DRArch

JOURNAL OF **DESIGN FOR RESILIENCE** IN ARCHITECTURE & PLANNING

APRIL 2026 Issue 01

vol 07

www.drarch.org
info@drarch.org editor@drarch.org

JOURNAL OF DESIGN FOR RESILIENCE
IN ARCHITECTURE & PLANNING

E-ISSN: 2757-6329

Editorial

Mehmet Topçu (Editor in Chief)

The *Journal of Design for Resilience in Architecture and Planning (DRArch)* is pleased to present Volume 7, Issue 1, continuing its commitment to advancing high-quality, interdisciplinary, and forward-looking research at the intersection of architecture, planning, and resilience. In a period marked by environmental uncertainty, technological acceleration, and shifting socio-spatial paradigms, this issue brings together a diverse body of work that collectively reconsiders how space is conceived, experienced, and transformed.

This issue opens with the review article by **Eda Nur Aydemir Kutluer** and **Betül Bakır**, titled *"Human health oriented design approaches in office buildings: Salutogenic model."* The authors develop a holistic framework that repositions architectural design as an active agent in promoting physical, psychological, and social well-being. By adopting the salutogenic perspective, the study moves beyond risk-oriented approaches and contributes a comprehensive model for health-centered office environments.

The first research article, *"Symbiotic spatiality in domestic interiors: A spatial model for human-animal cohabitation"* by **Neşe Başak Yurttaş**, challenges anthropocentric spatial paradigms by conceptualizing domestic interiors as multispecies environments. The proposed symbiotic spatial model offers a novel analytical framework in which spatial hierarchies, circulation patterns, and boundaries are redefined through human–animal coexistence, contributing to emerging posthumanist architectural discourse.

This is followed by the study *"A framework to design and implement cross-platform WebVR walkthrough for a Chettinad heritage building"* by **Antony Zharon, Ajith Paul, Balakrishnan C, Biju Kunnumpurath and Anitha Suseelan**. The article presents a systematic workflow for creating immersive virtual environments that enable remote access to heritage sites. By integrating WebVR technologies into architectural documentation and interpretation, the study highlights the potential of digital tools to support conservation, accessibility, and sustainability.

In *"Bilateral relations of tectonics through physical models: Anchoring architecture to the site,"* **Bilgen Dündar** and **Aslı Uzunkaya** revisit tectonics as a generative design concept. Through the use of physical models within an educational framework, the study foregrounds the reciprocal relationship between site and architectural production, proposing a methodology in which tectonics becomes a critical and operative component of the design process.

The pedagogical dimension of resilience is further explored in *"Designing resilience in historical environments: A pedagogical analysis of a 'healing'-themed studio"* by **Begüm Demiroğlu İzgi** and **Ayşegül Koç Ünlüsoy**. Focusing on a design studio set in a historical context, the study demonstrates how architectural education can foster socio-spatial awareness, collective memory, and spatial healing. The findings reveal measurable improvements in students' cognitive and perceptual engagement, underlining the transformative potential of resilience-oriented pedagogy.

The issue then turns to vernacular heritage with *"Rock-cut vernacular architecture in northeastern Kayseri: Architectural characteristics and conservation challenges"* by **Bahar Elagöz Timur** and **Özlem Kevseroğlu Kurban**. This study documents the intricate relationship between geology, construction techniques, and cultural practices, while addressing pressing conservation challenges. By emphasizing both tangible and intangible heritage values, the research advocates for adaptive and community-based preservation strategies.

Urban identity and competitiveness are examined in *"The city branding potential of Sakarya: A tourism-oriented evaluation"* by **Esra Parıldı** and **Güliz Öztürk**. Through a mixed-methods approach, the study evaluates the role of natural, cultural, and infrastructural assets in shaping city branding processes, highlighting the importance of stakeholder participation and integrated planning strategies in enhancing urban identity.

Sustainability in rural contexts is addressed in *"The importance of local materials in sustainable rural planning: Case of Gelemiç"* by **Figen Altıner** and **Ayşegül Ağan**. The study emphasizes the ecological and cultural significance of local materials, particularly adobe, in achieving low-carbon development and preserving regional identity. By integrating climatic, geological, and socio-cultural parameters, the research underscores the relevance of traditional knowledge systems in contemporary sustainable planning.

The issue continues with *"From rural landscapes to urbanized shores: Rurbanization and second-home dynamics in the Lake Van region"* by **Berfin Karabakan Gökhan** and **Yelda Mert**. This study investigates the transformation of rural landscapes under the influence of second-home developments, revealing patterns of spatial clustering, land-use change, and socio-economic restructuring. The findings contribute to a deeper understanding of hybrid rural–urban dynamics and the need for strategic planning interventions.

E-ISSN: 2757-6329

Finally, the issue includes *"Cost analysis and feasibility of green building adaptation in low-rise residential housing: Evidence from Türkiye"* by **Zübeyde Özlem Parlak Biçer, Merve Bıyıklı Hasözhan, and Nurbanu Şahin**. This study evaluates the economic and environmental implications of green building practices, demonstrating that while initial costs may be higher, long-term benefits in energy efficiency and sustainability provide a strong case for their broader adoption. By offering localized empirical evidence, the research contributes to the ongoing discourse on sustainable housing and policy development.

Collectively, the contributions in this issue expand the understanding of resilience as a multidimensional concept that transcends environmental response to encompass health, coexistence, pedagogy, heritage, and spatial transformation. From multispecies domesticity to immersive heritage technologies, from vernacular landscapes to hybrid rural-urban territories, the articles reflect a wide spectrum of approaches that reframe architectural thinking in response to contemporary challenges.

As DRArch continues to provide a platform for critical inquiry and interdisciplinary dialogue, we invite readers to engage with these studies, reflect upon their implications, and contribute to the evolving discourse shaping the future of resilient design and planning.

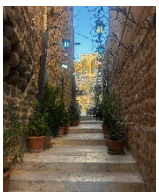
We extend our sincere gratitude to all authors, reviewers, and contributors for their valuable efforts and dedication. We hope this issue inspires further research, collaboration, and innovative thinking toward more adaptive, inclusive, and sustainable built environments.

Best regards...

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

İlknur Acar Ata, (Assoc. Prof. Dr.), Niğde Ömer Halisdemir University
Begüm Aköz Çevrimli, (Res. Assist.), Istanbul Technical University
Ayşenur Albayrak, (Assist. Prof. Dr.), Çanakkale Onsekiz Mart University
Kerem Yavuz Arslanlı, (Assoc. Prof. Dr.), Istanbul Technical University
Saadet Aytıs, (Prof. Dr.), Mimar Sinan Fine Arts University
Rümeysa Bayar, (Assist. Prof. Dr.), Erzurum Technical University
Ebru Bingöl, (Assoc. Prof. Dr.), Iskenderun Technical University
Alan Dilani, (PhD), International Academy for Design and Health
Barış Ergen, (Prof. Dr.), Erciyes University
Cemile Sanem Ersine Masatlıoğlu, (Assist. Prof. Dr.), Gebze Technical University
Aliye Ahu Gülümser, (Prof. Dr.), Istanbul Technical University
Kağan Günçe, (Prof. Dr.), Eastern Mediterranean University
Elif Gündüz, (Assoc. Prof. Dr.), Konya Technical University
Shreya Kanthert, (PhD), Thomas Jefferson University
Fatih Kiraz, (Assist. Prof. Dr.), Nuh Naci Yazgan University
Erdem Köymen, (Lect. Dr.), Istanbul Sabahattin Zaim University
Gülnihal Kurt Kayalı, (PhD Candidate), Çukurova University
Mustafa Tahir Ocak, (Res. Assist.), Istanbul Technical University
Osman Özsoy, (Prof. Dr.), Kayseri University
Mahmut Atilla Söğüt, (Assist. Prof. Dr.), Mimar Sinan Fine Arts University
Sezen Tarakçı, (Assist. Prof. Dr.), Istanbul Technical University
Binumol Tom, (Prof. Dr.), Rajiv Gandhi Institute of Technology
Hatice Umut Tuğlu Karslı, (Prof. Dr.), Istanbul Technical University
İlknur Zeren Çetin, (Assist. Prof. Dr.), Ondokuz Mayıs University
Tülay Zıvalı, (Assist. Prof. Dr.), Samsun University

**sorted by last name*



Cover photo: Image copyright ©Mehmet Topçu, (2025). The image on the left is detail "A photo from the historic streets of Mardin, Türkiye, July, 2025"

E-ISSN: 2757-6329

DRArch's objectives are:

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

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

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

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

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

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

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

E-ISSN: 2757-6329

Editorial Team

JOURNAL OF DESIGN FOR RESILIENCE
IN ARCHITECTURE & PLANNING

E-ISSN: 2757-6329

Table of Contents

JOURNAL OF DESIGN FOR RESILIENCE IN ARCHITECTURE & PLANNING

Review Article
Online: www.drarch.org
Volume 7, Issue 1 (01-20), 2026
DOI: 10.47818/DRArch.2026.v7i1200

Human health oriented design approaches in office buildings: Salutogenic model

Eda Nur Aydemir Kutluer*
Betül Bakır**

Abstract

Office buildings have frequently changed from the past to the present due to historical factors (the collapse of empires, colonialism and expansionist policies, the industrial revolution, wars, the development of technology, epidemics, etc.) and the transformations these factors have created in user needs. Office designs, based on user health and productivity, have also had to keep pace with the changing needs of the age. Therefore, the design of office spaces is an important criterion that reflects how people feel and how it affects their work performance. Research examining the relationship between health and office environments often focuses on a single variable (noise, lighting, office layout, air quality, etc.) and addresses the pathogenic effects of the physical environment, while largely ignoring salutogenic components. Thus, there is a need for a theoretical framework and a holistic approach that encompasses health-promoting research data by adopting the concept of "salutogenic," introduced by sociologist Aaron Antonovsky, which aims to address the origins of health and promote well-being in a positive manner. The aim of this article is to explore how the adoption of salutogenic principles in the architectural design of offices can positively affect the physical, mental, and social health of employees and how this process should be managed. The data obtained through a literature review method enable the application of salutogenic models in office buildings. Within the scope of this study, Antonovsky's concept of the salutogenic model is examined, and the adaptation of design models developed based on this concept is discussed in the context of office buildings.

Keywords: Aaron Antonovsky, human health, office buildings, salutogenic approach, salutogenic design theories

1. Introduction

Office buildings have undergone significant changes from past to present due to historical factors such as the collapse of empires, colonialism and expansionist policies, the industrial revolution, wars, technological developments, and epidemics, as well as the transformations these factors have created in user requirements. Accordingly, office design, shaped by considerations of user well-being and efficiency, has had to adapt to the evolving needs of each era. In this context, the early 20th century marked a critical turning point with the emergence of Taylorism and the increasing emphasis on employee well-being, which brought worker health to the forefront as a key concern. Given that individuals spend a considerable portion of their daily lives indoors, the built environment has both direct and indirect impacts on health. Within this framework, the design of a space establishes the conditions for the activities that take place within it, either facilitating or hindering professional tasks and social interactions. In this way, it influences how individuals perceive, experience, and behave in that environment (Ruohomäki et al., 2015). Therefore, the spatial organization and atmosphere of office environments play a crucial role in shaping individuals' well-being, productivity, and overall work experience.

This study adopts a salutogenic perspective by integrating sustainability considerations into architectural design and explores how office spaces can be organized and managed to promote and

*(Corresponding author), Department of Architecture, Balıkesir University, Balıkesir, Türkiye edanuraydemir@outlook.com
**Department of Architecture, Balıkesir University, Balıkesir, Türkiye betül.bakir@balıkesir.edu.tr
Article history: Received 04 July 2025, Revised 22 December 2025, Accepted 21 March 2026, Published 30 April 2026

enhance human health. The concept of "salutogenesis," introduced by sociologist Aaron Antonovsky, focuses on promoting health through a positive framework (Antonovsky, 1979). Rather than concentrating on factors that cause illness, the salutogenic approach emphasizes the enhancement of well-being by addressing the fundamental origins of health. In this respect, it highlights the relationship between individuals and the built environment in terms of well-being, vitality, social interaction, and mental health. Furthermore, it supports the development of sustainable and health-oriented ecosystems by emphasizing environmental factors such as air, water, and soil.

The salutogenic approach seeks to understand how individuals manage and adapt to stress. According to Antonovsky, a stronger sense of coherence in response to stress is associated with improved physical and psychological well-being. In this regard, the model explains the dynamic relationship between health, environmental context, stressors, and coping mechanisms. Antonovsky (1979) defined health not merely as the absence of illness, but as an active process in which individuals maintain coherence and functional capacity while navigating internal changes and evolving relationships with their surroundings.

In healthcare research, a paradigm shift has occurred from pathogenic approaches toward health-promoting approaches. In this context, numerous empirical studies have examined the effects of building environments on user well-being and performance. A substantial body of evidence addresses health and comfort issues among office workers (Clements-Croome, 2011; Bluyssen, 2013). However, most empirical studies on office environments have adopted a pathogenic perspective, focusing on factors such as indoor environmental quality, thermal comfort, visual comfort, air quality, and acoustics, primarily aiming to prevent illness or discomfort. Research exploring positive spatial qualities that enhance user satisfaction, health, and well-being in workspaces remains limited (Ruohomäki et al., 2015). Within the built environment context, healthcare architecture researchers have explicitly adopted the salutogenic paradigm and examined architectural strategies designed to strengthen patient health (Golembiewski, 2010). Yet, the salutogenic concept has received relatively little attention in workplace-related literature. Existing studies often take a general approach, without specifically addressing how workplace interventions influence individuals' sense of coherence—comprising meaningfulness, manageability, and comprehensibility (Dilani, 2009; Ruohomäki et al., 2015; Roskams & Haynes, 2020).

Architect Alan Dilani, founder of the International Academy of Design and Health, proposed integrating Antonovsky's principles into the built environment, particularly in healthcare architecture. Following this approach, many designers have adopted a health-focused philosophy and incorporated it into architectural, interior, and urban design practices within workplace environments (Ziegler, 2014). As salutogenic principles have been applied in healthcare facilities, it has become increasingly important to develop and integrate design strategies that support human health from a psychosocial perspective into contemporary office design practices.

Today, architectural design approaches are shifting from viewing spaces solely through functional and aesthetic criteria toward a more holistic perspective that supports individuals' social, physical, and psychological health. Within this framework, design approaches such as biophilic, active, neuro-architectural, adaptive, agile, inclusive, and mindfulness-based design offer valuable insights into promoting health across multiple dimensions. However, these approaches often address health through relatively isolated aspects, such as physical activity, cognitive performance, emotional regulation, or accessibility. From a health-oriented perspective, they implicitly support components of Antonovsky's Sense of Coherence—comprehensibility, manageability, and meaningfulness. Nevertheless, this support often remains fragmented, as design strategies are treated as thematic interventions rather than being explicitly integrated within a holistic theoretical model. In this context:

- Biophilic design supports psychological well-being by reconnecting with nature,

- Active design encourages physical activity,
- Neuro-architecture focuses on cognitive and emotional processes,
- Adaptive design prioritizes functional flexibility,
- Agile design aims for flexible and productive work environments that save time,
- Inclusive design emphasizes accessibility and equality principles,
- Mindfulness-based design supports calmness and focus.

In contrast, salutogenic architecture offers a more comprehensive and systematic approach by integrating physical, psychological, and social health parameters within the framework of the Sense of Coherence, rather than treating these aspects as independent strategies. This study contributes to the literature by systematically adapting Antonovsky's Sense of Coherence framework to office environments. The three components of the Sense of Coherence—comprehensibility, manageability, and meaningfulness—are examined through spatial, environmental, and organizational design factors specific to office buildings. In this context, comprehensibility is linked to open-plan layouts that enhance spatial readability, as well as color and lighting strategies that support wayfinding. Manageability is promoted through biophilic design elements that strengthen employees' perceived environmental control, adjustable lighting systems, and ergonomic, flexible furniture. Meaningfulness is addressed through design approaches such as shared spaces that encourage social interaction, and by fostering emotional connections between users and their work environments through corporate identity and opportunities for personalization. By translating abstract salutogenic principles into practical design parameters, this approach provides a structured framework for evaluating and improving office environments from a holistic, health-oriented perspective.

Accordingly, this study adopts a theory-driven narrative literature review to examine the relationship between office design and physical, psychological, and social health within a salutogenic framework. This study focuses on open-plan offices, encompassing health-oriented environments that integrate flexible work arrangements, such as activity-based design, agile design, and hybrid work, along with design strategies like biophilic and inclusive design. The literature was surveyed using academic databases and platforms, including PubMed, Google Scholar, Elsevier, SpringerLink, Wiley Online Library, Taylor & Francis Online, BMJ, and IJERPH (MDPI). Searches employed combinations of keywords such as Aaron Antonovsky, salutogenic approach, salutogenic design, salutogenic architecture, health-oriented office buildings, Sense of Coherence, psychosocially supportive design, and health and well-being. The review covers studies published from 1979, when Antonovsky introduced the salutogenic model, through 2025, reflecting the development of salutogenic and health-oriented design research up to the present.

2. Human Health Parameters

The Constitution of the World Health Organization, adopted at the International Health Conference held in New York in 1946 and entering into force in 1948, defines health as "a state of complete physical, mental, and social well-being, and not merely the absence of disease or disability" (World Health Organization, 2020). As the concept of health encompasses multiple dimensions, including medical, social, economic, and spiritual factors, ongoing debates regarding its definition have persisted (Larson, 1999). However, this definition has also been criticized for its ambitious use of the term "complete" in describing health (Huber et al., 2011).

In 1986, during the first International Conference on Health Promotion and Development, the World Health Organization introduced a new perspective through the Ottawa Charter, defining health as a process that enables individuals to increase control over and improve their own health. According to this framework, achieving complete physical, mental, and social well-being requires that individuals or groups be capable of identifying and fulfilling their aspirations, addressing their needs, and adapting to or transforming their environment. Health, therefore, is understood not as

the ultimate goal of life, but as a fundamental resource for everyday living. It encompasses both personal and social resources, in addition to physical capacities. Consequently, promoting health is considered a shared responsibility that extends beyond the healthcare system alone (World Health Organization, 1986). A balanced approach that equally values the physical, mental, and social dimensions of health throughout the lifespan is a key determinant in enhancing overall well-being (Azzazi & Nafiz, 2016).

Health is defined in terms of various factors that interact in a complex, comprehensive, integrated, and synergistic manner. Beyond the health sector, which plays a leading role in the process of health development, individuals, groups, organizations, communities, and nations all have significant responsibilities. While each individual is responsible for improving their own lifestyle, organizations are responsible for providing healthy, safe, and supportive environments that promote well-being (Azzazi & Nafiz, 2016).

It is essential to create environments in which individuals can feel healthy, comfortable, and secure; freely express themselves through their ideas and actions; and maintain positive social relationships. In addition to needs that individuals can directly control (such as nutrition, sleep, and stress management), individuals must also maintain good physical, mental, and social health to cope with environmental factors beyond their control (such as the built environment, culture, and economy). The physical, social, and mental dimensions of health integrate the individual with their environment, enabling movement toward higher levels of functioning or optimal well-being. Due to the dynamic interaction among these dimensions, no single dimension can be separated from or function independently of the others (Roscoe, 2009) (Figure 1).

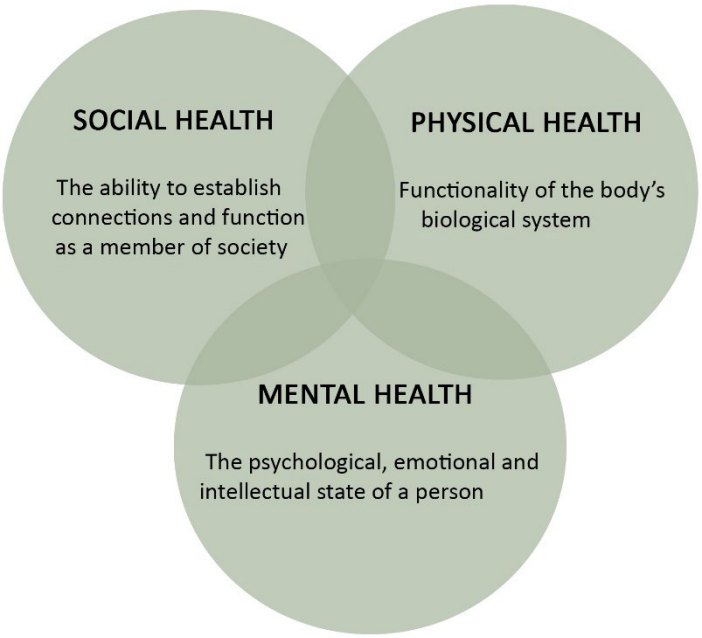


Figure 1 Dimensions of health (Amzat & Razum, 2014)

Understanding the concept of health is essential, as an imbalance in any part of the body can affect the functioning of the entire system. Accordingly, a disruption in one component of health may lead to short-term or long-term effects on other components. Adequate sleep, balanced nutrition, and regular physical activity are key determinants of physical health. For instance, inadequate nutrition and the consumption of carbohydrate-rich snacks may lead to hypoglycemia (a drop in blood sugar below normal levels), resulting in reduced cognitive performance, including slower perception and shorter attention span. Conversely, proper and sufficient nutrition that provides adequate protein, vitamins, and minerals to meet energy requirements has been shown to increase work productivity by approximately 20% and to reduce negative outcomes such as absenteeism, workplace accidents, and stress (Bor, 2020).

Sleep quality and duration play a decisive role in cognitive and psychological functioning. Insufficient or poor-quality sleep is associated with negative outcomes such as reduced perception speed, anxiety, and stress (Litwiller et al., 2017). Sleep is essential for various physiological processes, including brain function and overall systemic regulation. In this context, the short-term consequences of sleep disturbances include increased stress sensitivity, somatic pain, reduced quality of life, emotional distress, and impairments in cognition, memory, and performance (Medic et al., 2017). Conversely, even short daytime naps have been shown to improve cognitive performance, particularly by enhancing alertness. Accordingly, napping is culturally accepted in the business environment in Japan and is supported by some organizations as a productivity-enhancing practice (Dutheil et al., 2021). Similarly, companies such as Googleplex, Zappos, and Uber have incorporated dedicated rest areas into their office environments, allowing employees to sleep and rest during working hours.

Insufficient physical activity negatively affects not only physical health but also personal and behavioral attributes such as self-confidence, leadership, and empathy. It is also associated with social and mental health issues, including depression and anxiety (Park et al., 2022). In response, some organizations have begun to integrate physical activity into daily work routines. For example, Unilever's headquarters in Hamburg promotes cycling to work and organizes in-office sports programs.

Beyond individual health behaviors such as sleep, nutrition, and physical activity, both the built and social environments serve as important contextual determinants of health. Environmental factors—including indoor air quality, access to nature, thermal comfort, acoustics, and lighting conditions—along with social interaction, organizational culture, and social support, have significant effects on individuals' physical and psychological well-being. For example, studies indicate that contact with nature supports mental health (Xiang et al., 2025), enhances attention and cognitive performance (Fukumoto et al., 2024), and fosters creativity (Williams et al., 2018). Furthermore, empirical research demonstrates that visual exposure to natural elements or landscapes in work environments can positively influence employee well-being (Gilchrist et al., 2015; Kaplan, 1993).

3. Salutogenic Approach

3.1. Definition of the Concept of Salutogenic

To fully grasp the salutogenic perspective, it is essential to trace the evolution of how health has been defined globally. According to medical sociologist Antonovsky (1979), people constantly encounter stress, illness, or challenges throughout their lives. Therefore, by criticizing the WHO's conception of health as "not merely the absence of disease or disability, but a state of complete physical, mental, and social well-being," he argues that it is impossible for everyone to be in a state of complete well-being. Furthermore, while the WHO's definition treats illness and health as completely separate concepts, Antonovsky argues that people are never completely healthy or completely ill; instead, they are constantly somewhere between health and illness (Antonovsky, 1979). In his influential work Health, Stress, and Coping (1979), Antonovsky introduced the term "salutogenic," which emphasizes the promotion of health and well-being rather than the prevention of disease. The word itself combines the Latin salus (health) and the Greek genesis (origin), referring to the study of the origins of health (Boscherini, 2017).

Antonovsky (1996) emphasized that salutogenesis should encompass the whole person, rather than concentrating solely on specific diseases, disabilities, or individual traits. He argued against narrowing the focus to isolated aspects, instead advocating for a more comprehensive understanding of human health. The primary goal of the salutogenic model is to enhance individuals' capacity for health and to position well-being as a foundation for leading a fulfilling and productive life (Eriksson & Lindström, 2008). Broadly speaking, the term "salutogenic" describes a scientific orientation centered on identifying the origins of health and the elements that actively support it, as opposed to examining the causes of illness and associated risks (Mittelmark & Bauer,

2017). While the salutogenic approach directs attention toward resources that foster positive health outcomes, the pathogenic model focuses on mitigating risk through prevention, protection, and treatment. Despite these differing approaches, both ultimately aim to support individual health (Figure 2) within the surrounding environment (Mittelmark & Bauer, 2017). This framework aligns with Antonovsky's perspective that people continuously move along a spectrum between health and disease.

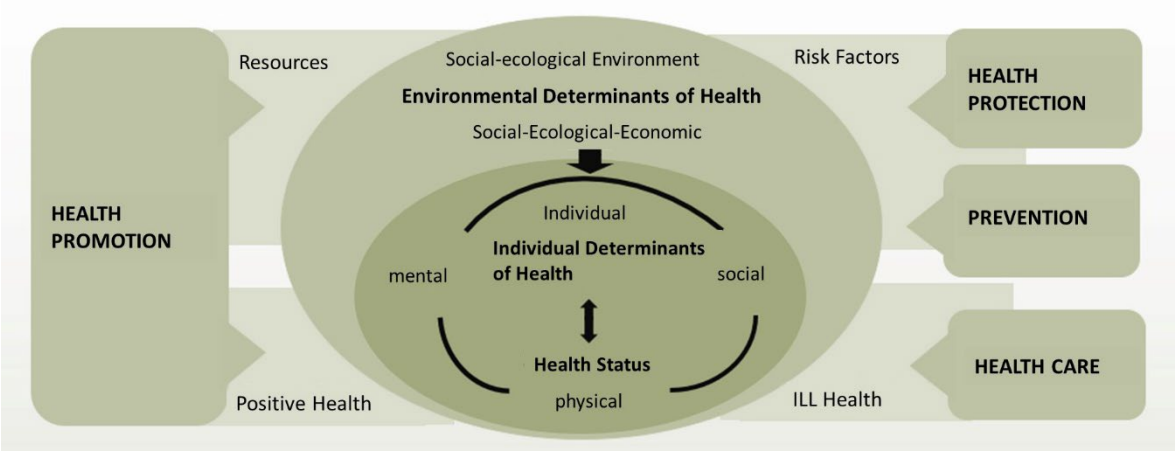


Figure 2 Relationship between salutogenic and pathogenic approach (Mittelmark & Bauer, 2017)

Salutogenic theory is a model that focuses on health rather than disease (Golembiewski, 2022; Mittelmark & Bull, 2013). Traditional medical approaches are usually pathogenic-oriented; that is, they aim to prevent or treat diseases. However, Antonovsky argues that this is not sufficient. The salutogenic approach aims to ensure that people remain healthy by improving their ability to cope with stress and difficulties. Antonovsky explains the difference between salutogenic and pathogenic approaches using the metaphor of "teaching swimming instead of preventing falling into the river." He emphasizes that individuals cannot completely avoid stress or illness; however, they should be enabled to cope with these challenges by developing resilience (Antonovsky, 1987). The characteristics of Antonovsky's (1987) salutogenic orientation are summarized as follows:

1) Instead of a sharp categorisation of sick-healthy, Antonovsky sees health as an ever-changing process in which everyone is at a certain point.
2) While conventional medicine focuses on the causes of the disease, Antonovsky emphasises that this is not enough, it is important to consider the individual's whole life history, environment and coping strategies.
3) Instead of focussing on the causes of disease, it is necessary to focus on the factors that help people to maintain their health and become healthier.
4) Antonovsky states that stress is not a negative thing and in some cases it can strengthen the individual.
5) Rather than looking for a single miracle cure, Antonovsky recommends addressing all the factors that support the individual's adaptation to their environment.
6) It also emphasises that studying individuals who can stay healthy in the same environment will contribute to health policies as well as disease factors.

3.2. Salutogenic Design Parameters

Salutogenic originated in 1971 when Antonovsky, based on interviews with a group of Israeli women who survived concentration camps during the Holocaust in World War II and entered menopause, introduced the Sense of coherence in stressful situations and serious difficulties, where some remained healthy while others failed to remain healthy (Eriksson & Lindström, 2008). Thus, salutogenic, the source of health, is a stressor-oriented concept that focuses on resources,

sustaining and developing movement towards health. It answers why people stay well despite stressful situations and difficulties (Lindström & Eriksson, 2005).

Antonovsky's salutogenic model includes several core concepts for understanding how health is maintained and improved. One of the main defining features of the model is the sense of coherence. Another key concept is generalized resistance resources, which refer to protective factors that enable individuals to cope with stress. Antonovsky argues that generalized resistance resources—such as cognitive resources (problem solving, critical thinking), social support (family, friends), material resources (economic security), cultural resources (beliefs, values), and psychological resources (self-confidence)—function as protective factors that help individuals manage stress. He also emphasizes that these resources play an important role in the development of the sense of coherence (Antonovsky, 1987). The stronger these resilience resources are, the more effectively individuals can cope with stressful situations.

The sense of coherence refers to the ability to perceive life as meaningful, manageable, and understandable. According to Antonovsky, the stronger this sense is (Figure 3), the more resilient individuals are to stress. For the sense of coherence to be high, individuals must possess sufficient generalized resistance resources. Accordingly, individuals with strong social support, education, and economic security are expected to be more resilient to stress. For generalized resistance resources to function effectively, it is therefore essential that individuals have developed a strong sense of coherence.

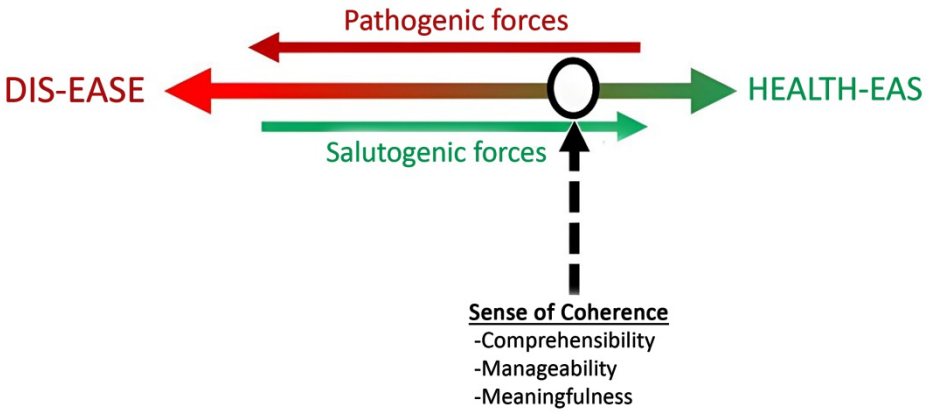


Figure 3 A sense of coherence on the health – illness continuum (Roskams & Haynes, 2020)

The concept of sense of coherence represents an individual's perception of life and their ability to handle stressful experiences. It reflects a mindset and behavioral orientation shaped by internal assurance, enabling individuals to recognize, access, and effectively apply the resources available to them (Lindström & Eriksson, 2005). According to Antonovsky (1987), this sense is composed of three core dimensions: comprehensibility, manageability, and meaningfulness.

Manageability: Manageability refers to an individual's belief that they have the resources required to cope with the difficulties in their life. In other words, individuals should perceive that they are not alone in facing sources of stress and that they can overcome these difficulties through internal and external resources, such as social support, skills, and economic opportunities (Antonovsky, 1987). Manageability also refers to having the physical resources and actions necessary to sustain life. In architectural terms, it encompasses environments designed in a way that allows individuals to meet their physical needs. In this context, accessibility and inclusive design are considered important elements of manageability (Golembiewski, 2022).

Comprehensibility: Comprehensibility refers to an individual's perception of the events they encounter as logical, structured, and predictable. In other words, individuals should feel that the events in their lives are not random or chaotic, but occur within a certain order (Antonovsky, 1987). Comprehensibility relates to an individual's ability to make sense of both their internal and external

environment. In an architectural context, it is associated with the ability to easily read one's surroundings, orient oneself, and understand the functioning of space (Golembiewski, 2022).

Meaningfulness: Meaningfulness refers to an individual's perception of life events as meaningful and worth overcoming. It reflects the belief that life's challenges are not merely burdens, but also opportunities for development and personal growth (Antonovsky, 1987). Meaningfulness is considered the strongest motivational resource enabling individuals to continue their lives. While manageability and comprehensibility may facilitate survival, they are not sufficient on their own; meaningfulness is the most critical component. Meaningfulness is an abstract concept, whereas architecture deals primarily with concrete and physical realities. Since individuals' search for meaning is abstract and personal, this may pose challenges for architects attempting to design spaces that respond to diverse user needs (Golembiewski, 2022).

According to Lindström and Eriksson (2005), comprehensibility corresponds to the cognitive dimension, manageability reflects behavioral responses, and meaningfulness represents the motivational component. In the model proposed by Rakhshani and Khakzand (2025), comprehensibility is associated with mental health, manageability with physical health, and meaningfulness with social well-being. When these three components function together, individuals are better able to cope with stress and maintain a healthier life (Antonovsky, 1996). Empirical studies examining the relationship between sense of coherence, mental health, and psychosocial behaviors indicate that individuals with a strong sense of coherence experience fewer mental health problems, such as depression and anxiety, and show lower susceptibility to heart disease. Additionally, positive physical health indicators—such as lower diastolic blood pressure, lower resting heart rate, and higher oxygen uptake capacity—have been identified among these individuals (Eriksson & Lindström, 2006).

Burton and The World Health Organization (2010) defines a healthy workplace as an environment in which everyone works together toward a common vision that supports the health and well-being of employees and the surrounding community. Such workplaces include elements that protect and promote health and safety in terms of physical, psychological, social, and organizational conditions (Burton & World Health Organization, 2010). Although the salutogenic model and the concept of sense of coherence have increasingly gained attention in various fields, including architecture and the built environment, comprehensive research identifying specific physical elements that support health remains limited. The majority of existing studies focus on the salutogenic approach primarily within treatment and rehabilitation settings (Rakhshani & Khakzand, 2025; Dietscher et al., 2017; Pelikan, 2022). The concept of a salutogenic work environment has not been extensively explored in the academic literature, even though several positive architectural elements have been implemented not only in healthcare facilities but also in conventional workplace settings (Dilani, 2005).

Office designs that support the Sense of Coherence contribute to reduced stress levels, increased productivity, and greater employee well-being. Comprehensibility is supported by factors such as spatial order, clarity, and functional organization, while manageability can be enhanced through ergonomic solutions and technological support. Meaningfulness can be fostered through motivating design elements that help employees perceive value and purpose in their work. Numerous design strategies related to these components can be further developed and integrated into office environments. This approach, which aligns closely with salutogenic design principles, contributes to transforming offices into environments that actively support employee health and well-being rather than serving solely as places of work. Roskams and Haynes (2020) examine the non-exhaustive list that is open to developing the office design approach regarding the sense of coherence as follows:

Comprehensibility in Offices:

- Establishing clear and regular rules regarding the use of different functional work areas.
- Ensuring active participation of employees in change processes.

Manageability in Offices:

- Supporting employees' perception of environmental control through the use of biophilic design elements.
- Making arrangements that encourage social harmony in shared areas.
- Increasing physical activity through adjustable furniture.

Meaningfulness in Offices:

- Designing personal desks to allow for individual identity expression.
- Clearly communicating the organizational purpose to employees through the corporate brand.

3.3. Salutogenic Design Theories

3.3.1. Alan Dilani – Psychosocial Supportive Design

In the 1990s, architect Alan Dilani, founder and general manager of the International Academy of Design and Health (IADH), built upon Antonovsky's health-supporting model and proposed its application to architecture. Dilani addressed architectural design approaches that support health rather than disease by associating design qualities and building materials with the characteristics of the physical environment (Ziegler, 2014). He introduced the Psychosocially Supportive Design paradigm in the architectural design of healthcare facilities by applying Antonovsky's salutogenic principles. Dilani argued that interdisciplinary approaches are necessary to explore the applicability of positive architectural features that reduce stress not only in healthcare facilities but also in existing workplaces and the broader built environment (Dilani, 2005). Following this, Dilani—together with numerous architects, designers, and theorists—has explored Antonovsky's theory more comprehensively and has begun to reinterpret architecture, interior environments, and urban planning through a salutogenic lens (Ziegler, 2014). The aim of Psychosocially Supportive Design is to stimulate mental processes that attract human attention—such as creativity, satisfaction, pleasure, and fulfillment—by positively supporting health both psychologically and socially, and to provide a practical guide for designers and planners seeking to enhance health through physical design (Dilani, 2001, 2004).

As emphasized by Dilani, the Psychosocially Supportive Design approach serves as an effective framework for helping designers and planners understand how the built environment can positively influence human health. It highlights that the implementation of salutogenic design strategies is essential for creating environments that support human well-being and encourages collaboration across multiple professional disciplines to establish optimal living and working conditions. These principles primarily aim to initiate cognitive engagement by capturing human attention, thereby helping to reduce anxiety levels and stimulate positive emotional states (Yeang & Dilani, 2022). According to Dilani, the essential elements of these principles can be outlined as follows (Dilani, 2009; Yeang & Dilani, 2022):

1) Comprehensibility: It includes order, such as eliminating visual chaos that requires predictability and readability. For example, Wayfinding / Colors / Nature / Perception / Landmarks / Novelty / Interesting Elements (such as making interior stairways interesting)
2) Manageability: It includes access to resources that can be managed, familiarity with the environment, social support, etc. For example, Natural Light / Aesthetic Elements / Ergonomic Design / / Green Environments / Interior Design / Restoration / Stimuli
3) Meaningfulness: It includes interest in positive stimuli, providing visual and aesthetic meaning. For example, Comfort / Music / Art / Social support / Culture / Sports / Positive Distractions / Pets

The senses—such as sight, taste, hearing, smell, and touch—are fundamental elements that shape the aesthetic experience. Surfaces that provide a pleasant tactile sensation, evocative scents, or expressive colors strengthen this sensory interaction. As a result, individuals' interaction with the environment is enhanced, and the value of a well-designed place is perceived more clearly

(Dilani, 2005). Consequently, psychosocial design supports individuals' sense of coherence by stimulating them both mentally and socially.

3.3.2. Rachel and Stephen Kaplan – Restorative Theory of Attention

Attention Restoration Theory, developed by Rachel Kaplan and Stephen Kaplan (1989), was introduced in their book The Experience of Nature: A Psychological Perspective, in which they outlined how exposure to natural environments can support and improve mental well-being (Kaplan & Kaplan, 1989). Interaction with nature reduces cognitive fatigue by helping to replenish depleted attentional resources. According to this theory, the attentional resources of the human mind are limited and become depleted through excessive use. The theory also distinguishes between two types of attention—directed and involuntary—and examines the interaction between them. Involuntary attention refers to a form of focus that arises naturally without conscious effort, whereas directed attention requires individuals to concentrate through deliberate effort (Kaplan & Kaplan, 1989; Kaplan, 1995; Yeang & Dilani, 2022).

Within the restorative approach, it is stated that natural environments should possess four basic characteristics in order to meet individuals' needs for renewal and mental restoration (Kaplan & Kaplan, 1989; Kaplan, 1995):

Being Away: This characteristic provides a break from the pressures of daily life and from elements that cause mental fatigue. Nature offers individuals a setting that enables relief from stress and pressure. However, the sense of separation does not necessarily require physical distance from the environment. Mental disengagement from stressful thoughts within the same physical setting can also generate a feeling of being away (Kaplan & Kaplan, 1989; Kaplan, 1995; Herzog et al., 2003).

Extent: This characteristic suggests that the environment should be explorable and sufficiently inclusive. In this sense, the environment should draw individuals in, create a sense of continuity, and offer a meaningful sense of wholeness (Kaplan & Kaplan, 1989; Kaplan, 1995). Such environments do not need to be large in scale; even compact spaces can evoke a sense of completeness, provided that they offer adequate cognitive stimulation through their content and organization (Herzog et al., 2003).

Fascination: Fascination is one of the most important qualities offered by nature in the process of attentional restoration. It includes elements that capture an individual's attention effortlessly, without causing mental fatigue. Natural features such as flowing water, leaves moving in the wind, or birdsong support mental renewal by directing attention in a gentle and non-demanding way (Kaplan & Kaplan, 1989; Kaplan, 1995).

Compatibility: Compatibility describes the degree of alignment between an individual's needs and the environmental conditions or resources available to meet those needs. An environment functions as a more effective restorative setting when it supports the expectations, intentions, and goals of the individual (Kaplan & Kaplan, 1989; Kaplan, 1995).

Prolonged use of directed attention increases the likelihood of errors by leading to impatience, irritability, and mental exhaustion. Consequently, negative outcomes such as loss of concentration, inattention, reduced willingness to cooperate, and decreased performance may occur (Yeang & Dilani, 2022). Attention Restoration Theory suggests that employees' exposure to nature in workplace settings depends both on the frequency of outdoor green breaks and on the extent to which work environments possess restorative qualities. The presence of indoor plants, water features, windows with views of nature, nature-themed visual elements (such as photographs, images, or videos), and the use of natural sounds enhance the restorative capacity of workspaces, thereby supporting employees' cognitive renewal. As a result, attention can be directed more efficiently and levels of mental fatigue are reduced (Gonçalves et al., 2023).

3.3.3. Heerwagen – Salutogenic Design Theory

Heerwagen, Heubach, Montgomery, and Weimer (1995) investigated the impact of the work environment on employees' health and examined how environmental changes can be used to manage occupational stress in the workplace. In their studies, they emphasized the positive effects of designing office buildings in accordance with salutogenic principles on employee health and work efficiency (Heerwagen et al., 1995). For example, factors such as daylight, natural landscapes, visually engaging wall surfaces, biophilic elements such as plants, and opportunities for social interaction influence individuals' psychological (mood) and cognitive responses (productivity, motivation), thereby playing an important role in stress reduction and overall health (Heerwagen et al., 1995; Bergefurt et al., 2023).

Heerwagen et al. (1995) examined the physical environment from the perspective of person–environment fit by developing a design framework grounded in environmental psychology. They emphasized that, within the context of person–environment fit, individual characteristics such as age and personal preferences, as well as users' physical needs, should be taken into consideration (Heerwagen et al., 1995). This conceptual framework supports Antonovsky's concept of sense of coherence by providing a general evaluative tool for understanding the relationship between the work environment and user well-being (Heerwagen et al., 1995; Ziegler, 2014).

1) Defining the fundamental human needs associated with workplace environments.
2) Determining the environmental attributes and conditions that influence the satisfaction of these needs.
3) Recognizing indicators that signify alignment or misalignment within the work setting, particularly in relation to stress levels and overall well-being (Heerwagen et al., 1995).

These indicators are closely associated with the core components of manageability, meaningfulness, and comprehensibility. Research has highlighted several critical environmental factors—such as acoustic regulation, control over social interactions, and opportunities for personalizing space—as essential elements in shaping these experiences (Ziegler, 2014). The elements that support employee health in effective office design, addressed within the framework of person–environment fit, are articulated in Heerwagen's (1998) article "Design, Productivity and Healthy Living: What Are the Links?" as follows:

- Environmental sustainability includes environmentally sensitive designs with the use of energy efficient systems and materials. Solutions that encourage natural light and ventilation both save energy and increase employee comfort. In addition, the integration of green spaces and biophilic design elements provides a healthier working environment by reducing employee stress levels.
- Organisational effectiveness is directly related to open office spaces and flexible space arrangements that encourage collaboration. Modular designs allow workspaces to be reshaped according to need, while noise control and acoustic comfort increase employee focus and productivity.
- Human well-being (employee health and well-being) is supported by meeting employees' needs for privacy and personal space. The ability to control temperature, light and air quality in the workspace improves individual comfort and increases overall job satisfaction. In addition, common areas and recreation zones that support social interaction positively affect employee motivation and psychological well-being.

Design elements under these three headings contribute to the creation of healthy and sustainable working environments by increasing productivity at both individual and organisational levels (Heerwagen, 1998).

3.3.4. Daniel Stokols – Socioecological Theory

The socioecological approach developed by Stokols (1992) offers a holistic model that evaluates human health within the framework of multi-layered relationships between personal attributes and

both physical and social environmental factors. In this approach, first, health is shaped not only by biological or behavioral factors but also through the dynamic interplay between the individual and both the physical environment (architecture, geography, technology) and the social environment (culture, economy, politics) in which they live (Stokols, 1992; Stokols et al., 2013). Second, environments are evaluated not only in terms of their physical or social characteristics but also through multidimensional perspectives, such as objective (actual) and subjective (perceived by the individual) effects, proximity to individuals and groups, independent environmental characteristics (e.g., noise, temperature, lighting, spatial arrangement, and group size), and broader structural patterns (Stokols, 1987, 1992; Schneider & Stokols, 2009).

Third, the socioecological approach advocates the combined use of multiple methods and analyses at different scales by examining participants across multiple levels, including individuals, small groups, organizations, and societies, suggesting that multi-actor health interventions are likely to be more effective. Fourth, while individuals are influenced by their environments, they also actively shape those environments through their own behaviors, and this reciprocal relationship plays a significant role in the formation of health conditions (Stokols, 1992; Schneider & Stokols, 2009).

Stokols (1992) explains the socioecological approach within the framework of environmental design principles based on physical health, emotional well-being and social harmony (Table 1) (Stokols, 1992; Yeang & Dilani, 2022). These design principles guide what features health-supporting spaces should have.

Table 1 Dimensions of Health-Promoting Environments from an Ecological Perspective (Stokols, 1992)

Facets of healthfulness	Environmental resources	Behavioral, psychological, and physiological outcomes
Physical health	Injury-resistant design; ergonomically sound design; nontoxic and nonpathogenic environment, physical comfort	Physiologic health; perceived comfort, absence of illness symptoms and injury; genetic and reproductive health
Mental and emotional well-being	Environmental controllability and predictability; environmental novelty and challenge; symbolic and spiritual elements; low distraction; aesthetic qualities	Sense of personal competence, challenge and fulfilment; developmental growth; strong sense of personal identity and creativity; feelings of attachment to one's physical and social milieu; minimal experience of emotional distress
Social cohesion at organizational and management community levels	Availability of social support networks; participatory design and processes; organizational flexibility and responsiveness: economic stability; health-promotive media and programming; low potential for intergroup conflict	High levels of social contact and cooperation; productivity and innovation at organizational and community levels; conunitment to and satisfaction with organization and community; high levels of perceived quality of life; prevalence of health-promotive, injury- preventive and environmentally protective behavior

This socioecological approach was developed to understand the effects of environmental factors on individual health and to support the creation of health-promoting environments, and it provides a comprehensive foundation for health policies and environmental design approaches (Stokols, 1992). In addition, by examining health–environment interactions across multiple levels, it encourages the involvement of actors operating at different scales—such as individuals, families, groups, organizations, and societies—within the process (Stokols, 1992; Stokols et al., 2013).

3.3.5. Roger Ulrich – Supportive Design Theory

Supportive Design Theory, developed by Roger S. Ulrich in 1991 in response to the increasing effects of environmental factors on human psychology, offers an important perspective, especially

in the fields of health and architectural design, by emphasizing the stress-reducing role of the physical environment. According to Ulrich's research, especially in healthcare structures, he argues that, in addition to the physical needs of different types of users (patients, staff, visitors), stimuli such as social support and positive distractions are also important for health (Ulrich, 1991, 1992). Supportive Design Theory, which focuses on the concept of stress, includes three components that will positively promote health:

Ulrich (1991) emphasizes that an individual's perceived ability to influence their surroundings significantly contributes to stress reduction. When users are able to modify environmental factors such as lighting, sound levels, thermal conditions, privacy, and spatial layout based on their personal needs and preferences, this fosters a sense of psychological well-being and autonomy (Ulrich, 1991). Similarly, Steptoe and Appels (1989) state that individuals with a sense of control cope with stress more effectively and that this has positive consequences for health (Steptoe & Appels, 1989).

Access to social support: Ulrich argues that supportive design should be organized in a way that strengthens individuals' social networks. In this context, shared spaces, comfortable seating arrangements, furniture arrangements, and spatial organizations that encourage interaction support psychological well-being by increasing social ties between individuals (Ulrich, 1991).

