintain a Paris branch.

While existing scholarship has primarily relied on the Society's 1911 statutes and 1913 general report, newly identified


SOCIÉTÉ DES AMIS DE STAMBOUL

constituée
par arrêté du gouvernorat de Péra,
en date du 13/26 Février 1911, approuvé par arrêté
du vilayet de Constantinople, en date
du 2/15 juillet 1911.

STATUTS

IMP. AHMED IHSAN & CIE, CONSTANTINOPLE.

1911

Figure 1. The cover page of 1911 Statutes of the Society (Société des Amis de Stamboul: Statuts, 1911b).

sources, including the Ottoman and French press, institutional archives, and personal papers, offer deeper insights into its activities. In this paper, newly identified documents pertaining to the Society are presented to contribute to an understanding of Istanbul's preservation history.

ESTABLISHMENT AND ADMINISTRATIVE ORGANIZATION OF THE SOCIETY

In her memoirs, titled *Au fil des jours* (Throughout the Days), drafted between 1935 and 1942, Madame Bompard recounts her initiative to propose the establishment of a society for the preservation of antiquities to Halil Edhem Bey, the Director of the Imperial Museum who had pioneered the systematic documentation and cataloging of cultural heritage through his scholarly publications. Furthermore, she portrays Halil Edhem Bey as a complex personality, noting that she initially introduced the idea to İsmail Cenani Bey—the French-educated Minister of General Ceremonies *(Teşrîfât-ı Umûmiyye Nâzırı)* who, although having no direct influence on heritage conservation, became her preferred choice due to his French background (Blignières-Bompard, 2016, pp. 27–28). Behind her endeavors lay not only the goal of preserving and promoting Istanbul's urban heritage, but also a strategic dimension linked to France's efforts to expand its cultural influence within the Ottoman Empire. She further expressed the hope that the Society would eventually pave the way for either an extension of the *École française d'Athènes* (French School at Athens) in Istanbul or an independent French Institute (Blignières-Bompard, 2016, pp. 27–28).

The Society's founding core consisted of eight members: Halil Edhem Bey, İsmail Cenani Bey, Madame Bompard, a representative of the Sultan, and a representative of the Prefecture of Istanbul *(Şehremâneti*), alongside delegates from the Ministries of Education *(Maârif)*, Endowments *(Evkaf)*, and Public Works *(Nâfia)*. Throughout the six-month foundational period, the group convened every Monday at the Imperial Museum to submit and discuss their respective reports (Blignières-Bompard, 2016, p. 28). Thus, the Society was officially established by the decree of the Governorate of Pera *(Beyoğlu Mutasarrıflığı)* on 26 February 1911 (Rumi: 13 February 1326[2]) and subsequently approved by the Vilayet of Istanbul *(İstanbul Vilâyeti)*[3] on 15 July 1911 (Rumi: 2 July 1327) (İstanbul Şehri Muhibbleri Cem'iyyeti Nizâmnâmesi, 1327, p.1) The Society's statute was prepared in 1911 and published in four printed editions[4].

The establishment and operational framework of the Society must be evaluated in tandem with contemporary international civic preservation initiatives. Specifically, the Société des Amis de Versailles (SdAV), founded in 1907 for the protection of the Versailles Palace, served as a direct organizational and administrative model for the Society. This institutional transfer is verified by a draft of the Society's statutes preserved in the French Diplomatic Archives (*La Courneuve, No.83*), which demonstrates that the Society's regulations were explicitly adapted from those of the SdAV (Figure 2). Accordingly, the administrative system, membership statuses and conditions, and operational rules were formulated by drawing direct references from the SdAV's statute. (Ministère des Affaires étrangères, n.d.).

According to the first article of the statute, the Society was established to render Istanbul's aesthetic and artistic values visible through publication, while simultaneously aiming to support authorities in safeguarding the city's historical monuments, natural landscapes, and traditional appearance. The headquarters of the Society was located at the Imperial Museum (now Istanbul Archaeological Museums). The administrative structure of the Society consisted of three bodies: the Executive Committee *(Bureau, Hey'et-i İdâre),* the Administrative Council (*Conseil d'Administration, Meclis-i İdâre*)[5], and the Initiative Committee *(Comité d'Initiative, Hey'et-i Müteşebbise).*The Administrative Council was composed of eighteen members, who subsequently elected a president, two vice-presidents, and a secretary-general from among their own numbers to form the Executive Committee

2 During the late Ottoman period, three calendar systems were used: the lunar Hegira (*Hijri*) for religious matters, the solar Rumi for fiscal and administrative business, and the Gregorian for international and French-language press relations. While original dates are cited for archival accuracy, their Gregorian equivalents are used throughout this study for chronological consistency.

3 This study uses the Prefecture of Istanbul for the Şehremâneti (municipal administration), following the Society's French documents which employ La Préfecture de la Ville to distinguish it from the provincial governorship (*Vilâyet*). While "Istanbul" is added here for spatial clarity, subordinate district offices (*daireler*) are referred to as Municipalities per the original sources. A formal distinction is maintained between the Prefecture, holding municipal jurisdiction, and the Vilayet of Istanbul, representing the provincial administration under the Governor (*Vali*).

4 The first was issued in Ottoman Turkish at the Mahmud Bey Press in 1911/1912 (Rumi: 1327) (İstanbul Şehri Muhibbleri Cem'iyyeti Nizâmnâmesi, 1327.). In the same year, two French editions were published at the Ahmed İhsan Press (Société des Amis de Stamboul: Statuts, 1911a; 1911b). The latter (1911b) includes an additional note listing the professional and administrative roles of the Society's Administrative Council (*Meclis-i İdâre*) members (Gündoğdu, 2004, pp. 15–16). The fourth edition, published in French in 1912 by the Ahmed İhsan Press, is identical in content to the 1911 version printed at the same press (Société des Amis de Stamboul: Statuts, 1912).

5 The other members of the Administrative Council included: Ahmed Midhat Efendi, a professor at the Darülfünûn; İsmail Cenani Bey, Minister of General Ceremonies (*Teşrîfat-ı Umûmiyye Nâzırı*); Emrullah Efendi, Minister of Education (*Maârif Nâzırı*); Cavid Bey, former Minister of Finance (*sabık Maliye Nâzırı*); Diran Kelekyan, editor-in-chief of the Sabah newspaper; Monsieur Paul Révoil, General Manager of the Ottoman Bank (*Bank-ı Osmanî*); Arif Bey Master of Ceremonies to the Khedive (*Hıdîv Hazretlerinin Teşrîfât Nâzırı*); Abdurrahman Efendi, former Minister of Education (*sabık Maârif Nâzırı*); İsmet Bey, member of the Municipal Council (*Şehremâneti Meclisi*); Theodor Makridi Bey, curator at the Imperial Museum; Nusret Bey, former member of the Council of State (*Şûrâ-yı Devlet sabık azası*); Vedad Bey (Figure 3), architect and professor at the School of Fine Arts (*Sanâyi-i Nefîse Mektebi*); Hoca Efendi, member of the Council of State; and Yusufyan Efendi, member of the Grand Council of Education (*Meclis-i Kebîr-i Maârif*).