Positive distractions in physical environments: Ulrich's research shows that elements of nature and aesthetically pleasing spatial elements serve as positive distractions. According to experimental studies, elements such as plants, water features, works of art, natural light, and outdoor views have been shown to reduce individuals' stress levels, relieve cognitive load, lower blood pressure, reduce anxiety, and support general well-being. These stimuli have increased the importance of biophilic design principles by affecting emotional, cognitive, and behavioral perception (Wohlwill, 1968; Ulrich, 1991). Ulrich's (1991) studies show that the restorative effect of nature creates positive results both psychologically and physiologically. Studies show that patients who stay in rooms with a view of trees after surgery recover faster than those who stay in rooms with a view of brick walls (Ulrich, 1991, 1992).

Ulrich's Supportive Design Theory aims to reduce individuals' stress levels and promote a healthy life through the conscious organisation of the physical environment. The combination of social support, a sense of control, and positive distractions creates healing environments at both individual and societal levels. Although this theory has been used especially in healthcare buildings, it also provides an important framework to guide design decisions in spaces with high stress levels, such as offices and educational buildings.

4. Findings and Discussion

According to the findings obtained as a result of the literature review, health in office design should be addressed not only with a pathogenic approach aimed at preventing diseases, but also with a salutogenic perspective that focuses on mental, physical, and social well-being. The sense of coherence (comprehensibility, manageability, meaningfulness), which is the basis of the salutogenic model, improves employees' health in a positive way by increasing their ability to cope with stress. According to the salutogenic approach, open plans, orientation systems, and spatial order in office structures are compatible with the principle of comprehensibility; ergonomic furniture, biophilic design elements, and environmental control opportunities are compatible with the principle of manageability; and personalization opportunities, art, culture, and social interaction areas are compatible with the principle of meaningfulness, affecting employees' motivation and general well-being. A conceptual framework that aims to develop employees' sense of coherence, and that reveals how office spaces can be best designed and managed to mitigate workplace stress (Figure 4), offers important implications for office practices (Roskams & Haynes, 2020). This figure presents the study's original contribution by operationalizing the Sense of Coherence framework within office environments and translating its components into actionable design strategies.

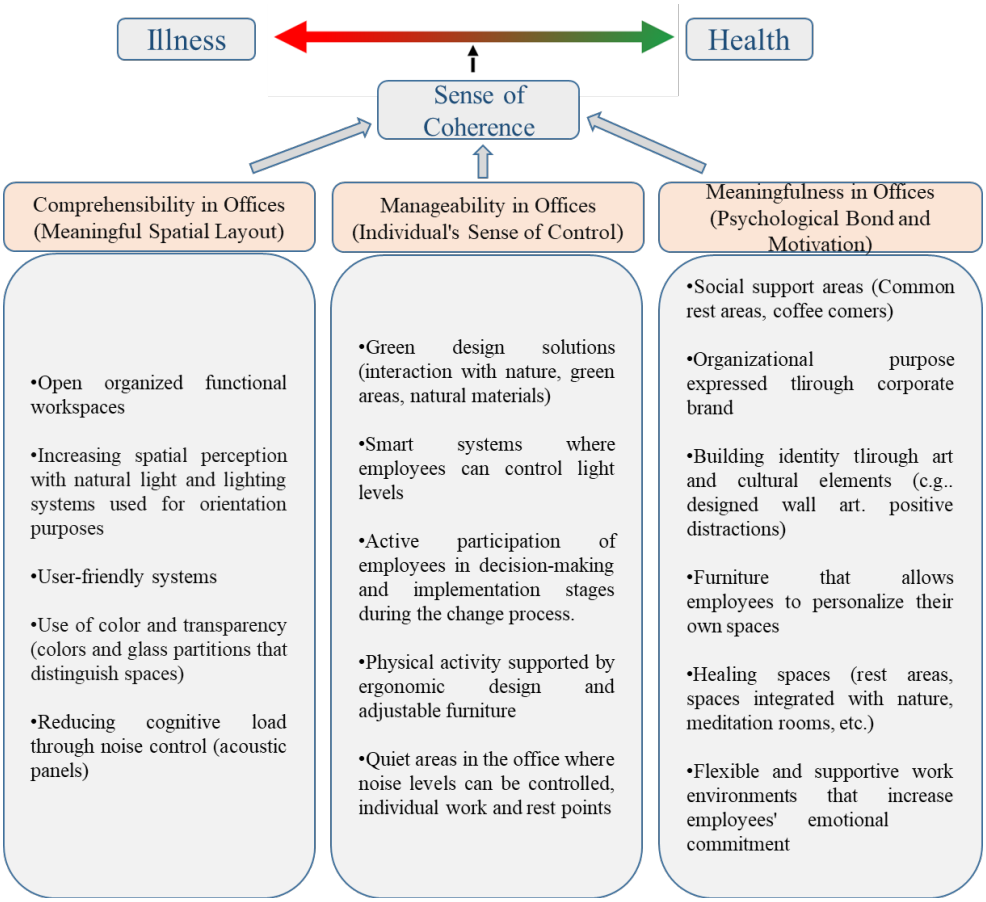


Figure 4 Suggested design factors associated with a sense of coherence (It was developed based on the work done by Roskams and Haynes (2020), Dilani (2009))

Although reducing pathogenic elements in the office environment is an important step, it is not enough to fully optimize workplace health and productivity. Environmental resources defined as salutogenic elements increase motivation by supporting the psychological well-being of employees and contribute positively to work performance. Therefore, both reducing pathogenic risks and strengthening salutogenic elements in office design offers a holistic approach to design.

Within the scope of design theories, Alan Dilani's Psychosocial Supportive Design Theory, Rachel and Stephen Kaplan's Attention Renewal Theory, Heerwagen's Salutogenic Design Theory, Stokols' Socioecological Approach, and Ulrich's Supportive Design Theory offer a guiding framework for integrating the salutogenic approach into architectural design (Table 2). These approaches address human health through different dimensions of environmental impact and explain these relationships from various methodological perspectives, evaluating health not only as a biological phenomenon but also as a holistic structure encompassing psychological, environmental, and social dimensions (Table 3).

Table 2 Classification of Theoretical Frameworks Based on Salutogenic Design Principles

Theorist, Theory	Comprehensibility	Manageability	Meaningfulness
Alan Dilani - Psychosocial Supportive Design	Wayfinding, Colors, Natural light, Perception, Landmarks, Landmarks, Innovation, Interesting Elements	Aesthetic Elements, Lighting, Green Environments, Stimuli, Interior Design, Restoration, Ergonomic Design	Social support, Music, Art, Culture, Sports, Pets, Comfort, Positive Distractions
Judith Heerwagen - Salutogenic Design Theory	Organizational efficiency (open office spaces and flexible space)	Environmental sustainability (Natural light, ventilation, green areas etc.), Organizational efficiency (Modular designs), Comfort systems	Need for privacy and personal space, common areas and rest areas that support social interaction

Roger Ulrich - Supportive Design Theory	Spatial arrangement. Natural light	Biophilic design, Sense of environmental control (lighting, noise, temperature)	Privacy, Social areas, artwork, water features, Positive distractions
Daniel Stokols - Socioecological Theory	Factors that reduce distraction	Ergonomic Design, Non-toxic and pathogen-free environment, Environmental controllability and predictability. Environmental innovation and challenge, Economic stability, Participatory design and management processes	Aesthetic values. Symbolic and spiritual elements, Existence of social support networks, Organizational flexibility and sensitivity
Rachel ve Stephen Kaplan - Restorative Theory of Attention	Extent (environment is explorable and space is inclusive), Fascination (attention-grabbing)	Compatibility (Restorative space appropriate to the individual's needs)	Fascination (Elements that do not cause mental fatigue). Being Away (Mental renewal with nature)

Table 3 The Relationship Between Theoretical Frameworks and the Sense of Consistency

Theorist, Theory	Content / Methodological Approach	Design Implication	SOC Component
Alan Dilani - Psychosocial Supportive Design (2001;2008)	Conceptual frameworks linking psychosocial well-being and sense of coherence with supportive environmental design, based on interdisciplinary theoretical synthesis.	Environmental legibility, perceived environmental control, and social support → reduced anxiety levels and enhanced positive emotional states through increased cognitive engagement.	Comprehensibility /Manageability/ Meaningfulness
Judith Heerwagen - Salutogenic Design Theory (1986; 1995; 1998; 2010)	Within the context of office environments, environmental comfort, spatial flexibility, and perceived control have been examined in relation to employees' well-being and performance through literature-based research and field studies.	Environmental comfort, opportunities for personalization, acoustic regulation, perceived control over workspace conditions, and integration of biophilic design elements → increased individual comfort, higher job satisfaction, and improved focus and productivity in office environments.	Manageability
Roger Ulrich - Supportive Design Theory (1984; 1991; 2008)	Empirical studies, primarily conducted in healthcare settings, show that exposure to natural landscapes, sunlight, and supportive environmental features is associated with reduced stress levels.	Access to nature, environmental control, and social support → reduced perceived stress and improved well-being.	Manageability/ Meaningfulness
Daniel Stokols - Socioecological Theory (1992; 2013)	The theory presents a conceptual perspective that addresses the interactions between health-promoting behavior change, environmental remediation, and socioecological models.	Design strategies that strengthen social interaction and collective participation → enhanced meaningfulness and reduced stress within a socioecological framework.	Manageability/ Meaningfulness
Rachel ve Stephen Kaplan - Restorative Theory of Attention (1989; 1995)	A theoretical model explaining the restorative effects of natural environments on the human mind through attention restoration.	Natural elements and restorative environments → reduced mental fatigue, restoration of directed attention, and improved cognitive performance and well-being.	Comprehensibility /Meaningfulness

Beyond the theoretical framework discussed in the literature, empirical studies consistently demonstrate that spatial readability, wayfinding systems, and well-organized spatial structures reduce cognitive load, support spatial orientation and task performance, and thereby enhance comprehensibility in office environments. Environmental control features such as adjustable lighting, acoustic regulation, ergonomic design, and biophilic elements are associated with increased perceived environmental control, reduced stress levels, and strengthened coping capacity, directly supporting the principle of manageability. Opportunities for personalization, social interaction spaces, and restorative (healing) environments are associated with employees' emotional attachment to the workplace, intrinsic motivation, and psychological engagement with

their work, indicating a stronger sense of meaningfulness (Colenberg et al., 2020; Haapakangas et al., 2017; Lamb & Kwok, 2016; Bjørnstad et al., 2016; Forooraghi et al., 2021; Colenberg et al., 2023).

It should be emphasized that office spaces are not merely workspaces but built environments that affect an individual's quality of life. Based on the studies examined above, Table 4 summarizes the proposed design criteria based on the theoretical results of the salutogenic framework, to provide a reference for future research.

Table 4 Holistic Salutogenic Design Decisions for Office Environments

SOC Component	Design Lever	Proposition	Expected Outcome	Suggested Method
Comprehensi-bility	Spatial readability	Clear spatial hierarchy, visual corridors	Reduced cognitive load, improved orientation	Wayfinding performance tasks, spatial cognition tests, post-occupancy evaluation (POE), perceived comprehensibility scales
Comprehensi-bility	Orientation and wayfinding	User-friendly guidance systems and technological interfaces, directional lighting	Reduced mental mapping time and cognitive load	POE, navigation tasks, self-reported orientation and cognitive load measures
Manageability	Individual environmental control	Adjustable lighting, acoustic control, ergonomic furniture, green design practices	Increased perceived control, reduced stress	Pre–post intervention surveys, perceived environmental control scales, stress-related self-report measures (optionally supported by physiological indicators)
Manageability	Flexibility	Spatial and temporal flexibility (Movable partitions, hybrid working, relaxation corners)	The freedom to choose one's work style and hours strengthens an individual's sense of managing work-life balance and reduces burnout.	Comparative user surveys, observational studies, focus group interviews
Manageability	Participation and autonomy	Employee involvement in decisions, choice of work settings	Enhanced coping capacity	Questionnaires on autonomy and participation, qualitative interviews, focus group discussions
Meaningfulness	Personalization and identity	Customizable workstations, symbolic elements, cultural artifacts	Emotional attachment, motivation	Surveys measuring place attachment and work-related meaning; comparison of personalized vs. standardized workstations
Meaningfulness	Social and restorative support	Social spaces, quiet rooms, biophilic features	Psychological engagement, well-being	Mixed-method POE, qualitative interviews, well-being and engagement scales

5. Conclusion

Although health is today often approached as a service-based commodity, it fundamentally remains a human right and represents a dynamic and positive concept. While individual lifestyle choices play a significant role in shaping well-being and quality of life, the influence of environmental determinants on health outcomes has become increasingly evident. This situation necessitates that the concept of health be addressed not solely within the domain of healthcare, but rather through interdisciplinary approaches encompassing multiple sectors and disciplines.

This study examines salutogenic design approaches focused on human health in office buildings and highlights the importance of spatial arrangements that support physical, mental, and social well-being. In contrast to pathogenic approaches that primarily emphasize disease prevention, the salutogenic approach focuses on the origins of health and aims to enhance user well-being. In this context, office environments should be considered not only in relation to productivity goals, but also in terms of their contribution to individuals' quality of life and psychosocial well-being.

The research findings indicate that the components of comprehensibility, manageability, and meaningfulness, as defined within Aaron Antonovsky's salutogenic model, provide a holistic conceptual framework for strengthening user experience and psychosocial well-being in office design. In addition, the works of theorists such as Alan Dilani, Rachel and Stephen Kaplan, Heerwagen, Stokols, and Ulrich demonstrate the adaptability of the salutogenic approach to architectural design and offer important conceptual insights for health-oriented design models. In this respect, the study serves as a theoretical reference point for future research.

In the future, prioritizing health-oriented design criteria as a fundamental design input in office buildings will be of critical importance. However, for this approach to be effective, it should not be limited solely to the arrangement of the physical environment; rather, it should be integrated with employer policies, organizational culture, organizational structures, and employee support programs.

The proposed design opportunities are based on findings from the literature and on designers' theoretical assumptions. Although designers may aim to support certain behaviors, users may choose to engage with spaces in different ways, or design decisions may not perform as anticipated. Therefore, to better understand the gap between design intentions and user experiences, future studies are encouraged to place greater emphasis on qualitative methods, multi-researcher evaluations, and user-centered empirical research.

Note

This article is derived from the author's ongoing master's thesis study.

CRediT Authorship Contribution Statement

Eda Nur Aydemir Kutluer: Writing – review & editing, Writing – original draft, Methodology, Investigation, Analysis, Data curation, Conceptualization, Data visualization. Betül Bakır: Writing – review & editing, Writing – original draft, Methodology, Investigation, Analysis, Data curation, Conceptualization, Data visualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

All data are available within the paper.

Ethics Committee Approval

Ethics committee permission is not required.

References

Amzat, J., & Razum, O. (2014). Health, disease, and illness as conceptual tools. In *Medical sociology in Africa* (pp. 21-37). Springer. https://doi.org/10.1007/978-3-319-03986-2_2

Antonovsky, A. (1979). *Health, stress and coping*. Jossey-Bass.

Antonovsky, A. (1987). *Unraveling the mystery of health: How people manage stress and stay well*. Jossey-Bass.

Antonovsky, A. (1996). The salutogenic model as a theory to guide health promotion. *Health Promotion International*, *11*(1), 11-18. https://doi.org/10.1093/heapro/11.1.11

Azzazi, A., & Nafiz, J. (2016). *Psychosocially supportive design within workplaces* [Doctoral dissertation, The British University in Dubai].

Bergefurt, L., Appel-Meulenbroek, R., & Arentze, T. (2023). How salutogenic workplace characteristics influence psychological and cognitive responses in a virtual environment. *Ergonomics*, *67*(3), 339-355. https://doi.org/10.1080/00140139.2023.2223372s

Bjørnstad, S., Patil, G. G., & Raanaas, R. K. (2016). Nature contact and organizational support during office working hours: Benefits relating to stress reduction, subjective health complaints, and sick leave. *Work*, *53*(1), 9-20. https://doi.org/10.3233/WOR-1522

Bluyssen, P. M. (2013). *The healthy indoor environment: How to assess occupants' wellbeing in buildings* (1st ed.). Routledge. https://doi.org/10.4324/9781315887296

Bor, H. (2020). The relationship between nutrition and worker efficiency. *Turkish Journal of Family Medicine and Primary Care*, *14*(2), 305-11. https://doi.org/10.21763/tjfmpc.642063

Boscherini, G. (2017). A sense of coherence: Supporting the healing process. *Architectural Design*, *87*(2), 108-113. https://doi.org/10.1002/ad.2159

Burton, J., & World Health Organization. (2010). *WHO healthy workplace framework and model: Background and supporting literature and practices*. World Health Organization.

Clements-Croome, D. (2011). Sustainable intelligibility gent buildings for people: A review. *Intelligent Buildings International*, *3*(2), 67-86. https://doi.org/10.1080/17508975.2011.582313

Colenberg, S., Appel-Meulenbroek, R., Romero Herrera, N., & Keyson, D. (2023). Interior designers' strategies for creating social office space. *Ergonomics*, *67*(7), 995_1007. https://doi.org/10.1080/00140139.2023.2270788

Colenberg, S., Jylhä, T., & Arkesteijn, M. (2020). The relationship between interior office space and employee health and well-being – A literature review. *Building Research and Information*, *49*(3), 352-366. https://doi.org/10.1080/09613218.2019.1710098

Dietscher, C., Winter, U., Pelikan, J. M. (2017). The application of salutogenesis in hospitals. In Mittelmark, M., et al. *The handbook of salutogenesis*. Springer, Cham. https://doi.org/10.1007/978-3-319-04600-6_27

Dilani, A. (Ed.). (2001). *Design & health: The therapeutic benefits of design. Proceedings of the 2nd International Conference on Design and Health*, Stockholm, Sweden. Svensk Byggtjänst.

Dilani, A. (2004). A new paradigm of design and health. In *Health promotion through environmental design*, 1525.

Dilani, A. (2005). Psychosocially supportive design. In A. Dilani (Ed.), *Design and health IV: Future trends in healthcare design* (pp. 13-22).

Dilani, A. (2009). Psychosocially supportive design: A salutogenic approach. In *The 1st International Conference on Sustainable Healthy Buildings* (pp. 55-65).

Dutheil, F., Danini, B., Bagheri, R., Fantini, M. L., Pereira, B., Moustafa, F., Trousselard, M., & Navel, V. (2021). Effects of a short daytime nap on the cognitive performance: a systematic review and meta-analysis. *International Journal of Environmental Research and Public Health*, *18*(19), 10212. https://doi.org/10.3390/ijerph181910212

Eriksson, M., & Lindström, B. (2006). Antonovsky's sense of coherence scale and the relation with health: A systematic review. *Journal of Epidemiology and Community Health*, *60*(5), 376_381. https://doi.org/10.1136/jech.2005.041616

Eriksson, M., & Lindström, B. (2008). A salutogenic interpretation of the Ottawa Charter. *Health Promotion International*, *23*(2), 190-199. https://doi.org/10.1093/heapro/dan014

Forooraghi, M., Miedema, E., Ryd, N., & Wallbaum, H. (2021). How does office design support employees' health? A case study on the relationships among employees' perceptions of the office environment, their sense of coherence and office design. *International Journal of Environmental Research and Public Health*, *18*(23), 12779. https://doi.org/10.3390/ijerph182312779

Fukumoto, H., Shimoda, M., & Hoshino, S. (2024). The effects of different designs of indoor biophilic greening on psychological and physiological responses and cognitive performance of office workers. *Plos One*, *19*(7), e0307934. https://doi.org/10.1371/journal.pone.0307934

Gilchrist, K., Brown, C., & Montarzino, A. (2015). Workplace settings and wellbeing: Greenspace use and views contribute to employee wellbeing at peri-urban business sites. *Landscape and Urban Planning*, *138*, 32-40. https://doi.org/10.1016/j.landurbplan.2015.02.004

Golembiewski, J. A. (2010). Start making sense: Applying a salutogenic model to architectural design for psychiatric care. *Facilities*, *28*(3/4), 100-117. https://doi.org/10.1108/02632771011023096

Golembiewski, J. A. (2022). The meanings of salutogenesis. In *The handbook of salutogenesis* (2nd ed., pp. 259-274). Springer.

Gonçalves, G., Sousa, C., Fernandes, M. J., Almeida, N., & Sousa, A. (2023). Restorative effects of biophilic workplace and nature exposure during working time: A systematic review. *International Journal of Environmental Research and Public Health, 20*(21), 6986. https://doi.org/10.3390/ijerph20216986

Haapakangas, A., Hongisto, V., Eerola, M., & Kuusisto, T. (2017). Distraction distance and perceived disturbance by noise – An analysis of 21 open-plan offices. *The Journal of the Acoustical Society of America*, *141*(1), 127-136. https://doi.org/10.1121/1.4973690

Heerwagen, J. H. (1998). Design, productivity and well being: What are the links. *AIA Highly Effective Facilities*, 1-23.

Heerwagen, J. H., Heubach, J. G., Montgomery, J., & Weimer, W. C. (1995). Environmental design, work, and well being: Managing occupational stress through changes in the workplace environment. *AAOHN Journal*, *43*(9), 458-468. https://doi.org/10.1177/216507999504300904

Herzog, T. R., Maguire, P., & Nebel, M. B. (2003). Assessing the restorative components of environments. *Journal of Environmental Psychology, 23*(2), 159-170. https://doi.org/10.1016/S0272-4944(02)00113-5

Huber, M., Knottnerus, J. A., Green, L., Van Der Horst, H., Jadad, A. R., Kromhout, D., Leonard, B., Lorig, H., Loureiro, M. I., van der Meer, J. W. M., Schnabel, P., Schnabel, P., Smith, R., van Weel, C., & Smid, H. (2011). How should we define health? *BMJ*, *343*. https://doi.org/10.1136/bmj.d4163

Kaplan, R. (1993). The role of nature in the context of the workplace. *Landscape and Urban Planning, 26*(1-4), 193-201. https://doi.org/10.1016/0169-2046(93)90016-7

Kaplan, R., & Kaplan, S. (1989). *The experience of nature: A psychological perspective*. Cambridge University Press.

Kaplan, S. (1995). The restorative benefits of nature: Toward an integrative framework. *Journal of Environmental Psychology*, *15*(3), 169-182. https://doi.org/10.1016/0272-4944(95)90001-2

Lamb, S., & Kwok, K. C. (2016). A longitudinal investigation of work environment stressors on the performance and wellbeing of office workers. *Applied Ergonomics*, *52*, 104_111. https://doi.org/10.1016/j.apergo.2015.07.010

Larson, J. S. (1999). The conceptualization of health. *Medical Care Research and Review*, *56*(2), 123-136. https://doi.org/10.1177/107755879905600201

Lindström, B., & Eriksson, M. (2005). Salutogenesis. *Journal of Epidemiology and Community Health*, *59*(6), 440-442. https://doi.org/10.1136/jech.2005.034777

Litwiller, B., Snyder, L. A., Taylor, W. D., & Steele, L. M. (2017). The relationship between sleep and work: A meta-analysis. *Journal of Applied Psychology*, 102(4), 682-699. https://doi.org/10.1037/apl0000169

Medic, G., Wille, M., & Hemels, M. E. (2017). Short-and long-term health consequences of sleep disruption. *Nature and Science of Sleep*, *9*, 151. https://doi.org/10.2147/NSS.S134864

Mittelmark, M. B., & Bauer, G. F. (2017). The meanings of salutogenesis. In *The handbook of salutogenesis* (pp. 7-13).

Mittelmark, M. B., & Bull, T. (2013). The salutogenic model of health in health promotion research. *Global Health Promotion*, *20*(2), 30-38. https://doi.org/10.1177/1757975913486684

Park, A. H., Zhong, S., Yang, H., Jeong, J., & Lee, C. (2022). Impact of COVID-19 on physical activity: A rapid review. *Journal of Global Health*, *12*. https://doi.org/10.7189/jogh.12.05003

Pelikan, J. M. (2022). Applying salutogenesis in healthcare settings. In Mittelmark, M.B., et al. *The handbook of salutogenesis.* Springer. https://doi.org/10.1007/978-3-030-79515-3_36

Rakhshani, Z., & Khakzand, M. (2025). Salutogenic architecture, non-therapeutic environments and the health of the elderly: A systematic review. *HERD: Health Environments Research and Design Journal*, *18*(2), 51-77. https://doi.org/10.1177/19375867251313980

Roscoe, L. J. (2009). Wellness: A review of theory and measurement for counselors. *Journal of Counseling and Development, 87*(2), 216-226. https://doi.org/10.1002/j.1556-6678.2009.tb00570.x

Roskams, M., & Haynes, B. (2020). Salutogenic workplace design: A conceptual framework for supporting sense of coherence through environmental resources. *Journal of Corporate Real Estate*, *22*(2), 139-153. https://doi.org/10.1108/JCRE-01-2019-0001

Ruohomäki, V., Lahtinen, M., & Reijula, K. (2015). Salutogenic and user-centred approach for workplace design. *Intelligent Buildings International*, *7*(4), 184_197. https://doi.org/10.1080/17508975.2015.1007911

Schneider, M., & Stokols, D. (2009). Multilevel theories of behavior change: A social ecological framework. In S. A. Shumaker, J. K. Ockene, & K. A. Riekert (Eds.), *The handbook of health behavior change* (3rd ed., pp. 85-105). Springer.

Steptoe, A. & Appels, A. (1989). *Stress, personal control, and health.* John Wiley and Sons.

Stokols, D. (1987). Conceptual strategies of environmental psychology. In D. Stokols, & I. Altman (Eds.), *Handbook of environmental psychology* (pp. 41-70). Wiley.

Stokols, D. (1992). Establishing and maintaining healthy environments: Toward a social ecology of health promotion. *American Psychologist*, *47*(1), 6. https://doi.org/10.1037/0003-066X.47.1.6

Stokols, D., Lejano, R. P., & Hipp, J. (2013). Enhancing the resilience of human-environment systems: A social ecological perspective. *Ecology and Society*, *18*(1). https://www.jstor.org/stable/26269281

Ulrich, R. S. (1991). Effects of interior design on wellness: Theory and recent scientific research. In Journal of Health Care Interior Design: Proceedings from the. Annual National Symposium on Health Care Interior Design. *Symposium on Health Care Interior Design* (Vol. 3, pp. 97-109).

Ulrich, R. S. (1992). How design impacts wellness. *In The Healthcare Forum Journal* (Vol. 35, No. 5, pp. 20-25).

Williams, K. J., Lee, K. E., Hartig, T., Sargent, L. D., Williams, N. S., & Johnson, K. A. (2018). Conceptualising creativity benefits of nature experience: Attention restoration and mind wandering as complementary processes. *Journal of Environmental Psychology*, *59*, 36_45. https://doi.org/10.1016/j.jenvp.2018.08.005

World Health Organization. (1986). *Ottawa charter for health promotion*. (No. WHO/EURO: 1986-4044-43803-61677). World Health Organization. Regional Office for Europe.

World Health Organization. (2020). *Basic documents*. World Health Organization.

Xiang, J., Mansor, N., & Azmi, A. (2025). Effects of vr-based interactive interior design on the emotional and mental health of office worker. *Journal of Asian Architecture and Building Engineering, 24*(6), 5723-5736. https://doi.org/10.1080/13467581.2024.2418513

Yeang, K., & Dilani, A. (Eds.). (2022). *Ecological and salutogenic design for a sustainable healthy global society.* Cambridge Scholars Publishing.

Ziegler, E. (2014). *Application of a salutogenic design model to the architecture of low-income housing* [Doctoral dissertation, University of British Columbia].

Resume

Eda Nur Aydemir Kutluer received her Bachelor's degree in Architecture from Yıldız Technical University (YTU) in 2018. She is currently a Master's degree student in the Department of Architecture at Balıkesir University, where she started her graduate studies in 2024. She currently works in her own architectural office, Kutluer Mimarlık.

Betül Bakır graduated from the Faculty of Architecture at Yıldız Technical University (YTU) in 1983. She completed her master's degree in Building Physics at Yıldız Technical University in 1986, and received her PhD in Restoration from the same university in 1994. She is currently working as an Associate Professor in the Department of Restoration at Balıkesir University.

JOURNAL OF DESIGN FOR RESILIENCE IN ARCHITECTURE & PLANNING

Research Article
Online: www.drarch.org
Volume 7, Issue 1 (21-36), 2026
DOI: 10.47818/DRArch.2026.v7i1201

Symbiotic spatiality in domestic interiors: A spatial model for human-animal cohabitation

Neşe Başak Yurttaş*

Abstract

Domestic interiors have historically been organized through anthropocentric spatial logics in which architectural layouts, circulation systems, and spatial hierarchies are structured primarily around human needs and bodily experience. However, the increasing presence of animals as everyday companions within contemporary households has gradually transformed domestic environments into shared multispecies habitats. Despite this transformation, architectural responses often remain limited to functional adjustments rather than reconsidering interior spatial organization itself. Addressing this gap, the study proposes the Symbiotic Spatial Model as an analytical framework for examining how domestic interiors reorganize when animals are recognized as spatial actors rather than accommodated occupants. The model translates post-humanist spatial discourse into three operational layers: hierarchical reconfiguration, multi-species circulation, and negotiated boundaries. The framework is applied through a comparative spatial analysis of two contemporary residential projects that explicitly integrate human–animal cohabitation. The findings demonstrate that symbiotic coexistence emerges through different spatial mechanisms, including plan-based redistribution of hierarchy and sectional stratification of movement systems. By operationalizing multispecies theory through spatial parameters, the study contributes a methodological framework for interpreting human–animal coexistence within interior architecture.

Keywords: multispecies architecture, human-animal cohabitation, posthumanist design, interior spatial organization, symbiotic spatial model

1. Introduction

Domestic interiors have traditionally been designed as environments organized exclusively around human bodies, routines, and spatial priorities. However, as animals increasingly inhabit domestic spaces as everyday companions, interiors are gradually transforming into multispecies environments in which spatial organization is negotiated among multiple forms of life. In many contemporary households, animals are no longer positioned solely as external companions but as participants in everyday domestic routines. This shift has gradually redefined the spatial dynamics of domestic interiors, where animals occupy circulation routes, resting zones, observation points, and vertical surfaces alongside human inhabitants. As a result, domestic environments increasingly function as shared habitats rather than exclusively human-centered living spaces.

Despite this transformation, architectural and interior design practices have only partially responded to the spatial implications of multispecies living. Design approaches that address animals in domestic interiors often focus on practical adjustments such as hygiene management, durable materials, specialized furniture, or localized spatial modifications. While these strategies may improve practical compatibility between humans and animals, they rarely reconsider the spatial logic of interiors at the level of plan organization, circulation systems, or vertical spatial structure. Consequently, animals are frequently treated as accommodated occupants rather than as spatial actors capable of reshaping interior environments.

*(Corresponding author), Department of Interior Architecture and Environmental Design, Biruni University, İstanbul, Türkiye
nyurttas@biruni.edu.tr
Article history: Received 06 February 2026, Accepted 01 April 2026, Published 30 April 2026

Recent theoretical developments in post-humanist and relational spatial thought challenge the anthropocentric assumptions that have historically shaped architectural discourse. These perspectives emphasize that spatial environments emerge through networks of interactions among human and non-human actors rather than through purely human agency. Within this framework, interiors can be understood as relational environments produced through the movements, behaviors, and sensory experiences of multiple species. However, while such theoretical perspectives increasingly recognize multispecies coexistence, their translation into operational spatial frameworks within interior architecture remains limited.

This gap highlights the need for analytical approaches that examine how domestic interiors respond to multispecies habitation at the spatial level. In particular, there is a lack of systematic frameworks that enable researchers and designers to evaluate how spatial hierarchy, circulation patterns, and boundary conditions are reorganized when animals are recognized as active participants in interior environments. Addressing this gap requires models that translate multispecies theory into spatially observable parameters for examination within built environments.

In response to this need, the present study proposes the Symbiotic Spatial Model as a conceptual and analytical framework for examining human-animal coexistence within domestic interiors. The model interprets multispecies living not merely as a social or ethical issue but as a spatial phenomenon that can be analyzed through observable design parameters. By focusing on the redistribution of spatial hierarchy, the reconfiguration of circulation systems, and the negotiation of spatial boundaries, the model enables a systematic reading of how interior environments adapt to shared habitation between humans and animals.

Within this framework, the study investigates two contemporary residential projects that explicitly address human-animal cohabitation through spatial design strategies. Through a comparative spatial analysis, the research examines how different architectural approaches reorganize interior space in response to multispecies living conditions.

The objective of this study is to examine how multispecies habitation reorganizes interior spatial structures and to develop an analytical framework to interpret these transformations. The following research questions guide the study:

RQ1: How do interior spatial hierarchies change when animals are recognized as active occupants within domestic environments?

RQ2: In what ways do circulation systems adapt to accommodate multispecies movement within interior spaces?

RQ3: How are spatial boundaries negotiated between human and non-human occupants within shared domestic environments?

Based on these questions, the study advances the following hypothesis:

H1: When animals are recognized as spatial actors rather than accommodated occupants, domestic interiors exhibit observable transformations in spatial hierarchy, circulation structures, and boundary configurations.

By operationalizing multispecies theory through spatial parameters, the study aims to contribute to the emerging discourse on post-humanist interior architecture. The proposed model provides a methodological framework for analyzing symbiotic living conditions in domestic environments and a structured approach to interpreting spatial adaptations that support human-animal coexistence.

The remainder of the article is structured as follows. Section 2 reviews the theoretical foundations of multispecies coexistence and its implications for interior architecture. Section 3 outlines the research methodology and analytical approach adopted in the study. Section 4 introduces the Symbiotic Spatial Model and defines its operational layers. Section 5 presents the

comparative spatial analysis of the selected case studies. Finally, Section 6 discusses the findings and reflects on the implications of symbiotic spatial thinking for future interior design practices.

2. Literature Review

The Interior architecture has historically evolved within an anthropocentric conceptual framework in which space is primarily defined through human scale, perception, and patterns of use. Domestic interiors, in particular, have long been conceived as environments optimized for human comfort, functionality, and aesthetic order. Phenomenological approaches to architecture have frequently emphasized human sensory experience and bodily perception as the primary basis for spatial understanding (Pallasmaa, 2012, pp. 61-125). Within this paradigm, non-human living beings have generally been positioned as peripheral or secondary occupants whose presence is accommodated rather than structurally integrated into spatial organization. As a result, the design logic of interiors has largely prioritized human circulation patterns, ergonomic standards, and sensory preferences while overlooking the spatial implications of multispecies coexistence. From a relational perspective, however, space may also be understood as a network of interactions among human and non-human actors rather than a domain exclusively produced by human agency (Latour, 2005, pp. xii).

In recent decades, the growing visibility of animals within domestic environments has begun to challenge these assumptions. Increasing rates of pet ownership, the transformation of urban domestic life, and the evolving recognition of human-animal relationships have contributed to new forms of shared living environments. In many contemporary households, animals are no longer treated merely as external companions but as participants in everyday domestic routines. Despite these transformations in living practices, architectural and interior design responses frequently remain limited to functional adjustments such as hygiene management, furniture adaptation, or localized design modifications. Such strategies typically operate within design frameworks that continue to prioritize human spatial logic rather than reconsidering interiors as multispecies environments (Wakkary, 2021, pp. xii).

The limitations of anthropocentric spatial thinking have been extensively discussed within post-humanist scholarship, which challenges the hierarchical distinction traditionally drawn between humans and non-human actors. Post-humanist theory argues that human subjectivity cannot be understood independently from the networks of relations that connect humans with other living beings, technologies, and environments. Within this perspective, humans are no longer interpreted as the sole producers of space; instead, spatial environments emerge through interactions among multiple forms of agency. Braidotti's critique of human exceptionalism challenges the humanist assumption that centers the human subject in knowledge and design (Braidotti, 2013, pp. 13-54). Similarly, Haraway's concept of "companion species" emphasizes the co-evolutionary relationships between humans and animals, suggesting that shared living environments are produced through ongoing processes of mutual adaptation and interaction (Haraway, 2003, pp. xii). Anthropological perspectives on ontology further reinforce this argument by demonstrating that distinctions between humans and other living beings are culturally constructed rather than universally fixed (Descola, 2013, pp. 1-30).

Relational approaches to spatial theory have also expanded the understanding of how environments are produced. Actor-network theory highlights the distributed agency of both human and non-human actors within social and spatial systems, suggesting that built environments emerge from complex networks of relationships rather than singular human intentions. Ingold's concept of "meshwork" similarly describes space as a dynamic field of interconnected trajectories, movements, and interactions rather than a static container (Ingold, 2011, pp. xii). From this perspective, interiors may be understood not merely as enclosed volumes but as relational environments shaped by the movements, behaviors, and practices of the beings that inhabit them.

Ecological thought adds dimension to these discussions by emphasizing the interdependence of living organisms and environmental systems. Ecosystem theory demonstrates that environmental

conditions emerge from networks of reciprocal relationships among organisms, energy flows, and material exchanges (Odum, 1971, pp. 1-30). The concept of the ecosphere further extends this understanding by framing life on Earth as a complex system in which biological, chemical, and atmospheric processes interact continuously (Lovelock, 2000, pp. xii). Within built environments, these ecological perspectives encourage designers to view interiors not merely as human shelters but as micro-environments embedded within broader environmental systems (Chapin et al., 2011, pp. 4-20).

Environmental perception research has further broadened architectural discussions of space by highlighting the multisensory nature of spatial experience. Architectural theorists have emphasized that spatial perception is shaped not only by visual form but also by sensory conditions such as sound, temperature, air movement, and tactile qualities (Pallasmaa, 2012, pp. 40-60). Environmental psychology research similarly suggests that spatial well-being is influenced by atmospheric conditions and environmental stimuli that affect both physiological and psychological responses (Ulrich et al., 2008, pp. 61-125). These insights highlight the importance of recognizing that different species perceive and experience spatial environments through distinct sensory modalities.

Studies in animal behavior and cognition reinforce this perspective by demonstrating that animals interact with spatial environments through species-specific behavioral patterns such as climbing, hiding, territorial observation, and seeking sheltered retreats (Bekoff, 2007, pp. xii). Animals also perceive environmental stimuli differently from humans, often exhibiting heightened auditory sensitivity, olfactory awareness, and spatial orientation behaviors (Grandin & Johnson, 2005, pp. xii). When design strategies fail to account for these differences, conflicts between spatial organization and animal behavior may arise, leading to stress, spatial competition, or environmental incompatibility. Conversely, environments that account for behavioral and perceptual diversity can support more balanced forms of coexistence between humans and animals (Bradshaw, 2017, pp. xii).

Material and environmental conditions also play a critical role in shaping multispecies interiors. Material properties such as toxicity, durability, surface resilience, and environmental performance also influence the ecological quality and environmental conditions of interior spaces (Ashby et al., 2016, pp. 80-109). These considerations demonstrate that design decisions regarding materials, surfaces, and environmental systems significantly contribute to the quality of shared habitats.

Despite these growing theoretical insights, much of the existing literature addressing animals in domestic environments remains focused on product design, specialized furniture, or isolated functional adaptations. Design strategies described as “pet-friendly” often focus on practical concerns such as durability, hygiene, and containment rather than on reconsidering the spatial organization of interiors from a multispecies perspective. As a result, animals are frequently treated as accommodated occupants rather than as spatial actors whose presence may reshape circulation patterns, spatial hierarchies, or vertical movement systems. Overall, the literature increasingly challenges anthropocentric assumptions and calls for design approaches that treat non-human occupants as active spatial stakeholders rather than accommodated add-ons. However, within interior architecture, this shift has only partially translated into operational spatial frameworks that can guide design decisions at the plan, section, and circulation scales. Recent work has begun to address this gap by examining post-humanist cohabitation in interior and furniture design for pets, highlighting the need for more systematic spatial models (Yurttaş & Altuncu, 2022, pp. 281-283).

This limitation reveals a significant gap within contemporary interior architecture discourse. While multispecies relationships are increasingly recognized within theoretical discussions, their spatial implications within interior architecture remain insufficiently examined. Addressing this gap requires analytical frameworks that translate multispecies theory into spatially observable design parameters.

In response to this need, the present study introduces the Symbiotic Spatial Model as a conceptual and analytical framework for examining multispecies coexistence within domestic interiors. By translating post-humanist and ecological perspectives into spatially readable parameters, the model enables a systematic examination of how interior environments respond to the presence of multiple species. The framework focuses on the spatial negotiation of hierarchy, circulation, and boundaries within shared domestic environments, providing a methodological basis for analyzing symbiotic living conditions in human-animal shared spaces.

3. Methodology

This study adopts a model-oriented analytical approach to examine the spatial organization of domestic interiors accommodating multi-species living. The methodology comprises three stages: the development of an analytical framework grounded in post-humanist spatial discourse; the identification of contemporary residential projects that meaningfully engage with human-animal cohabitation; and a layered spatial reading of selected examples. Through this process, the study seeks to clarify how symbiotic coexistence can be interpreted as a spatial regime rather than a purely functional accommodation.

3.1. Development of the Symbiotic Spatial Model

The Symbiotic Spatial Model was developed through a critical reading of post-humanist spatial discourse alongside architectural discussions on human-animal cohabitation. While these discussions frequently address issues such as decentered hierarchy, multi-species agency, and negotiated coexistence, they often remain at a conceptual level. This study examined how such ideas might be recognized in the spatial organization of domestic interiors.

To do so, recurring theoretical themes were translated into spatial questions: Who occupies the dominant zones of a plan? How are circulation paths structured and shared? Where are boundaries fixed, and where are they adjustable? By reformulating abstract concepts into spatial parameters that can be read in plan and section, three interrelated layers were defined: (1) Reconfiguration of Spatial Hierarchy, (2) Multi-Species Circulation and Bodily Negotiation, and (3) Negotiated Separation and Co-presence.

The model was articulated before project selection and operates as an analytical framework that enables a structured spatial reading rather than prescribing a specific design solution.

3.2. Project Identification and Selection

Contemporary residential projects addressing human–animal cohabitation were identified through a focused review of architectural publications and professional repositories. The search was carried out across widely recognized platforms, including ArchDaily, Dezeen, Designboom, Architizer, Divisare, and Interior Design Magazine.

Using keywords such as “co-living with pets,” “multi-species housing,” “pet-friendly residence,” and related variations, approximately 30 contemporary projects were initially identified. The first stage of filtering excluded projects in which animal accommodation was limited to additive interventions, such as furniture insertions, wall-mounted pathways, or accessory-based integrations, that had no measurable impact on the spatial organization of the domestic plan.

A second stage focused on the availability of technical documentation. Projects lacking accessible plans or sectional drawings were excluded, as this limited the ability to conduct a plan-based analysis. The remaining projects were then evaluated according to the extent to which circulation systems, zoning strategies, and boundary conditions suggested structural spatial integration rather than peripheral accommodation. Two projects were ultimately selected for their ability to demonstrate distinct degrees of spatial reorganization in relation to the proposed analytical framework.

3.3. Analytical Procedure

The selected projects were examined through a layer-by-layer spatial reading based on the three components of the Symbiotic Spatial Model. Rather than treating the projects as isolated case studies, the analysis focused on identifying specific spatial operations within their plan organization and sectional articulation.

For each project, the first layer, “Reconfiguration of Spatial Hierarchy”, was examined by observing how dominant zones were distributed, whether central areas remained exclusively human-oriented, and how spatial priority was allocated across the interior. This involved assessing the relative size, position, and connectivity of spaces attributed to different forms of inhabitation.

The second layer, “Multi-Species Circulation and Bodily Negotiation”, was analyzed through the configuration of movement paths. Circulation systems were examined for continuity, overlap, and accessibility, with attention to whether non-human movement was structurally integrated into the primary interior flow or confined to residual surfaces and peripheral routes.

The third layer, “Negotiated Separation and Co-presence”, was evaluated by identifying how boundaries were articulated. Particular attention was given to thresholds, partitions, and visual permeability: whether separation operated as rigid exclusion or as calibrated adjacency enabling simultaneous presence without enforced overlap.

The findings from each layer were then comparatively interpreted to identify varying degrees of spatial reorganization. This comparative reading does not rank the projects by success; instead, it reveals how different domestic interiors negotiate multi-species coexistence through spatial logic.

To enhance comparative clarity, the layer-based observations were additionally synthesized into a qualitative evaluation matrix. Each operational layer was assessed based on the extent to which it reorganized the spatial hierarchy, circulation systems, and boundary conditions. Rather than introducing a quantitative scoring system, the matrix employs a two-level qualitative distinction, Primary and Secondary, indicating whether the spatial reorganization constitutes a structural driver of the project or a supportive but non-dominant operation. This classification does not rank the projects but clarifies the relative intensity of spatial integration across the three operational layers.

3.4. Scope and Limitations

This study is limited to the spatial organization of domestic interiors accommodating human-animal cohabitation. The analysis focuses specifically on architectural spatial logic, plan configuration, circulation systems, and boundary articulation, rather than legal ownership structures, urban policy frameworks, or behavioral and veterinary considerations.

The projects examined are interpreted through published drawings and visual documentation. As such, the study does not evaluate post-occupancy performance, user satisfaction, or measurable indicators of animal welfare. Instead, it investigates how spatial organization itself may enable or constrain symbiotic coexistence.

The scope is further confined to residential typologies, including individual dwellings and multi-unit housing, and does not extend to urban-scale interspecies planning.

4. The Symbiotic Spatial Model

The increasing visibility of human-animal cohabitation in domestic environments has not necessarily translated into a structural transformation of interior spatial organization. While pet-inclusive strategies often accommodate animals through additive or accessory-based solutions, the underlying spatial hierarchy of the domestic plan frequently remains anthropocentric. In response to this spatial condition, this study proposes a Symbiotic Spatial Model that reconsiders the interior not as a human-dominated arrangement with animal adaptations, but as a negotiated spatial system structured through multi-species interaction.

The model is grounded in three interrelated layers that operate at the level of plan organization and sectional articulation: (1) the reconfiguration of spatial hierarchy, (2) multi-species circulation and bodily negotiation, and (3) negotiated separation and co-presence.

4.1. Reconfiguration of Spatial Hierarchy

Domestic interiors have historically been organized through an implicit hierarchy that positions the human subject as the primary spatial reference. Rooms are distributed according to human routines; circulation follows human ergonomics; thresholds, levels, and visual axes are calibrated to human perception and bodily scale. Within this framework, animals are typically accommodated secondarily, through localized adaptations, peripheral zones, or movable additions, without fundamentally altering the underlying spatial order.

Reconfiguration of spatial hierarchy, as proposed in the Symbiotic Spatial Model, does not imply the elimination of human centrality, but rather its recalibration. The interior is reconsidered as a field of negotiated priorities, where spatial allocation, adjacency, and degrees of access are distributed in response to the needs, movements, and spatial occupation of multiple species, rather than determined solely by human functional sequences. Instead of attaching animal-related functions onto an already fixed plan, the hierarchy itself becomes adjustable, allowing different species to exert influence over spatial distribution.

At the level of plan organization, this reconfiguration becomes visible through shifts in zoning logic. Spaces traditionally considered secondary, corridors, transitional zones, and service areas, may acquire structural significance when multi-species occupation is acknowledged. Circulation cores can transform from purely connective elements into shared infrastructures. The hierarchy of private versus common, primary versus auxiliary, expands to accommodate species-specific needs without reducing them to accessory status.

This layer, therefore, operates primarily at the scale of spatial ordering. It asks not whether animals are present within the domestic interior, but whether their presence has reorganized the distribution of space. A symbiotic hierarchy emerges when the plan reflects negotiated spatial priorities rather than unilateral human dominance, producing an interior in which multiple forms of occupation are embedded in the plan's spatial organization rather than added as secondary layers.

4.2. Multi-Species Circulation and Bodily Negotiation

If the first layer concerns the allocation of space, the second layer addresses how bodies move through it. In most residential plans, circulation is organized around human routines: entry sequences, room-to-room transitions, visual axes, and ergonomic dimensions are all designed according to human scale and habitual patterns of use. Movement paths are typically linear and horizontally organized, structured through room sequences, openings, and spatial alignments defined by human scale. When animals are considered, their movement is often accommodated by adding elements such as wall-mounted pathways, surface extensions, or localized openings, without altering the dwelling's primary circulation system.

Within a symbiotic spatial framework, circulation becomes a site of multi-species negotiation. Movement is no longer conceived as a single, human-dominated trajectory but as an overlapping set of routes shaped by different bodily scales, speeds, and spatial preferences. This does not necessarily require duplicating entire circulation systems; rather, it entails recalibrating spatial thresholds, vertical connections, and transitional zones to enable multiple forms of movement to coexist within the same interior structure.

At the plan and section levels, such negotiation may manifest through layered pathways, vertically articulated circulation cores, or differentiated levels of access embedded in walls, platforms, or structural elements. Instead of confining animals to peripheral routes, the circulation is structurally reorganized so that their movement intersects, parallels, or occasionally diverges

from human paths. The primary flow of the plan is therefore reconsidered rather than replaced, enabling multiple trajectories to coexist within a shared spatial framework.

In this layer, bodily negotiation is articulated through measurable spatial decisions: variations in height, sectional layering, calibrated passage widths, visual permeability across levels, and controlled points of intersection. These decisions acknowledge that bodies occupy space differently and that movement patterns are species-specific. A multi-species interior does not merely tolerate animal mobility; it anticipates and integrates it into the architectural logic of circulation itself.

4.3. Negotiated Separation and Co-presence

Domestic interiors that include animals often oscillate between two spatial extremes: unrestricted integration or strict segregation. In the first case, animals move freely throughout the dwelling, resulting in shared but frequently unstructured occupation. In the second, they are confined to enclosed rooms, cages, or isolated zones, thereby disconnecting them from daily domestic life. Both approaches rely on fixed boundaries, either none at all or entirely rigid ones.

Within the Symbiotic Spatial Model, separation and co-presence are not treated as opposites but as spatial conditions that can be calibrated. Rather than drawing permanent dividing lines, the interior incorporates controlled thresholds, adjustable partitions, semi-transparent surfaces, and layered boundaries that allow varying degrees of visibility, proximity, and interaction. Separation becomes partial and reversible; co-presence becomes structured rather than incidental.

At the level of architectural articulation, this negotiation is expressed through sliding panels, elevated platforms, half-height enclosures, perforated partitions, or translucent materials that permit visual continuity without unrestricted access. The emphasis is not on isolating species from one another, but on designing spatial relationships that enable moments of closeness and moments of withdrawal within the same framework. These calibrated boundaries allow domestic life to fluctuate between shared occupation and differentiated inhabitation without collapsing into spatial conflict.

In this layer, co-presence is spatially staged rather than assumed. Animals and humans may occupy adjacent zones, maintain visual connection across levels, or intersect at controlled points of overlap. The interior thereby acknowledges proximity as an architectural condition, not merely a behavioral one. Negotiation is embedded in thresholds, edges, and intermediate zones, ensuring that separation does not eliminate interaction, and interaction does not eliminate spatial autonomy.

This operational structure is schematically represented in Figure 1 through a neutral, rectilinear residential plan. The left diagram illustrates an anthropocentric default configuration, in which the spatial hierarchy is centralized and dominated by a primary human living zone. Although non-human movement is present, it remains fragmented and structurally unallocated, occurring within a spatial order that has not been reorganized to accommodate multiple forms of occupation. Boundaries are fixed, and overlap emerges incidentally rather than through calibrated design.

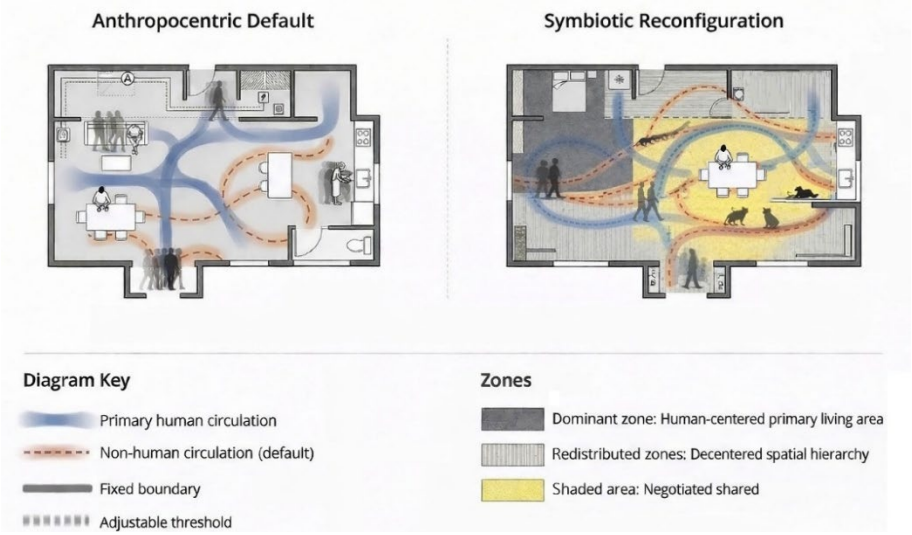


Figure 1 Conceptual diagram of the Symbiotic Spatial Model contrasting anthropocentric spatial organization with symbiotic reconfiguration. The diagram illustrates how multispecies habitation reorganizes spatial hierarchy, circulation systems, and boundary conditions within domestic interiors (Created by the author)

The diagram on the right visualizes the transition toward a symbiotic spatial regime. While the geometric envelope of the plan remains unchanged, the distribution of zones, circulation trajectories, and boundary conditions is reorganized. Dominant areas are redistributed, shared infrastructural zones emerge, and thresholds become adjustable rather than absolute. The diagram does not propose a specific architectural typology; instead, it clarifies how shifts in spatial hierarchy, circulation logic, and boundary calibration transform the interior from a human-centered arrangement into a structurally integrated multi-species environment.

5. Spatial Analysis Through the Symbiotic Spatial Model

The following section applies the three-layered Symbiotic Spatial Model to two contemporary residential projects that explicitly engage with human-animal cohabitation. Rather than presenting isolated project descriptions, the analysis is structured around the model's three operational layers. Each layer is examined comparatively, allowing the spatial logic of both projects to be read in parallel.

This parallel reading does not seek to rank the projects, but to clarify how different degrees of spatial reorganization emerge when domestic interiors are reconfigured beyond anthropocentric defaults. The focus remains on plan organization, circulation structure, and boundary articulation, as defined within the three-layered Symbiotic Spatial Model.

5.1. Reconfiguration of Spatial Hierarchy

The first operational layer of the Symbiotic Spatial Model addresses how spatial priority is distributed within the domestic plan. Reconfiguration of the spatial hierarchy does not imply the elimination of human-centered organization; rather, it involves questioning which zones are treated as dominant and which are treated as residual. A symbiotic approach shifts this balance so that animal inhabitation is considered at the level of spatial organization rather than as a secondary insertion.

In Home of Pets, hierarchy is reorganized through a systematic redistribution of territorial domains. This redistribution does not merely allocate resting areas for pets but also restructures circulation cores, light access, and boundary permeability in relation to feline movement. The conventional domestic core, living, cooking, and sleeping areas, is no longer treated as the fixed spatial nucleus around which animals circulate peripherally. Instead, the plan establishes two interlocking systems: one structured primarily for human occupation and another designed as a continuous feline habitat. Corridors, cabins, and transitional zones are redefined as part of a

cohesive pet-oriented domain, while human living areas become more compact and clearly bounded.

A key spatial device in this reorganization is a sliding translucent partition, which the designers describe as a spatial "valve." This movable element operates as a calibrated threshold, mediating expansion, visibility, and circulation between the two spatial domains. When closed, circulation privileges human movement and limits feline access to the central core. When opened, the animal domain expands toward the light well and the circulation axis, allowing cats to traverse areas that would otherwise remain under human control. In this sense, hierarchy is no longer fixed; it can shift with daily use and with negotiated proximity between species. The depth of this recalibration is legible in the before-and-after plan transformation and the adjustable zoning logic (Figure 2).

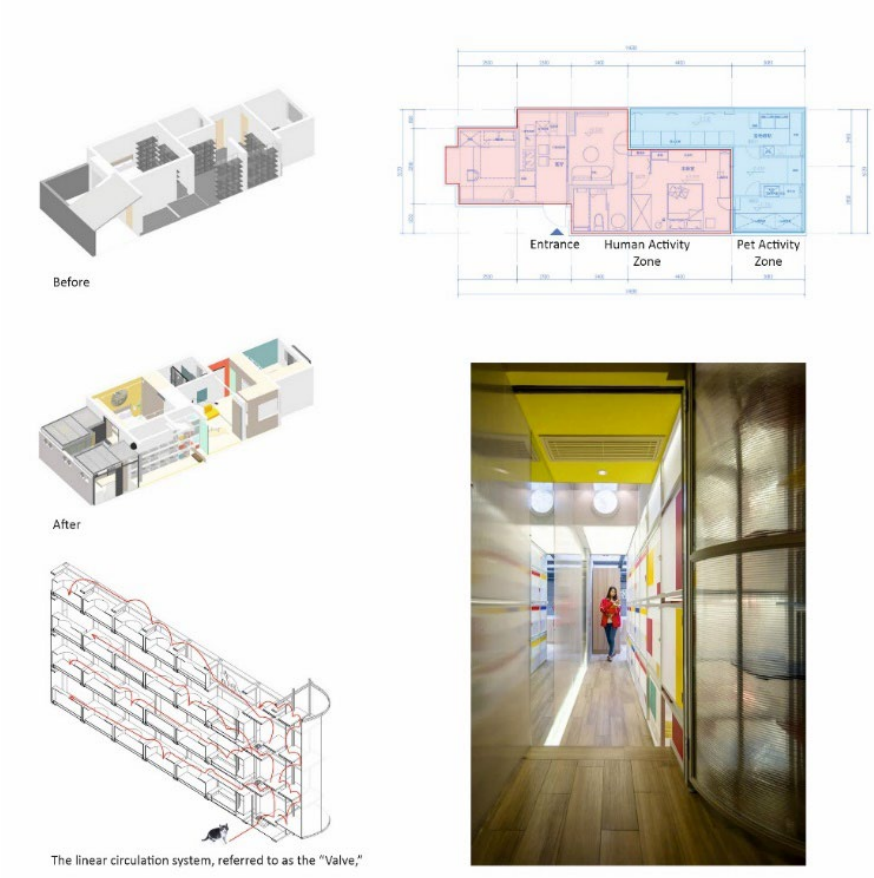


Figure 2 Before-and-after spatial transformation of *Home of Pets*: Plan reorganization, human – pet zoning strategy, axonometric circulation system "Valve", and interior view illustrating the adjustable territorial relationship between human and feline domains (Created by author)

In contrast, Positive House operates through a different spatial strategy. The ground plan remains recognizable as a conventional domestic layout, with primary functions arranged according to a familiar human-centered logic. Rather than redistributing these core zones, the project introduces vertical layering through elevated platforms, suspended surfaces, and a cylindrical climbing core. These elements generate alternative trajectories for animal movement above and across the main inhabitable plane.

Here, hierarchy is not overturned but expanded. Human occupation continues to define the primary horizontal organization; however, sectional articulation allows animals to inhabit a parallel spatial system without being confined to residual floor-level territories. The result is a vertically stratified spatial field in which differentiated platforms, suspended elements, and sectional layering create parallel trajectories without disrupting the primary horizontal plan (Figure 3).

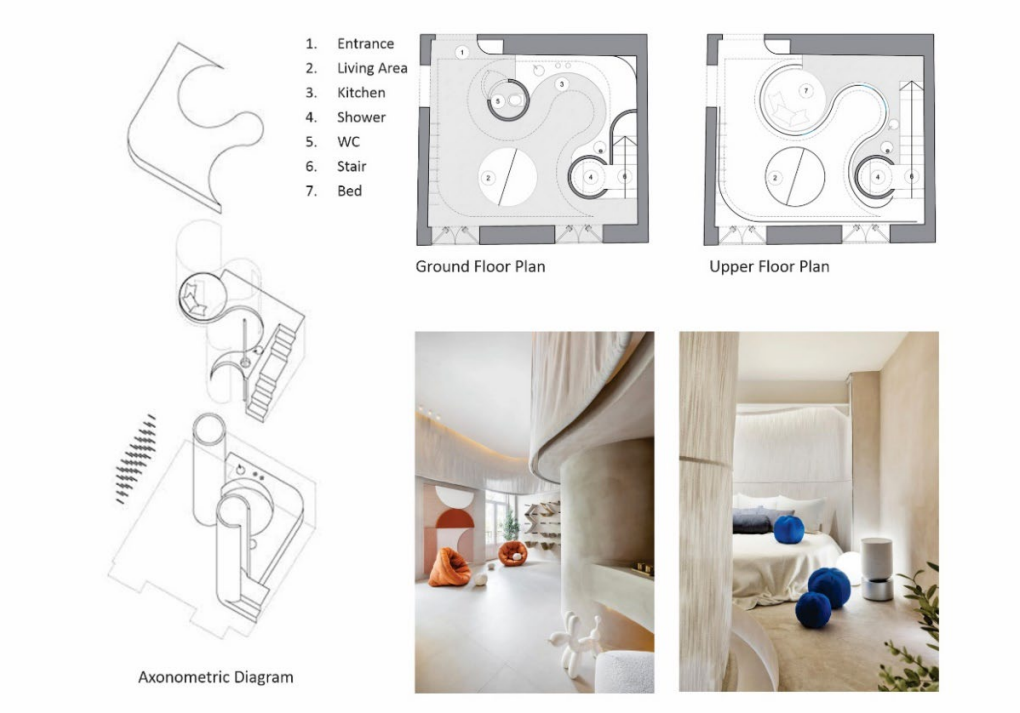


Figure 3 Spatial organization of *Positive House*: Axonometric diagram, exploded circulation system, ground and upper floor plans, and interior views illustrating vertical differentiation and layered spatial integration (Created by author)

The comparison clarifies that hierarchical reconfiguration can emerge through distinct mechanisms. In Home of Pets, spatial priority is recalibrated through the redistribution of the structural plan and adjustable territorial control. In Positive House, hierarchy remains largely stable at the plan level but is diversified through sectional and volumetric enrichment. What differentiates the two is not the acknowledgment of multiple species, but the extent to which hierarchy itself becomes negotiable within the domestic system. Within the Symbiotic Spatial Model, this distinction corresponds to two different modes of hierarchical recalibration: structural redistribution versus sectional augmentation.

5.2. Multi-Species Circulation and Bodily Negotiation

While the previous layer examined how spatial hierarchy is redistributed, the second operational layer of the Symbiotic Spatial Model focuses on circulation as a site of bodily negotiation. In multi-species domestic environments, movement is not a neutral condition; it structures access, visibility, and territorial overlap. Circulation, therefore, becomes a primary mechanism through which coexistence is either stabilized or contested.

In Home of Pets, circulation is deliberately fragmented and recalibrated to accommodate feline movement patterns. Rather than relying solely on floor-based pathways, the project integrates elevated cabins, concealed passages, and a continuous peripheral route that allows cats to move independently of human trajectories. The reorganization of corridors is particularly significant. What would conventionally function as a transitional space for humans becomes an extended habitat for animals. This shift transforms circulation from a residual connector into an inhabitable system structured around species-specific mobility.

The designers' description of the sliding translucent partition as a "valve" takes on added relevance in this context. Beyond regulating territorial expansion, the valve also modulates the intensity of circulation. When closed, it compresses feline movement into the peripheral network; when open, it allows animals to intersect the primary human axis. Circulation thus becomes dynamically adjustable rather than statically assigned. Movement is negotiated through spatial thresholds rather than enforced separation (see Figure 4).

Figure 4 The linear circulation system, referred to as the "Valve," reorganizes corridor space in *Home of Pets*, enabling adjustable thresholds between the human and feline domains (ArchDaily, 2026a)

In contrast, Positive House constructs coexistence through vertical differentiation rather than plan-based rerouting. The circulation logic remains legible for human users at ground level, but is complemented by elevated surfaces, suspended platforms, and a cylindrical climbing core that generate alternative spatial trajectories. These elements enable animals to occupy overhead and interstitial zones while maintaining a visual and spatial connection with human activities below.

Here, bodily negotiation is structured through sectional layering rather than corridor redistribution. Animals are neither confined to the floor nor fully merged with human pathways; instead, a parallel vertical circulation network emerges. The result is a multi-scalar movement system in which bodies of different sizes and locomotive capacities coexist without direct spatial competition (Figure 5).

Figure 5 Vertical circulation system for pets in *Positive House*, illustrating sectional stratification and parallel movement trajectories (ArchDaily, 2026b)

The comparison reveals two distinct strategies of circulatory negotiation. In Home of Pets, circulation is reorganized horizontally through territorial redistribution and adjustable thresholds.

In Positive House, coexistence is achieved through vertical multiplication of trajectories within an otherwise stable plan. Within the Symbiotic Spatial Model, these correspond to two operative approaches: circulatory reprogramming and sectional stratification. Both move beyond anthropocentric defaults, yet differ in the degree to which bodily negotiation is embedded in the structural core of the domestic system.

5.3. Boundary Articulation and Degrees of Co-Presence

The third operational layer of the Symbiotic Spatial Model addresses the articulation of boundaries and the degrees of co-presence that emerge between species. While hierarchy defines priority and circulation structures movement, boundaries regulate visibility, access, and proximity. In multi-species domestic environments, boundaries are not merely separators; they become calibrated interfaces that mediate shared occupation.

In Home of Pets, boundary articulation is closely tied to the concept of adjustable permeability. The translucent sliding partition described as the “Valve” operates not only as a circulation regulator but also as a visual filter. Its materiality allows partial visibility while maintaining spatial distinction. As a result, separation does not equate to isolation. Humans and animals remain visually connected even when territorially differentiated. This produces a condition of controlled co-presence: proximity without total overlap.

Beyond the Valve, the project integrates mesh panels, semi-open cabins, and framed openings that support layered interaction. These devices avoid both extremes of enclosure and full exposure. Instead of rigid segregation or complete integration, the spatial system permits fluctuating degrees of encounter. Boundaries function as negotiable membranes rather than static walls. The domestic interior thus accommodates simultaneous autonomy and relational awareness (see Figures 2 and 4).

In Positive House, boundary articulation operates through curvature, elevation, and material continuity. The cylindrical climbing core does not isolate animals from human space; rather, it inserts a distinct yet visually accessible vertical domain within the shared interior volume. Soft material transitions and rounded enclosures reduce the perceptual rigidity of separation. Boundaries are expressed through sectional differentiation rather than planar division.

Here, co-presence is structured spatially rather than mechanically. Elevated surfaces allow animals to inhabit zones above human eye level while remaining visually legible within the same volumetric field. The absence of opaque partitions reinforces an atmosphere of spatial continuity. Instead of thresholds that open or close, the project establishes gradational distances shaped by height, curvature, and material tactility (see Figures 3 and 5).

The comparison clarifies two boundary logics within the Symbiotic Spatial Model. In Home of Pets, boundaries are adjustable and threshold-based, enabling dynamic modulation of co-presence. In Positive House, boundaries are stratified and volumetric, producing stable yet layered coexistence. Both strategies move beyond conventional anthropocentric enclosure by transforming walls into mediating interfaces.

Within the broader framework of the model, this layer demonstrates that symbiotic spatiality is not solely a matter of shared access, but of calibrated relational distance. Degrees of co-presence are spatially constructed through permeability, visibility, and sectional differentiation. The domestic interior becomes a negotiated field of interspecies awareness rather than a hierarchy of isolated zones.

5.4. Comparative Matrix and Operative Synthesis

The preceding sections have examined both projects through the three core operational layers of the Symbiotic Spatial Model. While the layer-based readings clarify distinct spatial strategies, their structural orientation becomes more legible when synthesized comparatively. Table 1

consolidates the findings across the model's framework by distinguishing between (A) core operational layers and (B) dominant spatial mechanisms that extend or intensify those layers.

Table 1 Comparative Matrix of the Symbiotic Spatial Model (Created by Author)

A. Core Operational Layers		
Operational Layer	**Home of Pets**	**Positive House**
Layer 1: Hierarchical Reconfiguration	Primary	Secondary
Layer 2: Circulatory Reprogramming	Primary	Secondary
Layer 3: Boundary Modulation	Primary	Secondary
B. Dominant Spatial Mechanisms		
Dominant Spatial Mechanisms	**Home of Pets**	**Positive House**
Sectional Stratification	Secondary	Primary
Volumetric Differentiation	Secondary	Primary

Note: "Primary" indicates that the identified spatial mechanism functions as a structural driver of the project's spatial organization. "Secondary" indicates a supportive yet non-dominant operation that reinforces but does not fundamentally define the spatial system.

The first part of the matrix evaluates the three core operational layers: Hierarchical Reconfiguration, Circulatory Reprogramming, and Boundary Modulation. These layers correspond directly to the analytical structure defined in Section 4. In this respect, Home of Pets demonstrates Primary engagement across all three layers. Spatial hierarchy is redistributed at the plan level, circulation is reprogrammed through adjustable thresholds, and boundaries operate as calibrated mediating interfaces. The transformations are embedded within the structural logic of the domestic plan.

In Positive House, by contrast, these same layers operate in a Secondary capacity. While the project integrates multi-species considerations, the primary horizontal plan organization remains relatively stable. Circulation and boundary articulation are reinterpreted, yet not fundamentally restructured at the level of plan hierarchy.

The second part of the matrix identifies dominant spatial mechanisms that characterize each project's mode of intervention. Here, Sectional Stratification and Volumetric Differentiation become Primary in Positive House. The project constructs coexistence through vertical layering, suspended platforms, and spatial thickening across levels, generating parallel trajectories without redistributing the plan's core zones. In Home of Pets, these mechanisms are present but operate in a Secondary capacity, supporting a predominantly plan-based reorganization.

The comparative synthesis reveals that symbiotic spatiality does not correspond to a singular formal strategy. Rather, it emerges through different operative emphases within the same theoretical framework. One strategy embeds negotiation into the horizontal redistribution of the domestic plan; the other multiplies trajectories through sectional articulation and volumetric enrichment. The distinction, therefore, lies not in stylistic variation but in the spatial level at which negotiation becomes structurally embedded within the domestic system.

6. Conclusions

This study set out to examine how domestic interiors may be spatially reorganized when human-animal cohabitation is treated not as a functional accommodation but as an architectural condition. To address this question, the research developed the Symbiotic Spatial Model. This analytical framework translates post-humanist spatial discourse into three operational layers readable within

architectural plans and sections: hierarchical reconfiguration, circulatory negotiation, and boundary modulation.

The comparative analysis demonstrates that multi-species coexistence does not emerge solely from the presence of animals within domestic space, but from the extent to which spatial organization itself is recalibrated. The two examined projects illustrate different spatial pathways through which such recalibration can occur.

In Home of Pets, symbiotic coexistence is embedded in the plan's structural organization. Spatial hierarchy is redistributed by redefining corridors and transitional zones as continuous feline habitats; circulation is reorganized through adjustable thresholds and peripheral pathways; and boundaries operate as negotiable interfaces rather than fixed separations. In this configuration, multi-species inhabitation becomes a primary driver of spatial organization.

Positive House, by contrast, demonstrates an alternative strategy in which coexistence emerges through sectional articulation rather than through a redistribution of the plan. The horizontal domestic layout remains largely stable, while elevated platforms, cylindrical climbing elements, and suspended surfaces create parallel vertical trajectories for animal movement. Here, symbiotic spatiality emerges through sectional stratification and volumetric differentiation, enabling species-specific mobility without fundamentally altering the plan hierarchy.

The comparative matrix clarifies that symbiotic spatial regimes may operate through different operative emphases. One approach reorganizes the domestic plan horizontally, redistributing spatial hierarchy and circulation infrastructures. The other multiplies trajectories vertically, thickening the interior's sectional structure while maintaining the primary plan logic. These strategies do not represent opposing models but alternative spatial mechanisms through which negotiated coexistence can be embedded within architectural organization.

By translating post-humanist concepts into readable spatial parameters, the Symbiotic Spatial Model contributes a methodological tool for examining multi-species environments beyond descriptive discourse. Rather than prescribing design solutions, the model provides an analytical framework for identifying how hierarchy, circulation, and boundaries operate when domestic space accommodates multiple species.

At the same time, the scope of the study remains limited to the spatial logic of two contemporary residential examples interpreted through published documentation. The research does not evaluate post-occupancy performance, behavioral adaptation, or measurable indicators of animal welfare. Future studies could extend the framework by incorporating empirical observations, larger comparative datasets, or cross-cultural housing typologies to examine how symbiotic spatial regimes evolve across different domestic and urban contexts.

Despite these limitations, the study suggests that the architectural interior can be reconsidered as a negotiated spatial field rather than a fixed anthropocentric arrangement. When hierarchy, circulation, and boundaries are recalibrated through multi-species inhabitation, domestic space begins to operate as a shared spatial system in which coexistence is structured architecturally rather than accommodated incidentally.

CRediT Authorship Contribution Statement

Neşe Başak Yurttaş: Conceptualization, Methodology, Investigation, Data curation, Formal analysis, Visualization, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

The author declares that there are no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

Data will be made available on request.

Ethics Committee Approval

Ethics committee permission is not required.

References

ArchDaily. (2026a). *Home of pets / HDD*. Retrieved January, 12, 2026, from https://www.archdaily.com/893059/home-of-pets-hdd

ArchDaily. (2026b). *Pets and human positive house / Studio ruizvelazquez*. Retrieved January, 15, 2026 from https://www.archdaily.com/1023787/pets-and-human-positive-house-studio-ruizvelazquez

Ashby, M., Balas, D., & Cora, J. (2016). *Materials and sustainable development* (1st ed.). Butterworth_Heinemann.

Bekoff, M. (2007). *The emotional lives of animals: A leading scientist explores animal joy, sorrow, and empathy-and why they matter*. New World Library.

Bradshaw, J. (2017). *The animals among us: How pets make us human*. Basic Books.

Braidotti, R. (2013). *The posthuman* (1st ed.). Polity Press.

Chapin, F. S., Vitousek, P. M., & Matson, P. A. (2011). *Principles of terrestrial ecosystem ecology* (2nd ed.). Springer.

Descola, P. (2013). *Beyond nature and culture* (J. Lloyd, Trans.). University of Chicago Press.

Grandin, T., & Johnson, C. (2005). *Animals in translation: Using the mysteries of autism to decode animal behavior*. Scribner.

Haraway, D. (2003). *The companion species manifesto: Dogs, people, and significant otherness*. Prickly Paradigm Press.

Ingold, T. (2011). *Being alive: Essays on movement, knowledge and description* (1st ed.). Routledge. https://doi.org/10.4324/9780203818336

Latour, B. (2005). *Reassembling the social: An introduction to actor_network_theory* (1st ed.). Oxford University Press. https://doi.org/10.1093/oso/9780199256044.001.0001

Lovelock, J. (2000). *Gaia: A new look at life on Earth*. Oxford University Press.

Odum, E. (1971). *Fundamentals of ecology* (3rd ed.). W. B. Saunders.

Pallasmaa, J. (2012). *The eyes of the skin: Architecture and the senses* (3rd ed.). John Wiley & Sons.

Ulrich, R., Zimring, C., Zhu, X., DuBose, J., Seo, H.-B., Choi, Y.-S., & Joseph, A. (2008). A review of the research literature on evidence-based healthcare design. *HERD: Health Environments Research and Design Journal*, *1*(3), 61-125.

Wakkary, R. (2021). *Things we could design: For more than human-centered worlds* (1st ed.). The MIT Press.

Yurttaş, N., & Altuncu, D. (2022). New possibilities of living together in post-humanist society: Interior and furniture design for pets. *Journal of Design for Resilience in Architecture and Planning (DRArch)*, *3*(3), 281-294. https://doi.org/10.47818/DRArch.2022.v3i3058

Resume

Neşe Başak Yurttaş is an Assistant Professor in the Department of Interior Architecture and Environmental Design at Biruni University. She received her Ph.D. in Interior Architecture from Mimar Sinan Fine Arts University. Prior to her academic career, she worked for 19 years as a senior interior architect in international companies. She currently teaches undergraduate design studio courses. Her research focuses on themed spaces, spatial identity, inclusive design, and architectural design education.

JOURNAL OF DESIGN FOR RESILIENCE IN ARCHITECTURE & PLANNING

Research Article
Online: www.drarch.org
Volume 7, Issue 1 (37-52), 2026
DOI: 10.47818/DRArch.2026.v7i1202

A framework to design and implement cross-platform WebVR walkthrough for a Chettinad heritage building

Antony Zharon[*] Ajith Paul[**] Balakrishnan C[***] Biju Kunnumpurath[****] Anitha Suseelan[*****]

Abstract

Immersive walkthroughs are increasingly used to document, interpret, and communicate heritage sites to remote audiences. This study presents a framework for designing and implementing a cross-platform WebVR walkthrough of Athangudi Palace, a significant Chettinad mansion in Tamil Nadu, India. The project addresses limited physical access due to conservation sensitivity and geographic distance by developing a browser-based experience accessible on Head-Mounted Displays (HMDs), desktop computers, tablets, and mobile phones. It has a systematic workflow that involves on-site documentation, 360-degree image capture, spatial-audio recording, post-processing, WebVR development in A-Frame, refinement, and deployment. The walkthrough features panoramic shots, guided tours, hotspots, and contextual commentary, to convey the spatial nature and sustainability elements of the palace, such as passive cooling, material selections, and climate-adaptive planning. The paper contributes a reproducible workflow for documenting and interpreting domestic heritage architecture through a lightweight WebVR system. It demonstrates how browser-based immersive media can support remote heritage access, conservation awareness, and sustainability-oriented interpretation without increasing physical pressure on a sensitive site.

Keywords: Athangudi palace, Chettinad heritage, immersive media, virtual reality, virtual walkthrough.

1. Introduction

1.1. Heritage buildings and sustainability

Heritage buildings are examples of sustainable architecture built on traditional local knowledge and experience. These buildings are specifically designed to withstand the local climate using passive strategies such as thick walls, high ceilings, courtyards, shaded spaces, and natural ventilation, which play an essential role in the building's thermal performance. These buildings are mainly built using locally sourced materials, including imported materials, as they were constructed during the economic prosperity period. This influences the building's architectural style, which contributes to environmental sustainability by reducing construction impacts and extending building life. Preserving these heritage buildings supports sustainability in many ways. Virtual Walkthroughs and Virtual Reality experiences provide a sustainable way to document and share these buildings.

1.2. Virtual reality for cultural heritage

In modern times, Virtual reality (VR) is used to document and present cultural heritage buildings (Cecotti, 2022). Virtual reality is an innovative tool that can be used to create immersive content and educational resources. In this way, users can explore and learn more about heritage sites from anywhere in the world, at any time. This tool is effective because, due to preservation concerns, most heritage sites are not open to the public or are only partially open. VR also supports narrative

[*]*Department of Computer Science, CHRIST University, Bangalore, India* antonyzharon2@gmail.com
[**]*(Corresponding author), Department of Media Studies CHRIST University, Bangalore, India* ajith.paul@res.christuniversity.in
[***]*Department of Computer Science, CHRIST University, Bangalore, India* balakrishnan.c@christuniversity.in
[****]*Department of Media Studies, CHRIST University, Bangalore, India* frbiju@christuniversity.in
[*****]*School of Architecture, CHRIST University, Bangalore, India* anitha.suseelan@christuniversity.in
Article history: Received 20 January 2026, Revised 04 April 2026, Accepted 14 April 2026, Published 30 April 2026

engagement, which plays a crucial role in fostering a deeper understanding of spatial and environmental designs.

This study presents a design-and-implementation framework for a browser-based WebVR walkthrough of Athangudi Palace. Its contribution lies not in proposing a new immersive technology, but in demonstrating how a lightweight, open-source, cross-platform workflow can be applied to a less-represented domestic heritage context in South India while making architectural sustainability legible to remote audiences.

1.3. Aim and research questions

This study aims to develop a virtual walkthrough and VR experience application for the Athangudi palace. The primary research questions include:

1. How can VR be used to document and represent the architectural features of a heritage building?

2. In what ways does a VR walkthrough improve access and understanding of heritage sites?

2. Literature Review and Background

Immersive technologies have significantly expanded the ways in which cultural heritage can be documented, interpreted, and communicated. Previous digital heritage projects tended to focus on visual reconstruction and archival representation, but more recent ones are starting to explore immersive media as a medium for access, participation, and interpretation. Bekele et al. (2018) describe this broader shift by showing how virtual, augmented, and mixed reality have evolved into mature systems capable of supporting both heritage documentation and public engagement. This transition is important because it places heritage VR not only within the domain of digital preservation, but also within educational and interpretive practice.

The later review papers affirm that the field has evolved to become more diverse in both usage and intent. Chong et al. (2022) demonstrate that cultural heritage virtual reality has adopted reviews, case studies, system design, and evaluation research, indicating that the field has moved beyond spectacular representation to learning, interpretation, and user participation. Similarly, Rodríguez-García et al. (2024) underline the importance of clear workflows for data acquisition, modelling, and user interaction, indicating that the value of immersive heritage systems does not necessarily lie in their visual realism but in how well their documentation and design logic are explained. These reviews, combined, indicate that successful heritage VR must unite three dimensions in a consistent manner: technical documentation, content, and user experience.

At the implementation level, many heritage VR projects still rely on detailed 3D reconstruction workflows, institution-specific systems, or museum-based installations. In contrast, lighter alternatives, such as browser-based and panoramic WebVR, can be more suitable for conservation-sensitive, resource-constrained heritage settings. Although earlier projects have demonstrated the value of immersive heritage environments for access and interpretation, fewer studies have emphasised open-source, cross-platform workflows that can operate across HMDs, desktops, tablets, and mobile devices without requiring dedicated software installation. The present study is positioned within this smaller but important design space, where the aim is not to produce a highly complex reconstruction, but to develop a reproducible WebVR framework for architectural interpretation, remote accessibility, and sustainability-oriented heritage communication.

There is a parallel literature associating digital heritage technologies with long-term conservation and sustainability. According to Mendoza et al. (2023), virtual reality, 3D documentation, and sensor-based systems are increasingly used tools for communicating with the public and for conservation planning, monitoring, and risk awareness. Rambach et al. (2020) also note the greater environmental and educational opportunities offered by immersive media. In this framing, heritage VR is not only worthwhile because it enhances access to remote locations, but

also because it conveys the environmental acumen of traditional architecture, such as climate-sensitive design, material performance, and low-energy spatial reasoning. This view is particularly pertinent when historic buildings are interpreted to align with modern discourse on sustainability.

The case-based studies also reveal how immersive systems can transcend documentation to become interpretative environments. Cantatore et al. (2020) reveal how VR could unite architectural documentation, material data, and maintenance expertise in a teamwork heritage context. Similar examples of using immersive environments to increase access to conservation-sensitive sites and to help experts communicate with broader audiences are presented by Comes et al. (2020) and Banfi et al. (2023). These works are significant because they demonstrate that the most effective digital heritage systems are those in which documentation is incorporated into a well-organised visitor experience rather than displayed as isolated visual products.

The quality of the virtual visit itself is another issue that is replicated in the literature. Studies of virtual tours and museum experiences indicate that user engagement is highly influenced by navigability, interface clarity, authenticity, and whether the spatial content is legible. According to Resta et al. (2021), perceived architectural space, clearly represented artefacts, and navigability are the main factors influencing visitor engagement in virtual environments. Ren and Chen (2021) also found that positive reactions to the 360-degree heritage tour were strongly associated with authenticity, ease, and technical reliability. This knowledge is particularly applicable to domestic heritage contexts, where the visitor needs to know not just what they are looking at, but also how spatial layout, daily activities, and environmental design contribute to the building's cultural sense. These concerns are also consistent with broader findings from immersive learning research, which emphasise the need for clearer links between design choices, user engagement, and educational outcomes (Radianti et al., 2020).

Even with the rapid development of the field, significant gaps remain. To begin with, much of the literature remains devoted to museums, archaeological sites, monuments, or mass reconstructions, whereas domestic heritage architecture is still relatively underrepresented in immersive studies. Second, numerous published projects rely on resource-intensive modelling processes, custom installations, or institution-specific solutions, and place less emphasis on lightweight, browser-based, and cross-platform solutions that can be viable when working on a limited budget to document heritage and make it accessible to a broader audience. Third, sustainability is frequently viewed as an aspect of the context rather than as content actively communicated through the immersive experience, per se. These constraints indicate the necessity of structurings which are technically viable, situationally based and specifically directed at architectural comprehension.

Such gaps are particularly apparent in Chettinad architecture. Chettinad mansions in South India are notable examples of domestic heritage not only for their historical and social importance, but also for their design that responds to the climate, the use of materials, artisans, and a sophisticated spatial hierarchy. However, even immersive reenactments of such buildings remain minimal compared to museum-based or archaeological heritage applications. Digital structures that can reflect Chettinad architecture not merely as visual heritage but as a form of environmental and cultural knowledge decipherable by distant viewers are required in this regard.

The current research addresses this requirement by creating a WebVR virtual tour of Athangudi Palace. Unlike more reconstruction-oriented pipelines, the project uses a lightweight workflow, built on panoramic documentation, spatial audio, guided navigation, and hotspot-based interpretation, in an open-source A-Frame environment. The value of the study is thus less in its proposal of wholly new technology than in showing how a repeatable and cross-platform workflow can be utilised in a less-represented domestic heritage environment and the familiarisation and comprehension of sustainable architectural knowledge. In this regard, the project is placed as a design-and-implementation structure that integrates documentation, accessibility, and interpretive communication.

The argument also concurs with broader issues in heritage education and sustainable development. Cultural heritage conservation is also related to SDG 11, particularly the conservation of cultural assets in sustainable cities and communities, and the transmission of traditional building knowledge falls under the educational objectives connected with SDG 4. Through its presentation of Athangudi Palace as a heritage site and a reservoir of climate-responsive design information, the walkthrough is not only intended as a remote-access tool but also to convey the ever-relevant nature of vernacular architectural intelligence.

3. Case Context: Athangudi Palace & Its Sustainable Features

3.1. Historical and Cultural Context

Sri Letchmi Vilas popularly known as 'The Athangudi palace', is located in the district of Sivaganga, in Tamil Nadu. This mansion reflects the cultural and social values of the Chettinad region. The palace was built around 1929-32 by Shri N.AR. Nachiappa Chettiar. The construction was aided by the foreign connections of the Chettiar community through trade. The mansion used both local and imported materials, preserving the region's sustainability and cultural significance. The builders tried to keep the traditional architectural features and amenities fit to the climatic conditions with proper plan and vision (Rajivkumar & Kesavaperumal, 2018).

3.2. Architectural and Sustainable Features

This construction blends the features of both Western and traditional architecture. Notable features include open spaces for airflow and light, extensive wood carving on doors and pillars, rainwater harvesting outlets, and temperature regulation using homemade tiles called 'Athangudi tiles'. One major achievement is that this was created at a time when machinery and sophisticated tools were not available. The credit goes to the manual efforts of hundreds of craftsmen from regions like Tirunelveli and Nagercoil. This method of using sustainable features in heritage buildings can be made feasible by careful design and material use (Krishan et al., 2001; Kasiviswanathan et al., 2024).

3.3. Rationale for a VR Walkthrough

Athangudi Palace is a major heritage site in Chettinad and a climate-sensitive domestic building. The building, in addition to its historical and cultural significance, demonstrates the principles of sustainable design through spatial planning, material selection, and passive environmental design. Consequently, it can be of great interpretive benefit to students, architects, researchers, and broader audiences (Table 1). Nevertheless, the accessible areas are restricted due to geographical separation, transportation constraints, ownership, and conservation sensitivity.

A virtual walkthrough is a feasible solution to these constraints. The site allows a broader audience to experience it by enabling remote exploration through immersive visual and auditory representations, without causing additional wear and tear on the physical structure. Virtual reality, in this manner, can aid in heritage conservation and public education by making the building more accessible while maintaining its integrity.

Table 1 Contextual Overview of Athangudi Palace and the VR Walkthrough

Aspect	**Description**
Geographic Location	Athangudi village, Chettinad region, Tamil Nadu, India 10.1540° N, 78.7265° E
Cultural Affiliation	Nattukottai Chettiar mercantile community
Period of Construction	Late 19th to early 20th century (colonial-era economic boom)
Heritage Value	Domestic residence and social space for trade-based households

Aspect	Description
Geographic Location	Athangudi village, Chettinad region, Tamil Nadu, India 10.1540° N, 78.7265° E
Conservation Status	Privately owned heritage structure with restricted access
Key Sustainability Logic	Passive cooling, material efficiency, climate-responsive design
Educational Relevance	Demonstrates traditional sustainable practices and spatial intelligence
Role of VR	Enables access, interpretation, and preservation without physical impact
Target Users	Students, researchers, and the general public

4. System Design and Implementation

4.1. Content Creation Framework

A plan for creating a digital capture of the place was done with detailed steps. A team of researchers formed a group and planned the application's features and content process beforehand. The process starts with on-site documentation, followed by data capture. The team captured high-resolution images and 360° panoramic pictures of the palace. In the post-processing stage, the captured images are stitched, colour-corrected, and compressed for VR compatibility. The images are then formatted and optimised for web rendering. Spatial audio, in the form of a narration explaining the palace's structure, was integrated into the application. It is evident from existing studies that high-quality standards and a structured methodology must be followed in virtual reality applications (Wang et al., 2020). This is essential for better understanding and educational purpose.

The content creation diagram (Figure 1) illustrates the workflow of creating the VR scene. It describes the process from documentation to application deployment. User testing was also implemented before final deployment to identify flaws in the application. In summary, the workflow progressed through site documentation, media capture, post-processing, WebVR implementation, internal testing, and iterative refinement, with each phase informing subsequent design decisions.

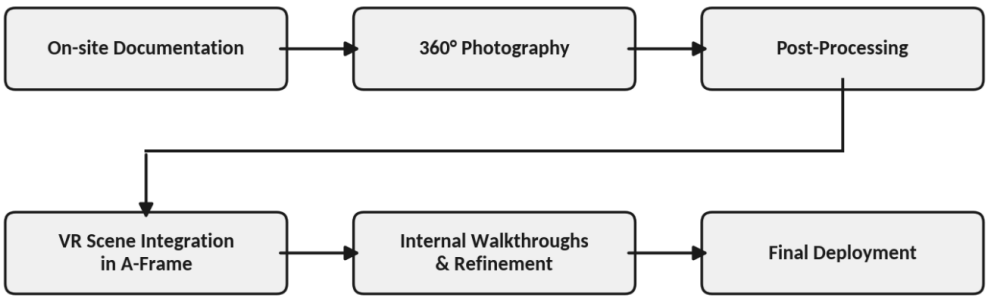


Figure 1 Content Creation Framework

4.2. Design and Implementation

4.2.1. Design-Oriented Research Workflow

The project followed a design-oriented development workflow in which documentation, content preparation, interaction design, testing, and refinement were iteratively integrated into the final WebVR environment (Yang et al., 2024; Innocente et al., 2023). Figure 2 shows the application development process, which begins with on-site documentation. This phase involved conducting multiple visits to the site, during which high-resolution photography, 360-degree panoramic photographs, and spatial sound recordings were captured.

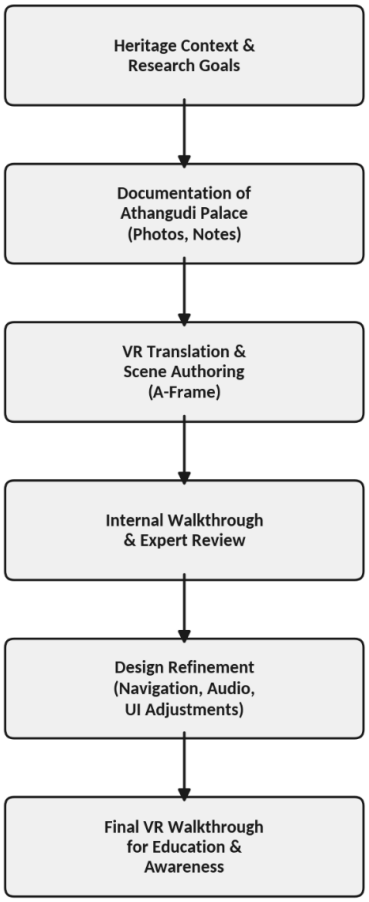


Figure 2 Design-Oriented Research Workflow

4.2.2. On-site Documentation

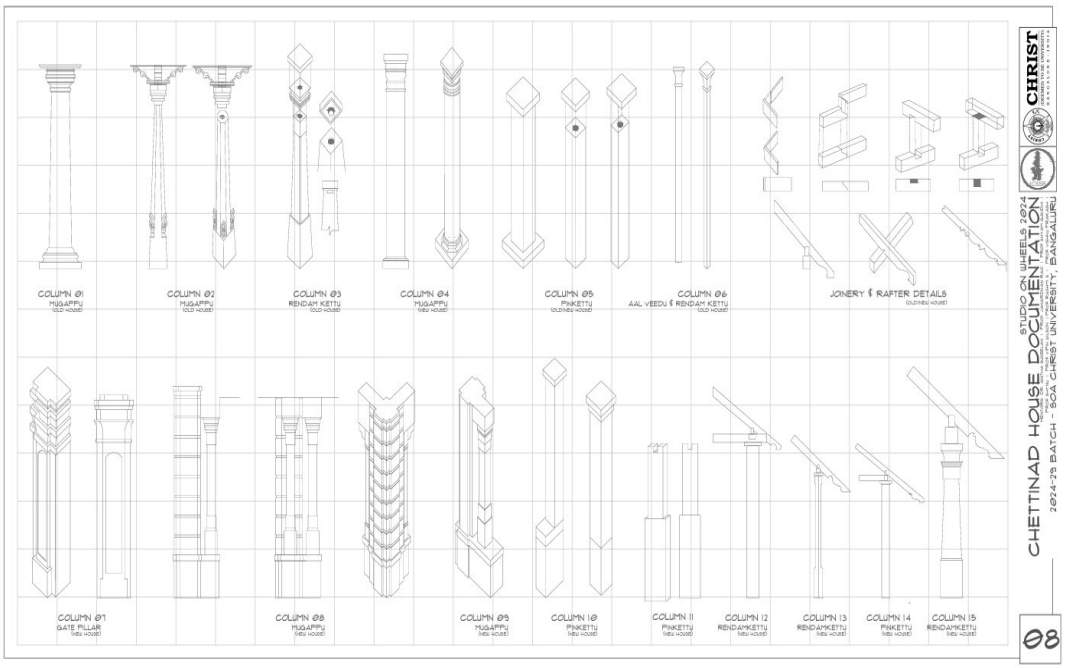


Figure 3 On-site documented pillar documentation (Source: Authors' Sketch)

Detailed written documentation was also prepared on the building's spatial features and other architectural components (Figure 3). These physical data played an important role in providing a basis for creating an accurate representation of the spatial environment's logic in the Athangudi palace, which allows subsequent replication of the experience and intangible aspects of the palace's heritage (Rodríguez-García et al., 2024).

After the on-site documentation, the next phase involved classifying and identifying the sustainable design features and attributes of the palace. This step was crucial in creating the accurate VR scenes and associated production process. For example, the panorama images were stitched together, 'optimisation' and 'colour correction' were conducted prior to usage for full immersion. The placement of navigation nodes and hotspots was designed to allow the user to have both a guided and exploratory experience of the palace.

4.2.3.Capturing 360° Photographs and Spatial Audio

After preparing the user journey script, the team captures high-resolution 360° images of the palace using a Ricoh Theta Z1 and records spatial audio using a Zoom H3-VR Handy Audio Recorder. Each photo was taken 5 feet apart to replicate a real walkthrough experience while covering the entire space. Audio was recorded along with the camera path using a Zoom H3-VR. These collected captures were later edited and optimised for creating the walkthrough and VR.

4.2.4.Creating WebVR Walkthrough

Technically, the Virtual Reality walkthrough of the Athangudi palace was developed as a web-based VR experience using the A-Frame framework, which is built on top of WebGL and WebXR (A-Frame, 2025; Mozilla, 2025). WebGL serves as the underlying graphics API that allows real-time rendering of 3D graphics directly in the web browser, while WebXR provides standardised support for both immersive and non-immersive VR/AR devices, ensuring cross-platform compatibility (Mozilla, 2025). This configuration has enabled the experience to be accessed across platforms, running on both standalone virtual reality headsets and web browsers on desktop and mobile devices, without requiring any special software installation.

The virtual environment is structured as a scene graph, comprising sky items, high-resolution equirectangular panorama images, and other 3D components for scene translation. The Scene translation facilitates users' journey throughout the environment. For this, 3D interactive navigation planes, raycaster-based inputs, gaze-based interactions and controller-based interfaces were used throughout the scenes. Another critical practice is maintaining assets throughout the application's runtime. Asset Management practices were implemented to ensure that the application's visual quality and performance were balanced, controlling image and audio configurations and thereby significantly reducing download time.