Megaron, Vol. 21, No. 3, pp. 438–460, September 2026

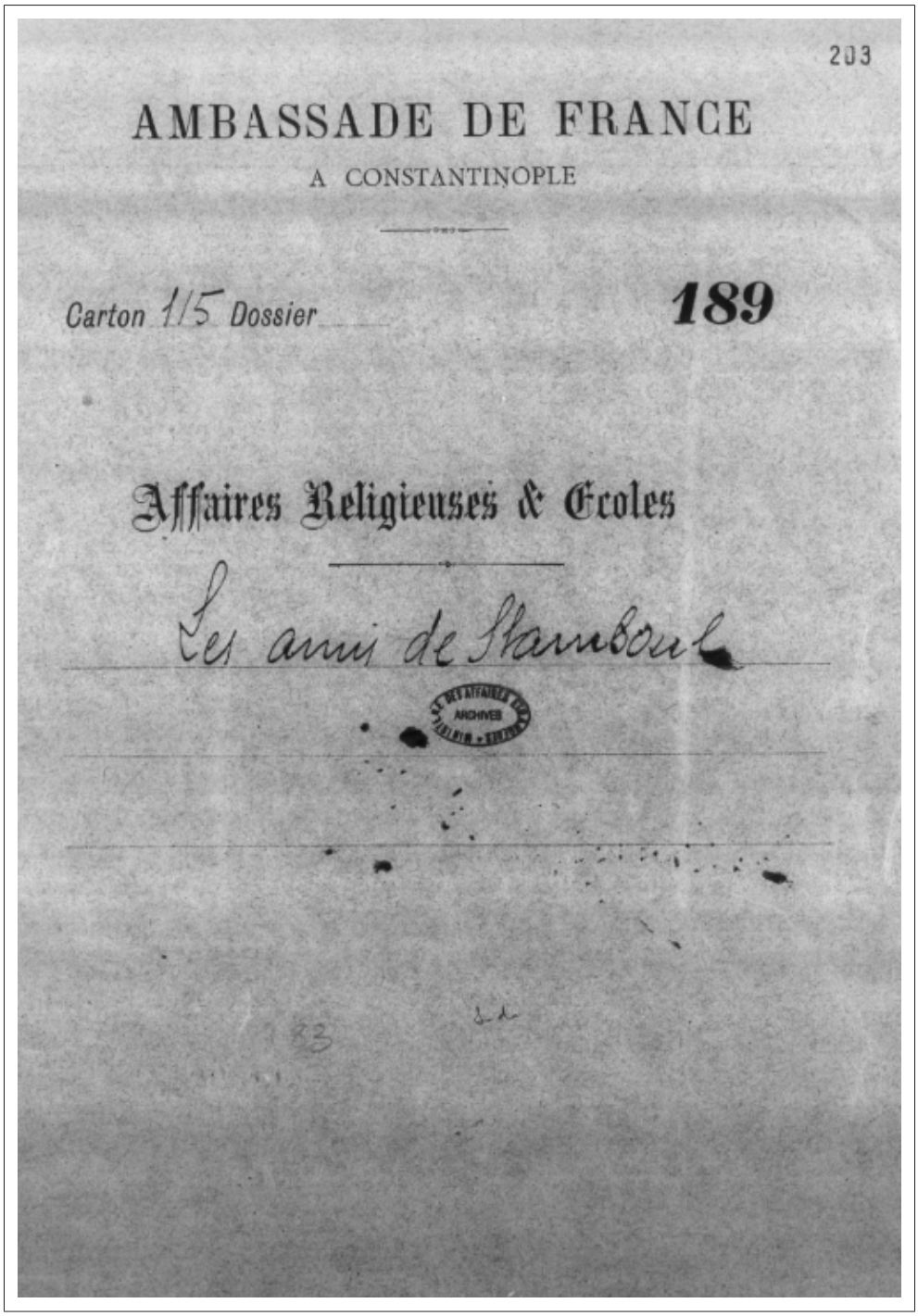


Figure 2. Cover page of the Society's draft statutes (Ministère des Affaires étrangères, n.d.).

(Cem'iyyet Nizâmnâmesi, 1327, pp.3-4; Statuts, 1911a, pp.2-3). This Executive Committee was formally established with the election of Said Halim Pasha, President of the Council of State *(Şûrâ-yı Devlet)*, as the Society's President *(Reis)*. Halil Edhem Bey, Director of the Imperial Museum, and Count Leon (Walerian) Ostroróg, advisor to the Ministry of Justice *(Adliye Nezâreti)*, served as Vice Presidents *(Reis Vekili)*, while the position of General Secretary *(Kâtib-i Umûmî)* was entrusted to Vahid Bey—chief clerk of the Public Debt Administration *(Düyûn-ı Umûmiyye)*, who had already spearheaded the documentation of the Imperial Museum's collections through his 1907 guidebook, Müze-i Hümâyûn-u Osmaniye Mahsus Muhtasar Rehnüma (Cem'iyyet Nizâmnâmesi, 1327, p.4; Naipoğlu, 2008, p. 111).

The Society of the Friends of Istanbul operated in close cooperation with the public institutions responsible for the

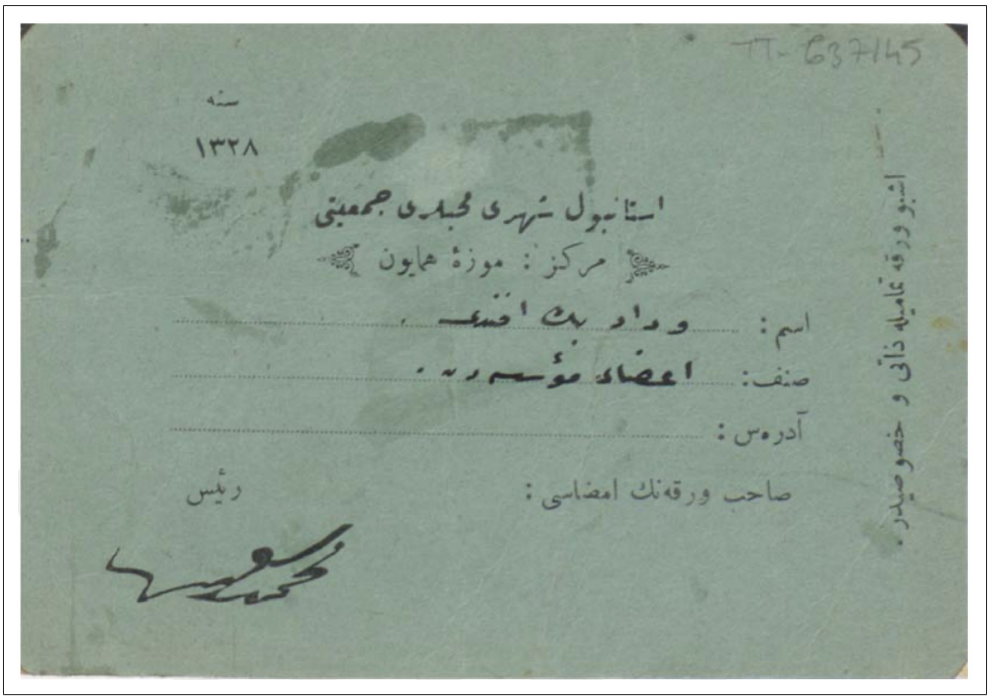


Figure 3. Membership card of Architect Vedad Bey, a member of the Administrative Council of the Society (Gümüş, 2024, p. 174).

preservation and maintenance of antiquities. The inclusion of representatives from these institutions among the Society's members ensured continuous coordination with the relevant authorities. Throughout its operational framework between 1911 and 1915, when the Society was unable to secure sufficient funding for restoration projects, it prevented the demolition of several structures and secured their repair either by mobilizing public opinion through conferences and site visits or by submitting formal petitions.

ACTIVITIES OF THE SOCIETY (1912–1915)

The Introduction of the Society to the Public

Although the Society was officially established in 1911, it did not become fully operational until 2 February 1912 (Rapport Général, 1912, p.1). The Society's activities were concentrated across four primary axes: promoting the organization to the public, preventing urban destruction resulting from modernization pressures and vandalism, organizing excavations for Byzantine monuments, and fostering preservation awareness through conferences and publications. Starting from March 1912, the Society pursued an active outreach strategy by publishing a series of news and articles in major Ottoman newspapers to enhance its public visibility. The article *titled İstanbul Şehri Muhibbleri Cem'iyyeti: Maksad ve Faâliyet* (The Society of the Friends of Istanbul: Purpose and Activities) in *Sabah* and *Tanin* on 3 March 1912 indicated that the 1911 statute had been submitted to Sultan Mehmed Reşad for approval, reflecting the Society's pursuit of legitimacy both bureaucratically and publicly. It emphasized that, as seen from Çamlıca Hill, Istanbul's natural and architectural beauties rivaled those of other ancient European cities, and that preservation efforts similar to those implemented there were necessary (Sabah, 3March 1912, p.2, col.7–p.3, col.1; Tanin, 3 March 1912, p.2, col. 5-6) Following this conceptual introduction, on 13 March 1912, the imperial press issued announcements inviting individuals to join the Society by applying directly to Vahid Bey (Sabah, 13 March 1912, p.3, col.4).