By attaching event listeners to hotspot interactions, spatial audio narration is triggered in a contextual way, allowing for greater immersion without requiring continuous background playback (which may increase cognitive load). The technical optimisations applied include limiting draw calls, reducing the number of real-time lighting calculations, and ensuring stable frame rates throughout VR use to enhance comfort during the VR experience. Through internal testing across various devices, we focused on evaluating latency, loading times, user responsiveness when interacting with objects and surroundings, and how to minimise symptoms of motion sickness and disorientation during VR use. When combined, the above-mentioned technical decisions provided users with an enhanced, lightweight, stable, and accessible experience while still offering an immersive educational experience and conveying the rich architectural and environmental complexity of Athangudi Palace.

4.3. VR platform and technical stack

With A-Frame (A-Frame, 2025) and support for the WebXR Device API (Mozilla, 2025), the VR application can be accessed on desktops, laptops, mobile devices, and standalone VR headsets without requiring additional software installation. The VR environment is created with tags. The

assets are preloaded, so the scenes load faster. To create interactivity, the component provides precise control over the camera's movement, navigation nodes, audio triggers, and animation sequences.

For every VR prototype, performance optimisation remains a significant focus. The images are compressed to reduce download sizes while retaining clarity. Implementing Lazy Loading for models is essential to achieving an optimal frame rate (>60 FPS). The Asset Management Diagram (Figure 4) illustrates the hierarchical structure of the VR components.

1. The User's view is centred about the camera rig.

2. The Navigation and Teleportation Nodes indicate what paths will be available for the user for movement.

3. The Hot Spot provides associated text labels, audio components, and visual highlights.

The modular design allows for the easy addition of more scenes or the potential development of more advanced features, such as interactive energy simulations for future integration.

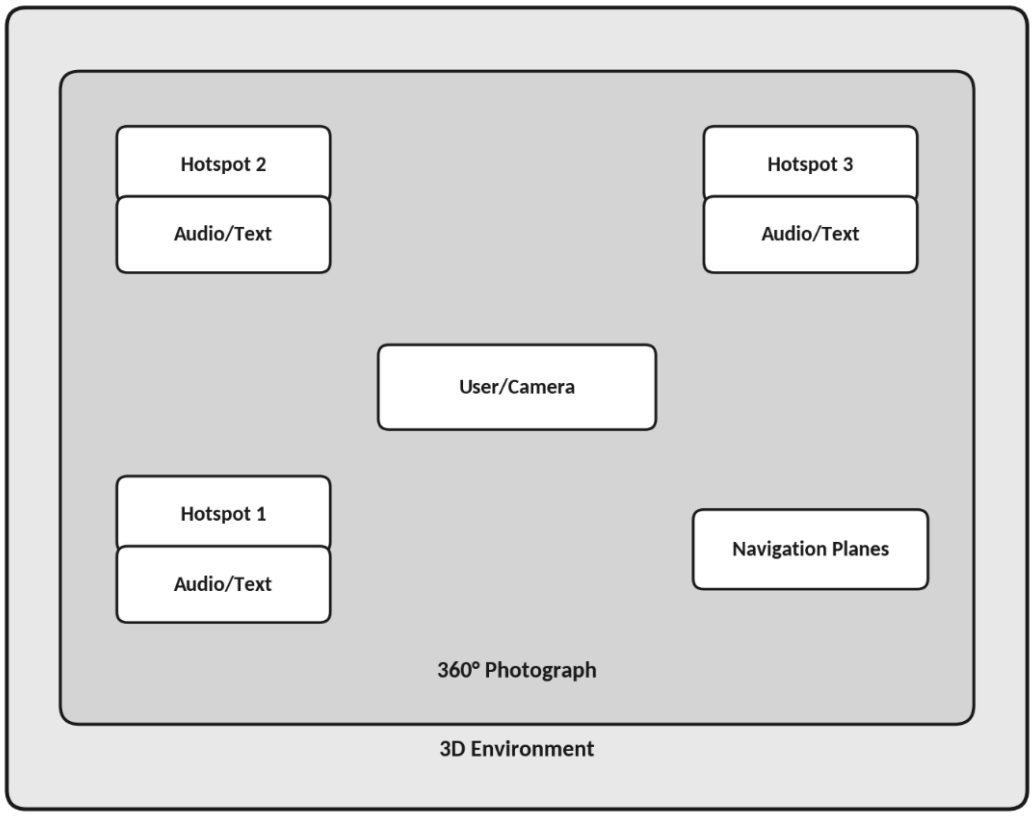


Figure 4 Interaction and Information Architecture

4.4. Overall concept and user journey

The application was divided into two parts: a walkthrough application that supports all devices (phones, laptops), and a VR application made specifically for Head-Mounted Displays (HMDs). Both divisions share the same resources, which aim to provide users with an immersive cultural learning experience while raising awareness of the conservation of heritage sites. The application guides the user throughout the palace, starting from the entrance, where they navigate through various scenes, including the central courtyard, Mugappu halls, veranda, thinnai, and many more. A structured user navigation flow diagram is given in Figure 5 A narrative flow was set in the application to visually and auditorially guide users throughout the palace, using audio cue buttons and navigation panels. The application was designed to mimic the real immersive experience of the palace; to this end, pre-recorded palace spatial sounds were added in the background, along with

high-quality panorama images, to give the user a point-of-view (POV) perspective while highlighting specific points of interest.

The user journey flow diagram (Figure 5) shows the user journey in the application, starting at the entrance scene, progressing through the introductory interfaces, scene navigation, and scene hotspots, and concluding with an exit Scene. The application also allows users to revisit previous scenes and has a playback option for the same audio cues. The flexibility in terms of navigation aids users for a better understanding of the details, especially in virtual reality head-mounted displays.

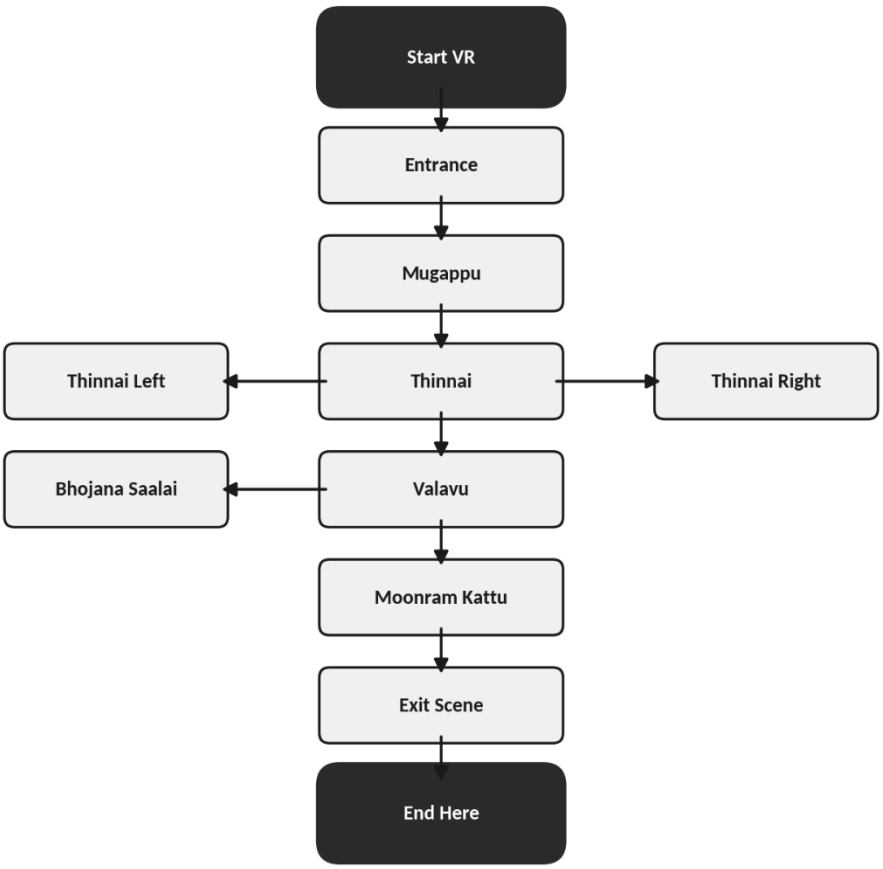


Figure 5 User Journey Flow Diagram

4.5. Interaction and information design

The interaction system aims to strike a balance between open-ended exploration and educational guidance. Users navigate by utilising both hotspots and teleport nodes located at significant architectural features. Hotspots have been created that provide users with:

- Audio narration that provides detailed explanations of different environmental strategies.
- Visual highlights that draw users' attention to specific design elements.

Users can navigate linearly through rooms or take non-linear routes for self-directed learning. This will allow users to develop a cognitive map that connects their understanding of spatial navigation with their knowledge of the building. The design of these interactions was created with accessibility in mind. The text overlays feature high contrast, making them easy to read. Motion paths and camera rotations are designed to minimise the effects of motion sickness. Audio or text descriptions can also be replayed for users who utilise different learning styles.

4.6. Audio and immersion design

Audio is a key component in creating a compelling and realistic experience of Virtual Reality (VR) and fosters greater immersion and understanding of how Athangudi Palace’s architectural design

functioned. Every scene features ambient sounds that replicate the palace's acoustic environment, including the natural reverberation from high ceilings in open hallways, the faint sound of wind in open courtyards, and the subtle sounds of footsteps and people throughout the surrounding space. Hotspots are supplemented with audio narration that provides information on sustainable building techniques, building material choices, and the building's historical background, so users can have multiple experiences or layers of information on top of what they see. Audio interactive sounds have been created to accompany user-triggered actions, such as scene transitions or hotspot activations, allowing users to receive immediate auditory feedback and providing a greater sense of place and presence when interacting with the space, and encouraging users to engage further. Audio placed in specific spatial locations enables users to experience the dynamic elements of an environmental system, such as airflow through an extension porch or cooling areas created by shaded locations in a courtyard, very physically, at the point where ambient sounds occur. Layering both ambient and instructional audio in a binaural format, which enables spatial audio listening through headphones, provides a more realistic atmosphere by identifying key factors within the user's view, thereby leading the user towards learning by retaining the essential components (Zoom Corporation, n.d.). Audio capture was conducted in two stages. In the first stage, the ambient bed was captured using the first-order ambisonics microphone Zoom H3- VR. The second stage involved recording narration in a soundproof studio. The 3D spatialisation and audio post-production were done using Reaper digital audio workstation (evaluation version), and Free (Proprietary) audio plugins such as dearVR PRO 2 and dearVR spatial connect (Figure 4). These plugins helped position the audio segments in the desired places so users would feel a realistic sense of the environment.

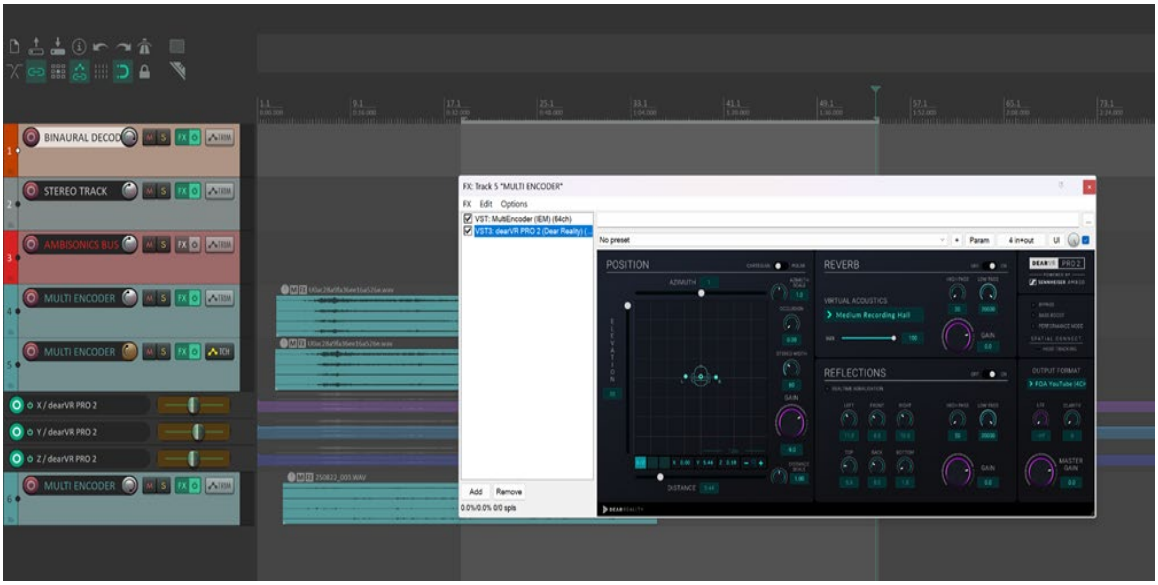


Figure 6 Spatial audio production in Reaper software (Source: Authors' screen capture)

4.7. Interface and usability considerations

A home page was designed (Figure 7). This page provides a brief description of the Athangudi palace. From here, users can choose between two options: a walkthrough feature accessible on any device (mobile or desktop), or a custom VR application designed for Head-Mounted Displays (HMDs). Both of these parts provide the same experience, though in HMD devices, the immersion will be comparatively higher. With these technologies, users can now experience the spatial and environmental characteristics of a palace without direct physical contact (Bekele et al., 2018; Cecotti, 2022). The home page also features an interactive header that rotates and displays random 360-degree images of the palace. The user interface design focuses on creating a comfortable, accessible, and educationally transparent experience for users with varying backgrounds and abilities, enabling them to interact within the virtual environment.

Therefore, all interactions are made as easy as possible to engage with via simple point-and-click or touchscreen controls (Jerald, 2015; Katona, 2021). The interface was designed to remain legible and approachable for users with limited prior VR experience. (Figure 8). Visual elements, such as overlays, captions, and labels, are created with high-contrast and clear typefaces for easy readability (Jerald, 2015). These visual elements provide users with information without interfering with their immersion in the immersive environment, using fade-ins, fade-outs, and transition techniques throughout the programme's configuration, as well as adjustable settings.

The user interface was designed to balance historical representation and the educational objectives. Virtual models have been simplified and enhanced to showcase the heritage's sustainable aspects while maintaining visual realism. The information is presented as hotspots, allowing the user to control how much information they take in at any one time while still maintaining focus on their desired level of learning. This allows the learner to build an immersive cognitive experience and create spatial relationships to the environmental context, thereby appreciating the sustainable principles behind the design of Chettinad architecture. At the end of the application, we have an exit page that provides a conclusion text and returns the user to the home page (Figure 9: Conclusion Page).

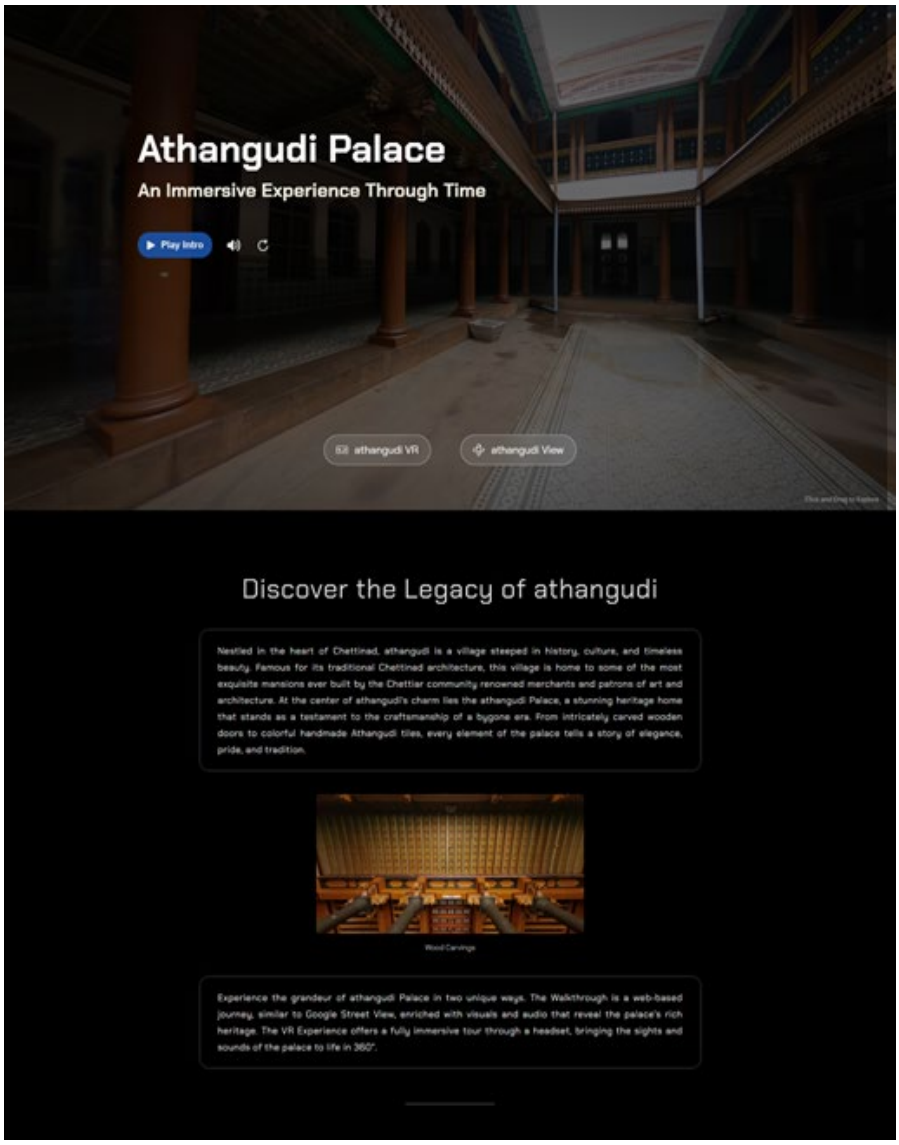


Figure 7 Home Screen (Source: Authors' Tool)

Figure 8 Walkthrough Screen (Source: Authors' Tool)

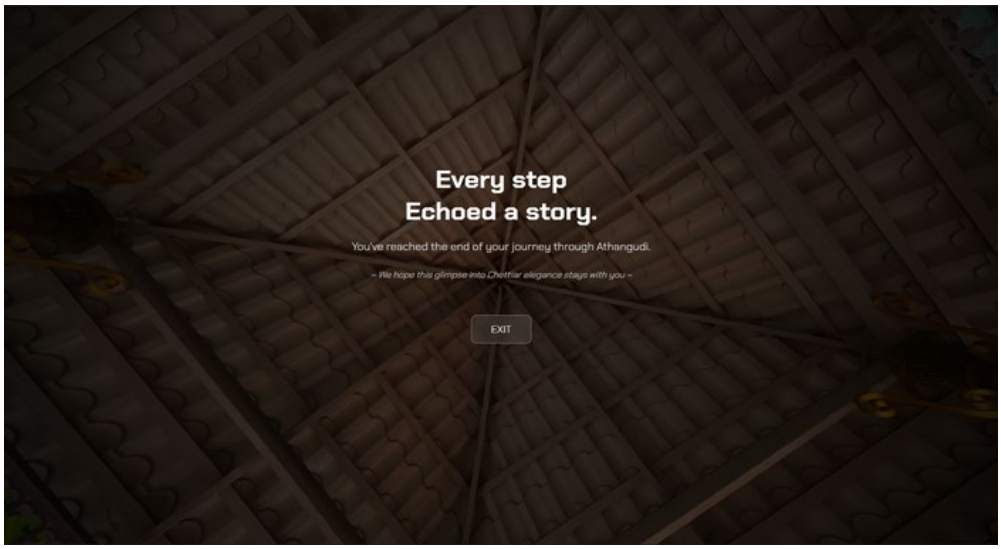


Figure 9 Exit Screen (Source: Authors' Tool)

5. Refinement & Testing

Refinement occurred through iterative internal testing during development (Figure 10). The project team reviewed the walkthrough across the intended access modes, including HMD and browser-based use, to identify issues with loading time, hotspot responsiveness, scene transitions, navigation clarity, audio triggering, and overall interaction comfort. Feedback from these checks informed asset compression, interface adjustments, and interaction refinements. In addition, consultations with heritage experts and design practitioners were used to improve the accuracy of architectural representation and the clarity of interpretive content. This phase should be understood as development-oriented in-house refinement rather than a formal usability or learning evaluation.

Figure 10 User Testing (Source: Authors' Test)

Use the following link to see the virtual walkthrough: https://zzz1750.github.io/Chettinad-Heritage-VR-Athangudi/

6. Discussion

The paper illustrates that a WebVR framework based on a browser can offer a feasible approach to documenting and interpreting a conservation-sensitive heritage building in a lightweight, accessible, and educative form. A-Frame and panoramic media can also enable a relatively low-cost, flexible workflow, which is particularly valuable in heritage settings where budgets, access, and technical infrastructure are constrained. The project also demonstrates that sustainable architectural knowledge can be integrated into the walkthrough through layered narration, navigational guidance, and hotspots with visual anchoring, rather than being viewed as background information. At the same time, the study has clear limitations. The current contribution is the design framework and the implementation logic, not a formal measure of user learning, usability, or behavioural impact. Subsequent development should then be based on this prototype, using systematic user testing, comparisons, usability improvements, and additional interpretive capabilities such as multilingual narration or environmental simulation. In this sense, the framework does more than provide visual access; it reorganises architectural knowledge into an interpretable sequence of spatial views, narrated cues, and interactive hotspots through which users can understand passive cooling, material logic, and spatial hierarchy as lived design principles rather than as static descriptive facts. Although developed for Athangudi Palace, the framework is also transferable to other vernacular, domestic, and conservation-sensitive heritage typologies that require low-cost, browser-based interpretation.

7. Conclusion

Athangudi Palace is a significant example of Chettinad heritage architecture with limited access. This study addressed that challenge by developing a cross-platform WebVR walkthrough that can be experienced on HMDs, desktops, tablets, and mobile devices. The study adds a systematic, repeatable process that includes documentation, media capture, asset preparation, browser-based implementation, and refinement. The panoramic representation, guided interaction, and spatial narration allow visitors to be more aware of the architectural and sustainability-related features of the palace without placing physical stress on the site, thereby enabling remote users to better understand the physical site. As a low-cost and adaptable model, the framework can inform future digital heritage projects involving vernacular and domestic architecture, while also providing a basis for subsequent user-based evaluation of learning, usability, and interpretive impact.

CRediT Authorship Contribution Statement

Antony Zharon: Writing – review & editing, Writing – original draft, Methodology, Investigation, Analysis, Data curation, Conceptualization. Ajith Paul: Writing – review & editing, Writing – original draft, Methodology, Investigation, Analysis, Conceptualization, Data visualization. Balakrishnan C: Writing – review & editing, Methodology, Investigation, Analysis, Data curation, Conceptualization. Biju Kunnumpurath: Methodology, Investigation, Analysis, Data visualization. Anitha Suseelan: Methodology, Investigation, Analysis, Data curation.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

Data will be made available on request.

Ethics Committee Approval

Ethics committee permission is not required.

Acknowledgement:

This paper is supported by the ICSSR, New Delhi for the Research Programme titled "Digitalising Chettinad Architectural and Cultural Heritage in Tamil Nadu for Sustainable Knowledge Management: An Empirical Analysis" (F. No. ICSSR/RPD/RPR/2023-24/34 Dated: 23/03/2024).

References

A-Frame. (2025). *Introduction. A-Frame Documentation*. https://aframe.io/docs/

Banfi, F., Stanga, C., & Landi, A. G. (2023). Virtual access to heritage through scientific drawing, semantic models and VR-experience of the Stronghold of Arquata del Tronto after the earthquake. *SCIRES-IT – Scientific Research and Information Technology, 13*(1), 83–100. https://doi.org/10.2423/i22394303v13n1p83

Bekele, M. K., Pierdicca, R., Frontoni, E., Malinverni, E. S., & Gain, J. (2018). A survey of augmented, virtual, and mixed reality for cultural heritage. *Journal on Computing and Cultural Heritage, 11*(2), Article 7. https://doi.org/10.1145/3145534

Cantatore, E., Lasorella, M., & Fatiguso, F. (2020). Virtual reality to support technical knowledge in cultural heritage: The case study of cryptoporticus in the archaeological site of Egnatia (Italy). The International Archives of the Photogrammetry, *Remote Sensing and Spatial Information Sciences, XLIV-M-1-2020*, 465–472. https://doi.org/10.5194/isprs-archives-XLIV-M-1-2020-465-2020

Cecotti, H. (2022). Cultural heritage in fully immersive virtual reality. Virtual Worlds, 1(1), 82–102. https://doi.org/10.3390/virtualworlds1010006

Chong, H. T., Lim, C. K., Rafi, A., Tan, K. L., & Mokhtar, M. (2022). Comprehensive systematic review on virtual reality for cultural heritage practices: Coherent taxonomy and motivations. *Multimedia Systems, 28*, 711–726. https://doi.org/10.1007/s00530-021-00869-4

Comes, R., Neamțu, C., Buna, Z. L., Bodi, Ș., Popescu, D., Tompa, V., Ghinea, R., & Mateescu-Suciu, L. (2020). Enhancing accessibility to cultural heritage through digital content and virtual reality: A case study of the Sarmizegetusa Regia UNESCO site. *Journal of Ancient History and Archaeology, 7*(3), 124–138. https://doi.org/10.14795/j.v7i3.561

Innocente, C., Ulrich, L., Moos, S., & Vezzetti, E. (2023). A framework for mapping structural vulnerability in built cultural heritage through virtual reality and GIS. *Journal of Cultural Heritage, 62*, 268–283. https://doi.org/10.1016/j.culher.2023.06.001

Jerald, J. (2015). The VR Book: Human-Centered Design for Virtual Reality. Association for Computing Machinery and Morgan & Claypool. https://doi.org/10.1145/2792790

Kasiviswanathan, Shri Harine, Narendran, Nived, & Nagammal, Jothilakshmy. (2024). *Chettinad vernacular architecture – A sustainable paradigm of modern design challenges*. In 2024 9th International Conference on Applying New Technology in Green Buildings (ATiGB). IEEE. https://doi.org/10.1109/ATiGB63471.2024.10717708

Katona, J. (2021). A review of human–computer interaction and virtual reality research fields in cognitive infocommunications. *Applied Sciences, 11*(6), 2646. https://doi.org/10.3390/app11062646

Krishan, A., Baker, N., Yannas, S., & Szokolay, S. V. (2001). *Climate responsive architecture: A design handbook for energy efficient buildings*. Tata McGraw-Hill.

Mendoza, M. A. D., De La Hoz-Franco, E., & Gómez, J. E. G. (2023). Technologies for the preservation of cultural heritage_A systematic review of the literature. *Sustainability, 15*(2), 1059. https://doi.org/10.3390/su15021059

Mozilla. (2025, April 4). *WebXR Device API*. MDN Web Docs. https://developer.mozilla.org/enUS/docs/Web/API/WebXR_Device_API

Napolitano, R. K., Scherer, G. W., & Glisic, B. (2018). Virtual tours and informational modeling for conservation of cultural heritage sites. *Journal of Cultural Heritage, 29*, 123_129. https://doi.org/10.1016/j.culher.2017.09.014

Radianti, J., Majchrzak, T. A., Fromm, J., & Wohlgenannt, I. (2020). A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda. *Computers & Education, 147*, 103778. https://doi.org/10.1016/j.compedu.2019.103778

Rajivkumar, S., & Kesavaperumal, T. (2018). Investigating the residents' attitude towards the preservation of palatial houses built heritage in Chettinad region, Tamil Nadu. *Journal of Community Archaeology & Heritage, 5*(4), 250–265. https://doi.org/10.1080/20518196.2018.1529549

Rambach, J., Lilligreen, G., Schäfer, A., Bankanal, R., Wiebel, A., & Stricker, D. (2020). *A survey on applications of augmented, mixed and virtual reality for nature and environment*. arXiv. https://arxiv.org/abs/2008.12024

Ren, W., & Chen, X. (2021). Evaluation of an online 360° virtual reality world heritage site during COVID-19. *Open Archaeology, 7*(1), 836–855. https://doi.org/10.1515/opar-2020-0188

Resta, G., Dicuonzo, F., Karacan, E., & Pastore, D. (2021). The impact of virtual tours on museum exhibitions after the onset of COVID-19 restrictions: Visitor engagement and long-term perspectives. *SCIRES-IT – Scientific Research and Information Technology, 11*(1), 151_166. https://doi.org/10.2423/i22394303v11n1p151

Rodríguez-García, B., Guillén-Sanz, H., Checa, D., & Bustillo, A. (2024). A systematic review of virtual 3D reconstructions of cultural heritage in immersive virtual reality. *Multimedia Tools and Applications, 83*, 89743–89793. https://doi.org/10.1007/s11042-024-18700-3

Wang, M., Lyu, X.-Q., Li, Y.-J., et al. (2020). VR content creation using immersive panoramic videos: A survey. *Computational Visual Media, 6*(4), 369–387. https://doi.org/10.1007/s41095-020-0162-z

Yang, R., Li, Y., Wang, Y., Zhu, Q., Wang, N., Song, Y., Tian, F., & Li, X. (2024). Panoramic VR maps for immersive exploration of cultural heritage sites. *Sustainability, 16*(13), 5281. https://doi.org/10.3390/su16135281

Zoom Corporation. (n.d.). H3_VR handy recorder: Operation manual. https://zoomcorp.com/media/documents/E_H3-VR_2.pdf

Resume

Antony Zharon holds a Bachelor's degree in Computer Applications from Christ University, Bangalore, and he worked as a Web Developer Intern at Computer Science department at Christ University, Bangalore. His core areas of interest include Web Development, Virtual Reality (VR), and immersive 3D environments. He is passionate about building interactive, user-friendly web solutions and exploring innovative applications of VR, especially in education and virtual walkthroughs. He is committed to continuously expanding his technical skills and contributing to projects that leverage emerging technologies.

Ajith Paul is a media academic and communication professional with over 12 years of experience in teaching, media production, and research. Currently a Research Scholar in Media Studies at Christ University, Bengaluru. He previously served as Assistant Professor at St. George's College, Kerala. His academic background includes an M.Phil. in Media Studies and an MS in Communication from Christ University. He specializes in video production, digital communication, and media education, with a strong interdisciplinary orientation toward immersive technologies, educational media, and student engagement. He has co-authored multiple peer-reviewed book chapters on emerging technologies like AI and augmented reality in education.

Dr. Balakrishnan C is an Associate Professor in the Department of Computer Science at Christ University, Bengaluru. He received his PhD from Bharathidasan University, Tiruchirappalli. Dr. Balakrishnan has extensive experience in computer science education and research, with expertise in vision-language models, machine learning, healthcare analytics, and IoT applications. He has been involved in multiple funded research projects, under ICSSR, UGC-STRIDE and MoE-RUSA initiatives. Dr. Balakrishnan was honoured with the India Prime 100 Researchers Award in 2021 and as a trained Innovation Ambassador (advanced level) for the Ministry of Education Innovation Cell. He holds four design patents.

Dr Fr Biju KC is a professor in the Department of Media Studies at Christ University Bengaluru. He received his PhD from Christ University, Bengaluru in Media Studies domain. Dr Biju has an experience of more than 20 years in academics and industry. He won a National Documentary Award on Livelihood (Jeevika 2004, Delhi) and worked on more than 20 documentary themes. Dr Fr. Biju KC has been involved in research projects as an investigator, including the ICSSR-funded "Digitalising Chettinad Architectural Heritage for Sustainable Knowledge Management" and a UNESCO-supported study titled 'Online-Merge-Offline Classrooms Wellbeing for Learners and Educators'.

Dr. Anitha Suseelan is a Professor of the School of Architecture at Christ University Bengaluru. She received her PhD from CEPT University, Ahmedabad, specializing in Urban Design and Architecture. Dr. Anitha has experience spanning more than 25 years in architectural education and research, with expertise in Urban Heritage Conservation, Ecological Urbanism, and Politics of Urban Design. Her work was published in UN Habitat-3. Dr. Anitha was honoured with the Sir Patrick Geddes Award of Excellence and Vastu Shilpa Foundation Award. She is the recipient of National Teachers' Award 2024.

JOURNAL OF DESIGN FOR RESILIENCE IN ARCHITECTURE & PLANNING

Research Article
Online: www.drarch.org
Volume 7, Issue 1 (53-68), 2026
DOI: 10.47818/DRArch.2026.v7i1203

Bilateral relations of tectonics through physical models: Anchoring architecture to the site

Bilgen Dündar*
Aslı Uzunkaya**

Abstract

Emphasizing the concentric relationship between the tectonics of Earth and the tectonics of architecture, this study argues that design ideas generated through this interaction have the potential to produce spatial constructs belonging to their sites, rather than objects merely positioned upon them. It examines a conceptually framed architectural design studio in which tectonics is explored as a design tool. By primarily questioning the concept of tectonics, it is defined in terms of relationalities, dualities, and dichotomies, thus offering students a robust and flexible methodology for idea generation. Within this framework, the scope is narrowed through the use of conceptual and physical tools. While tectonics is treated as a conceptual tool, the physical model is employed as a corporeal tool of inquiry. The discussions focus on analyzing the tectonics of the site and investigating its reproduction through physical models and how this form of representation affects architectural design. The study also critiques the process of analyzing the site and then moving on to idea generation, arguing that the site itself is a powerful datum for idea generation and that these processes are both incremental and deliberative. Within the architectural design studio that forms the scope of the study, the first stage was designed to question the concept of tectonics in order to raise students' awareness of the project site. Questioning the Earth's tectonics constituted a pillar of the tectonic discussions that spread throughout the semester. The question at the center of these discussions is, "How can architecture anchor to the site?" In addressing the question, the conceptual framework of inquiry was defined as the dichotomy between tectonics and stereotomics. As a result of this inquiry process, the three-dimensional model was the medium through which the students would concretize their interpretations and findings. While the physical models constitute student-generated material, their abstraction, classification, and visual representation reflect the authors' methodological reading of the design processes. The study ultimately proposes a methodological approach in which the relationship between site and tectonics is explored through physical modeling. On the other hand, it further argues that tectonics should be understood not merely as a descriptive category but as a critical operative concept within the design process. Owing to its inherently multilayered structure, tectonics offers a robust theoretical framework through which architectural production can be both interpreted and articulated. As such, the study provides a productive foundation for future research seeking to reassess the epistemological and methodological grounds of design practice.

Keywords: architectural design education, physical model, site, tectonics, topography

1. Introduction

The concept of tectonics, as theorized by Gottfried Semper and Karl Bötticher in the nineteenth century, has often been confined to the constructional aspects of buildings, predominantly discussed within the framework of structural articulation from the twentieth century onwards. However, a more nuanced examination of tectonic theory demonstrates that it operates across multiple scales—from its relationship with the earth to spatial adjacency, and from ornamentation to detail—offering critical perspectives for developing design ideas that transcend purely constructional logic.

*(Corresponding author), Department of Interior Architecture, İstanbul Beykent University, İstanbul, Türkiye
bilgendundar@gmail.com
**Department of Interior Architecture, İstanbul Beykent University, İstanbul, Türkiye asliuzunkaya@gmail.com
Article history: Received 17 October 2025, Revised 31 January 2026, Accepted 11 March 2026, Published 30 April 2026

The tectonics of architecture are fundamentally influenced by and coexist with the tectonics of Earth. The interplay between these two systems manifests in diverse forms. At a fundamental level, this coexistence is contingent upon the interaction between architectural artifacts and their physical contexts, often described as anchoring to the site. The engagement of architectural products with their topography is essential in defining the relationship parameters between architecture and the Earth. Their coexistence, stemming from the Earth's tectonics, determines the approach that sustains or disrupts their sequentiality.

Emphasizing the concentric relationship between the tectonics of Earth and the tectonics of architecture, this study argues that design ideas generated through this interaction have the potential to produce spatial constructs belonging to their sites, rather than objects merely positioned upon them. The research pays particular attention to the scope of tectonics as a conceptual tool, focusing on site relations through corporeal methods. It examines the miscellaneous properties of tectonics, which encompass activities related to making, producing, and designing connections to material, form, and meaning, highlighting its operation through bilateral relationalities.

Within this framework, the study examines a conceptually framed architectural design studio, in which the authors, acting as project coordinators, investigated how tectonics can be operationalized as a design tool. Focusing on student projects, the relationship between site and architecture is explored through the notions of earthwork and framework—two key components of Semper's tectonic theory—which Kenneth Frampton describes as a syntactical transition.

2. Research Design: A Studio-Based Inquiry into Tectonic Relationality

The concept of tectonics and its connection to the site involves complex and layered realities, a viewpoint supported by the literature examined. While this theoretical foundation shapes the study, the research places particular emphasis on the design phase, foregrounding physical data and the act of making as a mode of inquiry. Processes of making, understanding through making, material selection, and the relationships established take precedence. Although tectonics and sites encompass various meanings and properties, this study deliberately concentrates on their physical dimensions, with a specific focus on topography. In this regard, the interaction between the site and tectonics forms the core of this exploration, emphasizing how this interplay influences spatial design. The conceptual framework relies on an inquiry into tectonics, discussed from two perspectives: the tectonics of Earth and the tectonics of architecture. Communication between the tectonics of Earth and architecture involves complex relationships and can occur within a broad context and through various means. Therefore, it is essential to understand tectonics through relationalities, dualities, and dichotomies and to define them accordingly.

To establish this conceptual positioning, we draw upon existing literature to explain why we position tectonics as the focus of this study. Notably, alongside contemporary literature, the discussion centers on two prominent figures: Semper (1851/1989) and Bötticher (1844/2002). This literature review, combined with in-depth research into these figures' expressions and visualization of them as concepts, enables us to refine the notion of tectonics and reveal its bilateral relations. Accordingly, we also articulate our comprehension of the concept and present it visually, akin to previous works.

Within this conceptual framework, the study, based on a speculative design process, adopts a qualitative, observational case study methodology conducted in a first-year undergraduate architecture design studio. We employ a speculative thought process, developed by the authors as an analytical framework, to convey the execution of the architectural design studio process, with a particular focus on the tectonic relationality of the site and students' approaches to it. The authors assumed dual roles—studio instructor and researcher—allowing them to closely observe the design decisions that emerged throughout the students' model-building process. The research was

structured as a studio-based inquiry, prioritizing observation and interpretation over evaluation. The analytical approach is designed to explore bilateral relations as articulated through tectonics.

The case study is situated in the first phase of a semester-long course, involving approximately 40 students who were novice learners producing their first architectural design projects. This initial phase, spanning seven weeks, focuses explicitly on site reading and tectonic interpretation through physical model production, prior to the introduction of architectural programmatic requirements. The student group had no prior experience in producing design projects explicitly grounded in site anchoring, which positioned tectonics as a critical conceptual and operational framework for the studio.

Data was generated through continuous observation of students' analyzing the tectonics of Earth and its reproduction through models, examining how this form of representation affects spatial production. The study prioritizes observable design actions and their spatial consequences as manifested in three-dimensional physical models. These models, produced and iteratively developed by students, served as the primary empirical material for analysis. Viewing these reproductions regarding tectonics reveals implications that provide students with a valuable method of inquiry.

All diagrams, tables, and categorizations presented in the study were produced by the authors as analytical interpretations of student work. While the physical models constitute student-generated material, their abstraction, classification, and visual representation reflect the authors' methodological reading of the design processes. The interpretations offered are inherently contextual and reflective, shaped by the specific studio framework and the authors' analytical perspective.

3. Tectonics over Bilateral Relations

The term tectonics is taken from geology, which indicates the study of large-scale movements and changes in the form of planet Earth. It includes ideas of disintegration, reuniting, and merging components due to natural effects such as earthquakes, temperature differences, volcanic eruptions, or aeolian phenomena. In architecture, the term is employed with an added geographical meaning, including fragmentation and reunification. In different parts of the world's surface layers, this dual action may manifest as a continuous movement—sometimes slow, at other times rapid—across various layers of the Earth's surface. Therefore, while the Earth may predominantly exhibit stereotomic features, it can also be understood as possessing its inherent tectonics.

The etymology of "tectonics" is closely linked to the term "architecture," derived from the Greek word tekton, meaning carpenter or builder (Frampton, 1996; Karvouni, 1999). This dual reference to both carpentry and construction is significant; in ancient classification systems of the arts, architecture was included among the seven mechanical arts (Kristeller, 1951). Although Vasari categorized architecture as being among the visual arts, before establishing the fine arts system in the 18th century, architecture consistently belonged to a category related to construction (Kristeller, 1951, p. 508). Thus, the term archi-tekton, meaning architect, encapsulates this connection.

A review of the current literature indicates that the concept of tectonics, originally rooted in geology, primarily denotes the physical properties and structural formations of the Earth's crust. In architectural discourse, the term is employed in a manner parallel to its geological origins. It is predominantly examined through the lens of material properties, the relationships between structural elements, and the configuration of structural systems (Chih-Ming & Yu-I, 2011; McCoy & Duffy, 2022). Within architectural scholarship, tectonics frequently appears in studies grounded in traditional analytical frameworks (Kim & Park, 2017; Wijaya et al., 2024; Manav & Urak, 2024). These works typically situate material use and structural organization within specific local contexts, emphasizing construction techniques and regional building practices. Moreover, the concept has been employed to interpret the integration of traditional materials into contemporary spatial

designs, again with a primary focus on material expression and constructive logic (Talamini et al., 2024). Although certain authors acknowledge the multidimensional nature of tectonics, their analyses nonetheless remain largely centered on materiality (Lakkala & Pihlajaniemi, 2018). In addition, several studies extend the discussion into the cultural domain, interpreting tectonics as a framework through which material and structural decisions contribute to the formation of architectural language (Lucchini & Urban, 2023; Rociola, 2017). Nevertheless, even in these broader interpretations, material and structural considerations continue to constitute the principal analytical focus. Beyond these predominantly material-oriented interpretations, the conceptual foundations of tectonics provide a broader and more nuanced interpretative framework. Although limited in number, several studies in the current literature adopt this expanded perspective. For instance, Shou and Xu (2025) examine traditional architecture through the lens of Gottfried Semper's tectonic theory, conceptualizing tectonics as the relational interplay between natural terrain, mound construction, and interior architectural space. While the study considers existing building fabric and material usage, it simultaneously reveals the multilayered character of the concept, extending the discussion beyond purely material concerns. Other scholars approach tectonics from an anthropological standpoint, interrogating the relationship between space and human experience—an inquiry that echoes Semper's own theoretical orientation (Hale, 2020; Sántha et al., 2022). In a similar vein, certain studies engage more directly with the spatial–human nexus by interpreting tectonics through the framework of the human body, thereby foregrounding embodiment as a critical dimension of spatial formation (Buck, 2006; Hürol, 2014). Taken together, these contributions suggest that tectonics may be understood not only as a material or structural principle but also as a conceptual framework capable of articulating the complex interrelations among land, body, space, and culture.

An examination of the aforementioned studies reveals that the tectonics of the site and the tectonics of the structure are generally addressed as separate domains, often within different disciplinary frameworks. In contrast, the architectural design process—particularly during site analysis and site preparation—necessitates an integrated inquiry into the relationship between structure and ground. This relational condition constitutes the central concern of the present study.

Within this research, tectonics is employed as a conceptual framework through which the interaction between site and structure can be systematically investigated. Specifically, the study explores how the tectonics of the site may be interpreted, conceptualized, and represented through the use of physical models. In doing so, it shifts the focus from the analysis of existing buildings or the technical development of structural systems—approaches that dominate literature—to the early stages of idea formation. Tectonics is thus examined not as a descriptive or evaluative tool applied retrospectively, but as a generative instrument in the development of architectural thought. Accordingly, the study aims to contribute to literature by proposing an alternative approach to the conceptualization and representation of tectonic relationships, particularly within the context of architectural education and design studios.

Tectonics unfolds through bilateral relationality, as previously discussed about geography and the etymology of architecture. It encompasses making, producing, and designing activities while intertwining with material, form, and meaning. According to Stanford Anderson (1981), tectonics refer not merely to the construction with requisite materials of an object or space that answers a specific need, but to the activity that raises this construction to an artform. Therefore, a holistic perspective on architectural products and their production processes would also have to account for references for meaning and aesthetics. This holistic dimension of the term can be traced in the following theoretical explanations generally articulated through relationalities, particularly dualities and dichotomies. These explanations foreground the fact that bilateral relations are what the concept of tectonics progresses through.

The 19th century, marked by a quest for new architectural paradigms in Europe, also witnessed the emergence of the theory of tectonics. Amid the eclecticism prevalent in architectural practice, theorists Semper (1851/1989) and Bötticher (1844/2002) explored fundamental principles for new

architectural production. They played pivotal roles in developing and theorizing the debates surrounding tectonics. Their ideas diverge from the prevailing understanding of the period. While both emphasize the concept of space, their proposals differ markedly. Bötticher prioritizes internal forces over external factors in his theory. According to him, the structural systems that hold the building up should not be concealed by ornament, and these two elements should be integrated in a way that they mutually reinforce each other. This concept, which he defines as structural integrity, forms the basis of his tectonic theory (Schwartz, 2017, p. xxxvii). Unlike Bötticher, Semper considers the concept of enclosure in space to be more important than structure. The concept of Bekleidung (dressing) is the most important element in defining space and constitutes one of the four elements of architecture. Semper contends that architecture arises from construction and the fundamental need for enclosed space (Schwartz, 2017, p. xxxviii).

Semper's classification of 'The Four Elements of Architecture' is presented in Chapter 5 of his book Comparative Theory of Architecture. In this chapter, Semper draws upon his extensive study of Greek, Chinese, Egyptian, Assyrian, and Persian architecture. Unlike some of his contemporaries, he does not consider Greek architecture unique in isolation. Instead, he develops his theory with a keen awareness of the interactions among various civilizations and cultures. Semper defines these four elements: the hearth, the earthwork, the framework and roof, and the enclosing membrane or cladding (Semper, 1851/1989, p. 74).

In Semper's theory, the hearth represents the essence of architecture. The remaining three elements are designed to protect and enclose the hearth. The first element, the earthwork, serves as the foundation and is elevated for protective purposes. The second element, the framework, provides structural support and defines the spatial limits. The final element, cladding, is crucial in delineating and defining the space. It establishes the boundaries and creates a sense of enclosure (Schwartz, 2017, p. 43). Although Semper's classification involves physical counterparts, Mallgrave contends that the term 'element' is often misunderstood. In Semper's theory, an 'element' pertains more to 'motive' and 'ideas' than concrete materials and forms (Mallgrave, 1989, p. 24) (Figure 1).

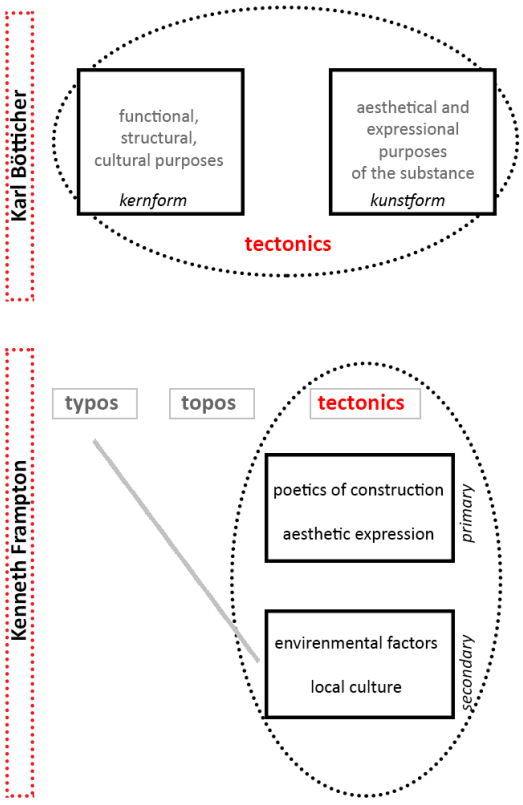


Figure 1 Semper's four elements of architecture (Authors' work)

Among the four elements identified by Semper, earthwork, and framework are particularly significant for this study. While earthwork is traditionally defined as a raised platform, accepting it as a broader conceptual framework—as suggested by Mallgrave—opens a critical dialogue about its role in design. The interrelationship between earthwork and framework underscores their inseparability; they must be considered in tandem during the design process. This article investigates how this integration can be effectively achieved within the studio process it examines.

On the other hand, Karl Bötticher approaches tectonics from two perspectives: their ontology, that of Kernform, and their representation, as in Kunstform. In his viewpoint, Kernform was related to the object's functional, structural, and cultural purposes, while the Kunstform was all about the aesthetics and purposes of its expression, that is, its representation. This holistic perspective combines structure and material, aesthetics, and expressionist purposes (Oechslin, 2002) (Figure 2).