Another key figure in the Society's promotional efforts was Charles Diehl, a member of the *Institut de France* renowned for his research on Byzantine Istanbul. Diehl's article, titled *İstanbul Şehri Muhibbleri Cem'iyyeti* was published in the newspapers *Sabah* and *Tanin* on March 5, 1912 (Diehl, *Sabah*, 5 March 1912, p. 3, cols. 1–2; Diehl, *Tanin*, 5 March 1912, p. 3, cols. 1–2). The text was also issued as a brochure in both French (Figure 4) and Ottoman Turkish (Diehl, n.d.-a; Diehl, n.d.-b). In the article, Diehl framed the modernization efforts in Istanbul as a threat to the city. He argued that planned infrastructure projects such as sewerage, lighting, and transportation networks brought Istanbul to the brink of transformation while also uncovering remnants of the Byzantine period. When discussing the city's heritage, he included both Byzantine monuments such as Hagia Sophia and the Hippodrome, and Islamic-era structures including Topkapı Palace and the mosques of Fatih, Bayezid, Süleymaniye, and Sultanahmet, emphasizing a comprehensive preservation approach. Accordingly, he argued that Istanbul should not become a soulless, Ameri-

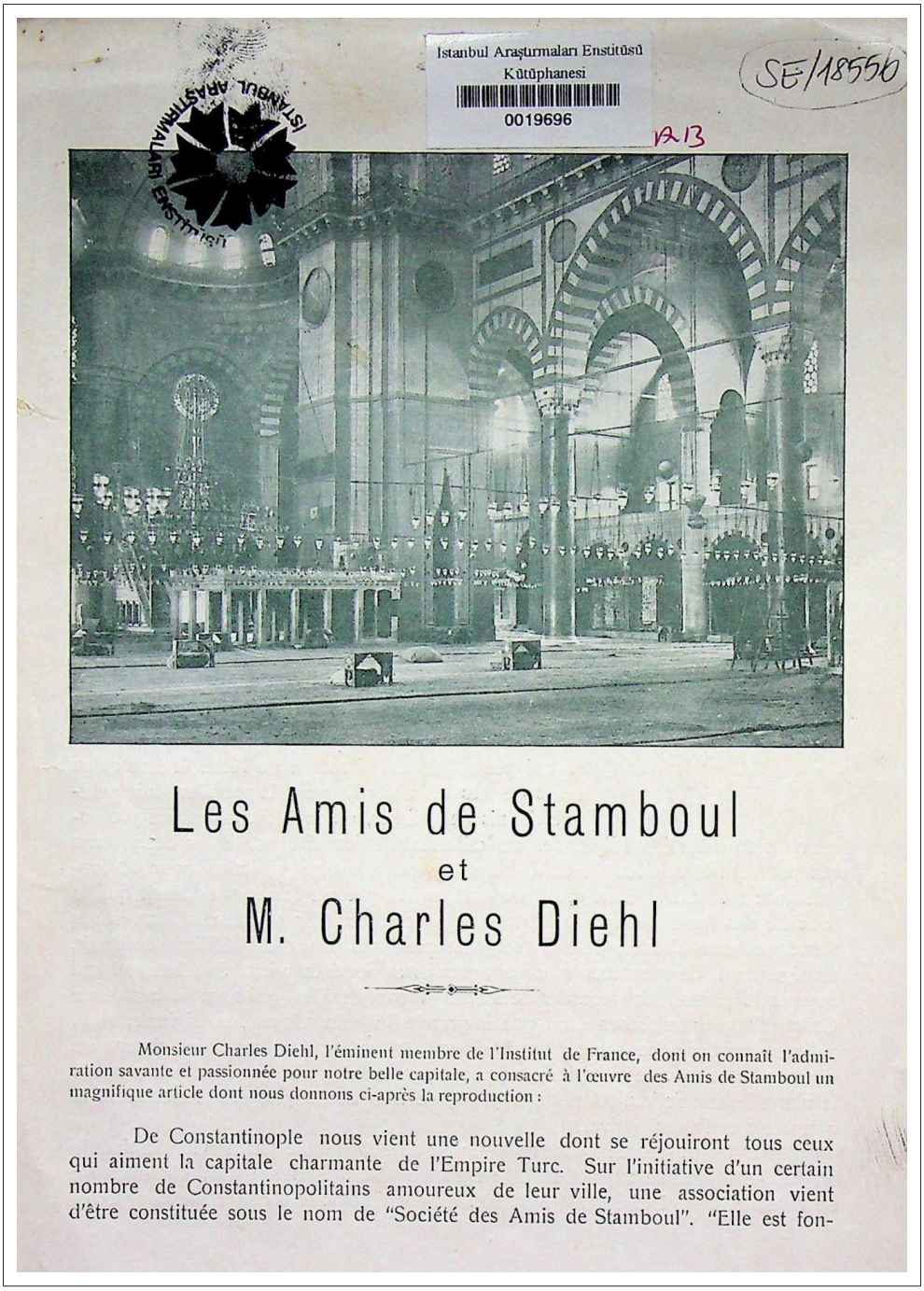


Figure 4. The first page of the French brochure of Charles Diehl's article (Diehl, n.d.-a).

can-style city driven by modernization. Diehl stressed the importance of not only preserving monuments but also documenting their current conditions (Diehl, n.d-a; Diehl, n.d.-b). These statements reflect the Society's preservation philosophy, showing that both Byzantine and Ottoman heritage were valued, and that archaeological work played a central role in conservation efforts.

Beyond the daily press, periodic publications also played a significant role in articulating and disseminating the organization's objectives. *Oriens: Revue Internationale Illustrée/Internationale Illustrierte Zeitschrift*, published between 1912 and 1913, served as a platform that directly reflected the organization's objectives during its brief run (Figure 5). The journal was edited by Dr. Max Rudolf Kaufmann—a Swiss journalist and orientalist on the editorial staff of the *Osmanischer Lloyd* and a member of the Society. The journal frequently featured contributions from the Society's members and pursued an editorial policy centered on Istanbul's historic monuments and

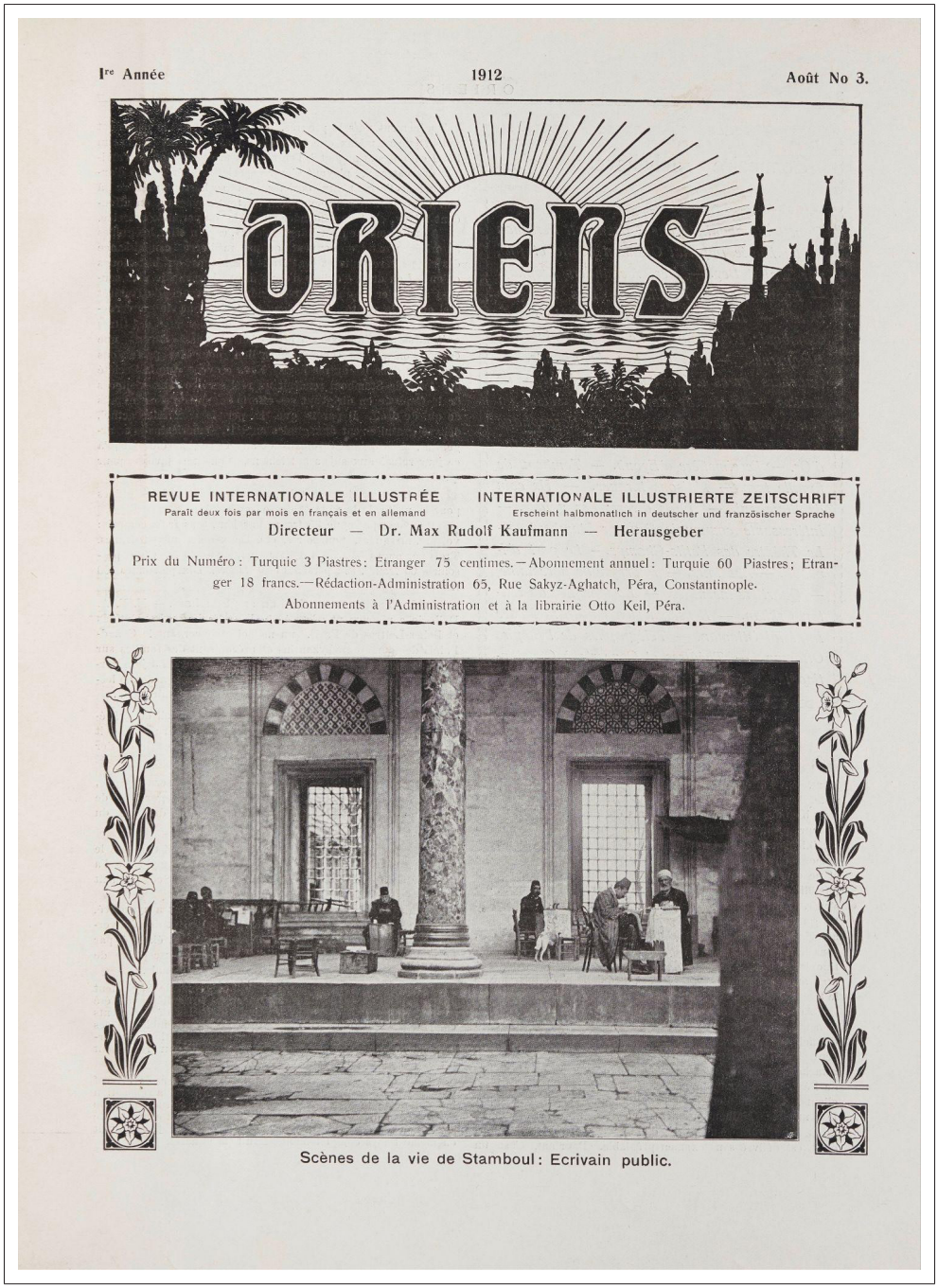


Figure 5. The cover page of Oriens: Revue Internationale Illustrée, No. 3 (Oriens, August 1912, No.3).