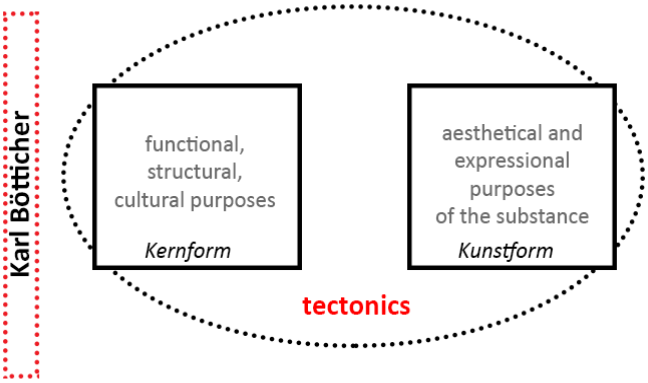


Figure 2 Reflections from Bötticher's ideas of tectonics (Authors' work)

In addition to Semper and Bötticher, Kenneth Frampton, a prominent contemporary architectural historian, has significantly advanced the concept of tectonics within architectural discourse (Frampton, 1998, p. 30). Frampton argues that "[t]he primary principle of architectural autonomy resides in the tectonic rather than the scenographic…", defining tectonics as a path focusing on the poetics of construction and aesthetic expression. Accordingly, environmental factors and local culture are also counted among the factors that affect tectonics (Frampton, 1995). Frampton identifies tectonics as one of three essential characteristics of architecture, alongside the topos (the site) and the typos (the meaning) (Frampton, 1998, p. 25). Here, the intricate relationship between dwelling and meaning within tectonics comes to the forefront. Related to the typos, Frampton also points out an alteration in the meaning of the concept throughout history. In Homer, the tectonic "alludes to the art of construction in general". In the fifteenth century, this meaning expanded to include "a more generic notion of making, involving the idea of poiesis" (Frampton, 1996, p. 3). After this point on, poiesis, an aspect of tectonics based on meaning and progressing at a more abstract level, emerges.

At this point, the relationship between architectural tectonics and the tectonics of the Earth becomes more explicit and operational. Toma Berlanda, quoting David Leatherbarrow and Eduardo Souta de Moura, expresses the relationship between the tectonics of architecture and the tectonics of the Earth as "preparation of the site," and emphasizes that, according to Moura, "the preparation of the site is the project itself" (Berlanda, 2014, p. 78). This understanding reinforces the inseparability of tectonic thinking from site-specific design processes.

Alongside conceptual explorations, the operational aspects of tectonics also encompass bilateral relations. Thus, Maria Karvouni explains the basic operations of tecton as follows: "A tecton cuts and joins, divides, and connects. According to Plato, dividing and composing are the two main modes of operation by which an art (techne) proceeds. Surprisingly, the tekton is the only artist-artisan who shares the common root tek with techne (Karvouni, 1999, p. 106). From this point of

view, Karvouni establishes the connection between tecton and techne not only because of their similar origin but also because they employ a similar methodology. The relation of the tecton of the techne, thus connected to poiesis, implies a meaning beyond being a work in mechanics. This relation implies something hidden and may refer to Frampton's concept of typos-meaning. Techne is the revelation of what is hidden. From this point of view, we see that the act of doing and its stages are associated with meaning rather than the simple act of doing. This, the action of doing being strictly related to poiesis, helps us unearth the embedded relations of tectonics with meaning.

With the separation and joining operations that techne and tecton contain, the difference between the concepts of tectonics and stereotomic also surface. Semper puts forward the dichotomy between stereotomy and tectonic as being based on the physical differences between them. He classifies building crafts by the differences between tectonic and stereotomic: "the tectonics of the frame, in which lightweight, linear components are assembled to encompass a spatial matrix, and the stereotomics of the earthwork, wherein mass and volume are conjointly formed through the repetitious piling up of heavyweight elements" (Frampton, 1996, p. 5).

Stereotomic can be defined as a design activity that originates from the whole. Although Karvouni does not explicitly use the concept of stereotomic, she interprets tecton in terms of the applied operation through the duality of using a tool and producing manually, including all the interruptions and continuities the process entails. She asserts that: "A tekton's mode of working requires a tool (the axe), unlike work done with bare hands, such as molding (platto, to mould, is related to palame, palm, hand). Whereas molding involves continuity, tectonics is defined first by the discontinuity of cutting and then by joining. Tectonics deals with the arrangement of 'distinct units' that the tecton first shapes with his tools and then places and joins together" (Karvouni, 1999, p. 106). Thus, the continuity and hand-shaping present in Karvouni's dualities seem to refer to the concept of stereotomic. From this point of view, the concept of tectonics also includes the idea of dividing and uniting the parts formed as a result of this division. Stereotomic, on the other hand, refers to a more holistic approach with mass rather than parts.

The various meanings and forms of application that the concept of tectonics has gained over time show that this concept cannot be understood solely in ontological terms; in other words, it cannot be reduced to the issue of technical making. It can potentially produce meaning regarding the whole of the architectural idea. In addition to the bilateral relations embedded in tectonics, the relationship established with stereotomics also gives us different possibilities both in terms of way of production and approach. The dualities of discontinuity/continuity, lightweight/heavyweight, sky/earth, immateriality/materiality, and parts/mass can also be traced in the dialectical relation between tectonics and stereotomics. Considering the literature here, we also conceive of tectonics through bilateral relations but in a narrower sense: specifically relating the tectonics of Earth (the natural) with the tectonics of architecture (the artificial). This relationship can be characterized by both similarities and contrasts and is related to concepts of meaning, aesthetics, and dwelling activities, both natural and artificial. Ultimately, this activity seeks not only to satisfy basic needs by forming a volume with the necessary material but also to elevate that volume to a Kunstform. (Figure 3).

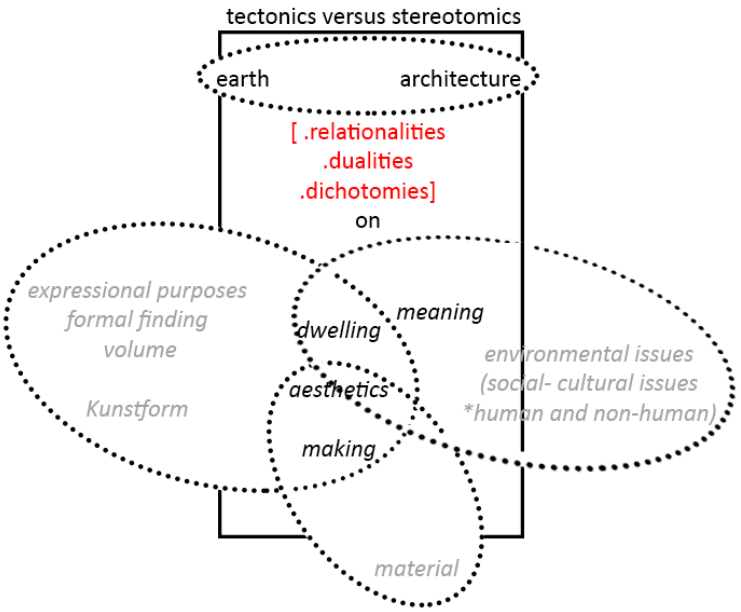


Figure 3 Tectonics over bilateral relations (Authors' work)

4. Tectonics as a Conceptual Tool: Anchoring to the Site

The literature reveals that the term 'tectonic' encompasses various sub-concepts and operations within architecture in a holistic framework. In his book Architectural Topographies, Toma Berlanda examines the relationship between significant buildings and their sites, categorizing these interactions into three main strategies: Interlock, Adjacency, and Separation. He notes that, with the support of technology, adjectives such as raised, stacked, inflated, vectorial, carved, and exposed are used to further define these relationships with the ground. He emphasizes that these terms align with his three primary strategies (Berlanda, 2014, p. 3).

In line with this statement and our definition of tectonics, we accept that bilateral relationalities of this concept can be discussed as the base for conveying the holistic being of architectural design activity to students, especially in their first year. This scope handles tectonics as a conceptual tool during the process. The binary oppositions and bilateral relations in the duality of tectonics and stereotomics are under discussion, along with the points where these oppositions sometimes get reconciled. Therefore, the attitude of the building at the point where it touches the ground and the effect of this attitude on the main idea of spatial organization has been one of the discussion points.

Accompanied by these thoughts, we prioritize the site's physical forces during the activity mentioned above. To reveal the physical forces of the site, in other words, its hidden features, we utilize the physical model as a tool. Thus, the physical model becomes the secondary building block as a corporeal tool. Models can both warn designers about potential future problems and spark curiosity throughout the process (Smith, 2004). The ability to construct three dimensions, test the possibilities of materials, and observe and design combinations and intersections makes the model a vital tool in the process. In essence, the model allows for an understanding of all the bilateral relations of tectonics and is a narrative tool to better convey the proposed methodology.

Within this framework, the primary position of instructors is to orient the students to reconsider these conceptual and corporeal tools. They were encouraged to analyze the site by considering the bilateral relations of its tectonics, re-representing the tectonic structure to internalize it, and then based their own designs again on the ties of tectonics. Free to choose whichever materials suited their model, the students thus explored the structure of the terrain, using different materials and methods of representation. As pertains to this research, the physical model underscores the activity

of making, highlighting how crafting and material selection deeply engage with the layered realities of tectonics and site.

The studies' contributions are processing these and adding the acquired data to the initial tectonic description with these reconsiderations in mind. In this context, the leading, production-oriented section of the study is based on the narration of these parts of the process in which tectonics are used as a primary building block, that is a conceptual tool along with the physical model, which operates as a corporeal tool.

While all components of the architectural design process are fundamentally interconnected, this study focuses specifically on revealing anchoring to the site in the context of tectonics. Our focus, though, depends on the idea that the whole process contains extensive information and interpretation that cannot be included in one single piece of research. In this context, reflecting on the role of Earth tectonics in architecture and the relationship between the two are crucial points of the process. This process consists of two main phases. The first stage is where the natural is grasped, the topography is understood and thus represented in line of subjective expressions. Then, in the second stage, the relationships are established between the natural and designed through relationalities, dualities, and dichotomies. In line with these stages, the students first understand the site and then establish a relationship with the site and the design proposal. The primary method employed in this process is to gain the ability to think in the proposed manner that belongs to the site root rather than thinking merely as a singular object. (Figure 4). Following sections present the key findings derived from the observation and analysis of students' model-making processes. These findings are structured around continuities and shifts between tectonic and stereotomic approaches, as observed throughout the studio process.

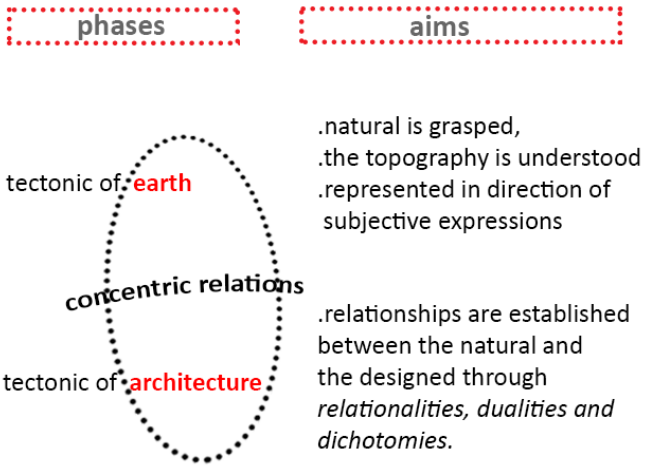


Figure 4 Phases of the process (Authors' work)

4.1. Tectonics of Earth

In the research production process, we aimed to investigate the tectonics of the topos and the relationship between spatial tectonics and these delineated tectonics of the topos. Alongside these assumptions, to conduct discussions on tectonics / stereotomics, we selected a site with a strong tectonic quality: the Mid-Atlantic Ridge on Iceland. This intriguing terrain describes a system with critical geological features indigenous to the planet. This system, mostly submerged, has many transformation faults and an axial rift valley along its length (UNESCO, n.d.). The Earth opens itself and reveals its underlying structures through these axes. The acts of concealing and revealing are observed simultaneously.

The existing dichotomies at the site include the heat of the magma juxtaposed with the cold of the snow, the pale, barren soil juxtaposed with the shine off the walls of underground caves, and the visibility of both the Eurasian and North American plates. Although most of the ridge system

there is submerged, the land forms a series of volcanic islands of various sizes that run along the Atlantic Ocean (UNESCO, n.d.). One such island, Grjótagjá, Iceland, serves as the selected site for this studio, where the ridge system reveals a series of caves. As a place where tectonic movements and the Earth can be observed from the bottom up, along with both land and water and the various continents, the site is considered rewarding in terms of interiorizing pure tectonics.

The ridge, which is the most prominent reason for choosing this area as a site, also stands as a symbolic representation of the dualities and dichotomies of the tectonics of Earth. The tectonic-stereotomic properties of the site, which we define as the place or the land for a certain given time, that is, the massive effect, appear as a predominant and given information. Anchoring to this site has defined the transition point between the existing natural tectonics of the world and the artificial ones. Thus, the problem is to design this cross-section where nothing has been built previously, and the reference is only to the natural tectonics of the site.

One remaining problem concerns the program components that require design, which are entirely alien structural additions to this place with such strong tectonics. Another challenge that students face is deciding whether to simulate these structures into being part of the natural terrain or, if deciding to establish a contrast, to create a fictional tectonic structure that increases and complements the value of the place. Accordingly, in the 1st phase, the potentials of the site and tectonics of Earth are explored, interpreted, and represented with different materials. Communication with the material progressed in the perception of topography in three-dimensional form, topography-material relationship, and then the interpretation-representation of the student with the selected material. At this point, the students reproduced (re-presented) the site in line with their unique expression and perception.

At this point, as previously outlined, we categorize these approaches according to modes of terrain internalization, using the models as the primary analytical tool. Considering the re-presentations of the tectonics of Earth, we infer two approaches in the way the students used the material and their execution patterns: stereotomics and tectonics. A majority initially approached the site through stereotomic representations, while another group fragmented the terrain into discrete tectonic elements.

While stereotomics studies are discussed through homogenous and heterogeneous use of solids and heavy materials, they are also classified as bringing a strong monolithic effect into play. This stereotomy is gained through the design of massive, solid, rigid, and unified models, all made of heavy materials (Figure 5).

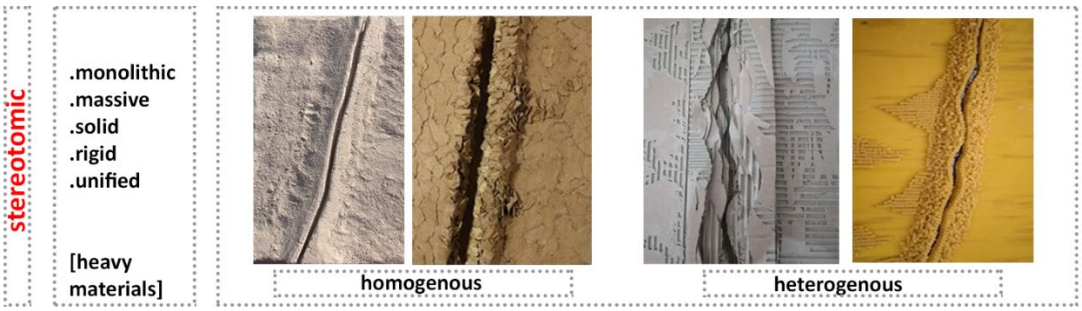


Figure 5 Representation of site: Stereotomics of earth (Student works, analytically redrawn by the authors)

However, tectonics studies progress through collating singular elements and light materials and using them in linear or vertical directions or in a way that results in a web reaching the whole. This method of execution in terms of repetition or using different forms of continuity, similar to assemblage, represents the site based on tectonics (Figure 6).

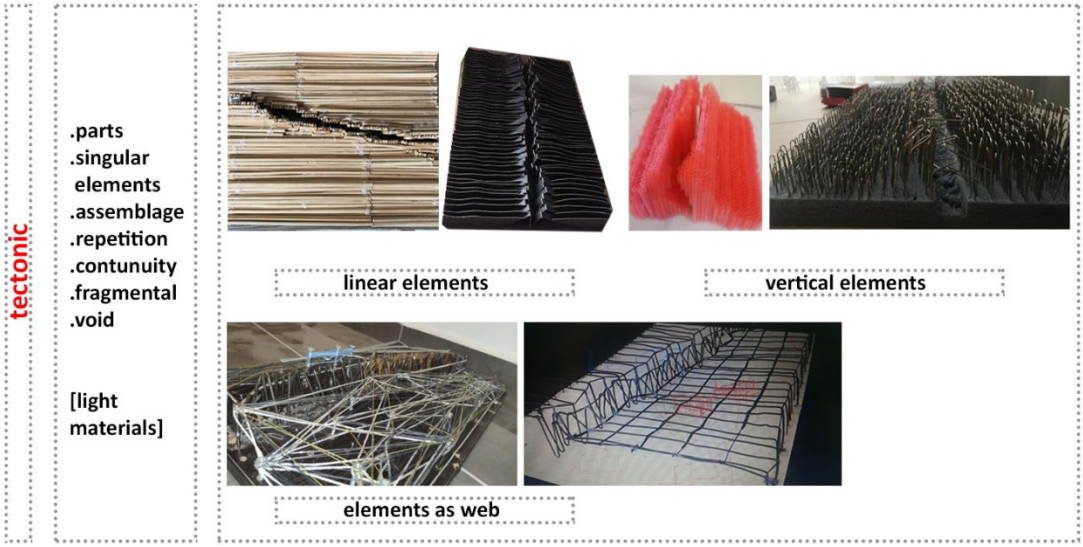


Figure 6 Representation of site: Tectonics of earth (Student works, analytically redrawn by the authors)

By identifying these two distinct approaches, we illuminate how students conceptualize their designs concerning tectonic principles. This understanding fosters a deeper engagement with the site and enhances the creative process, reinforcing the overarching theme of interaction between materiality and tectonics.

4.2. Concentric Relations in the Tectonics of (Earth and Architecture)

The styles of representation that the student perceives tectonics and topography significantly affect their approaches to the site and guide the design process. In this second stage, after grasping the natural terrain alongside subjective expressions, students derive clues and traces from the 'tectonics of Earth.' Moreover, particular attention is paid to creating open, semi-open, and closed areas in relation to tectonics and other characteristics of the site. In addition to this spatial organization, ensuring compliance with topography and correlation with the site's tectonics is essential when considering three dimensions.

The findings discussed in this section reveal that students' interactions with Earth's tectonics and architecture evolve through identifiable patterns of continuity and transformation. Analysis examining representation strategies and design practices demonstrates that tectonic and stereotomical approaches are considered relationally in anchoring to site.

Students represent the site in ways that reflect their understanding of different ideas and methods for generating spatial components. The analysis categorizes projects based on their methods, examining continuities and shifts in the relationships between tectonics and stereotomics. This engagement with materiality and form highlights how students navigate design complexities and the dualities inherent in their processes.

A key finding is that students' projects evolve through either continuities or shifts in their tectonic reasoning. While some projects progress as a continuation of their established methods, which are defined as -from stereotomics to stereotomics- or -from tectonics to tectonics-; others included alterations in expression, displaying the shift in their perceptions. These are generally categorized as –from stereotomics to tectonics-, or –from tectonics to stereotomics.

Continuous stereotomic projects emphasize themes like the mass of the site, folding, and mass dissolution. To clarify, projects that exhibit continuous progression in stereotomics are characterized and labeled by authors by expressions such as:

- 'continuation of massive being of the site to the mass';
- 'folding as a making way in both site and space' and

- ‘dissolution of the mass’.

Conversely, the projects that demonstrate a shift in perspective from the stereotomics of the Earth to the tectonics of architecture explore fragmentation and spatial relationships. These shifts are described and labeled as:

- the essential fragmentation of a whole and
- ‘spaces [in and on] land’

This stereotomics-based evaluation is also valid for tectonics. Projects that have pursued the approach of using singular elements in both tectonics of Earth and architecture, even if they include changes (such as repetition, framing, or web), are accepted as partaking in the approach from tectonics to tectonics. They are categorized as:

- repetition of vertical elements,
- framing of both site and space, and
- enclosure as a part of the web.

On the other hand, some students shifted their execution process from tectonics to stereotomy, as exemplified by phrases such as:

- ‘from fragmented pieces to monolithic pieces,’ or
- ‘from linear elements to massive pieces,’ or
- ‘web as a void forming the solid.’

These methods, continuities, and shifts in the relations can also be considered part of the previously discussed bilateral relations, particularly within the context of dualities and dichotomies. This analysis of projects demonstrates how students navigate the inherent complexities of tectonics in their design processes. They explore the nuanced relationships between materiality, form, and tectonic principles by engaging with these continuities and shifts.

From this perspective, the approaches in which students establish continuity between the tectonics of Earth and architecture, namely natural and artificial, and deal with both as a whole, are generally included in projects where both the material, the structural, and the construction techniques are similar to each other in all stages. These approaches are discussed as ones that border on similarities, dualities, and relationalities. In contrast, fragmentations-reunifications and interruptions-–continuities are the dichotomies specified in the execution phase. Choices to conceal or reveal are more related to spatial organization, while heavy or light materials are considered fundamental decisions that are mainly subjective.

The study illuminates how students perceive and interact with site-specific conditions by investigating these relational dynamics. Using three-dimensional models at these stages allows students to transform their understanding of tectonics into tangible forms, enabling them to engage deeply with the characteristics and nuances of the sites they are studying (Figure 7).

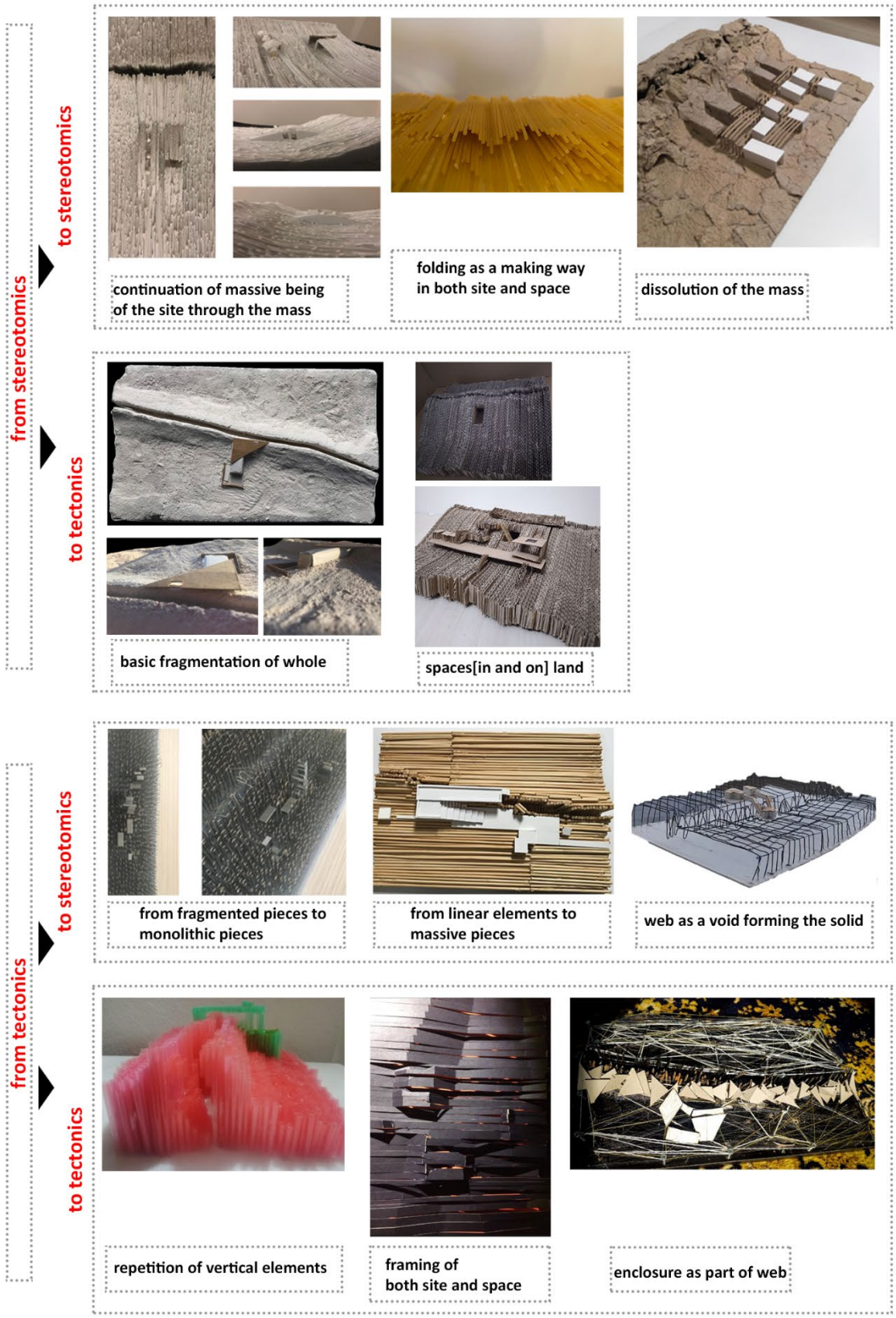


Figure 7 Continuities-shifts in relations of tectonics of earth and architecture (Student works, analytically redrawn by the authors)

5. Concluding Remarks

The way the site is defined forms the basis of the architectural design process, while the concept of tectonics offers multiple perspectives on anchoring architecture to the site. In this study, the relationship between place and architecture is discussed in the context of representing the site and preparing it for the project, within the framework of the concepts of earthwork and framework, two of the four architectural elements in Semper's tectonic theory. The various perspectives offered by the concept of tectonics in terms of site preparation, as defined by Berlanda (2014), are presented. This positioning reframes site not as a given condition, but as an active generator of architectural thought.

Aligning with existing literature, we conceptualize tectonics through bilateral relations, specifically examining the interplay between Earth's natural tectonics and architecture's artificial tectonics. By emphasizing the holistic nature of these relationships, the research deepens our understanding of how natural and artificial environments interconnect in architectural design. To elaborate, tectonics are discussed through bilateral relations; similarities, dualities, and dichotomies come to the forefront as the relationalities surface. Alongside these relationalities, the dichotomy between tectonics and stereotomics is incorporated as part of the conceptual framework informing the design process. Thus, correlating the tectonics of site (the natural) and architecture (the artificial) through these relations marks the demarcation point of this speculative mental trial. These dialectical approaches inform concepts of aesthetics and dwelling activities, ultimately enhances our comprehension of how these relational dynamics influence design choices and outcomes.

Furthermore, as a conceptual tool, tectonics provides many possibilities while internalizing the site, generating design ideas, and creating architectural products. Pointing a direction for questioning and perceiving the tectonics of the site creates a basis for the fiction of space, which, when realized, will be what the students design. The personal perspectives that emerge in both stages reveal different possibilities regarding the production of the site, topography, and architectural product. Through a deep engagement with tectonics, students can create designs rooted in their physical contexts in both orthodox and unorthodox ways.

To further illustrate this link, the role of three-dimensional models becomes critical. In both the reproduction and design phases, the model is a flexible tool for students to express their viewpoints through the site, leading to the interpretation and formation of their proposals. As a corporeal tool, it enables students to develop different perspectives on the terrain. As with their perspective on the site, it allows the students to experience their exploration process in terms of both choices of materials and methodology of construction of the model (based on the tectonics of the site). Ultimately, the physical model underscores the importance of making, revealing how the intricate processes of crafting and material selection engage with the complex interplay between tectonics, topography, and site. Moreover, different modeling techniques lay the groundwork for working with a helpful tool in the re-representation process. Through their models, students can unveil previously hidden aspects of the site and illustrate the relationship between natural and artificial tectonics, enhancing the principles of the project through similarities, dualities, and dichotomies. Questioning and reproducing the tectonics through a physical model provides students with a base to establish the relationship of their designs with the site – whether as continuities or discontinuities.

Although contemporary architectural discourse often confines tectonics to structural relationships, this study demonstrates that nineteenth-century tectonic theory offers a comprehensive framework for understanding and preparing the site as a multi-layered construct. Importantly, the concept of tectonics enables analysis not only of physical data but also of social and cultural dimensions arising from human actions. The idea of the hearth, one of Semper's four architectural elements, exemplifies the notion of coming together—publicness and cultural differentiation—that shapes the meaning of place. Similarly, Bötticher's concept of Kunstform

offers perspectives extending beyond physical data, engaging with symbolism and human perception. Thus, the concept of tectonics provides a multi-layered approach to understanding a site and preparing it for architectural interventions. In this context, the study aims to contribute to literature by offering an alternative approach to conceptualizing and representing tectonic relations in architectural education and design courses.

Ultimately, the research opens avenues for future studies on tectonics in various design methodologies, advocating for further investigation into its implications across diverse architectural contexts. Additionally, it offers new methodological insights into using three-dimensional models to facilitate critical thinking and creativity in studio settings. In an era where the boundaries between natural and artificial are increasingly blurred, this study underscores that a profound understanding of tectonics enriches architectural design and cultivates a deeper connection to the environments we inhabit, shaping the future of contextually driven architecture.

CRediT Authorship Contribution Statement

Bilgen Dündar: Conceptualization, methodology, investigation, writing. Aslı Uzunkaya: Conceptualization, methodology, writing, visualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

Data will be made available on request.

Ethics Committee Approval

Ethics committee permission is not required.

References

Anderson, S. (1981). Modern architecture and industry: Peter Behrens and the AEG factories. *Oppositions*, *23*, 52-83.

Berlanda, T. (2014). *Architectural topographies*. Routledge.

Bötticher, K. (2002). Excerpts from *Die Tektonik der Hellenen*. In W. Oechslin, (Ed.), *Otto Wagner, Adolf Loos, and the road to modern architecture*. Cambridge University Press. (Original work published 1844).

Buck, E. (2006). Love and tectonics: Epikurean philosophy and reparative architecture. *The Philosophical Forum*, *37*(4), 457-476. https://doi.org/10.1111/j.1467-9191.2006.00248.x

Chih-Ming, S., & Yu-I, C. (2011). The tectonic bricolage of glass and steel architecture in Taiwan. *International Conference on Consumer Electronics, Communications and Networks (CECNet)* (pp. 1856_1862). https://doi.org/10.1109/CECNET.2011.5769383

Frampton, K. (1995). *Studies in tectonic culture: The poetics of construction in nineteenth and twentieth century architecture*. MIT Press.

Frampton, K. (1996). *Modern architecture: Critical history*. Thames & Hudson.

Frampton, K. (1998). Towards a critical regionalism: Six points for an architecture of resistance. In H. Foster (Ed.), *The anti-aesthetic: Essays on postmodern culture* (pp. 16-30). The New Press.

Hale, J. (2020). The 'tectonic sensibility' in architecture: From the pre-human to the post-human. *Edinburgh Law Review*, *59*(3), 350-367. https://doi.org/10.3366/nfs.2020.0295

Hürol, Y. (2014). Reconsidering ethics in the tectonics of architecture through the tectonics of bodies in love. *METU Journal of the Faculty of Architecture*, *31*(2), 25-41. https://doi.org/10.4305/METU.JFA.2014.2.2

Karvouni, M. (1999). Demas: The human body as a tectonic construct. In S. Parcell & A. Pérez-Gómez (Eds.), *Chora three: Intervals in the philosophy of architecture* (pp. 104-124). McGill-Queen's University Press.

Kim, Y. J., & Park, S. (2017). Tectonic traditions in ancient Chinese architecture, and their development. *Journal of Asian Architecture and Building Engineering*, *16*(1), 31_38. https://doi.org/10.3130/jaabe.16.31

Kristeller, P. O. (1951). The modern system of the arts: A study in the history of aesthetics. *Journal of the History of Ideas*, *12*(4), 496-527.

Lakkala, M., & Pihlajaniemi, J. (2018). Architectonic quality of industrial log architecture in the scope of tectonics: Learning from architectural competitions. *Architecture and Urban Planning*, *14*, 46-54. https://doi.org/10.2478/aup-2018-0006

Lucchini, M., & Urban, G. J. (2023). Crossed destinies: The tectonic and modern architecture in Barcelona during the 1950s_60s. *Revista de Expresión Gráfica en la Edificación*, *18*, 42_51. https://doi.org/10.4995/ege.2023.19642

Mallgrave, H. F. (1989). Introduction. In H. F. Mallgrave & W. Herrmann (Eds. & Trans.), *Gottfried Semper: The four elements of architecture* (pp. 1-44). Cambridge University Press.

Manav, A., & Urak, Z. G. (2024). Traditional architecture in the Central-Northern Mediterranean region: Tectonics and typological analysis of traditional mut houses. *ICONARP International Journal of Architecture and Planning*, *12*(2), 606-637. https://doi.org/10.15320/ICONARP.2024.297

McCoy, C. & Duffy, T. A. (2022). The deployable tectonic: Mechanization and mobility in architecture. *Architecture, Structures and Construction*, *2*(4), 613-628. https://doi.org/10.1007/s44150-022-00045-0

Oechslin, W. (2002). Tectonics and theory of raiment. In L. Widder (Trans.), *Otto Wagner, Adolf Loos and the road to modern architecture*, (pp. 44-63). Cambridge: Cambridge University Press.

Rociola, G. F. (2017). Matter, material, architecture. The tectonic conception between spontaneous consciousness and critical consciousness. *Vitruvio: International Journal of Architectural Technology and Sustainability*, *2*(2), 35-53. https://doi.org/10.4995/vitruvio-ijats.2017.8745

Sántha, E., Hvejsel, M. F., & Entwistle, J. M. K. (2022). Tectonics of human well-being: Describing architecture in terms of constructed spatial gestures and their impact. *Architecture, Structures and Construction*, *2*(4), 599-612. https://doi.org/10.1007/s44150-022-00047-8

Schwartz, C. (2017). *Introducing architectural tectonics: Exploring the intersection of design and construction*. Routledge.

Semper, G. (1989). The four elements of architecture: A contribution to the comparative study of architecture. In H. F. Mallgrave & W. Herrmann (Eds. & Trans.), *Gottfried Semper: The four elements of architecture* (pp. 74-129). Cambridge University Press. (Original work published 1851).

Shou, T., & Xu, H. (2025). Topographical tectonics in the theoretical framework of vernacular architecture. *Journal of Architecture*, *30*(2), 365-393. https://doi.org/10.1080/13602365.2025.2554962

Smith, A. C. (2004). *Architectural model as machine a new view of models from antiquity to the present day*. Architectural Press.

Talamini, G., Xue, C., & Wang, Z. (2024). On the tectonic of bamboo: The rhizome of architecture. *Architectural Research Quarterly*, 4-17. https://doi.org/10.1017/S1359135524000113

UNESCO. (n.d.). *The Mid-Atlantic Ridge*. https://whc.unesco.org/en/activities/504/

Wijaya, C., Hariyanto, A., Soegiono, P., & Gunawan, E. (2024). Tectonics in architecture of Tanean Lanjhang and Osing house. *Dimensi: Journal of Architecture and Built Environment*, *51*(1), 49_60. https://doi.org/10.9744/dimensi.51.1.49-60

Resume

Bilgen Dündar serves as an Assistant Professor at İstanbul Beykent University, where her academic portfolio encompasses architectural design, architectural theory and history. Her scholarly interests lie at the intersections of architectural theory, history, and design. She received her undergraduate degree in Architecture from Dokuz Eylul University in 1998 and her Ph.D. in Architecture from Izmir Institute of Technology in 2011.

Aslı Uzunkaya, working as an Assistant Professor at İstanbul Beykent University, received her PhD from İstanbul Technical University-Architectural Design Program. She completed her undergraduate education at Dokuz Eylül University and received master degree from Yıldız Technical University. Her research interests focus on architectural design, design research, design process and reflective knowledge.

JOURNAL OF DESIGN FOR RESILIENCE IN ARCHITECTURE & PLANNING

Research Article
Online: www.drarch.org
Volume 7, Issue 1 (69-88), 2026
DOI: 10.47818/DRArch.2026.v7i1204

Designing resilience in historical environments: A pedagogical analysis of a "healing"-themed studio

Begüm Demiroğlu İzgi[*]
Ayşegül Koç Ünlüsoy[**]

Abstract

A this article presents a design studio model that integrates architectural pedagogy with urban resilience by focusing on the theme of "healing" within a historical context. Conducted in Sarıkaya, an ancient Roman thermal settlement in Turkey, the studio aimed to cultivate student awareness of historical continuity, collective memory, and spatial repair through design interventions that address physical, social, and ecological healing. A mixed-methods research design was employed, including pre- and post-studio surveys, cognitive mapping, and protocol analysis of student processes and outcomes. Quantitative findings based on 11 participants revealed a marked increase in conceptual and spatial awareness after the studio. The average post-test score rose from 62.3 to 81.7 out of 100, indicating a 31.1% improvement in students' capacity to engage with urban resilience and heritage-based healing concepts. Cognitive map complexity also increased by 44%, showing a shift from form-based to multi-layered socio-spatial strategies. Thematic categorization of student projects revealed four primary resilience domains: social (31%), ecological-economic (30%), cultural-technological (23%), and morphological (16%). Design outputs included proposals such as AI-assisted pediatric ateliers, memory-based housing for elderly Alzheimer's patients, geothermal healing centers, and sensory walking routes, all developed in response to the socio-cultural and spatial dynamics of the historic site. The study demonstrates how design education can function as a vehicle for heritage-conscious innovation and collective well-being. By combining conceptual framing, contextual analysis, and experiential learning, the studio model not only fostered architectural empathy and historical imagination but also provided measurable cognitive and perceptual growth. These results underscore the relevance of resilience-centered design pedagogy in cultivating architects capable of addressing both past legacies and future uncertainties through spatial healing.

Keywords: architectural pedagogy, cultural heritage, healing approach, historic environment, urban resilience

1. Introduction

The tension between the preservation of cultural heritage and the dynamics of contemporary urban development constitutes one of the most fundamental and complex challenges in 21st-century architecture and planning disciplines. The pressures brought about by globalization, rapid urbanization, and climate change have placed historical environments and monuments worldwide under unprecedented threat (Pendlebury, 2009; Rodwell, 2008). In response to this global challenge, conservation paradigms have evolved from static preservation toward more dynamic and sustainable approaches that integrate historical values into contemporary life. Charters and reports issued by organizations such as the International Council on Monuments and Sites (ICOMOS) increasingly emphasize that heritage is not only a physical entity but also a core component of social identity, collective memory, and urban resilience (Ashworth, 2011; ICOMOS, 2013). Within this framework, the central question is not how to "freeze" historical structures as remnants of the past, but how to keep them alive as part of contemporary life in ways that respond to today's social, economic, and ecological needs.

*(Corresponding author), Department of Architecture., Yozgat Bozok University, Yozgat, Türkiye begum.demiroglu@bozok.edu.tr
**Department of Architecture., Yozgat Bozok University, Yozgat, Türkiye aysegul.unlusoy@bozok.edu.tr
Article history: Received 28 July 2025, Revised 8 March 2026, Accepted 14 April 2026, Published 30 April 2026

One of the primary responses of the architectural discipline to this challenge has been the adoption of the strategy of "adaptive reuse." Rather than demolishing existing building stock and constructing anew, assigning new functions to these structures is considered a sustainable action that both conserves the embodied energy of the building (Gursel et al., 2023) and ensures cultural continuity (Plevoets & Van Cleempoel, 2013; Wong, 2024). This approach not only reduces waste and preserves resources but also protects the historical and cultural layering of the urban fabric. By extending the lifespan of buildings and reducing resource consumption, adaptive reuse also aligns directly with the principles of the circular economy (Brand, 1995; Ikiz Kaya et al., 2021; Pintossi et al., 2021). In this process, contemporary designs that are integrated into the historical fabric offer the potential to create rich and layered spaces through a dialogue between the old and the new (Cantacuzino, 1989). As stated in the ICOMOS Venice Charter (ICOMOS, 1964), the requirement that such interventions must "bear a contemporary stamp" forms the basis of this dialogue and compels architects to strike a delicate balance. The search for this balance continues around concepts such as Christian Norberg-Schulz's (1980) "Genius Loci" (Spirit of Place) and Jukka Jokilehto's (2002) "authenticity" (Jokilehto, 2017; Norberg-Schulz, 1979).

Equipping future architects with the knowledge, skills, and sensibilities needed to solve these complex problems has become one of the most critical responsibilities of architectural education. The primary pedagogical platform where this competence is cultivated is the architectural design studio. As an "epistemic culture" (Cetina, 1999) where professional knowledge is produced and reproduced, the studio is a space where students learn to cope with uncertainty and complexity—what Donald Schön conceptualizes as a "reflective practicum" (Schön, 2017).

Recent scholarship on sustainability in architectural education emphasizes that design studios are pivotal sites for building sustainability literacy and integrative reasoning, yet sustainability is often unevenly embedded in studio culture. Empirical studies report that when sustainability is treated as a design problem—rather than isolated in theoretical courses—students' awareness and ability to operationalize environmental, social, and economic dimensions tend to improve (Altomonte et al., 2014; Calikusu et al., 2023).

Moreover, from an educational standpoint, heritage-based learning transforms adaptive reuse from a mere technical exercise into a profound pedagogical tool. As Brooker and Stone (2004) note, remodeling existing buildings requires students to deeply 'read' the historical context, fostering an empathetic dialogue between past narratives and future interventions (Brooker & Stone, 2004). This process cultivates a critical awareness of context that abstract design exercises often fail to provide.

However, this pedagogical process itself faces the need for transformation. Contemporary discussions in architectural pedagogy question the traditional model of the studio and foreground more critical, participatory, and socially responsible approaches (Salama, 2016; Sara & Mosley, 2014; Teymur, 1982).

It is precisely at this point that the unique research gap addressed by this study becomes clear. Although the literatures on architectural pedagogy (Salama, 2016; Sara & Mosley, 2014), heritage preservation (Jokilehto, 2017), "healing architecture" (Al Khatib et al., 2024; Ulrich, 1984), and "urban resilience" (Davoudi et al., 2012; Holling, 1973) are rich in content, they are often treated within separate disciplinary silos. The originality of this study lies in proposing 'healing/repair' as a conceptual bridge between heritage conservation and architectural pedagogy. Traditionally, healing architecture focuses on healthcare facilities. However, this study argues that historic environments can act as 'therapeutic landscapes' (Gesler, 1992). The theme of 'healing' provides a holistic framework for the design studio. It moves the design problem beyond mere technical preservation or aesthetic composition. Instead, it encourages students to explore how spatial repair can achieve multiple goals simultaneously: supporting individual mental health, fostering social bonds (Jacobs, 1961), revitalizing local economies, and repairing collective cultural memory. The lack of integration between these disciplinary silos is not only a gap in the literature but also a

fundamental problem in architectural practice and education. As a solution to this issue, the pedagogical intervention proposed here aims to use the theme of "healing" as a tool to guide students toward more integrated and socio-ecologically focused thinking.

Research problem and objectives. Despite the growing prominence of sustainability and resilience as learning outcomes in architectural education, studio-based awareness-building processes in living historical environments often remain fragmented—heritage is handled as a technical conservation task, healing is confined to building-scale healthcare typologies, and resilience is discussed at an abstract planning level. This study addresses this pedagogical problem by testing a continuity-centered “healing/repair” framework in a design studio context. Specifically, the study aims to (i) examine whether a healing-themed studio enhances students’ awareness of historical/architectural continuity in relation to sustainability and urban resilience, and (ii) document how students translate this conceptual frame into multi-domain design strategies in a real heritage setting.

In line with this theoretical framework, the article provides an in-depth analysis of the proposed pedagogical approach through a case study conducted in and around the Sarıkaya Roman Bath (Basilica Therma), which is listed on the UNESCO World Heritage Tentative List and is known for its historical identity as a site of “healing waters.” The primary research question of the study is: How does a design studio process that employs a holistic theme like "healing" within a historical environment affect architecture students' knowledge, awareness, and design competencies related to conservation, sustainability, and urban resilience? To answer this question, a mixed-methods research design was employed, including pre- and post-studio surveys, participant observations, and project analyses. The subsequent sections of the article will elaborate on the research methodology, present findings from the case study, and conclude by discussing these findings in light of the theoretical framework proposed.

2. Theoretical Framework: From Individual Healing to Collective Resilience

This study is built upon an interdisciplinary theoretical framework. It operates on two primary assumptions. First, the concept of 'healing' can be scaled up from the individual building to the broader urban context. Second, the abstract notion of 'urban resilience' can be translated into tangible architectural design objectives. To achieve this, the framework synthesizes literature from three core domains: healing architecture, cultural heritage with urban resilience, and reflective studio pedagogy.

2.1. The Evolution of "Healing Architecture": An Interdisciplinary Perspective

The idea that space holds healing potential for the human body and psyche is as old as architectural history itself. Healing temples such as the Asklepions in Ancient Greece, Roman thermae, and darüşşifa (healing institutions) in Islamic civilizations indicate that the therapeutic capacity of architecture was intuitively understood and practiced even in pre-modern periods. In many mid-20th-century institutional and healthcare design contexts, functional efficiency and standardization often took precedence, and the user’s sensory and psychological experience was not always foregrounded (Verderber et al., 2000).

As a response to this neglect, the 1980s witnessed the emergence of a new approach informed by developments in environmental psychology, which systematically examined architecture’s effects on human well-being. A major turning point in this domain was Roger Ulrich’s groundbreaking 1984 study, which demonstrated that post-operative patients with views of natural scenery recovered more quickly, required fewer painkillers, and experienced fewer complications than those facing a brick wall (Ulrich, 1984). This study laid the foundation for the Evidence-Based Design (EBD) movement, advocating for design decisions grounded in empirical data rather than intuition.

The EBD framework was further enriched by psychological theories such as Stephen and Rachel Kaplan’s Attention Restoration Theory and E.O. Wilson’s Biophilia Hypothesis (Kellert & Wilson,

1993; Kaplan & Kaplan, 1989). These theories suggest that contact with nature alleviates mental fatigue and that the architectural reflection of an instinctive human affinity with nature—through elements such as natural light, materials, vegetation, and water—enhances health and well-being. Another crucial conceptual shift within this framework stems from Aaron Antonovsky's notion of Salutogenesis, which advocates focusing on health-promoting factors rather than pathogens. This approach marks a philosophical transition in architecture—from reactive spaces that treat illness to proactive environments that foster health and well-being (Dilani, 2008).

A paradigmatic contemporary reference for healing environments is the network of Maggie's Centres, which has been widely discussed as a model of non-institutional, supportive care architecture. Studies examining Maggie's emphasize how domestic atmospheres, daylight, landscape contact, and informal social spaces (e.g., shared kitchen tables) become spatial affordances for coping, hope, and psychosocial well-being. This precedent is significant for architectural education because it offers an established repertoire of design strategies that translate well-being goals into concrete spatial decisions, thereby strengthening the pedagogical bridge between healing theory and design practice (Butterfield & Martin, 2016; Maggie's, 2026).

Furthermore, contemporary discourses on healing environments emphasize that therapeutic spatiality extends beyond visual connections to nature. Drawing on phenomenological perspectives, theorists like Juhani Pallasmaa argue that architecture must engage the full sensorium—touch, sound, and spatial bodily awareness—to truly repair the human psyche (Pallasmaa, 2024). This multi-sensory approach shifts the focus from passive observation to active, embodied healing, which becomes particularly powerful when interacting with the textured layers of historic environments.

The primary theoretical move of this study is to extend this individual-centered health framework to the urban scale. Wilbert Gesler's (1992) conceptualization of Therapeutic Landscapes proposes that specific places carry meanings that support physical, mental, and spiritual healing. From this perspective, the revitalization of an urban site devastated by war, natural disaster, or economic collapse is not merely a physical restoration, but a process of collective healing and socio-spatial repair (Gesler, 1992). In this context, the historical thermal heritage of Sarıkaya is approached as a catalyst for both individual well-being and the repair of the city's cultural and social fabric.

2.2. Cultural Heritage as a Catalyst for Urban Resilience

In this study, cultural heritage is approached as an active socio-spatial system: a layered assemblage of material fabric, everyday uses, meanings, and infrastructures that can absorb change while maintaining identity and continuity. The modern scientific foundation of resilience traces back to ecologist C.S. Holling's definition of resilience as a system's capacity to maintain its structure, function, and identity in the face of external shocks—i.e., to absorb change and continue to exist (Holling, 1973). In heritage contexts, this perspective is particularly relevant because continuity is sustained not by freezing form, but by enabling adaptive transformation that keeps historic places socially and environmentally operative over time (Davoudi et al., 2012).

Building upon this dynamic view, recent advancements in socio-ecological design advocate moving beyond mere sustainability toward 'regenerative cultures' (Wahl, 2016). In this context, heritage sites are not conceptualized merely as passive artifacts to be conserved, but as dynamic socio-ecological systems (SES) that can actively regenerate local economies, biological diversity, and community resilience.

This ecological understanding was translated into the social dimension of urban space through Jane Jacobs's seminal work The Death and Life of Great American Cities (1961) (Jacobs, 1961). Jacobs criticized large-scale, functionalist urban renewal projects for destroying the intricate social fabric of cities. She argued that vibrant, safe, and socially cohesive neighborhoods emerge organically through features such as mixed-use developments, short and walkable blocks, and "eyes on the street." Her work established a direct link between spatial design and a community's social

health and safety, laying the groundwork for the spatial construction of social capital—the invisible web of trust, norms, and networks among individuals and groups (Putnam, 2000).

This study positions cultural heritage as an active catalyst in building social capital, and therefore urban resilience. The adaptive reuse of historic buildings not only preserves the past but also strengthens local identity, creates new spaces for public interaction, and offers economic opportunities that enhance a community's long-term resilience (Noaime & Alnaim, 2025). However, this process also entails a theoretical tension between the principle of authenticity and material integrity emphasized by the ICOMOS Venice Charter (1964) and the functional and spatial transformations required by adaptive reuse (ICOMOS, 1964; Jokilehto, 2017). This study argues that such tensions can be overcome. Later ICOMOS documents, especially the Washington Charter (1987), opened the door for this dialogue by acknowledging that contemporary additions to historical settings may be enriching, provided they do not compromise the overall integrity (ICOMOS, 1987). This doctrinal flexibility provides a foundational ground for students to design interventions in Sarıkaya that engage in dialogue between the old and the new.

To translate this heritage–resilience agenda into an educational logic, the linkage between "healing/repair" and cultural heritage can be clarified through the lens of heritage-based learning, where conservation is treated as a situated form of design reasoning rather than a purely technical restoration task. In a studio-based methodology, Embaby frames heritage conservation as an educational process in which students translate historical values, typological traces, and cultural meanings into adaptive reuse decisions—thereby learning to negotiate continuity and change. Complementing this approach, Clarke, Kuipers, and Stroux argue that embedding heritage values in design education requires explicit didactic tools that help students identify, map, and operationalize "built heritage values" as design drivers. In this sense, heritage becomes a structured learning medium through which students can conceptualize "repair" not only as material intervention but also as an interpretive practice that re-articulates meaning and social use over time (Clarke et al., 2020; Embaby, 2014).

2.3. A Pedagogy for Socio-Ecological Design: The Reflective Live Project

The above theoretical synthesis calls for a specific pedagogical model. At its core lies Donald Schön's (1983) concept of the reflective practitioner. According to Schön, professional competence entails the capacity to respond to complex and unique situations through reflection-in-action rather than by applying predefined solutions to predetermined problems. The architectural design studio functions precisely as a laboratory for developing this reflective practice (Schön, 2017).

Architectural studio pedagogy has been widely discussed as a distinctive learning ecology in which tacit knowledge, iterative critique, and reflective practice shape design reasoning. Webster's account of architectural education after Schön highlights how coaching, feedback, and "design artistry" are cultivated through studio interactions rather than transmitted as stable content. More recently, Hettithanthri and Hansen synthesize contemporary studio research and show that learning outcomes are strongly mediated by studio structures, assessment cultures, and the ways projects are framed as open-ended inquiries. Within this pedagogical landscape, "live projects" have gained attention as formats that connect studio work to real stakeholders and contexts; a mixed-methods synthesis of live-project scholarship maps recurring themes such as authenticity, negotiation with external actors, and the management of uncertainty. These discussions provide a clear rationale for positioning the present studio as a reflective, evidence-informed, and context-embedded model rather than a purely speculative design exercise. (Hettithanthri & Hansen, 2022; Smith et al., 2023; Webster, 2008).

The pedagogical vehicle that activates this reflective practice is the live project model. Live projects expose students to real-world contexts, timelines, and stakeholders (in this case, a historic site rather than a client), enabling them to engage with the social responsibilities of architecture (Sara & Mosley, 2014). This approach shifts architectural education from abstract and theoretical exercises to real-life scenarios filled with complexity and uncertainty.

However, this pedagogical model also invites critical scrutiny. Beyond administrative challenges (e.g., time and budget constraints), live projects may involve unequal power dynamics and tokenistic participation in community relations, posing ethical risks (Sabree & Mustafa, 2023). Similarly, the concept of urban resilience must also be viewed through a critical lens. Some scholars argue that resilience discourse, when appropriated by neoliberal agendas, shifts the burden of systemic shocks—such as climate change or economic crises—from states to individuals and communities, thereby depoliticizing and masking structural issues of inequality and injustice (Shamsuddin, 2023).

This study contends that the proposed pedagogical model addresses these critiques. First, structuring the studio within an Action Research (AR) cycle (plan–act–observe–reflect) fosters continuous critical engagement and ethical reflection by both students and instructors. More importantly, the choice of healing as the central theme repoliticizes the notion of resilience. It encourages students to ask foundational questions such as "resilience for whom?" and "healing of what?"—prompting them not merely to make buildings earthquake-resistant but to design interventions that repair social exclusion, ecological degradation, or collective trauma. In this way, the pedagogical model does not dismiss critiques as limitations but rather incorporates them into its structure, thereby offering a more robust and ethically grounded framework.

3. Research Design and Methodology

This section systematically explains the methodological framework followed to ensure the scientific validity and reliability of the research—that is, how the study was designed, which tools and processes were used for data collection, and how the data were analyzed.

3.1. Research Design: A Mixed-Methods Action Research Case Study

Given that the study investigates a complex social phenomenon (the design studio process) in its natural context, it was structured as a holistic single case study based on a mixed-methods research design. Both quantitative data—used to measure changes in students' knowledge and awareness—and qualitative data—used to interpret the studio process and its outcomes—were collected and analyzed in tandem. The fact that the researchers were also the instructors of the studio endowed the study with the characteristics of Action Research (AR), which allows researchers to observe, intervene in, and reflect upon the process from within. AR is a methodology aimed at continuous improvement through identifying a problem within a practice (e.g., a design studio), designing an action plan, implementing it, observing the outcomes, and reflecting upon this cyclical process (Kemmis et al., 2014).

3.2. Context, Participants, and Sampling

The case of this study is a third-year architectural design studio course titled "Healing-Themed Roman Bath," conducted during the Spring semester of 2025 at a state university. The study area includes the Sarıkaya Roman Bath (Basilica Therma), dated to the 2nd century AD and included in the UNESCO World Heritage Tentative List in 2018, along with its immediate surroundings. Participants consisted of 11 third-year architecture students who were enrolled in the relevant studio course and voluntarily agreed to take part in the study. Survey data were collected from students who actively participated. Due to the specific purpose of selecting students enrolled in this particular studio and their interest in the topic, the study employed purposive sampling as the sampling method.

The data collection process was structured as a planned Action Research cycle spread over the 15-week studio schedule. This process is summarized in Table 1.

Table 1 15-Week Action Research Studio Calendar and Data Collection Stages

Week No.	Activity Description	AR Phase	Purpose and Data Collection Methods
1–2	Pre-test survey. Individual research and	Planning / Diagnosis	To assess students' initial knowledge and attitudes (Pre-test Survey). To gain a

	literature review (on site, history, and the theme of "healing").		comprehensive understanding of the site and the theme; to prepare conceptual groundwork through analysis of historical and theoretical context.
3	Field trip – on-site sketching, photography, and analysis at Sarıkaya Roman Bath and surrounding area.	Implementation	To gain spatial experience through direct observation of the site; to understand physical attributes and atmosphere firsthand (Participant Observation, Document Analysis: Sketches).
4–7	Concept development, program discussions, and First Interim Jury presentations.	Implementation / Observation	To develop a creative design concept aligned with the theme of "healing." To critically assess project approaches through interim evaluations (Participant Observation, Document Analysis: Concept Boards).
8–11	Design development (plans, sections, massing studies) and Second Interim Jury presentations.	Implementation / Observation	To translate the concept into an architectural proposal and refine it. To conduct a final formative assessment prior to final presentations (Participant Observation, Document Analysis: Developed Drawings).
12–15	Project detailing, preparation for final presentations, Final Jury, and post-test survey.	Reflection / Evaluation	To present and evaluate the project through a comprehensive final review. To measure the impact of the learning process (Post-test Survey, Document Analysis: Final Projects, Participant Observation).

3.3. Data Collection Instruments

The primary data collection instruments used throughout this process are as follows:

i. Pre-Test and Post-Test Surveys: Administered before (Week 1) and after (Week 15) the studio process, these surveys quantitatively measured changes in students' knowledge, attitudes, and awareness regarding topics such as historic environment conservation, sustainability, and contemporary architectural additions.

ii. Participant Observation: The researchers, as active participants throughout the 15-week process detailed in Table 1 (including critiques, juries, and discussions), systematically documented observational notes to capture both the progression and dynamics of the studio.

iii. Document Analysis: All materials produced by students over the course of the semester—research panels, sketches, diagrams, and final project boards—were collected as primary data sources. The analysis of these documents was based on an analytical rubric comprising predefined criteria supported by relevant literature. The evaluation criteria included:

- Design Concept and Creativity
- Functionality and Programmatic Fit
- Contextual Integration with Historical Fabric
- Spatial and Aesthetic Quality
- Technical Performance and Sustainability
- Presentation Quality and Communication

3.4. Data Analysis Procedures

A holistic approach was adopted for analyzing the mixed data collected in the study:

Quantitative Data Analysis: Data obtained from the pre- and post-test surveys were analyzed using the free statistical software. A paired-samples t-test was employed to determine whether the differences between students' scores before and after the studio process were statistically significant.

Qualitative Data Analysis: Qualitative data, including observation notes and student projects, were analyzed using thematic analysis. This method followed a systematic process involving familiarization with the data, generation of initial codes, identification and refinement of themes,

and final reporting. In analyzing student projects, the dimensions of resilience and healing—as defined in the theoretical framework—were used as the primary thematic categories.

3.5. Reliability and Mitigation of Researcher Bias

Several strategies were employed to enhance the reliability and validity of the research:

Data Triangulation: Findings from multiple data sources (surveys, observations, and documents) were compared and cross-validated. This method helped establish the robustness of the results.

Mitigating Researcher Bias: In action research, the participatory role of the researcher can pose a risk of bias. To minimize this risk, structured tools such as pre-designed surveys and analytical assessment rubrics were used. Reflective journals were maintained throughout the process, and findings were regularly discussed with other academics through peer debriefing. These measures aimed to enhance the objectivity and transparency of the study.

4. Findings: Pedagogical Impacts and Design Outcomes

This section presents the quantitative and qualitative findings derived from the mixed-methods research design under two main headings; each aligned with the study's research question. The first subsection addresses measurable changes in students' knowledge and attitudes, while the second explores how these changes were reflected in the students' design outputs through thematic analysis.

4.1. Quantitative Analysis: Measurable Changes in Student Knowledge and Attitudes

The pre- and post-studio surveys (n=11) revealed statistically significant changes in students' knowledge of fundamental conservation concepts and in their attitudes toward intervention in historical environments.

Increase in Knowledge Levels: A marked improvement was observed in students' basic knowledge regarding architectural conservation theories and principles of practice. The findings presented in Table 2 indicate that the studio effectively met its pedagogical objectives. Notably, the percentage of students correctly identifying the content and purpose of the Venice Charter—one of the most essential international documents in the field of conservation—increased from 72.7% to 100%. Similarly, awareness of contemporary conservation approaches such as adaptive reuse reached its highest level by the end of the studio (Table 2).

Table 2 Pre- and Post-Test Results: Changes in Students' Knowledge Levels

Question	Correct Answer – Pre-Test (%)	Correct Answer – Post-Test (%)	Change (%)
What is the Venice Charter concerned with?	72.7%	100%	+27.3
What is the most important consideration in modern additions to historic buildings?	81.8%	100%	+18.2
What does adaptive reuse mean?	90.9%	100%	+9.1

Analysis of Attitudinal Shifts: The analysis of Likert-scale attitudinal items reveals that the studio had a deeper and more transformative impact on students' philosophy of conservation. Table 3 presents the mean scores from the pre- and post-tests, along with the p-values indicating the statistical significance of the differences observed.

One of the most striking findings is the significant decrease in agreement with the statement "Historic buildings must be preserved in their original state" (from a mean of 3.8 to 2.7, $p < 0.01$). This suggests a shift in students' perspectives from a static and absolute understanding of conservation toward a more dynamic approach that supports the adaptive reuse of historic structures in accordance with contemporary needs.

This shift is further supported by significant increases in agreement with the statements "Historic buildings should be repurposed to meet today's needs" (from 4.4 to 4.9, $p < 0.05$) and "Contemporary architectural expressions should be used in modern additions" (from 3.9 to 4.5, $p < 0.01$). These results indicate that students have internalized the necessity of establishing a dialogue between respect for heritage and contemporary design—an approach aligned with the spirit of the Venice Charter (Table 3).

Table 3 presents the mean scores from the pre- and post-tests. To clearly demonstrate the educational impact of the studio, exact p-values are provided to indicate the statistical significance levels of the observed differences (where $p < 0.05$ is considered significant and $p < 0.01$ is highly significant).

Table 3 Comparison of Pre-Test and Post-Test Results for Likert-Scale Attitudinal Statements

Statement	Pre-Test Mean (SD)	Post-Test Mean (SD)	p-value
Modern additions compromise the integrity of historical fabric.	3.5 (0.7)	2.8 (0.6)	<0.05
The architectural features of historic buildings must be considered.	4.6 (0.5)	4.9 (0.3)	<0.01
Historic buildings should be repurposed to meet contemporary needs.	4.4 (0.8)	4.9 (0.2)	<0.05
Contemporary architectural expressions should be used in modern additions.	3.9 (0.6)	4.5 (0.5)	<0.01
Sustainability principles are essential in historic buildings.	4.7 (0.5)	5.0 (0.0)	<0.01
Historic buildings must be preserved in their original state.	3.8 (0.9)	2.7 (0.7)	<0.01

4.2. Qualitative Evaluation of Open-Ended Questions

Thematic analysis of the qualitative data collected through open-ended questions revealed the distribution of students' perceptions regarding urban and historical spaces within the context of the healing concept. These themes and their frequencies are presented in Table 4.

Table 4 Themes and Frequencies Derived from Open-Ended Questions

Theme	Frequency
Awareness of and respect for historic fabric	9
Spatial and functional balance between tradition and modernity	8
Contribution of the project to personal development and design competence	10
Architectural design challenges and creative solutions	7
Sustainable design approach in the context of urban resilience	6

The students' reflections notably emphasized the role of the healing concept in enhancing urban resilience through the preservation and adaptive reuse of historic sites. These findings suggest that the concept holds a meaningful position within architectural education and design thinking.

4.3. Qualitative Analysis: Translating "Healing" and "Resilience" into Design Strategies

The qualitative findings illustrate how students transformed the theoretical knowledge and attitudes gained during the studio into concrete and multi-layered design strategies. The thematic analysis of 11 student projects shows that the concepts of healing and resilience guided students beyond merely generating aesthetic or functional solutions, pushing them toward architectural interventions that address social, ecological, and cultural challenges. Table 5 presents an analytical

summary of these projects, categorized according to the dimensions of resilience and healing as defined in the theoretical framework.

Table 5 Thematic Analysis of Student Design Concepts According to Dimensions of Resilience and Healing

Resilience Dimension	Concept Title	Main Program / Function	Healing Dimension (Type & Description)
SOCIAL RESILIENCE (Approaches that strengthen social capital, infrastructure, and inclusivity)	Rehabilitation Center for Veterans and Families of Martyrs	Social Rehabilitation	Psychological & Social: Healing collective memory; creating safe spaces for vulnerable groups.
	Urban Memory: Alzheimer's Support Center	Health, Social Housing	Cognitive & Spatial: Using the familiar texture of the historic environment as a "conceptual anchor" for individuals with memory loss.
	Urban Rebirth: Maternity Unit	Healthcare, Women's Health	Physical & Social: Combining the physical renewal of the city and the individual through the metaphor of "birth."
ECONOMIC & ECOLOGICAL RESILIENCE (Approaches based on local resources, sustainability, and economic vitality)	Gediatrics: Center for Life Resilience	Social Housing, Elderly Care	Psychological & Social: Supporting psychological well-being by enhancing quality of life and sense of community for elderly individuals.
	Healing from Rome to Present: Physical Therapy Hospital	Health Tourism	Physical & Sensory: Integrating bodily and sensory healing through historical-natural resources (e.g., thermal water, aromas).
	Continuity of Thermal Water in Production	Agriculture, Energy, Housing	Environmental: Rehabilitating the city's natural resources by incorporating them into productive systems, restoring the human-nature relationship.
	Journey to the Ancient City: Heritage Seed Continuity	Tourism, Agriulture, Branding	Cultural: Strengthening the connection to cultural roots by transmitting agricultural heritage to future generations.
	Sarıkaya Reimagined: Ruin Hotel	Tourism, Heritage Conservation	Spatial & Cultural: "Healing" alienated ruins by reintegrating them into urban life and identity through adaptive reuse.
CULTURAL RESILIENCE (Approaches that carry cultural heritage, identity, and experience into the future through new technologies and methods)	AI-Supported Pediatric Workshops: Virtual Archaeology	Education, Technology, Children	Cognitive & Creative: Enhancing creativity by allowing children to form a positive relationship with history through technology and art.
	Sensory Circulation Route	Experiential Tourism, Landscape	Sensory & Psychological: Providing mental and physical relief through a sensory-focused route distanced from urban noise.

MORPHOLOGICAL RESILIENCE (Approaches that ensure continuity and adaptability of the city's physical structure and planning principles)	Modular Resistance of the Ancient City	Housing, Public Space	Spatial & Social: Repairing fragmented urban fabric by reconciling historical planning principles with contemporary living needs.

The architectural design projects developed throughout the studio process offer a rich framework for understanding how students conceptualized the historical environment, established relationships with the site, and interpreted the overarching theme of "healing." While each student was required to formulate their own unique design concept, they were also expected to approach it holistically by integrating not only the designated conservation site but also considering the broader urban context and morphological characteristics of the city. In this regard, the Roman Bath and its surrounding archaeological zone were compulsory components to be incorporated into each design proposal. However, the ways in which students engaged with the notion of healing—whether through spatial programming, symbolic interpretation, or sensory design—were left open to their individual conceptual decisions.

Qualitative analyses of the projects reveal multi-layered strategies extending from spatial organization to functional scenarios, from user profiles to aesthetic preferences, thereby shedding light on the original positions students developed regarding conservation, sustainability, and urban resilience. The projects not only generated architectural spaces but also proposed strategies for repair and resilience across social, economic, cultural, and morphological dimensions. Accordingly, the outcomes have been thematically grouped and evaluated along four primary axes: (1) Social Resilience and Collective Healing, (2) Continuity as Ecological and Economic Resilience, (3) Cultural Resilience and Experiential Awareness, and (4) Morphological Resilience and Spatial Repair. These themes are elaborated below through representative project examples.

Theme 1: Social Resilience and Collective Healing: A significant portion of the projects developed within the studio reinterpreted the historical environment of Sarıkaya as a "therapeutic landscape," (Figure 1d) in which social traumas could be repaired and collective memory reconstructed. In this context, the proposed "Rehabilitation Center for Veterans and Families of Martyrs" (Figure 1a) not only offers physical spaces for healing vulnerable groups but also anchors itself in a strong axis of collective memory embedded in the city's social identity. The high population density of Sarıkaya, the intense pedestrian access to the site, and the potential for social gathering reminiscent of the ancient agora reinforce the spatial and societal relevance of the proposal. The rehabilitation spaces are integrated holistically with urban open areas, aiming to make the healing process a part of public life and to embed it symbolically into the collective urban fabric.

Similarly, the project "Gediatrics: Elderly Resilience Center" (Figure 1b) responds to the high proportion of elderly residents in Sarıkaya by proposing a multilayered social program that supports active aging throughout the life cycle. This continuum ranges from self-sufficient elderly individuals to those requiring intensive care, making use of the city's existing Physical Therapy and Rehabilitation (FTR) hospital, refunctioning educational spaces, and promoting productive engagement among the elderly. The goal is to redefine the aging process through social integration and lifelong participation.

The "Alzheimer Care Center" project transforms the site's morphology into a pedestrian-oriented and controlled "memory corridor" system that allows individuals to remain connected to the city and social life while receiving structured care (Figure 1c). Sensory guidance systems, designed according to the progressive stages of Alzheimer's disease, ensure both freedom and safety. The city square, reinterpreted from the archaeological excavation area, serves as a central civic node of orientation and gathering. This dual focus on individual healing and collective memory aims to reweave both personal and communal narratives into the urban fabric.

Moreover, the "Therapeutic Gardens" project integrates locally grown aromatic plants with thermal water resources to stimulate health tourism while supporting economic sustainability. The holistic approach includes agricultural production, aromatic plant cultivation, and scenic walking routes that incorporate the archaeological site into a broader health-oriented tourism infrastructure. This not only enriches the spatial experience of the city but also reinforces Sarıkaya's ecological and economic resilience.

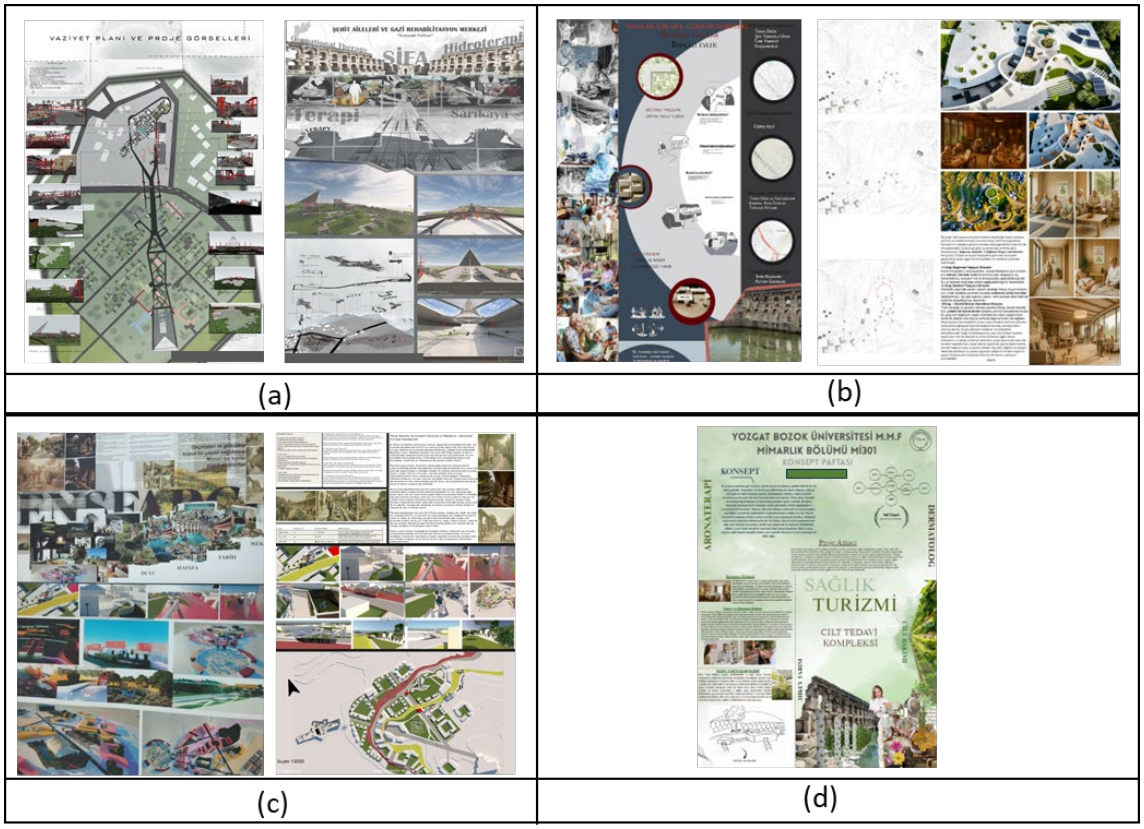


Figure 1 Projects related to the theme of social resilience and collective healing:
(a) The 'Rehabilitation Center for Veterans and Families of Martyrs' proposes collective healing by integrating therapy spaces with agora-like public gathering zones; (b) The geodesic greenhouse project highlights ecological and social continuity by utilizing thermal water in daily agricultural production; (c) The 'Urban Memory Center' employs sensory guidance and familiar urban textures as cognitive anchors for Alzheimer's patients; (d) The 'Health Tourism Unit' merges physical healing with social infrastructure through thermal water and aromatherapy

Theme 2: Continuity as Ecological and Economic Resilience: Another group of projects developed within the studio approached the concept of resilience through the principles of ecological balance and economic sustainability, placing the continuity of local resources—spanning from the past to the present—at the core of architectural design. This approach moves beyond a static preservation of the historical environment and instead proposes an adaptive reinterpretation that aligns the area's cultural and natural heritage with the productive dynamics of contemporary life.

In this context, the "Thermal Production Integration Center" project assumes that Sarıkaya's geothermal resources—utilized since antiquity—possess not only recreational and touristic value but also significant productive potential (Figure 2c). The project proposes an integrated production model in which thermal energy is harnessed in greenhouses, therapeutic health facilities, and urban heating systems. Without harming the region's ecological cycle, it introduces innovative infrastructure systems—both passive and active—that ensure the continuity of geothermal resources, thereby articulating a natural resource-based approach to ecological resilience.

Similarly, the "Heirloom Seed Preservation and Education Center" project reactivates Sarıkaya's rural agricultural traditions and heirloom seed diversity within a spatial framework that promotes

food security, biodiversity, and cultural continuity. Through spaces dedicated to cultivating, exhibiting, and disseminating heirloom seeds via educational programs, the project merges traditional agricultural wisdom with a contemporary model of ecological economy (Figure 2a, 2b).

Other projects that link economic resilience to cultural and health tourism reconceptualize historical structures not as passive preservation objects but as "active heritage" sites with renewed functions integrated into local economic cycles. In this regard, the "Physical Therapy and Rehabilitation (FTR) Hospital Integration Project" aims to transform existing healthcare infrastructure into a health tourism destination by aligning it with the thermal potential of the Roman Bath, offering treatment spaces focused on therapeutic cures. Similarly, the "Ruins Hotel" proposal offers a unique accommodation experience in which archaeological remains are spatially integrated into the interior design to preserve collective memory while also generating economic value (Figure 2b).

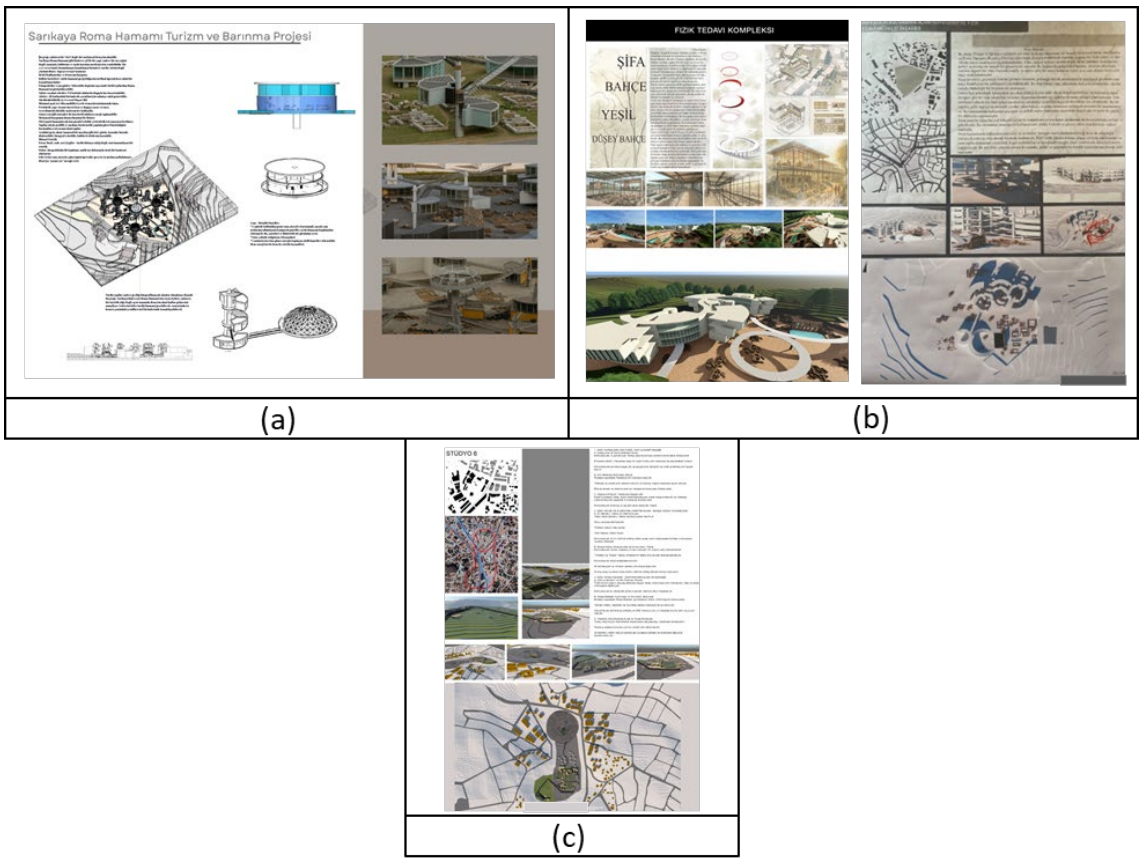


Figure 2 Projects representing the theme of continuity as ecological and economic resilience: (a) The 'Ruin Hotel' demonstrates spatial healing by actively incorporating archaeological ruins into contemporary accommodation, transforming passive remnants into economic assets; (b) The 'Physical Therapy Hospital' supports long-term economic resilience by converting local thermal water potential into a health tourism infrastructure; (c) The 'Heirloom Seed Preservation' project bridges rural agricultural traditions with a contemporary ecological economy to sustain cultural and biological diversity

Theme 3: Cultural Resilience and Experiential Awareness: Some of the projects developed during the studio process aimed to construct cultural resilience not solely through the physical preservation of the historical environment but through the sensory and experiential relationships that users establish with it. These proposals challenge the notion of the urban heritage site as a passive "monumental" presence, instead reimagining it as a multi-layered field of experience, continuously reproduced through embodied, cognitive, and sensory engagement.

Aligned with this approach, the "AI-Supported Pediatric Design and Education Workshop" project positions technology not merely as a tool but as a pedagogical bridge for the intergenerational transmission of cultural heritage. Through age-appropriate, AI-assisted

interactive modules, the project enables children to explore and internalize the historical layers of the Sarıkaya Roman Bath. In this setting, children not only engage with the site intellectually but also become active agents in the co-production of cultural meaning. Cultural sustainability is thus reframed as a process of awareness fostered through pedagogical participation.

Another proposal, the "Sensory Circulation Route," reconstructs spatial experience through auditory, visual, tactile, and olfactory stimuli, establishing a body-centered relationship between the individual and the historical context. Rather than relying solely on visual cues, this route guides visitors through a sensorially enriched spatial narrative. Sound stations, scent modules, and textured surfaces placed along the path facilitate both individual and collective encounters with the layered history of Sarıkaya.

Such projects assert that heritage is not merely an object of protection but also a performative and affective domain in which collective memory can be reconstructed through sensory and cognitive interaction. Cultural resilience, in this sense, is not confined to the preservation of the past but is actively sustained and revitalized through novel representational strategies and spatial narratives. Accordingly, the continuity of cultural heritage depends not only on the physical integrity of place but also on the multisensory, experiential bonds forged between the individual and the site (Figure 3a).

Theme 4: Morphological Resilience and Spatial Repair: Certain projects developed within the architectural studio addressed the concept of resilience not solely in structural or functional terms but through the lens of morphological continuity. Within this framework, the project titled "Modular Resistance of the Ancient City" reinterpreted the gridal urban morphology still traceable around the Sarıkaya Roman Bath by integrating it with contemporary housing and public space needs. The fundamental premise of the project is that the ancient urban order should not merely be regarded as a historical planning paradigm, but also as a resilient infrastructural model capable of informing contemporary spatial organization.

Rather than proposing a literal preservation of formal codes, this approach advocates for their reinterpretation in ways that can be integrated into the fabric of modern urban life. Here, the gridal structure is not only approached as a geometric ordering system but also as a spatial logic encompassing permeability, orientation, the balance between openness and enclosure, and neighborhood-scale sociability. The project synthesizes this modular system through housing clusters, public courtyards, green and open spaces, and pedestrian networks, thereby reestablishing morphological continuity in both functional and social dimensions.

Moreover, the proposed morphological continuity offers a critical lens through which to address the fragmented urban fabrics frequently encountered in small towns with stratified historical layers, such as Sarıkaya. The reconciliation between historical planning principles and contemporary needs is not merely interpreted as a process of physical renewal but as the restoration of a historically embedded urban continuity.

In this respect, the "Modular Resistance of the Ancient City" project investigates how historical morphology can be transformed under contemporary conditions, contributing an original architectural perspective to the concept of spatial resilience. It is proposed as a "spatial repair strategy" that maintains continuity between past and present, and establishes a theoretical bridge within design pedagogy between historical typology and contemporary adaptability (Figure 3b).

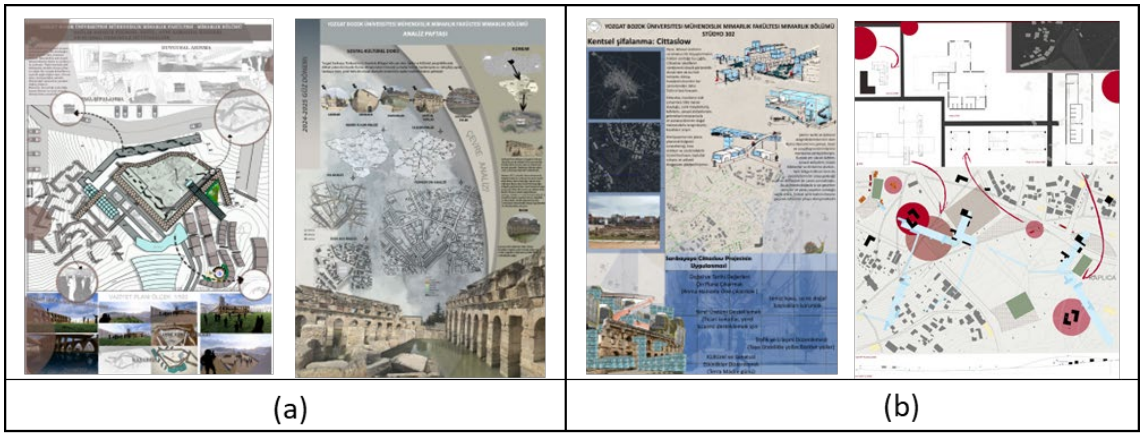


Figure 3 Projects Representing the themes of cultural resilience & experiential awareness and morphological resilience & spatial repair: (a) Diagrams from the 'Virtual Archaeology' and 'Sensory Circulation Route' projects illustrate how cognitive, performative, and sensory interactions—rather than purely visual preservation—help reconstruct cultural memory; (b) Boards from the 'Modular Resistance' project showcase spatial repair strategies that adapt the ancient Roman grid system to satisfy contemporary housing and social permeability needs

Table 6 Categorization of Student Project Concepts by Primary Themes and Programmatic Focus

Project Concept	Health & Healing	Social & Housing	Tourism & Economy	Ecology & Agriculture	Culture & Memory	Technology & Education	Experience & Sensory
1. Rehabilitation Center for Veterans & Martyrs' Families	✓	✓			✓		
2. AI-supported Pediatric Design Workshop						✓	✓
3. Sensory Circulation Route			✓		✓		✓
4. Urban Memory: Alzheimer's & Geriatric Center	✓	✓			✓		
5. Urban Rebirth: Maternity & Women's Health Unit	✓	✓					
6. Physical Therapy Hospital (Aromatherapy)	✓		✓	✓	✓		✓
7. Modular Resistance of the Ancient City		✓			✓		
8. Geriatrics: Center for Life Resilience	✓	✓					
9. Thermal Water: Geodesic Greenhouses & Housing		✓		✓			
10. Journey to the Ancient City: Ancestral Seed Branding			✓	✓	✓		✓
11. The Ruin Hotel		✓	✓		✓		

The data presented in the thematic matrix (Table 6) reveals that the students' design proposals were not confined to singular categories but were consistently intersectional in nature. The analysis of the matrix indicates a clear thematic hierarchy in the students' approach. Culture & Memory emerges as the most dominant theme, being a component in eight of the eleven projects, closely

followed by Social & Housing, which was present in seven. Health & Healing also constitutes a significant area of focus, appearing in five proposals. The matrix further highlights a strong pattern of thematic pairings; Health & Healing frequently co-occurs with Social & Housing, while Tourism & Economy is consistently linked with Culture & Memory. This demonstrates a tendency to synthesize social programs with health-based solutions and to ground economic strategies in cultural heritage. Moreover, certain projects, such as the 'Physical Therapy Hospital' (Project 6) and 'Ancestral Seed Branding' (Project 10), act as hyper-integrative models by simultaneously addressing five distinct themes, showcasing the multi-layered thinking that the studio process fostered.

5. Discussion

This study was grounded in the proposition that architectural education must be repositioned in response to the complex and interrelated challenges of the 21st century—namely, the climate crisis, social inequalities, and the erosion of cultural identity. Within this context, it introduced and evaluated an innovative pedagogical model that integrates disciplines such as historic environment conservation, urban resilience, and healing architecture by using the theme of healing as a conceptual bridge. The core findings of the research demonstrate that this integrated approach generated a multilayered and profound transformation in students' competencies.

Quantitative data revealed that the studio experience significantly shifted students' attitudes toward conservation—from rigid preservationism to a more dynamic and flexible understanding that embraces the integration of heritage into contemporary life. One of the clearest indicators of this cognitive shift was the statistically significant decrease ($p < 0.05$) in agreement with the prejudice that modern materials inherently conflict with historic fabric. This mental flexibility became the foundation for the sophisticated and context-sensitive design strategies developed by the students. Importantly, this cognitive shift mirrors the evolution of international conservation paradigms from the strict material focus of the Venice Charter to the Washington Charter's acceptance of contemporary dialogue. The cross-analysis of the project concepts confirmed this holistic approach, showing that students placed human-centered themes such as Culture/Memory and Social/Housing at the core of their projects, supported by programmatic tools like Health/Healing and Tourism/Economy.

The thematic analysis of student projects illustrates how theoretical concepts were translated into concrete, multi-layered spatial strategies. As proposed by Gesler (1992), the historical environment of Sarıkaya was successfully reinterpreted by students as a "therapeutic landscape." The design outputs seek not only to promote physical and mental well-being but also to strengthen the city's social infrastructure and inclusivity through public spaces. By reconstructing collective memory, enhancing social networks, and establishing a sustainable relationship with the urban context, the proposals ultimately become spatial manifestations of social resilience, aligning directly with Jacobs's (1961) conceptualization of social capital. Furthermore, projects addressing ecological and economic continuity moved beyond passive preservation. Collectively, these projects interpret ecological and economic resilience not merely as the sustainable management of resources but as the architectural continuity of cultural codes transmitted across generations. By transforming Sarıkaya's unique natural assets and cultural heritage into elements of a forward-looking spatial economy, the proposals aim to both safeguard the legacy for future generations and strengthen the structural resilience of the urban system through economic integration.

In terms of cultural and morphological resilience, the design outputs challenged the notion of heritage as a passive monument. Such projects assert that heritage is not merely an object of protection but also a performative and affective domain in which collective memory can be reconstructed through sensory and cognitive interaction. As supported by Pallasmaa's (2024) sensory approach, cultural resilience, in this sense, is not confined to the preservation of the past but is actively sustained and revitalized through novel representational strategies and spatial narratives. Accordingly, the continuity of cultural heritage depends not only on the physical integrity of place but also on the multisensory, experiential bonds forged between the individual

and the site. Moreover, the proposed morphological continuity offers a critical lens through which to address the fragmented urban fabrics frequently encountered in small towns with stratified historical layers, such as Sarıkaya. The reconciliation between historical planning principles and contemporary needs is not merely interpreted as a process of physical renewal but as the restoration of a historically embedded urban continuity. In this respect, the "Modular Resistance of the Ancient City" project investigates how historical morphology can be transformed under contemporary conditions, contributing an original architectural perspective to the concept of spatial resilience. It is proposed as a "spatial repair strategy" that maintains continuity between past and present, and establishes a theoretical bridge within design pedagogy between historical typology and contemporary adaptability.

The central argument of this study is that the healing theme served as a pedagogical catalyst, encouraging students to engage with the concept of resilience in a more critical and political manner. In conclusion, the analysis of these concepts demonstrates that students not only questioned how to design during the studio process, but more importantly, they began to explore why and for whom they design. In contrast to the risk of resilience discourse being used to preserve the status quo or to obscure systemic inequalities, this model directly confronted students with the questions: "Resilience for whom?". and "Which wounds need healing?" Rather than merely sustaining current conditions, student projects proposed transformative interventions: social resilience through new social infrastructure for vulnerable groups such as veterans, families of martyrs, and Alzheimer's patients; ecological and economic resilience through models based on local thermal resources and ancestral seed preservation; and cultural resilience through reinterpreting the city's historical morphology and sensory experience. These responses indicate a reframing of resilience—not simply as the capacity to bounce back after crisis, but as the potential to bounce forward toward a more just and sustainable future.

6. Conclusion

This holistic perspective repositions the architectural design studio as a resilience incubator—a space where students interweave various dimensions of resilience (social, ecological, cultural, and economic) through design. The projects developed throughout the studio provide compelling evidence that, with appropriate interventions, historic urban landscapes can be transformed into healing and resilient spaces—spaces that both carry the traces of the past and respond to the social and ecological challenges of the future. This study offers a pedagogical vision that redefines the architect not as an isolated form-giver, but as a socially embedded repairer and a resilience choreographer, embodying Donald Schön's ideal of the reflective practitioner working within complex socio-ecological systems.

Crucially, the implications of this study extend beyond the specific context of the Sarıkaya Roman Bath. The pedagogical framework tested here offers a reproducible model for international architectural education. By demonstrating how resilience, heritage, and health can be synthesized in the studio environment, this approach provides a valuable blueprint for global curricula aiming to equip future architects with the interdisciplinary tools necessary to tackle 21st-century urban challenges.

Naturally, a critical assessment of this pedagogical model requires acknowledgment of the study's limitations. Although the small sample size (N = 11) and single case study design constrain generalizability, the nature of action research allows for a contextually rich, in-depth understanding. The participatory dual role of the researchers as studio instructors introduces a potential for bias. While structured assessment rubrics and peer debriefings were employed to mitigate this, future studies should consider independent pedagogical evaluations. A more significant limitation lies in the absence of a direct co-design process with the local community. This shortcoming underscores the necessity of enriching future iterations of the model with participatory methodologies that enable students to design not only about a place, but with it. To address this, future implementations must incorporate joint design workshops, structured

stakeholder meetings, and community-led feedback loops to ground spatial healing in genuine public consensus.

These limitations also open productive avenues for future research—ranging from longitudinal studies that assess the retention of gained competencies, to comparative case analyses testing the model in diverse contexts, and participatory design processes that place community engagement at the center.

CRediT Authorship Contribution Statement

Dr. Öğr. Üyesi Begüm Demiroğlu İzgi (Corresponding Author): Conceptualization; Methodology; Investigation; Formal analysis; Data curation; Writing – original draft; Writing – review & editing; Visualization; Project administration; Supervision. Öğr. Gör. Ayşegül Koç Ünlüsoy: Conceptualization; Methodology; Investigation; Data curation; Writing – review & editing; Validation.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

Data will be made available on request.

Ethics Committee Approval

Ethics approval for this study was granted by the Yozgat Bozok University Social and Human Sciences Ethics Committee (Decision No: 20/07; Date: 19 December 2024). The application was evaluated under the committee's directive (incoming letter dated 03 December 2024, no. 272396), and the study was found appropriate/approved. The study was conducted in accordance with the approved protocol, with voluntary participation and confidentiality safeguards as described in the ethics submission.

References

Al Khatib, I., Samara, F., & Ndiaye, M. (2024). A systematic review of the impact of therapeutical biophilic design on health and wellbeing of patients and care providers in healthcare services settings. *Frontiers in Built Environment*, *10*, 1467692.

Altomonte, S., Rutherford, P., & Wilson, R. (2014). Mapping the way forward: Education for sustainability in architecture and urban design. *Corporate Social Responsibility and Environmental Management*, *21*(3), 143-154.

Ashworth, G. (2011). Preservation, conservation and heritage: Approaches to the past in the present through the built environment. *Asian Anthropology*, *10*(1), 1-18.

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

Brooker, G., & Stone, S. (2004). *Rereadings: Interior architecture and the design principles of remodelling existing buildings*. RIBA Enterprises.

Butterfield, A., & Martin, D. (2016). Affective sanctuaries: Understanding Maggie's as therapeutic landscapes. *Landscape Research*, *41*(6), 695-706. https://doi.org/10.1080/01426397.2016.1197386

Calikusu, A. N., Cakmakli, A. B., & Gursel Dino, I. (2023). The impact of architectural design studio education on perceptions of sustainability. *Archnet-IJAR: International Journal of Architectural Research*, *17*(2), 375-392.

Cantacuzino, S. (1989). *Re-architecture: Old buildings/new uses*. Abbeville Press.

Cetina, K. K. (1999). *Epistemic cultures: How the sciences make knowledge*. Harvard University Press.

Clarke, N., Kuipers, M., & Stroux, S. (2020). Embedding built heritage values in architectural design education. *International Journal of Technology and Design Education*, *30*(5), 867-883.

Davoudi, S., Shaw, K., Haider, L. J., Quinlan, A. E., Peterson, G. D., Wilkinson, C., Fünfgeld, H., McEvoy, D., Porter, L., & Davoudi, S. (2012). Resilience: A bridging concept or a dead end? "Reframing" resilience: Challenges for planning theory and practice interacting traps: Resilience assessment of a pasture management system in Northern Afghanistan urban resilience: What does it mean in planning practice? Resilience as a useful concept for climate change adaptation? The politics of resilience for planning: A

cautionary note: Edited by Simin Davoudi and Libby Porter. *Planning Theory and Practice*, *13*(2), 299-333.

Dilani, A. (2008). Psychosocially supportive design: A salutogenic approach to the design of the physical environment. *Design and Health Scientific Review*, *1*(2), 47-55.

Embaby, M. E. (2014). Heritage conservation and architectural education: "An educational methodology for design studios." *HBRC Journal*, *10*(3), 339-350.

Gesler, W. M. (1992). Therapeutic landscapes: Medical issues in light of the new cultural geography. *Social Science & Medicine*, *34*(7), 735-746.

Gursel, A. P., Shehabi, A., & Horvath, A. (2023). Embodied energy and greenhouse gas emission trends from major construction materials of US office buildings constructed after the mid-1940s. *Building and Environment*, *234*, 110196.

Hettithanthri, U., & Hansen, P. (2022). Design studio practice in the context of architectural education: A narrative literature review. *International Journal of Technology and Design Education*, *32*(4), 2343-2364.

Holling, C. S. (1973). Resilience and stability of ecological systems. *Annual Review of Ecology and Systematics*, *4*(1), 1-23.

ICOMOS. (1964). *International charter for the conservation and restoration of monuments and sites (The Venice Charter)*.

ICOMOS. (1987). *Charter for the conservation of historic towns and urban areas (The Washington Charter)*.

ICOMOS. (2013). *The Hangzhou declaration: Placing heritage and development on the same scale*. UNESCO.

Ikiz Kaya, D., Pintossi, N., & Dane, G. (2021). An empirical analysis of driving factors and policy enablers of heritage adaptive reuse within the circular economy framework. *Sustainability*, *13*(5), 2479.

Jacobs, J. (1961). *The death and life of great American cities*. Random House.

Jokilehto, J. (2017). *A history of architectural conservation*. Routledge.

Kaplan, R., & Kaplan, S. (1989). *The experience of nature: A psychological perspective*. Cambridge University Press.