architectural heritage. Published bilingually in German and French, the journal was described in the *Schwäbischer Merkur* on 25 September 1912 as the official periodical of the Society; however, neither the Society's general reports nor the extant issues of the journal include such an explicit statement. Nevertheless, the German and French press emphasized that the journal aimed to reflect the objectives and aspirations of the Society (Norddeutsche allgemeine Zeitung, 17 August 1912; La Jeune Turquie, 3 July 1912). Count Leon Ostroróg, a French jurist who served as a legal advisor to various Ottoman ministries and was a prominent member of the Society, published an article titled *Les Amis de Stamboul* in the inaugural issue of the journal dated July 1, 1912. This introductory text outlines the significance, objectives, and goals of the Society's establishment. Emphasizing the vital contribution of civil initiatives alongside public efforts in countries where preservation awareness has developed, Ostroróg argues that the formation of such organizations in Istanbul is both legitimate and essen-

tial (Ostroróg, 1912, p. 2).

In parallel with these press and publication activities, the Society also sought to extend its international outreach, particularly within the French cultural sphere. French poet, playwright, and novelist Jean Richepin (1849–1926) had promised to write an article on the Society for the *Figaro* newspaper, a commitment for which the Society expressed its preemptive gratitude in its 1912 general report. Additionally, Richepin's plans to deliver a lecture at the *Université des Annales* following his visit to Topkapı Palace were intended to support the Society's activities (Rapport Général, 1912, p.1). There is no evidence, however, that the article was published or that the lecture took place.

Institutional Collaboration: Countering Urban Destruction and Vandalism

Threats to historical structures from infrastructure and urban development projects in Istanbul prompted the Society to collaborate with public institutions. In a petition submitted to the Ministry of the Interior on April 23, 1913, the Society insisted that Istanbul's general mapping and subsequent street reorganization should not damage monumental or sacred heritage (BOA, BEO, 4165/312345; DH.MUİ., 166/9). A prominent example was the road expansion for Istanbul's electric tramway, specifically the Beyazıt-Edirnekapı route, which mobilized the Society by threatening several historical buildings (Rapport Général, 1912, p. 2). Among these was the Feyzullah Efendi Madrasa and Library (now the Millet Manuscript Library), built in 1700–1701 (Hijri: 1112) by Sheikh al-Islam *(Şeyhülislâm)* Erzurumlu Seyyid Feyzullah Efendi (Kütükoğlu, 1977, p.321). Located on Macar Kardeşler Street, part of the complex fell within the planned road boundaries and faced demolition under the initial widening project (Figure 6). The Society successfully intervened by framing the madrasa not merely as an isolated monument, but as an integral part of the urban aesthetic fabric of the area, thereby halting the planned demolition (Rapport Général, 1912, p.2). Although this intervention saved the building from the 1912 tramway expansion, the

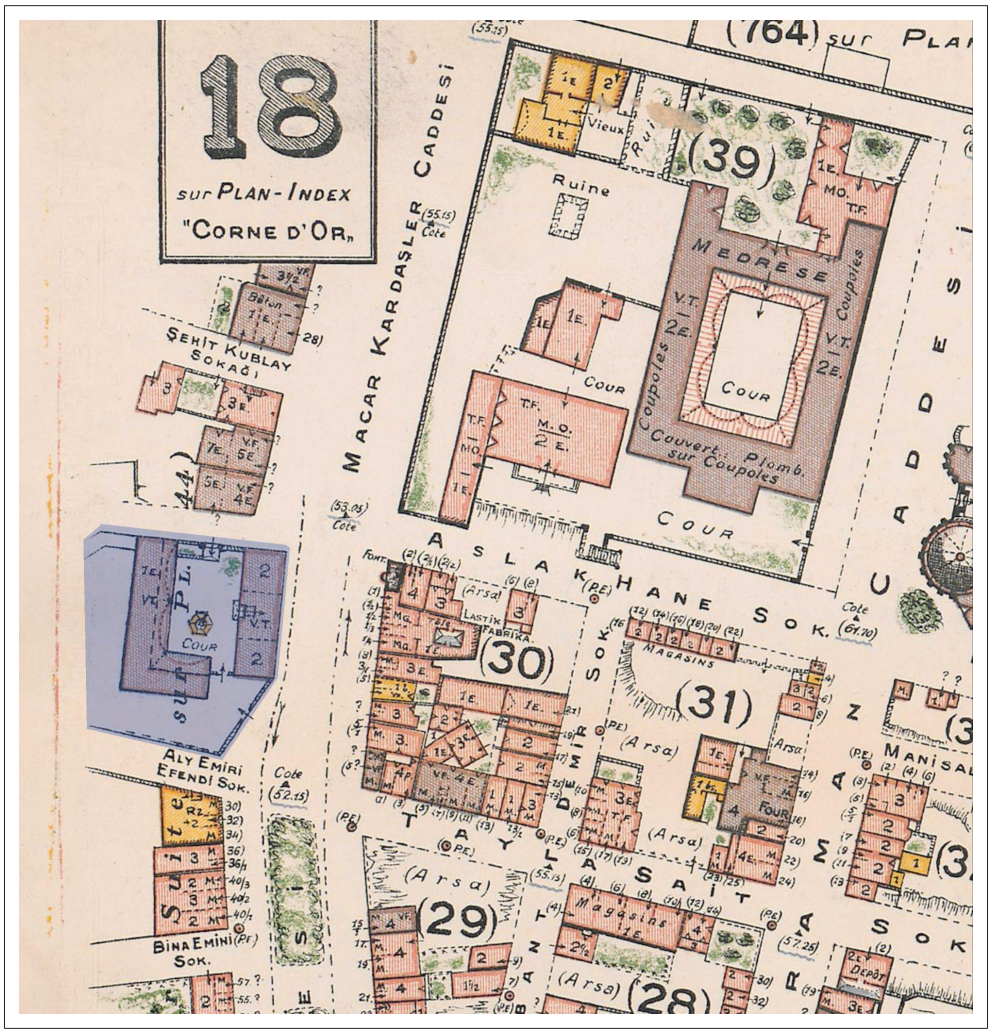


Figure 6. Location of the Feyzullah Efendi Madrasa and Library on the Pervititch Map (Pervititch, 1933, No. 18, SALT Research).

long-term preservation of the structure remained uncertain. Subsequent architectural assessments in 1914 revealed that the structure had become severely dilapidated (Kütükoğlu, 1977, p.321; Diren, 2003, pp.25–26). Consequently, four years after the Society's initial opposition, the madrasa was finally secured through a full-scale restoration initiated in 1916 by Minister of Endowments Hayri Bey (Altan, 1935, p. 224).

The 17th-century Ebu'l-fazl Mahmud Efendi Madrasa faced similar demolition threats by the Prefecture of Istanbul *(Şehremâneti)* due to the same Beyazıt–Edirnekapı electric tramway project (Kütükoğlu, 1977, p. 316; Figure 7). The bureaucratic struggle for the monument began in October 1912, when negotiations between public authorities resulted in a formal compromise to relocate, rather than entirely demolish, the madrasa (BOA, MV., 170-51; BOA, BEO, 4104-307735; ŞD, 199-19). Despite this protective decision, administrative pressure grew rapidly; a letter by Chief Architect Kemaleddin Bey published in the journal *Türk Yurdu* (Vol. 3, No. 6) indicates that actual demolition works commenced just a month later, in November 1912. The pro-modernization press openly backed the Prefecture's actions; for instance, an article in the newspaper *Tasvir-i Efkâr* dated 9 December 1912 sharply criticized the Ministry of Endowments for delaying the tramway infrastructure with its conservationist stance (Tekeli & İlkin, 1997, pp. 110–112). Confronted by this aggressive urban transformation, the Society, alongside the Prefecture, intervened directly during the 1912 Direklerarası road expansion. While they could not completely halt the project, their joint intervention successfully prevented the structure's total eradication, preserving its remaining architectural footprint (Rapport Général, 1912, p. 2).