Kellert, S. R., & Wilson, E. O. (Eds.). (1993). *The biophilia hypothesis*. Island Press.

Kemmis, S., McTaggart, R., & Nixon, R. (2014). *The action research planner: Doing critical participatory action research* (Vol. 200). Springer

Maggie's. (2026). *Our buildings and architecture*. https://www.maggies.org/about-us/buildings-architecture/

Noaime, E., & Alnaim, M. M. (2025). Heritage and resilience: Sustainable recovery of historic Syrian cities. *Buildings*, *15*(14), 2403.

Norberg-Schulz, C. (1979). *Genius loci: Towards a phenomenology of architecture*. Rizzoli.

Pallasmaa, J. (2024). *The eyes of the skin: Architecture and the senses*. John Wiley & Sons.

Pendlebury, J. (2009). The urbanism of Thomas Sharp. *Planning Perspectives*, *24*(1), 3-27.

Pintossi, N., Ikiz Kaya, D., & Pereira Roders, A. (2021). Assessing cultural heritage adaptive reuse practices: Multi-scale challenges and solutions in Rijeka. *Sustainability*, *13*(7), 3603.

Plevoets, B., & Van Cleempoel, K. (2013). Adaptive reuse as an emerging discipline: An historic survey. In G. Brooker & S. Stone (Eds.), *Reinventing architecture and interiors: A socio-political view on building adaptation* (pp. 13-32). RIBA Publishing.

Putnam, R. D. (2000). *Bowling alone: The collapse and revival of American community*. Simon & Schuster.

Rodwell, D. (2008). *Conservation and sustainability in historic cities*. John Wiley & Sons.

Sabree, M., & Mustafa, M. M. (2023). Importance and role of live projects in architectural education using a descriptive and analytical approach. *Education Science and Management*, *1*(1), 7-18.

Salama, A. M. (2016). *Spatial design education: New directions for pedagogy in architecture and beyond*. Routledge.

Sara, R., & Mosley, J. (2014). *The architecture of transgression*. John Wiley & Sons.

Schön, D. A. (2017). *The reflective practitioner: How professionals think in action*. Routledge.

Shamsuddin, S. (2023). Urban in question: Recovering the concept of urban in urban resilience. *Sustainability*, *15*(22), 15907.

Smith, S. G., Dupre, K., & Crough, J. (2023). Live projects: A mixed-methods exploration of existing scholarship. *Archnet-IJAR: International Journal of Architectural Research*, *17*(4), 793-811.

Teymur, N. (1982). *Environmental discourse: A critical analysis of environmentalism in architecture, planning, design, ecology. Social sciences and the media*. Question Press.

Ulrich, R. S. (1984). View through a window may influence recovery from surgery. *Science*, *224*(4647), 420-421.

Verderber, S., Fine, S. V. D. J., Fine, D. J., & Fine, P. D. J. (2000). *Healthcare architecture in an era of radical transformation*. Yale University Press.

Wahl, D. C. (2016). *Designing regenerative cultures*. Triarchy Press.

Webster, H. (2008). Architectural education after Schön: Cracks, blurs, boundaries and beyond. *Journal for Education in the Built Environment*, *3*(2), 63-74.
Wong, L. (2024). *Adaptive reuse: Extending the lives of buildings*. Birkhäuser.

Resume

Begüm Demiroğlu İzgi is currently an Assistant Professor at Yozgat Bozok University, Faculty of Engineering and Architecture, Department of Architecture. She received her BArch degree in Architecture from Selçuk University (2007–2013), MSc degree in Architecture from Selçuk University (2014–2017), and PhD degree in Architecture from Konya Technical University (2016–2020). She has been serving as a faculty member at Yozgat Bozok University since 2018. Her research spans rural and urban morphology, typomorphology, peri-urbanization, cultural heritage, and resilience-oriented spatial analysis, and she has contributed to funded projects addressing pedestrian mobility and resilience-related design/education themes.

Ayşegül Koç Ünlüsoy is currently a Lecturer at Yozgat Bozok University, Faculty of Engineering and Architecture, Department of Architecture, where she has been teaching since 2010. She received her MSc degree in Architecture from Selçuk University (2006–2009) and completed her postgraduate thesis on the analysis and stylistic evaluation of First National Architecture Period buildings in Yozgat (2010). Her academic interests focus on architectural conservation and restoration, history of architecture, restitution, and cultural-historical built environments, with an emphasis on studio-based learning and conservation education.

JOURNAL OF DESIGN FOR RESILIENCE IN ARCHITECTURE & PLANNING

Research Article
Online: www.drarch.org
Volume 7, Issue 1 (89-106), 2026
DOI: 10.47818/DRArch.2026.v7i1205

Rock-cut vernacular architecture in northeastern Kayseri: Architectural characteristics and conservation challenges

Bahar Elagöz Timur*
Özlem Kevseroğlu Kurban**

Abstract

The rock-cut heritage of the Kayseri Valleys represents a distinctive vernacular tradition shaped by technological skill, social practices, and environmental adaptation. These systems, evolving from carved spaces to masonry and then reinforced concrete, represent both tangible and intangible heritage, connecting past construction knowledge with community identity and collective memory while adding to the valleys' unique cultural landscapes. This study examines the relationship between rock-cut construction techniques and the topographic context of the Koramaz and Gesi Valleys. Using archival research, field surveys, and systematic documentation, it records settlement forms, underground cities, hillside shelters, dovecotes, and related production areas, along with their connections to daily life and agricultural activities. Through on-site observations, spatial measurements, and photographs, the research shows how these features are spread across mound, slope, and basin settlements, illustrating the link between geological conditions and architectural practices. The analysis emphasizes how these spaces were organized, adapted, and combined over time, demonstrating the deep relationship between geology, settlement, and material culture. The findings highlight major conservation challenges, including abandonment due to demographic changes, functional shifts driven by modern needs, material decay from neglect, the loss of craftsmanship, and unregulated interventions that threaten structural integrity. Additionally, the near extinction of rock-cut building as a living practice endangers the continuity of related knowledge systems. Focusing on both their tangible and intangible aspects, the study advocates for conservation strategies based on socio-cultural continuity, community involvement, and sensitive adaptive reuse. This comprehensive approach is crucial to preserving the Kayseri Valleys as dynamic cultural landscapes while maintaining their relevance for future generations.

Keywords: historic buildings, memory, perception, physical experience, virtual reality experience

1. Introduction

Vernacular construction techniques represent some of humanity's most enduring responses to building locally available materials and deeply embedded knowledge systems (Oliver, 2006; Vellinga, 2013; Jokilehto, 2006). Developed through centuries of empirical practice, these methods reflect an intimate understanding of material behavior, structural principles, environmental conditions, and cultural needs (Rapoport, 1969; Asquith & Vellinga, 2006). Unlike formal architectural traditions grounded in written treatises and professional training, vernacular construction knowledge is transmitted through apprenticeship, community participation, and intergenerational practice (Rudofsky, 1964; Alexander et al., 1977).

The status of vernacular construction in heritage policy has expanded over recent decades. UNESCO's recognition of cultural landscapes and intangible heritage reframed traditional building methods as embodying both tangible and intangible values (UNESCO, 2003, 2011). This dual character complicates conservation efforts by requiring not only the material preservation of these practices but also the safeguarding of the knowledge systems and skills that sustain them (Smith, 2006; Harrison, 2013; Avrami et al., 2000).

*(Corresponding author), Department of Architecture, Abdullah Gül University, Kayseri, Türkiye bahar.timur@agu.edu.tr
**Department of Architecture, Abdullah Gül University, Kayseri, Türkiye ozlem.kevseroglu@agu.edu.tr
Article history: Received 06 August 2025, Revised 11 December 2025, Accepted 03 March 206, Published 30 April 2026

Recent scholarship highlights the alignment between vernacular construction and contemporary sustainability goals. Traditional techniques naturally incorporate principles of low-carbon building, circular resource use, and climate-responsive design (Zhai & Previtali, 2010; Fernandes et al., 2015). Their dependence on locally sourced materials and passive environmental control methods reduces embodied energy and strengthens place-based ecological knowledge (Elert et al., 2021). In this way, protecting vernacular practices also preserves environmentally smart knowledge crucial for shifting toward sustainable development models.

Beyond its environmental aspect, vernacular construction represents cultural sustainability through the ongoing transmission of tacit building knowledge, community-based craftsmanship, and locally rooted ways of life (Polanyi, 1966; Pallasmaa, 2009). Recognizing vernacular practices as living heritage highlights their role in maintaining place-based identities and collective memory (Smith, 2006; Harrison, 2013). International frameworks such as UNESCO's 2003 Convention on Intangible Cultural Heritage and the Historic Urban Landscape Recommendation (2011) explicitly support integrating these cultural practices into conservation efforts. Theoretical perspectives on vernacular environments have evolved from Rapoport's (1969) focus on house form and culture towards frameworks that examine the interplay of environmental adaptation, embodied knowledge, and spatial practice (Asquith & Vellinga, 2006). This literature underscores how vernacular techniques emerge from iterative problem-solving and reflect dynamic interactions between people, materials, and landscapes.

Among the environmental factors influencing vernacular construction, topography is particularly important yet often overlooked. While much research has focused on climate adaptation and material use, fewer studies have explored how terrain morphology, such as slopes, depressions, ridges, and valleys, affects building techniques and knowledge systems (Smith, 2006; Lawrence & Low, 1990). Topography shapes material access, foundation choices, structural stability, drainage methods, and microclimate adaptation, integrating environmental awareness into traditional construction practices. Recent research has started to fill this gap by documenting terrain-sensitive building practices through case studies of hillside, valley, and ridge settlements. Slope-adaptive construction uses terracing, stepped foundations, and gravity-fed infrastructure (Treacy & Denevan, 1994; Allen, 1969), while valley settlements feature advanced drainage systems, flood-resistant structures, and soil stabilisation techniques (Jackson, 1984; Morgan, 1990). Ridge and exposed-site construction employs wind-resistant detailing and logistical strategies for material transport under difficult conditions (Oliver, 2006). These examples show vernacular construction as an integrated response where environmental adaptation and cultural practice come together.

This study examines the rock-cut as a vernacular approach to settlements in the northeastern valleys of Kayseri, where these techniques are still visible in the structures and linked to local daily practices. It analyzes how rock-cut construction reflects the relationship between topography, environmental adaptation, and cultural traditions across mound, hill, and lowland settlements. The research also considers the conservation challenges these settlements face. Using field documentation, archival research, and spatial analysis, the study aims to develop strategies to preserve both their physical integrity and the traditional knowledge systems inherent in rock-cut architecture.

2. Vernacular Construction as Cultural Heritage: Conservation Treats

The recognition of vernacular construction within international heritage policy has gradually evolved, reflecting a shift from protecting monuments to acknowledging ordinary buildings and settlement ensembles. Early milestones, such as the World Heritage Convention (UNESCO, 1972) and the European Charter of the Architectural Heritage (CoE, 1975), marked an important change by expanding the definition of heritage to include "groups of buildings" and characteristic rural villages that embody regional identity.

By the 1980s and 1990s, focus shifted from just listing vernacular sites to protecting the knowledge that keeps them alive. The Granada Convention (CoE, 1985) emphasized support for "declining craft trades," while UNESCO's Recommendation on Traditional Culture and Folklore (1989) called for documenting and transmitting building-related skills. This approach was consolidated in the Vernacular Charter (ICOMOS, 1999), which underscored the dependence of vernacular heritage on the continuity of practice rather than the preservation of isolated forms. This broadened perspective provides an early framework for interpreting the Kayseri valleys, where rock-cut dwellings form landscape-scale ensembles shaped by their topographic contexts.

Since the 2000s, heritage policies have increasingly connected vernacular construction with broader cultural rights, sustainability, and landscape-based approaches. The Intangible Heritage Convention (UNESCO, 2003) formally acknowledged traditional craftsmanship, while the Faro Convention (CoE, 2005) reframed heritage as an evolving relationship between people and place. The Historic Urban Landscape Recommendation (UNESCO, 2011) and the ICOMOS-IFLA Principles concerning Rural Landscapes (2017) emphasized the ecological and social contexts that shape vernacular settlements and endorsed landscape-scale perspectives for their conservation. These perspectives are particularly useful for interpreting vernacular settlements situated within distinct geomorphological settings, where construction practices, spatial organisation, and environmental adaptation operate as interconnected systems.

Building on this policy context, a review of recent studies indexed in the Web of Science (WoS) database shows that conservation challenges related to vernacular architecture mainly revolve around five recurring themes: physical deterioration, rural abandonment, loss of craftsmanship and building knowledge, depletion of material resources, and inappropriate interventions. Together, these themes highlight the interconnected technical, social, cultural, and ecological aspects that influence conservation practice.

Physical deterioration remains one of the most visible threats, especially in earthen, stone, and timber structures that depend on regular maintenance. Mileto and López-Manzanares (2022) emphasize how earthen buildings are highly susceptible to weathering and how a lack of routine maintenance speeds up their decay. Similarly, Elert et al. (2021) discuss issues such as water infiltration and material erosion in traditional stone. Fouseki and Cassar (2014) connect climate-driven temperature and humidity changes to increased deterioration rates.

Alongside material decay, rural abandonment and depopulation disrupt the continuity of both buildings and the landscapes they anchor. Martínez et al. (2022) document how deserted villages in Spain experience simultaneous structural collapse and a loss of cultural identity, while Samalavicius and Gabrenas (2022) note that semi-urban vernacular buildings in Lithuania risk disappearance unless they are adaptively reused. Ellis Burnet et al. (2021) argue that abandonment erodes the cultural landscapes that give meaning to these settlements. These dynamics resonate with the situation in parts of the Kayseri valleys, where reduced permanent habitation diminishes routine upkeep and contributes to the gradual deterioration of rock-cut dwellings.

Loss of craftsmanship and construction knowledge poses a major challenge for the long-term continuity of vernacular environments. Philokyprou and Michael (2021) note that intergenerational knowledge transfer has diminished in Cyprus, worsened by a lack of formal training in traditional construction. Similar concerns appear in stone-based traditions, where the declining number of skilled artisans threatens the viability of specialised techniques (Elert et al., 2021). As Fathy (2010) emphasizes, knowledge embodies not only technical conservation but also maintaining local identity and memory.

The depletion of traditional material resources further complicates conservation difficulties. Studies note how the closure of local quarries or shifts toward industrial substitutes restrict the availability of materials compatible with historic construction systems (Elert et al., 2021; Baquedano et al., 2021). As Zong et al. (2024) warn, ignoring resource sustainability challenges ultimately risks long-term vernacular conservation strategies.

Finally, inappropriate interventions often accelerate the loss of vernacular character. Samalavicius and Gabrenas (2022) describe modernization-driven restorations in Lithuania that weaken vernacular character. Bahramifar et al. (2022) show how incompatible changes in Iran undermine both environmental adaptability and cultural coherence. Similarly, Zong et al. (2024) note how poorly planned restorations damage material integrity, and Arfa et al. (2022) connect such practices to disruptions in local aesthetics and spatial logic.

Taken together, recent literature clearly shows that conserving vernacular architecture extends far beyond addressing material decay or structural repair. It requires sustaining the socio-cultural processes, ecological relationships, and practical knowledge systems that enable these environments to function as living heritage. This closely aligns with the integrated vision outlined by UNESCO (2011) and ICOMOS-IFLA (2017), in which vernacular construction is viewed not only as a tangible heritage resource but also as a living practice that supports cultural continuity and long-term resilience.

This conceptual and policy-oriented framework provides a critical basis for interpreting the conditions observed in the Kayseri valleys. The deterioration mechanisms, demographic shifts, declining craftsmanship, and intervention pressures identified in global studies closely mirror the challenges facing the region's rock-cut settlements. At the same time, the literature's emphasis on knowledge continuity, landscape-based interpretation, and community–place relations help explain why Kayseri's vernacular environments cannot be understood solely through their physical form. Rather, they represent a topo-cultural system shaped by long-standing construction practices, ecological adaptation, and everyday use. This alignment between global debates and local evidence establishes the analytical foundation for the case study that follows.

3. Materials and Methods

Kayseri has served as a significant cultural and commercial hub since the Chalcolithic period, sustaining its prominence through the Assyrian, Hittite, Phrygian, Roman, Byzantine, Seljuk, and Ottoman eras. Historical sources document the establishment of Assyrian karums (trading colonies) connected to Kaniş-Karum in Kültepe (Yurt Ansiklopedisi, 1982), while population movements from the 11th century onwards, including Armenian relocations during the Byzantine period, reshaped the region's demographic composition (Kévorkian & Paboudjian, 2012). Over time, the coexistence of Greek, Armenian, and Turkish Christian communities fostered a complex cultural landscape that continues to define Kayseri's rural valleys (Özkan, 2000).

The study area encompasses the Koramaz and Gesi Valleys, located approximately 20 km northwest of Kayseri. Gesi Valley, situated between the Koramaz and Derevenk Valleys, includes Yeşilyurt, Bağyurdu, Bahçeli, Kayabağ, and Güzelköy, while Koramaz Valley comprises Bağpınar, Vekse, Turan, Ağırnas, Küçükbürüngüz, Subaşı, and Büyükbürüngüz (Figure 1). The Koramaz Valley, listed on the UNESCO Tentative List in 2020 (Criterion V), illustrates long-term human–environment interaction shaped by volcanic geology, agricultural potential, and distinctive rock-cut architecture, including underground cities, dovecotes, and rock-cut churches (UNESCO, n.d.; Güngör Açıkgöz, 2007).

Research on rock-cut heritage has largely prioritized monumental and archaeological contexts, focusing on material decay, analytical techniques (e.g., micro-Raman, petrography), and geotechnical risk (Pelosi et al., 2016; Özata et al., 2024; Tunusluoğlu & Zorlu, 2009). Studies in comparable regions, such as Cappadocia, emphasize the conservation of ecclesiastical rock-cut sites (La Russa et al., 2014). However, vernacular rock-cut settlements, encompassing inhabited cave clusters, domestic architecture, and production facilities, remain underexplored, particularly regarding their integration into living heritage and environmental adaptation systems.

To address this gap, the study adopted a three-stage qualitative methodology combining archival research, spatial analysis, and systematic field surveys. Archival sources established a

historical and typological framework for the valleys' settlements. Field documentation involved in-situ observations, photographic recording, spatial measurements, and material assessments of rock-cut and masonry structures. Production-related carved spaces (e.g., dovecotes, oil mills) and agricultural tools were also recorded to contextualize daily life practices within the built landscape.

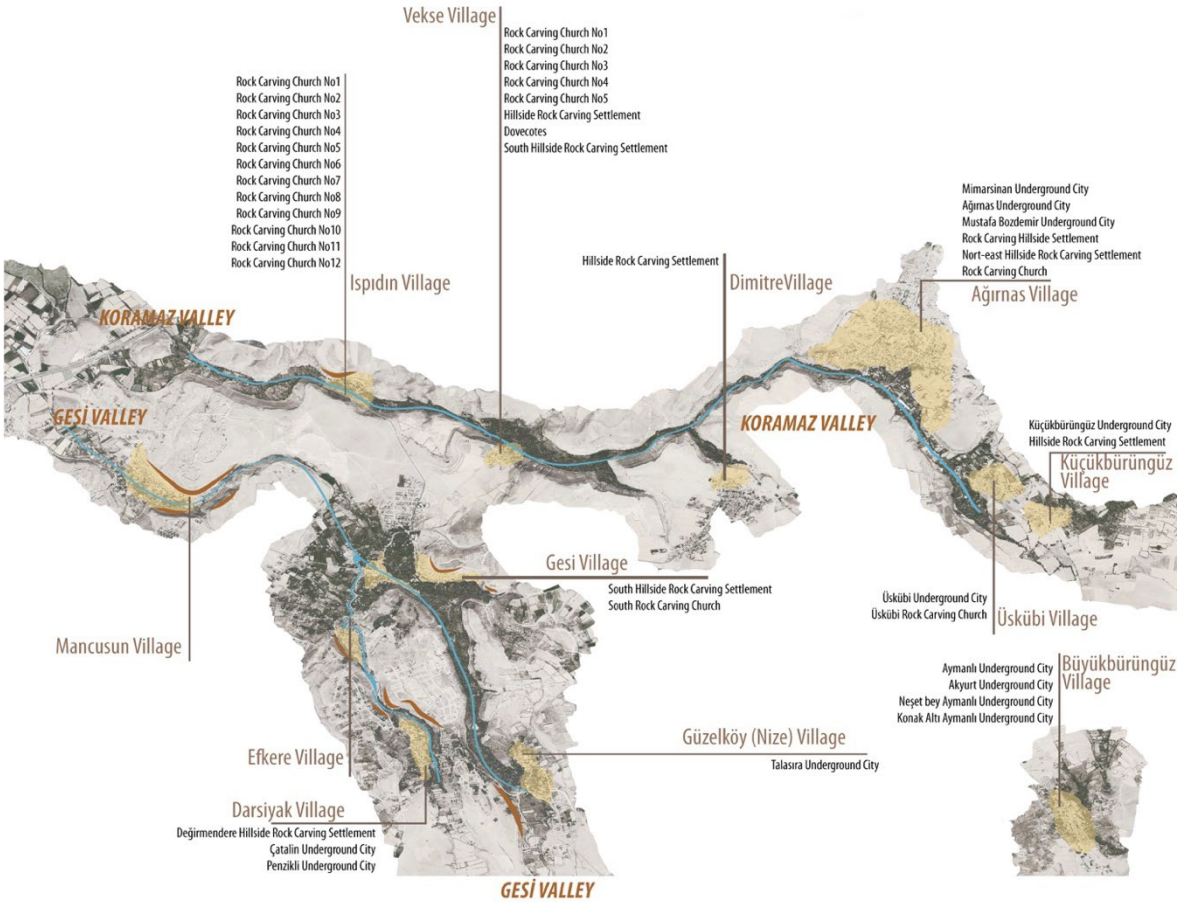


Figure 1 Map of settlements located in the Gesi and Koramaz valleys and their documented rock-cut structures

The data were analyzed comparatively, linking settlement typologies with geomorphological conditions such as valley slopes, volcanic tuff formations, and hydrological systems. Conservation threats, including material deterioration, unsympathetic alterations, and the erosion of traditional craftsmanship, were identified during fieldwork and cross-referenced with recent literature. Finally, findings were synthesized to develop context-sensitive conservation strategies that integrate local knowledge, ecological constraints, and sustainable heritage management practices.

4. Rock-Cut Construction System of Northeastern Kayseri

Rock-cut architecture represents one of the most striking examples of topographic adaptation and specialized construction techniques within vernacular traditions. Carved directly into geological formations, these settlements demonstrate an exceptional integration of site conditions with building practices (Ousterhout, 2017; Rodley, 1985). Unlike surface construction, rock-cut techniques required knowledge of geology, excavation methods, and structural behavior. Builders read rock stratigraphy, planned safe excavation sequences, and designed support systems suited to carved spaces (Bianca, 2000; Kostof, 1991; Heyman, 1995).

Beyond structure, these traditions employed the thermal mass of rock, natural ventilation, and moisture control to create stable interiors (Givoni, 1976). Carved spaces also carried symbolic and cultural significance, evident in their ritual alignments, acoustics, and visual connections to the landscape (Jackson, 1984; Cosgrove, 1984; Schafer, 1977; Pallasmaa, 2009).

To contextualize these traditions, the selected study area in Kayseri provides a unique example where geological conditions and cultural practices are deeply intertwined. Understanding these rock-cut traditions also involves examining the geological and geomorphological factors that have shaped both the landscape and settlement patterns of the region. The volcanic nature of Mount Erciyes has resulted in a karst-like topography. Eruptions that continued until approximately 2000 years ago formed the volcanic cones and rocks observed in the area today. The pyroclastic rocks, ejected from volcanoes and now covering nearly all of Kayseri, are mostly porous and easily eroded, such as tuff and ignimbrite. The mineral composition of these pyroclastic rocks, which range in color from light yellow to black, varies between eruptions (Yamaç, 2017). The eastern part of Kayseri is filled with valleys carved by streams flowing from high hills to the plain. Most of these valleys run parallel to each other from north to south, with occasional connecting branches created by stream bifurcations.

In this context, Binan's (1994) classification of Cappadocian settlement patterns into three groups, flat terrain, valley slope, and large volcanic tuff bases, and her identification of three rock-cut systems (underground, rock-cut, and slope-cut settlements) serve as a helpful reference. This typology aligns with patterns seen in the study area and will guide the comparative analysis of mound, slope, and hollow settlements. Using this approach, the connection between topography, construction techniques, and habitation practices in the study area can be critically discussed.

4.1. Layers of Rock-Cut Constructions

4.1.1. Underground Cities

The history of Kayseri, situated in the same geographical region as Cappadocia, stretches back thousands of years, with settlements in the area dating to the Neolithic period. Yet it remains unclear when the region's volcanic tuffs were first carved or when its inhabitants began to make the underground their home. The continuous use of these rock-cut spaces over millennia has made it nearly impossible to uncover clear archaeological answers to these questions.

Much like Cappadocia, this region is home to numerous underground cities that have yet to be fully explored or connected. Documenting these cave networks is particularly challenging because many lie directly beneath present-day towns and villages. The overlap between ancient underground spaces and modern settlement patterns creates complex difficulties for documentation and management, a challenge widely noted in the literature (Sani et al., 2012; Kilit & Dişli, 2022). Continuous occupation over centuries, later structural additions, and integration with surface parcels have further obscured their original layouts and purposes (Ulusay et al., 2006).

These underground cities are mostly concentrated in elevated and flat sections of the plateau, known as "mound settlements." According to the OBRUK Cave Research Group, ten such sites have been identified in the region. Seven are located in the neighborhoods of Büyükbürüngüz (2), Subaşı (1), Küçükbürüngüz (1), and Ağırnas (3), while three others are found in the Gesi Valley, in Kayabağ (2) and Güzelköy (1) (Kayseri Metropolitan Municipality, 2017, 2020). Research in the region, along with the discovery of "gate stones" sealing defensive tunnels, suggests that these underground settlements were built by Christian communities between the 7th and 10th centuries to protect themselves from Arab invasions (Kayseri Metropolitan Municipality, 2017, 2020).

As a prominent example, Ağırnas Underground City illustrates both the defensive function and the multi-layered nature of these rock-cut settlements (Figure 2). Covering an area of approximately 1,850 m², it features sliding stone doors, barrel-vaulted halls, storage spaces, and multi-level living areas typical of Cappadocian underground architecture. Excavation and cleaning works carried out between 2006 and 2008 led to the restoration and partial opening of the site to visitors. Today, the sections that have been cleared are accessible to the public, while other parts remain either unexplored or still locally used. This site vividly reflects the historical continuity of rock-cut habitation in the region (Yamaç, 2017).

Figure 2 Left: Ağırnas Mimarsinan House underground city, right: Ağırnas north-east hillside rock carving settlement (Kayseri Büyükşehir Belediyesi, 2020)

Figure 3 Carving spaces under and back to the masonry houses (Bağpınar)

Spatially, these underground cities are organized into interconnected narrow passages and low tunnels that open into larger "salon" spaces, typically spread across two or three levels. Unlike hillside settlements, they have no facades visible from the surface and are accessed only through hidden entrances. Ventilation is provided through vertical shafts reaching the surface (Yamaç, 2023). Altogether, these underground complexes tell a vivid story of adaptation to defensive needs, life carved into the earth, and the layered coexistence of history within living settlement patterns (Figure 3).

4.1.2. Rock-cut Hillside Shelters

Building on the typological framework outlined above, the second major formation seen in the valleys includes hillside settlements or shelters, which developed along the steep slopes typical of the study area. Carved into these inclines, they feature outward-facing facades and demonstrate how dwellings adapted to the rugged topography. The tradition of hillside settlement continued in a way that closely resembled the layout of today's neighborhoods until recent times. For centuries, most valley villages have been built on steep terrain, where modern houses often sit atop earlier rock-cut spaces, making it difficult to interpret their original purposes. Unlike underground cities, hillside settlements rarely have extensive tunnel networks; instead, short passages connect only a few interior spaces, with entrances opening directly from the valley's surface. These entrances are located at different elevations along the slopes, usually above watercourses and terrace gardens (Figure 4).

Figure 4 Rock-cut hillside shelters examples from Vekse (Koramaz Valley)

Beyond open spaces, hillside settlements include structures like churches, columbaria, pigeon lofts, livestock enclosures, defensive features, and storage rooms. Similar to underground cities, stone masonry walls serve as exterior boundaries and interior divisions, although many seem to be later additions. Most of these spaces are single-story, though there are also examples with two stories (Figure 5). Currently, 13 hillside settlements have been identified in the valleys. In Koramaz Valley, there are 11 such settlements: 1 in Subaşı, 1 in Küçükbürüngüz, 4 in Ağırnas, 1 in Turan, 1 in Vekse, and 3 in Bağpınar. In the Gesi Valley, 2 hillside settlements are located in Kayabağ and Güney (Kayseri Metropolitan Municipality, 2017, 2020).

Figure 5 Left and middle: Entrances of Değirmendere hillside rock carvings, right: Entrances of rock carving spaces (Bağpınar)

In addition to these settlements, isolated rock-cut structures are also present on the valley slopes. Among them, churches and columbaria stand out as the most prominent. Numerous undergrounds and above-ground churches belonging to different sects and ethnic groups reflect the region's historical and demographic diversity (Güngör Açıkgöz, 2007). Today, these churches are registered and protected by the Kayseri Regional Council for the Conservation of Cultural Property, although many have been damaged by treasure-hunting activities. They vary greatly in size and decorative details, similar to those in Cappadocia. Another notable type is the rock-cut columbaria, funerary structures dating back to the Roman Empire, several of which have been identified in the valleys. These consist of conical chambers with small niches carved into the walls

to hold urns of cremated remains. Because they resemble pigeon lofts, which were used as agricultural storage facilities, they can be hard to tell apart. In Koramaz Valley alone, 42 rock-cut churches, 11 Roman tombs, and 6 likely columbaria have been documented (Yamaç, 2023).

4.1.3. Rock-cut Daily Life Elements

One of the most common structures in the valleys is the dovecote. Unlike similar examples elsewhere in Anatolia, these pigeon lofts evolved locally as specialized production structures adapted to the region's environmental and socio-economic conditions (Figure 6). They provide insights into agriculture, trade, and daily life during the Ottoman period, particularly through their association with vineyards and buckthorn cultivation, when dove manure had notable economic value (İnceköse, 2019). As water availability declined, pigeon breeding ceased, and the structures were abandoned, becoming prominent cultural landscape markers, especially in Gesi and Koramaz Valleys. Architecturally, dovecotes combine carved chambers with stone-masonry chimneys serving as bird entrances. Many former rock-cut spaces, including churches, Roman tombs, and columbaria, were later converted into dovecotes, complicating dating efforts and obscuring stratigraphic evidence (Yamaç, 2023).

Figure 6 Yeşilyurt (Mancusun) dovecotes, middle: Inside of dovecote, right: A changed carving space as dovecote (Kayabağ)

Documentation studies also addressed daily-use objects shaped from rock, illustrating the adaptation of natural resources to local production (Figure 7). These include animal-husbandry structures (barns, stables), plant-based facilities (dye houses, oil mills), and carved agricultural tools. Bezirhane processed linseed oil for food, lighting, and craft uses, while şırahane served as communal sites for molasses making. Tools such as seten (vertical millstone), soku (stone mortar), and dorak (dairy container) supported grain milling and dairy processing, reflecting how subsistence practices shaped rock-carving traditions (Kevseroğlu et al., 2021).

Figure 7 Left to right: Oil mill (Bezirhane), vertical millstone (Seten), stone basin (Sirahane), stone mortar (Soku)

4.2. Underground Valley Morphology and Settlement Typologies

Valley orientation and topographic slope are naturally decisive factors in determining settlement locations. In such terrains, proximity to transportation routes or water sources is typically prioritized (Sümerkan, 1990). However, in the Koramaz and Gesi valleys of Kayseri, the presence of rock-cut construction systems is also observed to influence site selection. While these valleys differ in residential patterns, they share similar topographic and morphological

characteristics. Fertile flatlands near water sources are generally allocated for vineyards and garden agriculture, whereas the rocky mid-slopes are designated for cehri (Rhamnus petiolaris) cultivation. At higher elevations, dovecotes are found. Areas outside these zones, particularly mounds and flat lands, have historically been used for agricultural production.

Accordingly, settlements within the valleys can be categorized into three main morphological types: hillside, plateau, and basin (depression) settlements. While the organization of productive areas exhibits continuity across all types, the relationship between settlements and the topography, and thus the configuration of rock-cut spaces, varies significantly (Figure 8).

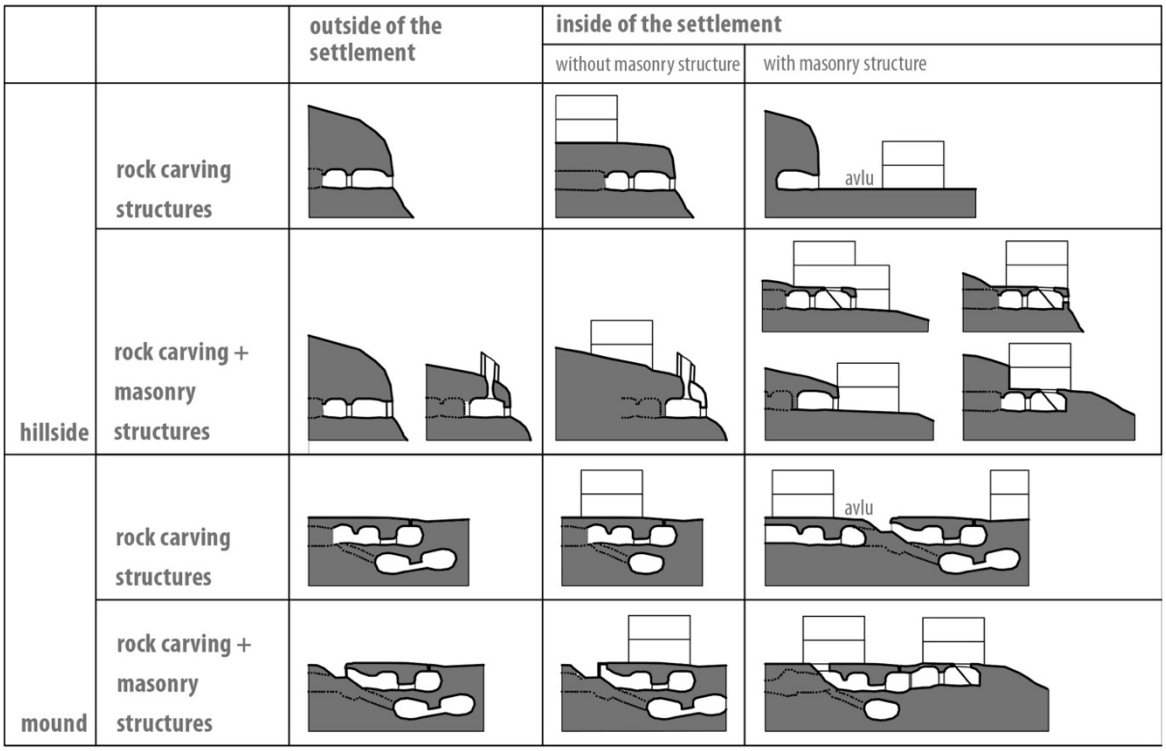


Figure 8 Rock carving relation with the settlement on the hillside and mound

Figure 9 Hillside shelter rock-cut settlement relationship

Hillside settlements exhibit a morphology that extends the tradition of rock-cut slope dwellings. Contemporary masonry houses are built atop or adjacent to earlier carved spaces, resulting in a hybrid typology. These houses often incorporate “in” spaces, rock-cut units, independent or shared, divided by masonry walls. Cubic masonry structures are aligned perpendicularly to the streets on narrow plots, with façades facing the valley. Although they appear two-storied from the street, the terrain slope causes them to read as three or four stories from the valley side. Lower levels house service spaces such as stables, cellars, or storerooms, all physically connected to upper-level living

areas through vertical and horizontal circulation elements. Carved spaces may be attached behind, below, or alongside the masonry buildings, often integrated at different levels or separated by small courtyards. Additions and reinforcement walls introduced over time complicate the identification of original functions. Due to their microclimatic advantages, particularly constant humidity and temperature, many of these carved areas are still used for storage today. Isolated shelters located further from the core settlements often serve as barns or haylofts (Figure 9).

Figure 10 Hillside settlement example from Bağpınar (Koramaz Valley)

Hillside settlements also provide insights into the evolution of morphology over time. Abandoned structures in Bağpınar and Vekse indicate earlier phases of expansion, while newer masonry buildings reflect subsequent growth. Present-day settlements now extend to the flat upper agricultural lands. In Ağırnas, however, former hillside areas have been almost entirely abandoned, with recent development concentrated on flatter terrain (Figure 10).

Plateau settlements, exemplified by Ağırnas and Büyükbürüngüz, are located in high and level areas and are closely associated with underground cities. Two-story stone masonry houses are arranged around large plots and courtyards, opening onto wide roads and squares. Unlike the shared gardens seen in hillside villages, each household in plateau settlements typically has its own private garden. Beneath these settlements, extensive underground spaces, sometimes reaching under homes, gardens, and roads, form expansive cave systems. Access is usually provided through vertical circulation shafts descending from courtyards or gardens. Masonry walls observed in these underground spaces suggest a subdivision pattern that reflects the above-ground parcel layout. However, there is no clear morphological continuity between underground and surface structures. Due to the lack of systematic documentation, most available data come from individual studies. Compared to the isolated, small-scale shelters found in hillside or basin contexts, the rock-cut spaces in Ağırnas and Büyükbürüngüz are larger, more complex, and more directly integrated with surface architecture (Figure 11).

Figure 11 Plateau settlement example from Büyükbürüngüz (Koramaz Valley)

Figure 12 Basin settlement example from Mancusun (Gesi Valley)

Basin settlements, represented solely by Yeşilyurt, differ from the others due to their position at the lowest point of the valley, near water sources and gardens. Although the terrain is not completely flat, it is more gently sloped than elsewhere. In the upper parts of the village, narrow and deep plots are arranged along stepped streets, forming a dense and continuous urban fabric. In contrast, the lower sections feature broader, near-square plots with larger houses and extensive gardens. No integrated carved spaces are observed within the masonry fabric of basin settlements,

though isolated rock-cut shelters exist along the valley slopes, generally serving as storage or agricultural service areas (Elagöz Timur et al., 2018). Unlike hillside and plateau types, basin settlements show little to no direct relationship with rock-cut traditions (Figure 12).

In sum, hillside settlements exhibit continuity with carved slope spaces; plateau settlements are more closely linked to underground cities; and basin settlements largely diverge from the rock-cut tradition. Nevertheless, shared elements such as water sources, cehri (Rhamnus petiolaris) gardens, dovecotes, and agricultural land create a unified cultural landscape across all settlement types.

5. Results and Findings

The heritage importance of vernacular construction techniques can be assessed using established cultural heritage evaluation frameworks adapted to intangible dimensions, recognizing their dual role as technical knowledge systems and community-rooted cultural practices (Australia ICOMOS, 2013; Mason, 2002). The rock-cut heritage of the Kayseri Valleys exemplifies this duality. These structures preserve evidence of historical technological development, from carved spaces to later masonry and reinforced concrete, while also reflecting long-term cultural adaptation shaped by local economies and social organisation. They also represent empirical knowledge systems grounded in a sophisticated understanding of local stone materials, carved-space construction, environmental regulation, and site-specific adaptation, insights highly relevant to sustainable building and climate-responsive design. Aesthetically, these techniques contribute to distinctive landscapes shaped by cultural preferences, material availability, and environmental conditions, producing authentic expressions of place-based identity.

As discussed in Section II, the main conservation challenges affecting vernacular systems include physical deterioration, abandonment, loss of craftsmanship, depletion of material resources, and inappropriate interventions (Figure 13 and Figure 14). Fieldwork in the Kayseri valleys confirms the presence of all five, but in forms shaped specifically by the region's rock-cut construction logic and topography. Abandonment emerges as the most influential driver, triggering cascading effects such as reduced maintenance, structural exposure, and the erosion of craft knowledge.

Figure 13 Various deterioration due to the natural and human-induced effects

A second phase of abandonment has emerged as rock-cut structures have increasingly failed to meet modern living standards. Independent carved spaces are no longer in use, though hybrid structures combining masonry and rock-cut elements remain partially inhabited. Functional changes have also taken place: spaces used for production, religion, or residence were repurposed for animal husbandry or storage; rock-cut tombs became dovecotes (Yamaç, 2023). The later decline in pigeon breeding and bans on animal husbandry under urban reclassification led to further abandonment. Field observations indicate that fully carved units located on steep slopes with limited access are predominantly vacant, whereas hybrid structures on more accessible terraces continue to be used. These changes are reflected in physical traces such as blocked openings, soot accumulation, and surface abrasion, which provide direct spatial evidence of how changing use patterns have accelerated abandonment (Figure 15).

Figure 14 Conservation problems due to the abandonment

Rock-cut techniques, which have a unique construction logic and spatial organization, often conflict with modern needs (Elagöz Timur & Asiliskender, 2024). Although adaptive reuse has helped preserve them, unregulated modifications, such as subdividing or reinforcing weakened underground areas, have compromised archaeological integrity. Field observations reveal that such interventions are particularly evident in hybrid structures, where later masonry additions and infrastructural adjustments disrupt the original spatial continuity of carved spaces. Urban infrastructure projects, like road widening and heavy vehicle traffic, have caused collapses and uncontrolled infill (Figure 15).

Figure 15 Inappropriate interventions

Material decay, mainly caused by deterioration and interventions, includes erosion, salt efflorescence, soot deposits, moisture issues, and biological growth, although no major structural failures were observed. Field observations conducted in the valleys confirm that these forms of decay are most evident in carved interiors subjected to altered use patterns and limited maintenance. Their scattered distribution also makes them susceptible to vandalism. This spatial dispersion, particularly in isolated hillside and peripheral units, complicates regular monitoring and preventive conservation. Meanwhile, the near disappearance of rock-cut construction as a living craft has resulted in knowledge loss, even though favorable geological conditions could support its revival. The absence of skilled practitioners restricts informed repair practices and increases reliance on incompatible materials and techniques. However, recent architectural reinterpretations indicate that such knowledge gaps are not irreversible. For example, modern reinterpretations of rock-cut architecture, such as the Kültepe Tablet Museum (Bağpınar), demonstrate how new techniques can connect with traditional principles.

Conservation strategies should prioritize sustaining vernacular heritage through local communities, operating within existing socio-cultural frameworks rather than relying on externally imposed user groups. In the Kayseri valleys, this implies supporting user-based maintenance models that build on existing patterns of partial use, particularly in hybrid rock-cut–masonry structures that

remain inhabited. Interventions must follow ICOMOS and Burra Charter principles, allowing only minimal and reversible adaptations. Adaptive reuse compatible with traditional patterns, such as converting barns or dovecotes into storage or residential spaces, should preserve carved spatial continuity and avoid subdivision or incompatible surface treatments. Community engagement models suitable for the Koramaz Valley may include locally coordinated stewardship schemes and basic training initiatives for the maintenance of carved spaces, integrating traditional knowledge with contemporary safety and comfort requirements.

Future research should build on the qualitative and spatial findings of this study by incorporating detailed structural assessments of rock-cut units, particularly within hybrid rock-cut–masonry contexts where inappropriate reinforcements were observed. Quantitative analyses focusing on stability, moisture behavior, and the long-term impact of infrastructure-related stresses would support more precise risk-based conservation planning. In parallel, applied research on the documentation, transmission, and potential revival of rock-cut construction knowledge, through pilot training programs or experimental conservation interventions, could help bridge the gap between heritage documentation and practice. Comparative studies across different Anatolian rock-cut landscapes may further clarify whether the conservation challenges identified in the Kayseri valleys reflect broader regional patterns or are shaped by context-specific environmental and socio-cultural conditions.

6. Conculusion

In the specific case of the Kayseri valleys, vernacular rock-cut techniques, although now rarely practised, represent a significant architectural tradition that should be understood and conserved primarily as an element of living and intangible heritage. Simultaneously, the Koramaz and Gesi Valleys, with their layered archaeological, architectural, social, and cultural values, constitute a tangible heritage landscape of exceptional local and regional importance. The conservation of these valleys, therefore, necessitates an approach that balances material preservation with the continuation of everyday use, local knowledge, and user-based adaptation strategies. This study examined the link between vernacular rock-cut construction methods and the topography of the Kayseri valleys, highlighting how settlement morphology, material practices, and spatial organisation are shaped by terrain and long-term cultural adaptation. By identifying conservation challenges through field-based spatial and technical evidence, the research underscores the need for context-sensitive conservation approaches grounded in the principles of living heritage. Framing rock-cut settlements as evolving cultural landscapes offers a more sustainable approach to safeguarding their historical identity while responding to contemporary needs.

CRediT Authorship Contribution Statement

Bahar Elagöz Timur: Writing – review & editing, Writing – original draft, Methodology, Investigation, Analysis, Data curation, Conceptualization, Data visualization. Özlem Kevseroğlu Kurban: Writing – original draft, Methodology, Investigation, Data curation, Conceptualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

Data will be made available on request.

Ethics Committee Approval

Ethics committee permission is not required.

References

Alexander, C., Ishikawa, S., & Silverstein, M. (1977). *A pattern language: Towns, buildings, construction*. Oxford University Press.

Allen, E. (1969). *Stone shelters*. MIT Press.

Arfa, F. H., Zijlstra, H., Lubelli, B., & Quist, W. J. (2022). Adaptive reuse of heritage buildings: From a literature review to a model of practice. *The Historic Environment: Policy and Practice*, *13*(2), 148-170. https://doi.org/10.1080/17567505.2022.2058551

Asquith, L., & Vellinga, M. (Eds.). (2006). *Vernacular architecture in the twenty-first century: Theory, education and practice*. Taylor & Francis.

Australia ICOMOS. (2013). *The Burra Charter: The Australia ICOMOS charter for places of cultural significance*. https://australia.icomos.org/publications/charters

Avrami, E., Mason, R., & de la Torre, M. (Eds.). (2000). *Values and heritage conservation*. Getty Conservation Institute.

Bahramifar, B., Gharehbashloo, E., & Hosseini, A. (2022). Environmentally responsive design in the vernacular housing of Iran. *Journal of Housing and the Built Environment*, *37*(3), 1283_1317. https://doi.org/10.1007/s10901-021-09880-7

Baquedano, P., Ramírez Eudave, R. R., Miranda, F. N., Graus, S., & Ferreira, T. M. (2021). Traditional earth construction in Latin America: A review on the construction systems and reinforcement strategies. In *Masonry construction in active seismic regions* (pp. 99-121). Elsevier. https://doi.org/10.1016/B978-0-12-821087-1.00011-9

Bianca, S. (2000). *Urban form in the Arab world: Past and present*. Thames & Hudson.

Binan, D. U. (1994). Güzelyurt örneğinde Kapadokya bölgesi yığma taş konut mimarisinin korunması için bir yöntem araştırması [Unpublished doctoral dissertation, Thesis Yıldız Technical University].

Cosgrove, D. E. (1984). *Social formation and symbolic landscape*. Croom Helm.

Council of Europe (CoE). (1975). *European charter of the architectural heritage*.

Council of Europe (CoE). (1985). *Convention for the protection of the architectural heritage of Europe (Granada Convention)*.

Council of Europe (CoE). (2005). *Framework convention on the value of cultural heritage for society (Faro Convention)*.

Elagöz Timur, B., & Asiliskender, B. (2024). Kırsal peyzaj mirası çalışmalarının habitus üzerinden değerlendirilmesi. *Milli Folklor*, *18*(141), 167-178. https://doi.org/10.58242/millifolklor.1129209

Elagöz Timur, B., Kevseroğlu Durmuş Ö., Baturayoğlu Yöney, N., & Asiliskender, B. (2018). Gesi Vadisi üzerinden kültürel sürekliliğinin belgelenmesi ve değerlendirilmesi: Kayseri, Mancusun (Yeşilyurt) Mahallesi. In *Türkiye Kentsel Morfoloji Araştırma Ağı II. Kentsel Morfoloji Sempozyumu Bildirileri*. İTÜ

Elert, K., García Baños, E., & Ibáñez Velasco, A. (2021). Traditional roofing with sandstone slabs: Implications for the safeguarding of vernacular architecture. *Journal of Building Engineering*, *33*, Article 101857. https://doi.org/10.1016/j.jobe.2020.101857

Ellis Burnet, J., Ribeiro, D., & Liu, W. (2021). Transition and transformation of a rural landscape: Abandonment and rewilding. *Sustainability*, *13*(9), 5130. https://doi.org/10.3390/su13095130

Fathy, H. (2010). *Architecture for the poor: An experiment in rural Egypt*. American University in Cairo Press.