This struggle against infrastructure-led urban transformation was not an isolated case; similar tensions emerged prominently within the historical core of the city, most no-

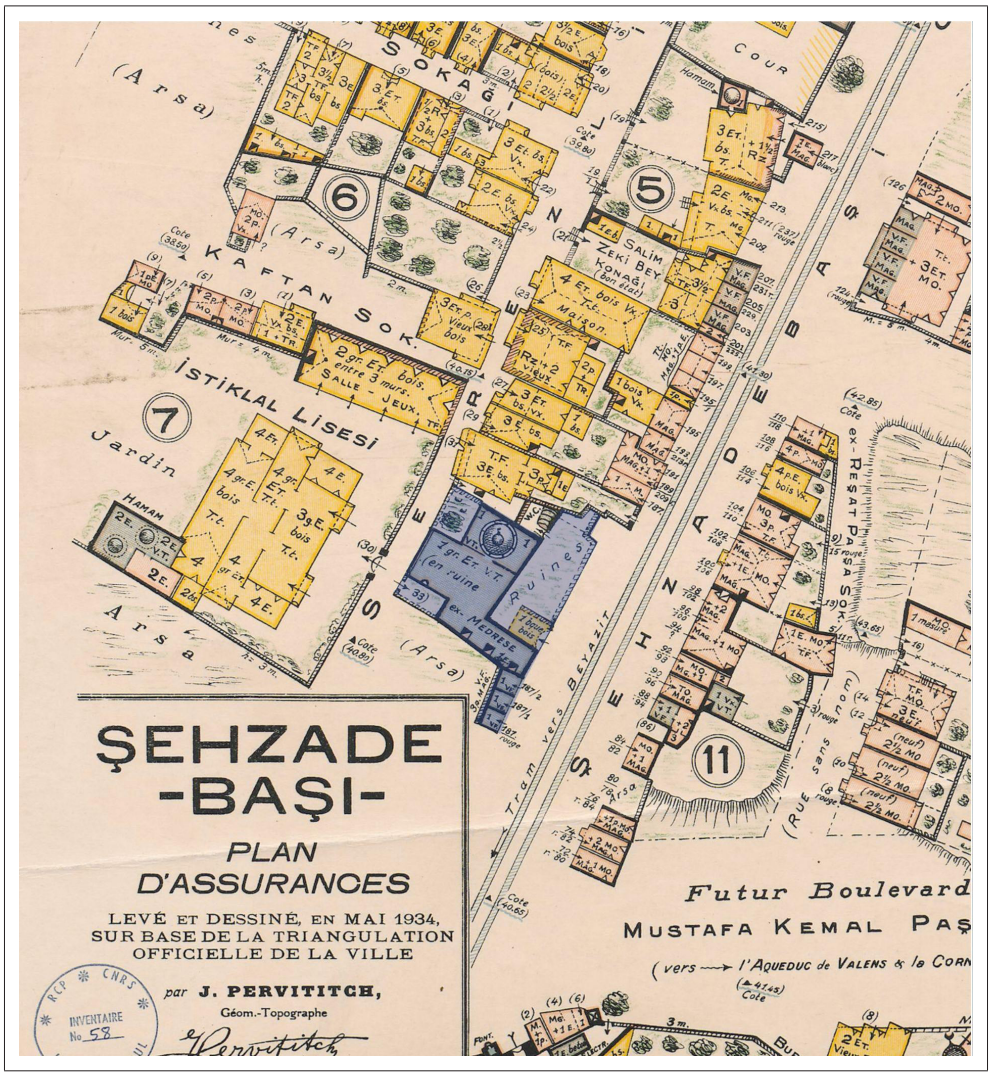


Figure 7. Location of the Ebu'l-fazl Mahmud Efendi Madrasa on the Pervititch Map (Pervititch, 1928, No. 37, SALT Research)

tably regarding the transformation of the Topkapı Palace grounds. The Prefecture's project to convert Topkapı Palace's outer courtyard into a public park led to the damage of certain palace sections, a development that the Executive Committee monitored closely. This project was spearheaded by Cemil (Topuzlu) Pasha (1912–1914), the Prefect of Istanbul (Şehremini), which represented a fundamental clash of modernizing visions: the municipal drive to create modern public green spaces versus the civic preservationist reflex aimed at safeguarding historical integrity (Rapport Général, 1913, p. 5). Among those opposing his development practices, Madame Bompard was particularly prominent. In response, the Ministry of the Imperial Treasury issued a memorandum requesting that Cemil Pasha halt the demolition; however, he disregarded the warning and continued the work. During the process, the discovery of a Byzantine church and a cistern provided significant archaeological evidence (Figure 8) that ultimately vindicated the concerns of both the Society and Madame Bompard (Topuzlu, 2004, pp.134–136). On 11 September 1913 (Rumi: 29 August 1329), the park was officially inaugurated (Servet-i Fünûn, Servet-i Fünûn, 18 Eylül 1913, pp.449–450).

Urban regulations were not the only threat to Istanbul's monuments; vandalism also posed a significant risk to the city's historical heritage. The city walls, in particular, suffered significant damage. In 1912, the Society took the lead, together with local authorities, in initiating a series of measures to protect the city walls (Rapport Général, 1912, p.2). Prompted by an *Osmanischer Lloyd* article on the ongoing destruction of the city walls (Figure 9), the Society petitioned the Prefecture of Istanbul. The presence of İsmet Bey, a member of the Council of the Prefecture, among the Society's members demonstrates the close ties between the Society and the municipal administration. Following this inquiry, The Prefect, Tevfik Bey (1911-1912) confirmed the damage and, despite the patriotic motives[6] of the perpetrator, initiated legal proceedings. He issued strict directives across all municipal units, threatening severe consequences for future negligence, while cautioning other municipal departments.To ensure site security, watchmen (*kolcular*) from the Ottoman Tobacco Regie were stationed in booths along the walls; these personnel were mandated to report any damage to both the Prefecture and the Imperial Museum (Rapport Général, 1912, p.2). On 25 April 1912, General Secretary Vahid Bey published notes in *Sabah* and *Tanin*, thanking municipal officials for supporting these nationally significant preservation efforts (Sabah, 25 April 1912, p.3, col.3; Tanin 25 April 1912, p.4, col.3)

In 1913, the Executive Committee expanded its scope to address the architectural deterioration of monuments caused by prolonged institutional neglect and natural disasters. The Society submitted an urgent-repair list to Minister Hayri Bey, successfully prompting the Ministry of Endowments to re-lead the dome of the İbrahim Pasha Mosque and restore the Süleymaniye and Şehzade tombs, while the Soci-



Figure 8. Relics of ancient antiquities discovered during the landscaping of Sarayburnu Park (Servet-i Fünûn, Rumi: 21 November 1329, p. 23).

6 The report published in the newspaper Sabah on 25 April 1912 emphasizes that although the individual responsible for damaging the land walls was understood to have acted out of patriotic motives, they would nonetheless face legal prosecution. This report serves as a critical document demonstrating that historical preservation awareness was increasingly framed through and intertwined with a sense of national values



Figure 9. The Walls of Theodosius in 1911 (Gertrude Bell Archive, 1911).

ety itself undertook the clearance of destructive vegetation from the Tophane Fountain (Figure 10, Figure 11) (Rapport Général, 1913, p.1). This collaboration with the Ministry also extended to complex urban projects, such as the two-year restoration of the Yeni Mosque under the supervision of Architect Kemaleddin Bey, which included removing unauthorized structures adjacent to the Sultan's quarters. Beyond managing large-scale restorations, the Society functioned as a meticulous field observer dedicated to the preservation of architectural memory. Its executive members carefully documented localized vandalism and heritage theft, taking immediate official action before the Ministry after discovering that the historic door knocker of the Nuruosmaniye Mosque had been illicitly removed and that the decorative metal studs on the monumental doors of the Sultanahmet Mosque were missing (Rapport Général, 1913, p.1).

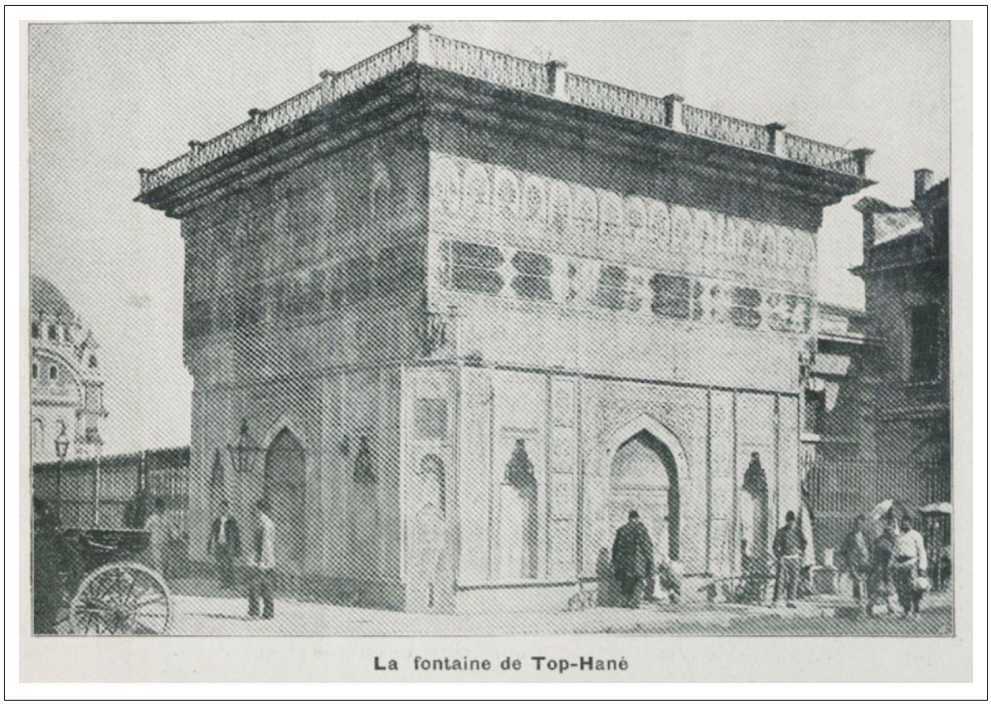


Figure 10. The Tophane Fountain (Oriens, September 1912, No. 6, p.1).



Figure 11. The Tophane Fountain, April 2013 (Photo by Caner Cangül).

Claiming the Byzantine Heritage: The Inaugural Excavations

Istanbul's architectural landscape is a dense weave of layers spanning the Roman, Byzantine, and Ottoman eras, many of which had fallen into disrepair. This was particularly crucial as modernization initiatives increasingly endangered these dilapidated structures. A critical turning point was the expansion of rail transportation; at the turn of the 20th century, the Orient Express connected Paris to Istanbul, transforming the city into a prominent destination for European travelers. However, the extension of railway infrastructure along the shoreline posed a significant threat to the historic heritage and archaeological remains situated on the coastal edges of the peninsula. Specifically, the 1910–1912 double-tracking between Sirkeci and Yeşilköy endangered the Boukoleon Palace (Justinian Mansion) (Figure 12), situated near the Ahırkapı-Çatladıkapı walls. In 1912, the Society intervened to prevent the palace's partitioning by a newly constructed wall (Rapport Général, 1912, p.2).

The Society maintained its focused interest in the Boukoleon Palace. Starting in 1912, the Society allocated a budget of 150 liras to finance the first excavation at the Boukoleon Palace, a site for which it had undertaken preservation efforts. At the personal request of Madame Bompard, Architect René Mesguich, a graduate of the École des Beaux-Arts in Paris, agreed to carry out the work free of charge. This excavation is notable for being the first conducted in Istanbul after the 1908 dig at the İmrahor İlyas Bey Mosque by the Russian Archaeological Institute of Constantinople. The first phase of the excavation, which began on 29 September 1913, continued until December. Mesguich presented a report on the excavation process to the *Académie des Inscriptions et Belles-Lettres*, which was subsequently published in the session records of the Academy's June 1914 bulletin *(Comptes rendus des séances de l'Académie des Inscriptions et Belles-Lettres)*. The excavations were halted as they approached the floor level beneath a light-framed house (Rapport Général, 1913, p.3-4).

Although reports in *Figaro* on 20 June 1914 and *Le Phare d'Alexandrie* on 1 July 1914 indicated that the excavations had been completed and that a full restitution of the Boukoleon Palace was planned, the onset of World War I and the suspension of the Society's activities prevented the continuation of the excavation work (Figaro, 20 June 1914, p.4, col.4; Le Phare d'Alexandrie, 1 July 1914, p.1, col.6).

Fostering Preservation Awareness: Conferences and Publications

The Society organized conferences aimed at providing information and raising awareness about significant Ottoman and Byzantine monuments in Istanbul. The audience for these conferences was primarily limited to the members of the Society rather than the general public. The Society's inaugural conference focused on Rumeli Hisarı, delivered by Halil Edhem Bey and translated by Gustave Mendel, a French archaeologist instrumental in integrating Ottoman archaeological research into European scholarly literature. (Tanin, 3 June 1912, p. 3, col. 1). Muhiddin Bey, the Governor of Pera, first drew attention to Rumeli Hisarı (Figure 13), proposing that the Society clear the area of all houses, huts, and trees surrounding the walls (Figure 14) and restore the room believed to have been occupied by Sultan Mehmed II to open it to

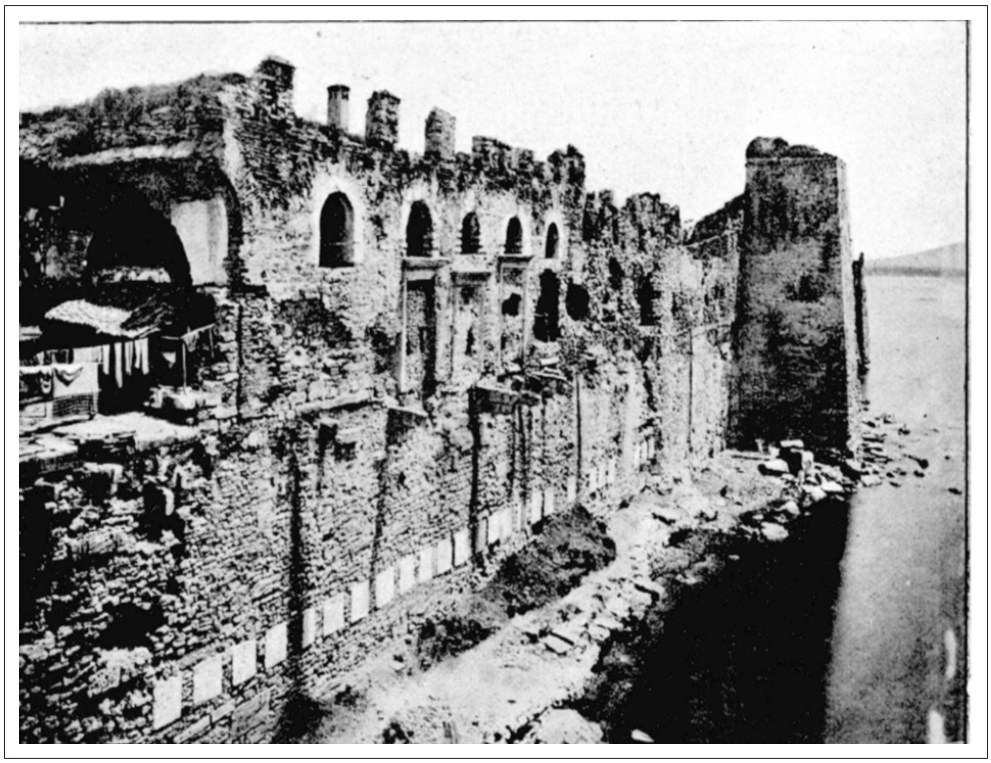


Figure 12. A Photograph of the Boukoleon Palace included in Mesguich's Report (Mesguich, 1914, p. 447).

visitors (Rapport Général, 1912, p.3). In accordance with Muhiddin Bey's recommendations, the Society organized a conference and tour at Rumeli Hisarı on 31 May 1912 (Tanin, 3 June 1912, p.3, col.1).

It was no coincidence that the Society organized its first tour and conference at Rumeli Hisarı. Built by the Ottoman state prior to the conquest of Istanbul as a preparatory fortification for the siege, Rumeli Hisarı can be regarded as the city's first



Figure 13. Rumeli Hisarı, today (Photo by Gülcan Acar).

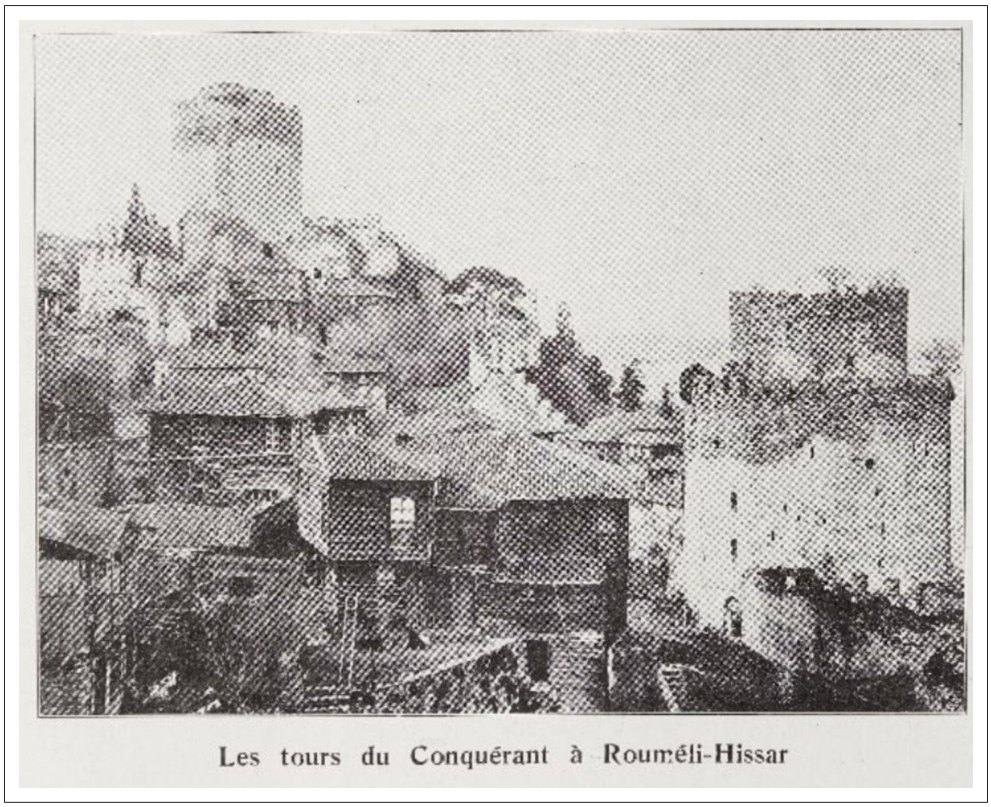


Figure 14. The Towers of the Conqueror at Rumeli Hisarı (Oriens, July 1912, No. 1, p. 3).

architectural trace from the Ottoman period. As noted by Celal Esad Arseven, one of the pioneering researchers of Turkish art history, in *Tanin* on 3 June 1912, this choice clearly reflected the Society's admiration for Ottomanism, an ideological framework emphasizing a shared imperial identity and the exaltation of Ottoman cultural heritage, and its intent to demonstrate institutional support (Tanin, 3 June 1912, p. 3, col. 1). This commitment was further solidified by the invitation of Prince Abdülmecid, a member of the Ottoman dynasty, to the Society as an honorary member (La Jeune Turquie, 12 June 1912, p. 2, col. 6); his participation in this tour, as in other Society events, underscores the profound significance attributed to the patronage of the imperial family.

Another conference organized by the Society took place on 16 August 1912 by Harry Griswold Dwight, an American writer renowned for his works on Istanbul, on the fountains of Istanbul in the garden of Halil Edhem Bey's mansion in Çubuklu. This event was presided over by Prince Abdülmecid Efendi (Sabah, 18 August 1912, p. 3, col. 5). In the September 1912 issue of *Oriens: Revue Internationale Illustrée*, Dwight published an article titled *Les Fontaines de Constantinople* (Dwight, 1912, pp. 83–90). This work provides a systematic and informative account of Ottoman fountains, offering valuable insight into the perspectives he shared during his earlier conference on the subject.

On 22 September 1912, Jean Ebersolt, a prominent Byzantinist and scholar of Constantinople's architectural topography, delivered a lecture on the Byzantine Imperial Palace (Figure 15) at the library of the Imperial Museum. During the conference, Ebersolt presented his findings on the Byzantine Imperial Palace revealed after the Ishak Pasha Fire of 3 June 1912, which had affected the area surrounding Hagia Sophia, comparing these findings with existing hypotheses about the palace. He illustrated the various sections of the palace to the audience using specially prepared plans and maps. In this lecture, Count Ostroróg requested that all participants who had opinions on the preservation and maintenance of Istanbul's historic monuments and structures submit their views in writing to the Society's Council or to the General Secretary Vahid Bey (Sabah, 18 September 1912, p.3, col.5).

This scholarly documentation and expert consultation soon evolved into a more formalized project to archive Istanbul's architectural heritage. The Society prepared a series of monographs on Istanbul's principal monuments, documenting their condition. The first of these monographs focused on the Bereketzâde Fountain. Built in 1732 (1145 AH) by the Defterdar Mehmed Efendi to replace an earlier fountain commissioned on the same site by the official responsible for leading the call to prayer *(müezzinbaşı)* of Sultan Mehmed II, the fountain takes its name from its proximity to the Bereketzâde Mosque (Göktürk, 1961, p. 2534). Accordingly, the painter Pinkas Efendi, a graduate of the School of Fine



Figure 15. The entrance to the Byzantine Imperial Palace (Ebersolt, 1918, p. 19).

Arts (Sanâyi-i Nefîse Mektebi), was commissioned to write an article on the Bereketzade Fountain (Rapport Général, 1913, p.3). Pinkas Efendi's article was published in Ottoman Turkish and French by Society at the Agop Matosyan (H. Matteosian) Press. The Ottoman Turkish section of the text also includes a short article on the Bereketzade Fountain by *İhtifalci* Mehmed Ziya Bey, a researcher who actively documented the city's vanishing landmarks through photography and writing (Bereketzade Çeşmesi, n.d.).

The Society not only prepared a monograph but also undertook the restoration of the fountain. Mehmet Yavuz (2013) identified, in a copy of the brochure on the Bereketzade Fountain prepared by the Society and held at the Political Archive of the German Foreign Office *(Politisches Archiv des Auswärtigen Amts)*, two separate photographs showing the fountain before and after its restoration (Figure 16, Figure 17). A comparison of the two photographs reveals that the eaves of the fountain underwent repair (Yavuz, 2013, p.566).

The Society's second major publishing initiative culminated in 1915 with the monograph titled *Le Yali des Keupruli à Anatoli-Hissar: côte asiatique du Bosphore*. Authored by Henri Saladin and René Mesguich, this work focused on the Amcazâde Hüseyin Pasha Mansion, which is one of Istanbul's rare waterfront mansions *(yalı)* dating back to the 17th century (Figure 18) (Saladin & Mesguich, 1915; Cephanecigil, 2009, p.61). The groundwork for this publication had begun much earlier; as early as 1912, the Society planned to place the structure under protection by leasing it from the Imperial Museum and reached an agreement with the Prefecture of Istanbul regarding the costs of its restoration (Rapport Général, 1912, p.3).

Through the parallel initiatives of Lady Alice (Blight) Lowther, wife of the British Ambassador Sir Gerard Lowther, and Armenak Sakizyan, Second President of the Court of Accounts *(Düyûn-ı Muhâsebât),* detailed architectural drawings of the Amcazâde Hüseyin Pasha Mansion (Figure 19) were prepared. These drawings were executed under the supervision of Yetvart Terziyan, assistant instructor at the School of Fine Arts *(Sanâyi-i Nefîse Mektebi)*, by Nuri Sırrı Bey, a graduate of the same school, and one of its students, Ömer Şerif (Sabah, 27 February 1912, p.3, col.5; Saladin & Mesguich, 1915, p.6). The drawings were presented as a gift to the Society and, having been accepted by the Administrative Council, were deposited in the library of the Imperial Museum for safekeeping (Sabah, 29 February 1912, p.4, col.1). These drawings subsequently illustrated the pages of the monograph, providing a detailed visual record of the structure.

The Society intended to have these drawings reproduced as printed engravings and sent them to Lionel Cust, editor of the *Burlington Magazine* in London, for engraving. The magazine undertook to produce a black-and-white print for each plan, with the most striking one issued as a large-format color engraving (Rapport Général, 1912, p.3). However, it remains unconfirmed whether these specific plans were ultimately engraved and printed[7].

Another initiative of the Society was a postcard collection

7 Correspondence with The Burlington Magazine Archive at the National Gallery revealed that their archives began in 1920; consequently, the 1912 drawings are not extant in their collection.



Figure 16. The Bereketzade Fountain before and after restoration (Bereketzade Çeşmesi, Agop Matosyan Press; Yavuz, 2013, p. 566).

in 1912, printed with the inscription *Société des Amis de Stamboul* and a seal at the center reading *İstanbul Şehri Muhibbleri Cem'iyyeti 1329* in Ottoman Turkish (Figure 20). This collection of postcards was produced by the visual publishing editor E.F. Rochat, active in Istanbul in the early 20th century, and was issued in three series, each comprising ten different postcards (Rapport Général, 1912, p.4).

At the suggestion of Halil Edhem Bey, it was decided that he would prepare a monograph on the walls of Rumeli Hisarı; however, this project was never realized. Another initiative that remained unexecuted involved the preparation of a tourist guide designed to facilitate visits to Istanbul's historic monuments and notable sites. Although the Executive Committee collaborated with Germany's former Consul General, Mr. Mordtmann, in planning this guide, the project was ultimately not carried out (Rapport Général, 1912, p.4; Rapport Général, 1913, p.6). These unrealized endeavors, while highlighting the limitations faced by the Society, underscore the expansive scope of its vision for the comprehensive documentation and promotion of Istanbul's cultural heritage.

With the outbreak of World War I, the significant number of foreign members within the Society departed from Istanbul, effectively ending its operational presence in the city. The Society held its final meeting in February 1914, marking the conclusion of its activities in Istanbul. Yet, the initiative did not entirely dissipate; a group of French members, including Madame Bompard, returned to Paris with the intention of sustaining this civil organizational effort dedicated to the preservation of Istanbul.

ESTABLISHMENT OF THE PARIS BRANCH AND ITS REFLECTIONS IN THE FRENCH PRESS

After returning to Paris, Madame Bompard spearheaded the initiative to establish a Paris branch of the Society of the Friends of Istanbul. The founding committee of this branch comprised prominent members of the Institut de France, including Gustave Schlumberger, Charles Diehl, Henri Auguste Omont, and Henri Jules Saladin. The establishment of the Society's Paris branch was widely and positively reported in the French press. Leading newspapers and journals, including *La Gazette de France and Le Pays: Journal des volontés de la France*, published detailed accounts of the branch's formation in their April and May 1914 issues (La Gazette de France, 14 May 1914, p. 2, col. 3; Le Pays, 12 May 1914, p. 4, col. 4; Le Temps, 13 March 1914, p. 4, col. 6).

In the 16 March 1914 issue of *Correspondance d'Orient* published by the Society of the Friends of Orient *(Société des Amis de l'Orient),* the French politician Louis Barthou praised Madame Bompard for her role in facilitating the founding of the Society and lauded its activities. This issue also announced the creation of the Paris branch and issued a call for new members (Correspondance d'Orient, 16 March 1914, p.251).

Numerous perspectives in the French press sought to legitimize the establishment of a Paris branch of a Society dedicated to the preservation of Istanbul's monuments and natural beauties, while simultaneously framing these efforts in a broader cultural and political context. The 1 May 1914 issue of the *Revue Mensuelle* of the *Touring Club de France*



Figure 17. Bereketzade Fountain, today (Photo from the Database for Ottoman Inscriptions).

announced the founding of the Society's Paris branch, presenting it as a means to enhance the Society's legitimacy in France. In this narrative, Ottoman lands were portrayed, albeit in a limited sense, as a kind of unadministered French colony. Framed within a colonial discourse, the article emphasized, in a manipulative tone, that French was the second most widely spoken language after Turkish and framed the guidance of travelers from France to Istanbul as a service to French tourism. It highlighted that the city, on the brink of transformation driven by a passion for modernization, faced the threat of losing many monuments, and that the Society had undertaken the task of preventing this unique Muslim city from turning into a mundane, American-style town. Byzantine Istanbul was described as the remnants of a glorious history lost in the depths of old Istanbul (Touring Club de France, May 1914, p.197)

Similarly, an article titled *Les Amis de Stamboul* in *La Jeune Turquie* on 25 May 1914 emphasized that the Society sought to preserve what attracted tourists to Istanbul, explicitly wishing these efforts to remain under French influence. Such portrayals reveal that French press narratives on Istanbul's preservation went beyond a mere *love of Istanbul*

Megaron, Vol. 21, No. 3, pp. 438–460, September 2026



Figure 18. The Köprülü Yalı Before 1915 (Saladin & Mesguich, 1915, p. 2).

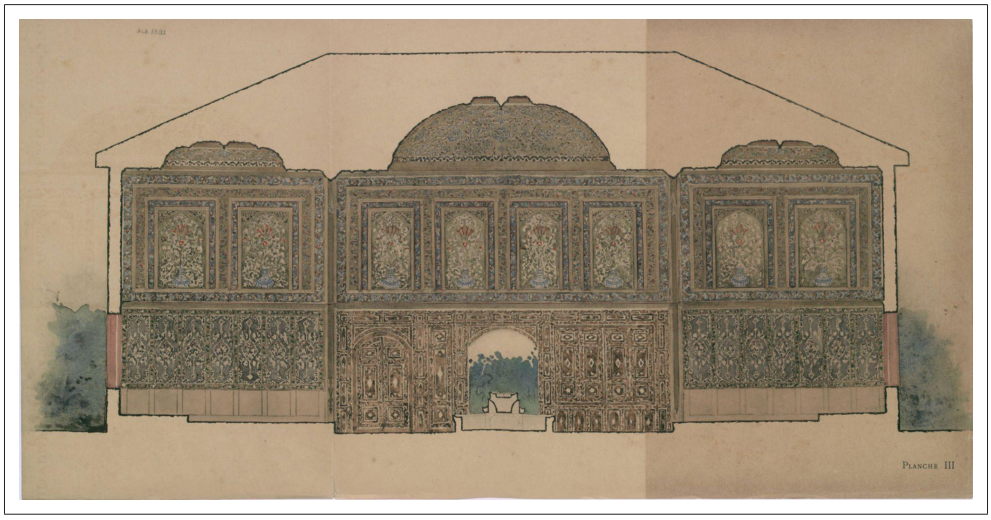


Figure 19. An Example of the drawings of the Amcazade Hüseyin Pasha Yalı prepared under the supervision of Architect Yetvart Terziyan (Saladin & Mesguich, 1915, Planche III).

and carried traces of an imperialist cultural agenda, framing the city's safeguarding as a service to French cultural and touristic interests (La Jeune Turquie, 25 May 1914).

Although documentation concerning the internal operations of the Paris branch is limited, it is clear that the Society's activities were not sustained beyond the early stages of World War I. As the onset of the conflict fundamentally altered the political and cultural landscape, the Society's efforts appear to have been eclipsed by the broader collapse of the era's diplomatic and social networks. Consequently, no further records or archival evidence pertaining to the Society have been identified following this period.

CONCLUSION

The Society of the Friends of Istanbul represents the first civil organizational effort of the heritage conservation consciousness that began to emerge in the late 19th-century Ottoman Empire. Despite its brief operational period, the activities documented in the 1912 and 1913 general reports indicate a noteworthy impact on the institutionalization of heritage preservation. The inclusion of representatives from various ministries and the Prefecture of Istanbul, alongside the patronage of Prince Abdülmecid Efendi, facilitated a critical cooperation between public institutions



Figure 20. The Asian Coast of the Bosphorus, Istanbul, from the Postcard Collection of the Society of the Friends of Istanbul (IBB Atatürk Library, Krt_026803).

and civil initiative. Furthermore, the Society's multinational membership, comprising archaeologists, art historians, architects, and bureaucrats, reflects the significant level of interest it attracted. This initiative was shaped not only by internal Ottoman dynamics but also by the cultural policies of European powers, particularly France, aiming to exert influence within Ottoman territories. The coverage of its establishment and initiatives in Ottoman, French, and German media further underscores the local and international interest it generated.

The Society of the Friends of Istanbul exhibits both similarities and differences when compared with other European civic heritage protection societies. The *Société des Amis des Monuments Parisiens (1885)*, which was established in response to the destructive attitudes of the Paris Municipality to raise public awareness of conservation (Swenson, 2013, p. 107), demonstrates a clear overlap in objectives with the Istanbul Society. In line with these aims, both organizations published periodicals and organized excursions and conferences. Similarly, while the *Associazione artistica fra i cultori di architettura* (1890) in Rome engaged more directly in restoration through academic collaboration (Jokilehto, 1986, p. 281), the Society of the Friends of Istanbul carved out a unique space by bridging the gap between bureaucratic support and civil advocacy. In contrast, the London-based Society for the Protection of Ancient Buildings (1877) maintained a more confrontational stance against public authorities (Glendinning, 2013, pp. 124, 128; Jokilehto, 1986, p. 211), whereas the Istanbul Society preferred a diplomatic and integrative approach.

The Society's adoption of a conservation policy encompassing both Byzantine and Ottoman heritage demonstrates a multi-layered approach to legacy. Consequently, the Society functioned not only as a guardian of physical monuments but also as an actor that highlighted Istanbul's heritage value amidst debates on modernization and cultural identity. Although Reşit Saffet Atabinen attempted to revive the Society's spirit, the Group of Friends of Istanbul *(İstanbul'u Sevenler Grubu)* within the Turkish Touring and Automobile Association, using the Society's remaining 800 Ottoman liras budget, this successor initiative, too, struggled to sustain its momentum (Eyice, 1994, s. 236). Thus, the Society of the Friends of Istanbul became the organization that laid the foundations of the civil preservation movement, extending from the Ottoman Empire to the Republic.

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