Fernandes, J., Pimenta, C., Mateus, R., Silva, S. M., & Bragança, L. (2015). Contribution of Portuguese vernacular building strategies to indoor thermal comfort and occupants' perception. *Buildings*, *5*(4), 1242-1264. https://doi.org/10.3390/buildings5041242

Fouseki, K., & Cassar, M. (2014). Energy efficiency in heritage buildings: Future challenges and research needs. *The Historic Environment: Policy and Practice*, *5*(2), 95_100. https://doi.org/10.1179/1756750514Z.00000000058

Givoni, B. (1976). *Man, climate and architecture*. Applied Science.

Güngör Açıkgöz, Ş. (2007). *Kayseri ve çevresinde 19. yüzyıl kiliseleri ve korunmaları için öneriler* [Unpublished doctoral dissertation, İTÜ.

Harrison, R. (2013). *Heritage: Critical approaches*. Routledge.

Heyman, J. (1995). *The stone skeleton: Structural engineering of masonry architecture*. Cambridge University Press.

ICOMOS. (1999). *Charter on the built vernacular heritage*.

ICOMOS-IFLA. (2017). *Principles concerning rural landscapes as heritage*.

İnceköse, Ü. (2019). Dovecotes in Kayabağ village: An assessment of landscape and architectural characteristics. *Journal of Architectural Conservation*, *26*(1). https://doi.org/10.1080/13556207.2019.1663647

Jackson, J. B. (1984). *Discovering the vernacular landscape*. Yale University Press.

Jokilehto, J. (2006). Considerations on authenticity and integrity in world heritage context. *City and Time*, *2*(1), 1-16.

Kayseri Metropolitan Municipality. (2017). *Kayseri yeraltı yapıları envanteri (4. ara rapor)*. Kayseri Metropolitan Municipality Publications.

Kayseri Metropolitan Municipality. (2020). *Kayseri yeraltı yapıları envanteri: Koramaz Vadisi*. Kayseri Metropolitan Municipality Publications.

Kevseroğlu, Ö., Ayataç, H., & Baturayoğlu Yöney, N. (2021). Understanding intangible aspects of cultural landscape: Living cultures of northeast Kayseri Valleys. *Milli Folklor*, *130*(17), 185-203.

Kévorkian, R. H., & Paboudjian, P. B. (2012). *1915 Öncesi Osmanlı İmparatorluğu'nda Ermeniler*.Aras Yayınları.

Kilit, R. M., & Dişli, G. (2022). Management planning of a rock-cut settlement: The case of the Taşkale heritage site in Turkey. *Conservation and Management of Archaeological Sites*, *24*(3), 189_207. https://doi.org/10.1080/13505033.2023.2256544

Kostof, S. (1991). *The city shaped: Urban patterns and meanings through history*. Thames & Hudson.

La Russa, M. F., Ruffolo, S. A., Rovella, N., Belfiore, C. M., Pogliani, P., Pelosi, C., Andaloro, M., & Crisci, G. M. (2014). Cappadocian ignimbrite cave churches: Stone degradation and conservation strategies. *Periodico di Mineralogia*, *83*, 187-206. https://doi.org/10.2451/2014PM0011

Lawrence, D. L., & Low, S. M. (1990). The built environment and spatial form. *Annual Review of Anthropology*, 19, 453-505.

Martínez, V. G., Ma, G., Pellegrini, P., & Costa, M. R. (2022). Vernacular architecture and cultural identity in shrinking rural settlements. *ACE: Architecture, City and Environment*, *17*(50), 11389. https://doi.org/10.5821/ace.17.50.11389

Mason, R. (2002). Assessing values in conservation planning: Methodological issues and choices. In M. de la Torre (Ed.), *Assessing the values of cultural heritage* (pp. 5-30). Getty Conservation Institute.

Mileto, C., & López-Manzanares, F. V. (2022). Earthen architectural heritage in the international context: Values, threats, conservation principles and strategies. *Journal of Cultural Heritage Management and Sustainable Development*, *12*(2), 192-205. https://doi.org/10.1108/JCHMSD-06-2021-0115

Morgan, W. N. (1990). *Precolumbian architecture in Eastern North America*. University Press of Florida.

Oliver, P. (2006). *Built to meet needs: Cultural issues in vernacular architecture*. Architectural Press.

Ousterhout, R. G. (2017). *Eastern medieval architecture: The building traditions of Byzantium and neighboring lands*. Oxford University Press.

Özata, Ş., Aktürk, B., & Aktürk, E. (2024). Material characterization and damage assessment of Byzantine rock-cut monastery: A case study of Kıyıköy Hagia Nicholas. *Art-Sanat*, *0*(21), 529_563. https://doi.org/10.26650/artsanat.2024.21.1274271

Özkan, S. (2000). Anadoluda Ortodoksluk Sadası gazetesi. In *III. Kayseri ve yöresi tarih sempozyumu bildirileri*, (pp. 363-378). ERÜ KAYTAM.

Pallasmaa, J. (2009). *The thinking hand: Existential and embodied wisdom in architecture*. Wiley.

Pelosi, C., Agresti, G., Andaloro, M., Baraldi, P., Pogliani, P., Santamaria, U., La Russa, M. F., Ruffolo, S. A., & Rovella, N. (2016). Micro-Raman and micro-stratigraphic analysis of the painting materials in the rock-hewn Church of the Forty Martyrs in Şahinefendi, Cappadocia (Turkey). *Archaeometry*, *58*(2), 291-307. https://doi.org/10.1111/arcm.12184

Philokyprou, M., & Michael, A. (2021). Environmental sustainability in the conservation of vernacular architecture: The case of rural and urban traditional settlements in Cyprus. *International Journal of Architectural Heritage*, *15*(11), 1741-1763. https://doi.org/10.1080/15583058.2020.1719235

Polanyi, M. (1966). *The tacit dimension*. University of Chicago Press.

Rapoport, A. (1969). *House form and culture*. Prentice-Hall.

Rodley, L. (1985). *Cave monasteries of Byzantine Cappadocia*. Cambridge University Press.

Rudofsky, B. (1964). *Architecture without architects: A short introduction to nonpedigreed architecture*. Museum of Modern Art.

Samalavicius, A. L., & Gabrenas, A. (2022). The legacy of Lithuanian urban and semi-urban vernacular architecture and possibilities of its preservation. *Buildings*, *12*(12), 2087. https://doi.org/10.3390/buildings12122087

Sani, F., Moratti, G., Coli, M., Laureano, P., Rovero, L., Tonietti, U., & Coli, N. (2012). Integrated geological-architectural pilot study of the Biet Gabriel-Rufael rock hewn church in Lalibela, northern Ethiopia. *Italian Journal of Geosciences*, *131*(1), 68-82. https://doi.org/10.3301/IJG.2011.26

Schafer, R. M. (1977). *The tuning of the world*. Knopf.
Smith, L. (2006). *Uses of heritage*. Routledge.
Sümerkan, M. R. (1990). *Biçimlendirilen etkenler açısından doğu karadeniz kırsal kesiminde geleneksel evlerin yapı özellikleri* [Yayınlanmamış doktora tezi, Karadeniz Teknik Üniversitesi Fen Bilimleri Enstitüsü].
Treacy, J. M., & Denevan, W. M. (1994). The creation of cultivable land through terracing. In N. F. Miller, & K. L. Gleason (Eds.), *The archaeology of garden and field* (pp. 91-110). University of Pennsylvania Press.
Tunusluoğlu, M. C., & Zorlu, K. (2009). Rockfall hazard assessment in a cultural and natural heritage (Ortahisar Castle, Cappadocia, Turkey). *Environmental Geology*, *56*(5), 963_972. https://link.springer.com/article/10.1007/s00254-008-1198-z
Ulusay, R., Gökçeoğlu, C., Topal, T., Sönmez, H., Tuncay, E., Ergüler, Z. A., & Kaşmer, Ö. (2006). Assessment of environmental and engineering geological problems for the possible re-use of an abandoned rock-hewn settlement in Ürgüp (Cappadocia), Turkey. *Environmental Geology*, *50*(3), 401_415. https://doi.org/10.1007/s00254-006-0222-4
UNESCO. (1972). *Convention concerning the protection of the world cultural and natural heritage*.
UNESCO. (1989). *Recommendation on the safeguarding of traditional culture and folklore*.
UNESCO. (2003). *Convention for the safeguarding of the intangible cultural heritage*.
UNESCO. (2011). *Recommendation on the historic urban landscape (HUL recommendation)*.
UNESCO. (n.d.). *Tentative lists*. https://whc.unesco.org/en/tentativelists/6473/
Vellinga, M. (2013). The noble vernacular. *Journal of Architecture*, *18*(4), 570-590.
Yamaç, A. (2017). Underground settlements and cave dwellings of Agirnas Village, Kayseri (Southeast Turkey). In *HYPOGEA 2017: Proceedings of International Congress of Speleology in Artificial Cavities*.
Yamaç, A. (2023). *Rock-cut architecture and underground cities in Koramaz Valley of Kayseri, Turkey*. Springer. https://doi.org/10.1007/978-3-031-29374-0
Yurt Ansiklopedisi. (1982). *Yurt ansiklopedisi* (Cilt 7). Anadolu Yayıncılık.
Zhai, Z., & Previtali, J. M. (2010). Ancient vernacular architecture: Characteristics categorization and energy performance evaluation. *Energy and Buildings*, *42*(3), 357_365. https://doi.org/10.1016/j.enbuild.2009.10.002
Zong, J., Wan Mohamed, W. S., Ja'afar, M. F. Z., & Ujang, N. (2024). Sustainable development of vernacular architecture: A systematic literature review. *Journal of Asian Architecture and Building Engineering*. Advance online publication. https://doi.org/10.1080/13467581.2024.2399685

Resume

Dr. Bahar Elagöz Timur received her B.Sc. in Architecture (2013) and her M.Sc. in Restoration (2015) from Istanbul Technical University, and completed her PhD in Architecture at Abdullah Gül University in 2024. She is currently an Assistant Professor in the Department of Architecture at Abdullah Gül University. Her research focuses on the intersection of building science and architectural conservation, with particular emphasis on traditional building systems and construction techniques, rural and vernacular architecture, risk and vulnerability assessment of historic environments, and sustainable heritage adaptation.

Dr. Özlem Kevseroğlu Kurban received her B.Sc. in Landscape Architecture (2008) and M.Sc. in Urban Design (2011) from Istanbul Technical University, and completed her PhD in 2022. Having served as a research assistant since 2014, she is currently an Assistant Professor in the Department of Architecture at Abdullah Gül University. Her academic work and teaching focus on the intersection of architecture, urbanism, and landscape. She also serves as the Vice Dean of the Faculty of Architecture and the Head of the Urban and Environmental Studies Department.

JOURNAL OF DESIGN FOR RESILIENCE IN ARCHITECTURE & PLANNING

Research Article
Online: www.drarch.org
Volume 7, Issue 1 (107-125), 2026
DOI: 10.47818/DRArch.2026.v7i1206

The city branding potential of Sakarya: A tourism-oriented evaluation

Esra Parıldı*
Güliz Öztürk**

Abstract

With the rise of global competition, developing city branding strategies has become vital for urban centres. The unique features and values of cities, especially their geographical, cultural, and historical traits, play a crucial role in shaping city identity and image during the branding process. This study aims to assess Sakarya's geographical, historical, and cultural tourism assets and their contribution to its potential as a city brand. Additionally, the research examines the impact of tourism-related projects on established city branding criteria. A mixed-methods approach was used, combining both qualitative and quantitative data collected through semi-structured interviews. Experts from various stakeholder institutions within the city participated in the study. Fifteen experts responded to six open-ended questions about Sakarya's tourism potential and branding process. Moreover, participants evaluated the effects of current or upcoming tourism projects on city branding criteria using a matrix-based scoring form. Experts identified natural assets such as Acarlar Floodplain Forest and the Sapanca River, historical and touristic sites including the Çark Watermill, the Justinianus Bridge, and traditional houses in Taraklı, and local gastronomic values as key tools for branding. Matrix analysis results show that projects centred on the city's natural areas, such as coastal recreation initiatives and the restoration of natural and historical sites, make the greatest contribution to city branding. Participants also noted that bicycle-related projects and events have given the city a distinctive identity and improved its international competitiveness.

Keywords: brand city, city branding, Sakarya, tourism

1. Introduction

Tourism, traditionally driven by various travel motives, has evolved into a strategic industry that significantly shapes urban development and growth through economic, social, and cultural effects. Among the strategies used, cities often compete by highlighting their unique tourist attractions. As this approach has become more important, cities have increasingly emphazised branding through tourism.

The tourism sector's interdisciplinary connections enhance its importance in city branding strategies. Simultaneously, a city's status as a "brand city" supports the sector by fostering a positive image through urban identity construction. However, branding processes that depend exclusively on promoting physical and cultural assets are insufficient. Successful city branding requires active participation and collaboration among local governments, tourism enterprises, residents, and other stakeholders (Hryhorieva et al., 2020).

This study examines Sakarya's tourism potential and its contribution to the city's branding process. Two key questions guide the research: (i) What are Sakarya's tourism assets and how do they contribute to city branding? (ii) To what extent do tourism projects in Sakarya align with city branding criteria?

*Landscape Architect, Sakarya Metropolitan Municipality, Sakarya, Türkiye esraparildi@hotmail.com
**(Corresponding author), Department of City and Regional Planning, Gebze Technical University, Kocaeli, Türkiye
gozturk@gtu.edu.tr

Article history: Received 21 August 2025, Revised 21 October 2025, Accepted 12 March 2026, Published 30 April 2026

A mixed-methods approach was used, combining qualitative interviews with local stakeholders to examine the impact of tourism assets on city branding and quantitative analysis to assess the contribution of existing projects to branding potential. Sakarya's natural, cultural, and historical tourism assets were explored, and the effects of both existing and planned projects based on these assets were analyzed in relation to city branding criteria.

Fifteen of the twenty invited experts participated in the study. The majority (80%) reside in Sakarya, hold managerial positions in public institutions, and have postgraduate degrees (93%). Participants come from diverse professional backgrounds, including public administration (20%), urban planning, environmental engineering, economics, civil engineering, landscape architecture, and forest engineering. Expert opinions were used to assess the city's potential, and stakeholder institutions' tourism-oriented projects in Sakarya were scored and analyzed for their contributions to city branding strategies.

2. The City Branding Process

Globalization has shifted economic competition from the national level to urban and regional levels, making the creation of 'brand value' a key policy focus in urban development strategies (Kotler, 2000; Begg, 1999). Since the 1970s, economic transformations in industrialized countries have intensified competition among cities both nationally and internationally to attract investment, tourism, skilled labour, and cultural activities. The emerging 'urban branding' approach during this period conceptualizes cities not merely as geographical locations but as destinations that differentiate themselves through unique cultural, historical, social, and economic characteristics, thereby enhancing their recognition and appeal (Başaran, 2008). From the latter half of the 20th century onwards, city branding has become a prominent component of marketing strategies in American and European cities, serving both regional marketing efforts and as a response to urban development challenges (Hryhorieva et al., 2020).

Keller (2013) defines a city brand as a mental association created by the city's physical, cultural, and social elements. A city brand thus distinguishes itself from competitors by uniquely defining its values, linking them to a strong image in target audiences' minds, and offering a comprehensive experience. These values include geographical location, cultural heritage, historical features, natural beauty, gastronomy, social life, and infrastructure (Yeoman, 2009; Başpınar, 2015). Helmy (2008) further highlights that urban branding involves not only promoting a positive city image but also transforming the entire city into a holistic experience.

However, Anholt (2006) emphasizes that national identities often overshadow perceptions of local identities. The author argues that Australia's strong, positive international reputation supports confidence in Sydney. In contrast, Lagos, like many other African cities, struggles to establish a positive image due to the continent's branding effect, which hinders its international reputation. Consequently, explains that, because city culture is generally difficult to separate from a country's overall culture, the national brand index and the city brand index should comprise distinct components.

In the city branding process, decision-makers aim to develop a strong image and identity by systematically assessing the city's tangible and intangible assets. In this context, Dinnie (2010) highlights that city branding is not only a marketing strategy but also a long-term planning approach that supports sustainable development objectives. Likewise, Ailawadi and Keller (2004) describe city branding as the comprehensive enhancement of a city's social, cultural, and commercial activities to create high value. This approach seeks to transform the city into both a tourist destination and a competitive centre of life, making it a desirable place to live, work, invest, and study. Harvey (2016) further observes that cities pursue such initiatives to attain a high quality of life. Research shows that city branding offers multidimensional benefits, including economic growth, improved quality of life, preservation of cultural heritage, increased investment appeal, and higher tourism revenues (Lever & Turok, 1999; Yeoman, 2009).

Considering the value created by city branding, competitiveness is a crucial factor in shaping a city's brand, as it drives that value. Cities compete at national and international levels by leveraging their distinctive characteristics, including natural advantages such as geography and climate, as well as human-made assets like architectural heritage and cultural events (Başpınar, 2015). Consequently, cities with similar infrastructures can establish their brand identities by emphasizing differences in their histories, cultures, and socio-economic structures. In this regard, Budd and Hirmis (2004) highlight that enhancing city competitiveness requires comprehensive strategic planning, participation from residents and visitors, targeted service development, and effective marketing of tourism and cultural heritage. Furthermore, a city's ability to attract investment, skilled labour, tourists, international events, and public incentives directly strengthens its city brand identity (Lever & Turok, 1999; Harvey, 2016).

The studies also present critical perspectives on this strategy. Simultaneously including multiple cities in the branding process may reduce efficiency in resource use and weaken competitive strength (Tek, 2009). Successful cases often focus on branding one or two cities exclusively. Moreover, Kavaratzis (2004) argues that although city branding initiatives emphasize urban identity and local character, marketing-driven approaches tend to create uniformity across cities, reducing their distinctive identities. The author underscores the importance of involving local stakeholders in the branding process to preserve local distinctiveness and maintain the authenticity of urban identity.

Risitano (2006) identifies six primary components of city branding: brand culture (including historical sites, traditions, and gastronomy), brand character (perceived trustworthiness), brand personality (the city's distinctive features), brand name (unique identifiers), brand logo and symbols, and brand slogan (Risitano, 2006; Kotler & Lee, 2009; Aaker, 1997). Conversely, Zeren (2012) categorizes city brand values into five main groups: physical, socio-cultural, functional, and administrative.

Different researchers emphasize various aspects, but all elements related to a city's unique values critically influence its image and brand strength. A notable example of converting local characteristics into branding elements is Bergen, Norway. The city's unfavorable weather conditions have been reframed as a positive branding asset through events such as the 'Rain Festival', thereby enhancing Bergen's brand value. Another internationally recognized example is New York's 'I♥ NY' campaign. Launched in 1977, this initiative transformed the city's negative economic image through the now-iconic logo, boosting tourism revenues and establishing a globally recognized model of brand identity construction (Ward, 2005).

Apaydın (2011) argues that the city branding process extends beyond promotional activities to include a multidimensional planning approach that strategically shapes urban identity and requires the involvement of all stakeholders. Therefore, city branding is not solely the responsibility of local governments; it is a coordinated process demanding collective action and strategic collaboration (Apaydın, 2011). Successful branding requires that local administrations' initiatives gain support from civil society organizations and city residents (Giritlioğlu & Avcıkurt, 2010; Budd & Hirmis, 2004). Cevher (2012) claims that cities must be selective in their branding efforts and develop strategies tailored to specific target audiences. The primary objective should be to attract qualified tourists, an educated population, and major investors. Furthermore, researchers highlight the importance of generating financial resources to build a sustainable urban image (Jansson & Power, 2006; Emin, 2012).

Culture, creativity, and creative industries have recently become key elements in city branding strategies, aligning with sustainable development goals (Tomaz & Caldeira, 2021; Kasemsarn et al., 2025). Since the 1990s, creativity-based strategies have been central to efforts to diversify economies and revitalize local communities. Culture has been recognized not just as an element of identity but also as a catalyst for economic development and innovation. To stand out in a globally competitive environment, cities have invested in cultural heritage, creative industries, and artistic

activities, thereby fostering entrepreneurial urban identities. Within this framework, the strategic use of cultural planning—including cultural tourism, the development of creative industries, and the conversion of cultural capital into economic value—plays a vital role in sustainable city branding processes (Cudny et al., 2020; Cerisola & Panzera, 2021; Kasemsarn et al., 2025).

According to Kasemsarn et al. (2025), city branding requires an integrated approach that considers economic growth, social progress, infrastructure, architecture, landscape, environment, culture, and history to build a marketable identity. In this way, branding reflects a perspective aligned with local development objectives and the global marketing of cities. Kasemsarn et al. (2025) also note that practices incorporating sustainability goals are emerging as a new trend in city branding. For example, they mention the 'Green Blue Youth Vision 2030' initiative in Southern Italy, which stands as a significant model for the circular economy and youth participation. The authors emphasize that practices strategically combining cultural heritage, creative tourism, creativity, and sustainability can foster the development of distinctive urban brands that attract diverse target groups.

3. The Role of Tourism in City Branding: Research and Strategic Approaches in Turkey

The tourism sector is a critical driver of city branding strategies, influencing both economic and cultural aspects. While tourism supports all three areas of local development, Ashworth and Page (2011) emphasize that its economic impacts more directly influence wider segments of society compared to its socio-cultural and environmental effects. Tourism revenues boost GDP growth and sectoral employment and create added value through multiplier effects, which, in turn, stimulate the development of other economic activities (Archer, 1977; Brown, 2000; Ferreia & Estevao, 2009; Salihoğlu & Gezici, 2018).

The process of urban branding differs from product and service branding due to its multidimensional nature. Branding a tourist destination requires creating a distinctive identity and a positive urban image that differentiates the city from others (Albayrak & Caber, 2008; Şahin, 2010). Gotham (2007) defines tourism-related branding as a process in which local tourism organizations employ place-based imagery, including cultural and arts institutions, museums, and protected heritage sites, to attract consumers and investors to a specific area, thereby promoting differentiation and diversity. Yılmaz and Çizel (2000) identify several advantages of establishing a city brand in tourism, such as increased city recognition, improved product marketing, quality assurance, and the development of emotional connections with tourists. Conversely, Anholt (2010) argues that place image and the marketing practices developed by Kotler, Haider, and Rein are primarily tools for promoting new products, services, and attractions, and criticizes their limited effectiveness in shaping a place's overall image or reputation.

Within the framework of city branding, tourism functions not only as a catalyst for economic growth but also as a strategic instrument for promoting cultural identity, improving quality of life, and enhancing global recognition (Kaypak, 2013). Beyond its economic impact, the tourism sector provides a comprehensive experience that integrates political, legal, natural, cultural, and technological dimensions (Özdemir, 2007). For these reasons, it is emphasized that cities' tourism policies should align with the overall brand vision and be designed to strengthen the destination image.

Although city branding processes are frequently managed by non-profit organizations, effective implementation also requires the involvement of public authorities (Giritlioğlu & Avcıkurt, 2010). In this process, local governments play a pivotal role, as the services they provide directly influence the quality of life of urban residents (Yavuz, 2007). Kavaratzis and Hatch (2013) challenge the dominant communication-based understanding of place branding and instead promote an identity-based perspective, arguing that branding and identity are inherently interconnected. Accordingly, they emphasize that place branding should engage a wide range of stakeholders and that the brand vision should be aligned with the principles of corporate branding. In this context, residents'

attitudes toward and satisfaction with the place and its brand identity are also considered significant.

Furthermore, it is emphasized that place branding practices can be advanced by drawing on conceptualizations of place culture—namely, how it is experienced, collectively produced, and shared. Zenker and Braun (2017), who point to the scarcity of research on how tourism and destination branding influence both tourists and residents, demonstrate that brand complexity—understood as multi-layered branding—is perceived more positively by both groups. Accordingly, destination brands characterized by multi-layered, multi-component, and multi-stakeholder structures positively affect satisfaction and exert a stronger influence on the development of identity and place attachment among residents.

Reports by the World Tourism Organization further emphasize that city administrators should develop strategies to manage increasing tourist numbers sustainably, enhance residents' quality of life, and reduce environmental impacts (World Tourism Organization, 2012). Decision-makers frequently prioritize environmental factors, as they serve both as marketing tools and as travel motivations in tourism. Various researchers argue that, in order to build a successful city brand, it is essential to address the city's geopolitical location, image, service quality, and distinctive assets alongside its tourism potential, and to approach the process from a holistic perspective (Lóránt & Tünde, 2010; Kotler & Lee, 2009; Kapferer, 2008).

Recent studies reveal a shift in city branding from market-oriented, competition-based approaches toward more integrated, sustainability-focused frameworks. While Kotler (2000) and Begg (1999) discuss city branding primarily as a tool for intercity competition and attracting investment, more recent research, such as that of Kavaratzis and Hatch (2013) and Tomaz and Caldeira (2021), emphasizes identity-based, participatory, and culture-focused perspectives. Although tourism is often a central component of city branding strategies (Budd & Hirmis, 2004; Helmy, 2008; Cevher, 2012), there is ongoing debate regarding the sector's role. It is variously conceptualized as a strategic economic driver (Kotler, 2000; Begg, 1999), a symbolic tool contributing to identity formation (Aaker, 1997; Risitano, 2006; Giritlioğlu & Avcıkurt, 2010; Cudny et al., 2020; Cerisola & Panzera, 2021), and a factor enhancing quality of life and sustainable development (Anholt, 2006, 2010; Keller, 2013; Zenker & Braun, 2017). In this context, the evolving literature increasingly underscores the importance of creative industries, cultural capital, and inter-institutional collaboration in shaping city brands in the context of tourism.

Since the 1980s, Turkey has become a significant destination in the global tourism market. The idea of city branding started to gain attention in the 1990s, and today the success of the tourism sector is evaluated not only through quantitative indicators but also in terms of destination value and branding efforts. In 2003, the first structured initiatives were launched, focusing on Istanbul, Antalya, and Konya. The Turkey Tourism Strategy 2023 Action Plan, developed by the Ministry of Culture and Tourism in 2006, highlights the goal of transforming cities into tourism development regions, development corridors, main development axes, tourism cities, ecotourism regions, and branded cities by 2023 (Şahin, 2010; Kültür ve Turizm Bakanlığı, 2007). The purpose of this strategy is to protect, utilize, and promote the country's natural, cultural, historical, and geographical assets, to diversify tourism offerings, and ultimately to increase Turkey's share of tourism-related economic benefits (Kültür ve Turizm Bakanlığı, 2007).

Within the framework of this strategy, 19 cities were targeted for elevation to brand-city status. The vision adopted in Turkey's urban branding strategy is defined as "transforming our cities, endowed with rich cultural and natural features, into destinations for tourists through branding." Under the plan, the Silk Road Tourism Corridor and the Western Black Sea Coastal Corridor—two of the seven thematic tourism development corridors—include the province of Sakarya. Although Sakarya is not listed among the designated brand cities, its cultural and natural assets nonetheless support the city's branding potential.

National studies enhance the national literature on tourism's role in city branding by highlighting the complex, multidimensional nature of urban branding and the necessity of strategic approaches for successful outcomes. For example, Çetinsöz and Temiz (2018) developed a comprehensive method to identify Anamur's brand identity and personality. Similarly, Cevher (2012) analyzed the city branding process and its regional benefits in Antalya, while Tezcan (2011) assessed intercity competition and the branding process in İzmir from a planning perspective.

Akturan and Oğuztimur (2016) highlight the multidisciplinary nature of urban branding, noting that urban planners, marketers, architects, and tourism professionals approach the issue from distinct paradigms. The authors note that this diversity makes it difficult to develop a holistic theoretical framework. Eraydın (2016), in her study on Ankara, examined the effects of urban branding strategies on urban memory and urban image, highlighting the weak connection between the city's history and its identity. Koç (2018), on the other hand, analyzed the city branding process in the case of Eskişehir, investigating the impact of the strategic approach implemented since 1999 on the city's social, cultural, and physical transformation. The study is significant in that it reveals the crucial role of local government and the process by which public administrators adopt branding strategies.

Furthermore, these studies provide insights that guide practical development by highlighting the importance of stakeholder involvement, preservation of local features, and sustainable planning methods. The next section assesses Sakarya's potential based on its tourism assets and planning strategies and offers related recommendations as another example from Turkey.

4. Case Study and Methodological Approach

Located in northwestern Turkey, the province of Sakarya is a prominent example with the potential to become a city brand, thanks to its geographical location, accessibility, and rich tourism diversity. The city sits at a critical intersection for access to major metropolitan areas such as Istanbul, Ankara, and Bursa, making it easy to access. The TEM and D-100 highways, the high-speed train line, the Northern Marmara Motorway, and port connections make Sakarya an easily accessible destination for both domestic and international visitors (Köseoğlu & Dursun, 2015). This strategic location makes Sakarya an attractive weekend or day-trip destination, particularly for domestic tourists seeking an escape from Istanbul's dense population (Bilgiç, 2007).

Sakarya offers a diverse range of alternative tourism types, including nature, culture, and coastal tourism. Sapanca Lake is one of the leading centres of nature-based tourism, offering opportunities for water sports such as canoeing and sailing, as well as hiking trails around the lake. Acarlar Floodplain Forest, the second-largest of its kind in Turkey, is a significant site for birdwatching and ecotourism (Orman ve Su İşleri Bakanlığı, 2016). Although the Karasu and Kocaali coasts have high potential for summer tourism, this potential has not been fully realized due to the limited scope of current tourism investments (Sakarya Valiliği, 2020).

Sakarya has gained international recognition in cultural tourism as a UNESCO-designated "Learning City," and the Taraklı district has received the "Cittaslow" (Slow City) certification. Cultural heritage assets like the Justinianus Bridge, Ottoman-era mosques and mansions, historic bazaars, and traditional handicrafts significantly strengthen the city's brand identity. Sports and adventure tourism are also developing rapidly. Paragliding in Serdivan, highland tourism in Akyazı and Hendek, the city's status as a bicycle-friendly destination, and its mountain biking trails are notable examples. Outdoor activities such as camping, caravan tourism, and ATV tours further enrich Sakarya's tourism diversity.

Table 1 presents the distribution of visitor arrivals, overnight stays, and average length of stay by district in Sakarya. Adapazarı records the highest number of overnight stays among both domestic and foreign visitors. Regarding arrivals, Adapazarı, Sapanca, and Serdivan report the largest numbers. Sapanca and Kocaali districts have the longest average lengths of stay, with Kocaali at 3 days. The provincial average length of stay is 2.1 days.

Table 1 Tourism Statistics (2021) per District[1]

Districts	Visitor Arrivals			Overnight Stays			Average Length of Stay (day)		
	Foreign	Domestic	Total	Foreign	Domestic	Total	Foreign	Domestic	Total
Adapazarı	7775	96965	104740	13590	163038	176628	1,7	1,7	1,7
Akyazı	878	29159	30037	2377	77291	79668	2,7	2,7	2,7
Erenler	1431	40401	41832	3851	74879	78730	2,7	1,9	1,9
Geyve	6	3276	3282	8	6382	6390	1,3	1,9	1,9
Hendek	312	14824	15136	1059	36630	37689	3,4	2,5	2,5
Karasu	33	5062	5095	44	12329	12373	1,3	2,4	2,4
Kocaali	86	10671	10757	270	32360	32630	3,1	3,0	3,0
Pamukova	134	10833	10967	218	17860	18078	1,6	1,6	1,6
Sapanca	8791	85118	93909	21055	165207	186262	2,4	1,9	2,0
Serdivan	5603	41303	46906	13526	69445	82971	2,4	1,7	1,8
Taraklı	5	1276	1281	12	2525	2537	2,4	2,0	2,0
Ferizli	38	2041	2079	76	3947	4023	2,0	1,9	1,9
Kaynarca	17	1386	1403	49	2740	2789	2,9	2,0	2,0
Arifiye	3090	19278	22368	4301	28068	32369	1,4	1,5	1,4
TOTAL	28199	361593	389792	60436	692701	753137	2,2	2,0	2,1

Data from 2021 indicate that Sakarya contains 118 accommodation facilities, comprising 4030 rooms and 8343 beds. In terms of spatial distribution, Serdivan emerges as the primary center, reflecting significant potential for both nature-based and cultural tourism. Sapanca, Karasu, and Kocaali follow, each providing opportunities for nature and coastal tourism. Figure 1 shows all tourism accommodation facilities in the city, based on 2021 data.

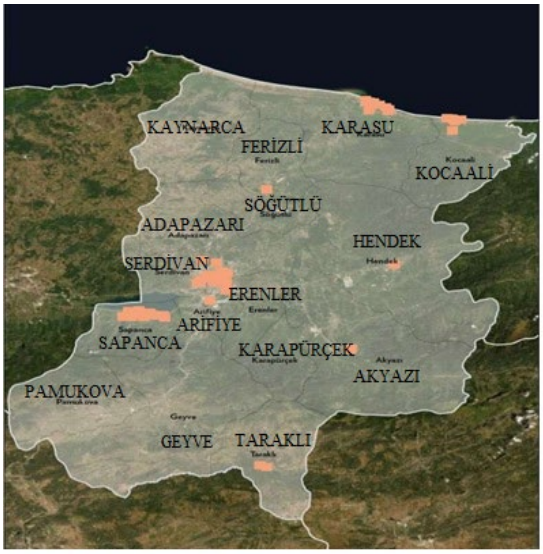


Figure 1 Distribution of accommodation facilities in Sakarya (Parıldı, 2023)

In addition to possessing numerous tourism centres, Sakarya is strategically situated at the intersection of major transportation routes. Its proximity to Istanbul provides a significant advantage for the tourism sector. There is considerable potential for same-day tourism from Istanbul, Ankara, and Kocaeli during weekends (Bilgiç, 2007; Zengin et al., 2023). Consequently, Sakarya's accessibility and closeness to metropolitan centres have facilitated its development as a prominent destination for domestic tourists.

Accordingly, this study aims to identify the city branding potential of Sakarya by evaluating its natural and cultural assets from a tourism perspective. The research specifically seeks to address the following questions:

(i) What are Sakarya's tourism assets, and how do they contribute to the city's branding?

[1] Data were obtained from publicly available official statistics published by the Ministry of Culture and Tourism, which report the total number of facilities certified by municipalities and the ministry.

(ii) To what extent do tourism projects in Sakarya align with city branding criteria?

A mixed-methods research design, integrating both qualitative and quantitative approaches, was employed. The qualitative approach is frequently utilized in tourism research as it facilitates an in-depth understanding of perceptions, experiences, and contextual conditions. In the city branding literature, local stakeholders' perceptions are recognized as a critical element in constructing urban identity (Kavaratzis & Ashworth, 2005). Accordingly, this study sought the views of experts from public and private institutions who represent local stakeholders. The qualitative method was used to assess the impact of tourism assets on the city branding process, while the quantitative method evaluated the contribution of existing projects to city branding potential. This approach enabled the findings to be analyzed within a comprehensive framework.

Guest et al. (2006) note that the literature offers varying recommendations on the appropriate sample size for qualitative research. They report that, particularly with homogeneous samples and focused research questions, 12 to 15 interviews are typically sufficient to achieve data saturation. Creswell (2012) recommends conducting 5 to 25 interviews for phenomenological studies. Mason (2010) observes that small sample sizes in qualitative research are often associated with diminishing returns. Consequently, data saturation is regarded as a key criterion; when saturation is reached, the lack of new themes or findings from additional data indicates that the number of interviews is adequate.

Participants were selected from among experts actively engaged in or knowledgeable about Sakarya's tourism policies and city branding processes. Purposive sampling was utilized to ensure the inclusion of individuals with substantial subject-matter expertise, thereby facilitating the collection of informed responses to the research questions. This approach was grounded in the participants' expertise and knowledge base.

The study involved experts and decision-makers who play an active role in developing Sakarya's tourism policies. Participants were selected from various institutions, including municipalities, universities, the Provincial Directorate of Culture and Tourism, the Eastern Marmara Development Agency, and non-governmental organizations. Of the 20 individuals initially invited, 15 consented to participate in interviews, and data collection was completed with these experts. The majority of participants (80%) reside in Sakarya, most occupy managerial roles in public institutions, and 93% hold postgraduate qualifications. Regarding professional backgrounds, the sample comprised public administrators (20%), urban planners (13%), environmental engineers (13%), economists (13%), civil engineers (7%), landscape architects (7%), and forest engineers (7%) (Figure 2).

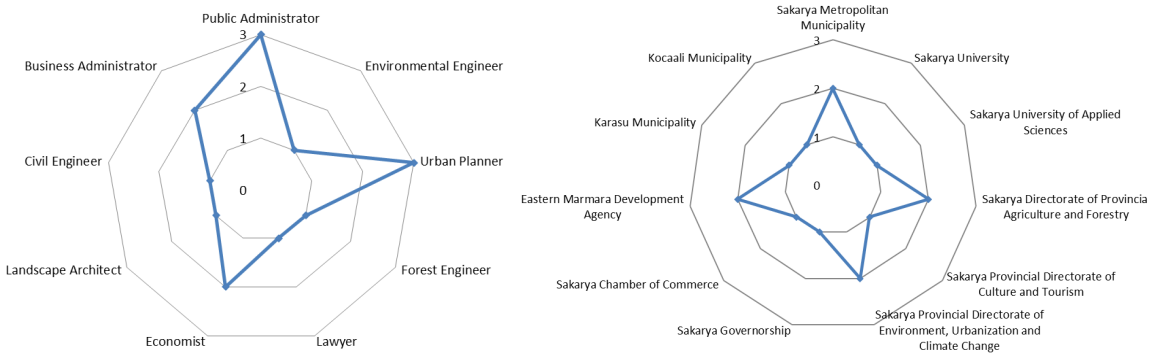


Figure 2 Distribution of professions and institutional affiliations among interviewed experts

A semi-structured interview form was developed as the primary data collection tool. This approach facilitates the systematic exploration of research questions while enabling participants to articulate their perspectives (Merriam, 2013). The interview form was designed with reference to established studies in the literature (Çetinsöz & Temiz, 2018; Cevher, 2012) and subsequently refined after a pilot implementation involving three participants. The finalized form comprised three sections: demographic information, open-ended questions evaluating Sakarya's tourism

potential, and an impact assessment matrix measuring the effects of tourism projects on city branding criteria.

The interview form utilized in this research was organized into two distinct sections. The initial section comprised six open-ended questions intended to investigate the city's brand potential within the tourism sector. Qualitative data obtained from these questions were analyzed using descriptive methods, and expert statements were documented in comprehensive notes during the interviews. The subsequent section required participants to evaluate the influence of selected projects on city branding criteria. A matrix was provided, with rows representing implemented or ongoing projects in Sakarya province and columns corresponding to branding criteria derived from the defining attributes of brand cities. Participants rated each project's impact using a scale from 0 (definitely no impact) to 3 (definitely important impact). Given that the study employed an impact analysis method based on expert opinions, an interval and absolute zero-point ratio scale was applied to convert qualitative assessments into quantitative data. This methodology was designed to streamline the response process for experts and facilitate the analysis of the resulting data using descriptive statistics, including mean, median, and variance.

Participants received project briefings through verbal explanations as well as visual and textual materials, such as photographs, reports, and relevant documents. After data collection, the median and mean impact ratings assigned by each participant were calculated, and an evaluation matrix was constructed. Interviews were scheduled by appointment after obtaining participants' legal permission, and they were informed of the semi-structured interview questions in advance. Direct quotations were used to accurately represent participants' perspectives. To enhance interview validity, summarized data were shared with participants for confirmation.

5. Findings

5.1. An Evaluation of Sakarya's Tourism Potential from a City Branding Perspective

The initial phase of the research analyzed Sakarya's potential to develop as a city brand using a qualitative approach grounded in expert opinions. During this stage, open-ended questions were selected because they facilitate more expressive responses and do not require adherence to a predetermined hypothesis (Karasar, 2004). The responses to the six open-ended questions posed to participants were then categorized thematically and are presented below.

Urban Elements Defining Sakarya: Participants most frequently identify Sakarya's natural assets (50%) and historical-cultural heritage as defining features. Notable natural attractions include Sapanca Lake, Acarlar Floodplain Forest, the Sakarya River, and the highlands. Architectural landmarks such as the Taraklı Houses and the Çark Watermill, which retain Ottoman-era features, contribute to the city's historical memory. Collectively, these elements shape Sakarya's identity and strengthen its potential for city branding (Çetinsöz & Temiz, 2018).

Participant U-4 stated: "*In Sakarya, the historical waterwheel mill, Turkish houses, along with Taraklı, have a distinctive beauty. The province of Sakarya is also one of the regions rich in lakes. The most important lake of the province is Sapanca Lake, which is of great significance for water sports, drinking and utility water supply, fisheries, industrial use, and tourism*." In addition, participant U-2 remarked: "*The most decisive features for the city's branding are its nature, culture, history, and gastronomic values. Because of their architectural character, the Taraklı houses were designated a Cittaslow town by UNESCO in 2011. The city also has natural beauties such as the Acarlar Floodplain Forest and the Sakarya River*." Similarly, participant U-10 emphasized the influence of historical and natural assets on the city brand, stating that tourists are drawn to the region for its culture, historical and natural richness, with the Taraklı Houses recognized for their cultural heritage and Sapanca Lake for its natural beauty.

Unique Touristic Values: Analysis of participant responses indicates that 'Natural Assets' represent the most significant differentiating factor for Sakarya as a tourist destination (49%). In contrast, 'Geographical Location Advantage' was the least frequently cited element (7%). The

'Taraklı Houses' and 'Sapanca Lake' emerged as the most distinctive features that contribute to the city's tourist value. The use of the Taraklı Houses in television series and film productions, as well as Sapanca Lake's function as a center for weekend tourism, demonstrates both the diversity of their applications and their tourism potential. Additionally, participants highlighted the city's gastronomic assets, emphasizing their role in distinguishing Sakarya as a destination.

Regarding the city's unique values, participant U-7 remarked: "*The Taraklı Houses, Sapanca Lake, and the Historical Çark Watermill are the most important. The Taraklı Houses, often used in TV series and films, take one on a historical journey with their Ottoman-era architecture. Sapanca Lake is a natural attraction where scenic beauty comes to the fore. With nearby residential centres and easy accessibility, particularly from Istanbul and other major cities, it has become a popular destination for excursions, picnics, and accommodation, especially on weekends.*" Similarly, participant U-4 highlighted Sakarya's significant potentials, including Sapanca Lake, its highlands, the Taraklı Houses, Acarlar Floodplain Forest, and the Karasu-Kocaali coast. U-4 further noted: "*In addition, in gastronomy, specialities such as special meatballs, pumpkin dessert, and various agricultural products stand out… It is a city that experiences all four seasons.*"

Definitions of Brand Image: The influence of Sakarya's tourism potential on the branding process is closely linked to the city's currently perceived brand image. Accordingly, participants were asked to propose definitions or slogans that accurately reflect Sakarya's present image. The most prevalent brand image definition was 'City of Bicycles. 'This perception is reinforced by developments such as the 'Bicycle-Friendly City' designation from the Union Cyclists International (UCI) and infrastructure investments, including the Sunflower Bicycle Valley (Sakarya Büyükşehir Belediyesi, 2022). In addition to the 'City of Bicycles' image, other definitions such as 'Green City ', 'Tourism City ', and, less frequently, 'Industrial City 'were also identified (Figure 3). These examples demonstrate the significant variations that underscore Sakarya's capacity to cultivate a multidimensional urban identity.

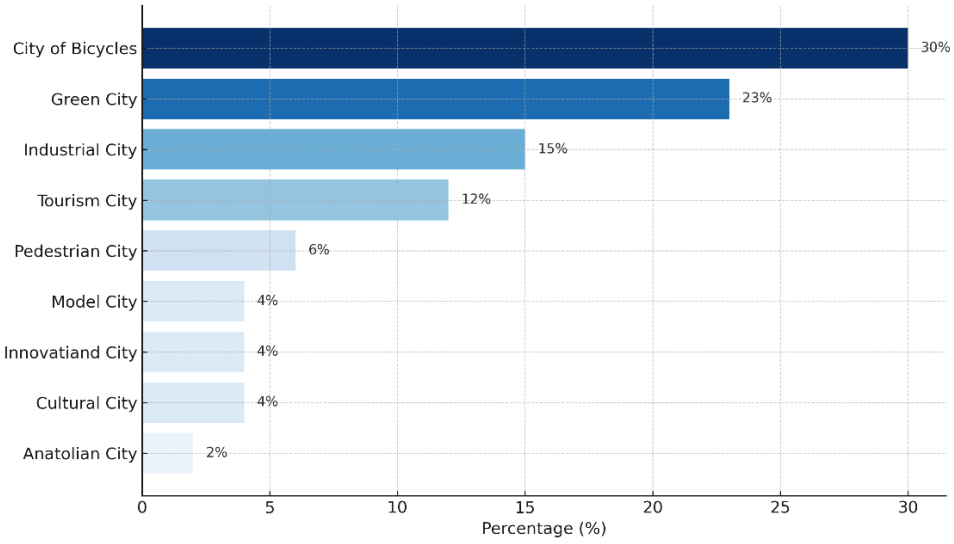


Figure 3 Definitions of perceived brand image for Sakarya

Participant U-15 stated: "Sakarya is the 13th city in the world to receive the title of City of Bicycles. The city is progressing with confident steps toward becoming a branded city in this regard. Our institutional investments are made within this framework." This participant further observed that the Sakarya Metropolitan Municipality has invested in bicycle lanes to foster the city's bicycle culture. In contrast, participant U-8 offered an alternative perspective on the city's brand image: *"Sakarya is a cultural mosaic and a city that hosts various ethnic groups; therefore, we may define it as a City of Culture."* Likewise, participant U-12 addressed the tourism city image, stating: *"Sakarya is a multicultural city where many nations live together. With its greenery, blue spaces,*

sea, lake, floodplain forests, and thermal springs, it is among Turkey's important cities. All these features are significant in terms of being a tourism city."

The Impact of City Image on Tourism: To evaluate Sakarya's potential in the tourism sector from a branding perspective, participants identified key image elements that contribute to the city's tourism appeal. The most significant elements cited were the Taraklı Houses (30%), Acarlar Floodplain Forest (24%), and Sapanca Lake (20%). Respondents further noted that the promotion of these assets remains inadequate and, combined with infrastructural shortcomings, has hindered the full realization of the city's tourism potential. They recommended enhancing not only natural and historical attractions but also expanding social and cultural events.

Participant U-8 emphasized that Sakarya possesses numerous elements conducive to branding. The participant highlighted key attractions, stating: "*Sakarya has many elements that could support branding. In fact, there are places visitors should not leave without seeing: the Taraklı Houses, which reflect Ottoman culture; the Sakarya River, from which the province takes its name; and the Acarlar Floodplain Forest, home to 180 bird species—these are important values in this regard*." Similarly, participant U-3 addressed the significance of city image, noting: "*One should view branding in Sakarya as a living spirit, because the branding of cities and their urban elements is significant. Historical values can advance branding only to a certain extent. By incorporating diverse social or cultural events, branding can gain greater value. …it is not enough to promote only historical and cultural assets… different services and diverse social activities must also be offered so that brand value becomes effective."*

Institutional Contributions and Coordination: As the research involved experts from various institutions, assessing these organizations' roles in enhancing the city's brand value and tourism development was deemed essential for interpreting the findings. To elicit participants' perspectives on potential institutional contributions to the city branding process in Sakarya, the following question was posed: 'What is, or what could be, the contribution of your institution to the tourism branding process of Sakarya?'

Participants identified a lack of cooperation among institutions in the branding process of Sakarya. They highlighted the need to establish structures such as joint tourism action plans and monitoring and evaluation committees. Participant U-11 stated: "*Rather than conducting independent activities, institutions should develop complementary efforts. A long-term tourism action plan should be jointly prepared by the institutions. In line with this plan, thematic working groups, an executive board, a monitoring and evaluation committee for follow-up, and a higher-level board for oversight should be established.*" This perspective was reinforced by participant U-3, who remarked: "*Institutions must act together. In this way, it becomes clear which stakeholders in the sector face which problems. For example, in recent years, there has been a shortage of intermediate staff in tourism, which has become a major problem in the sector.*" Overall, the interviews revealed a consensus on the need to implement joint initiatives at the institutional level, engaging central, local, and civil actors through more comprehensive and effective strategies.

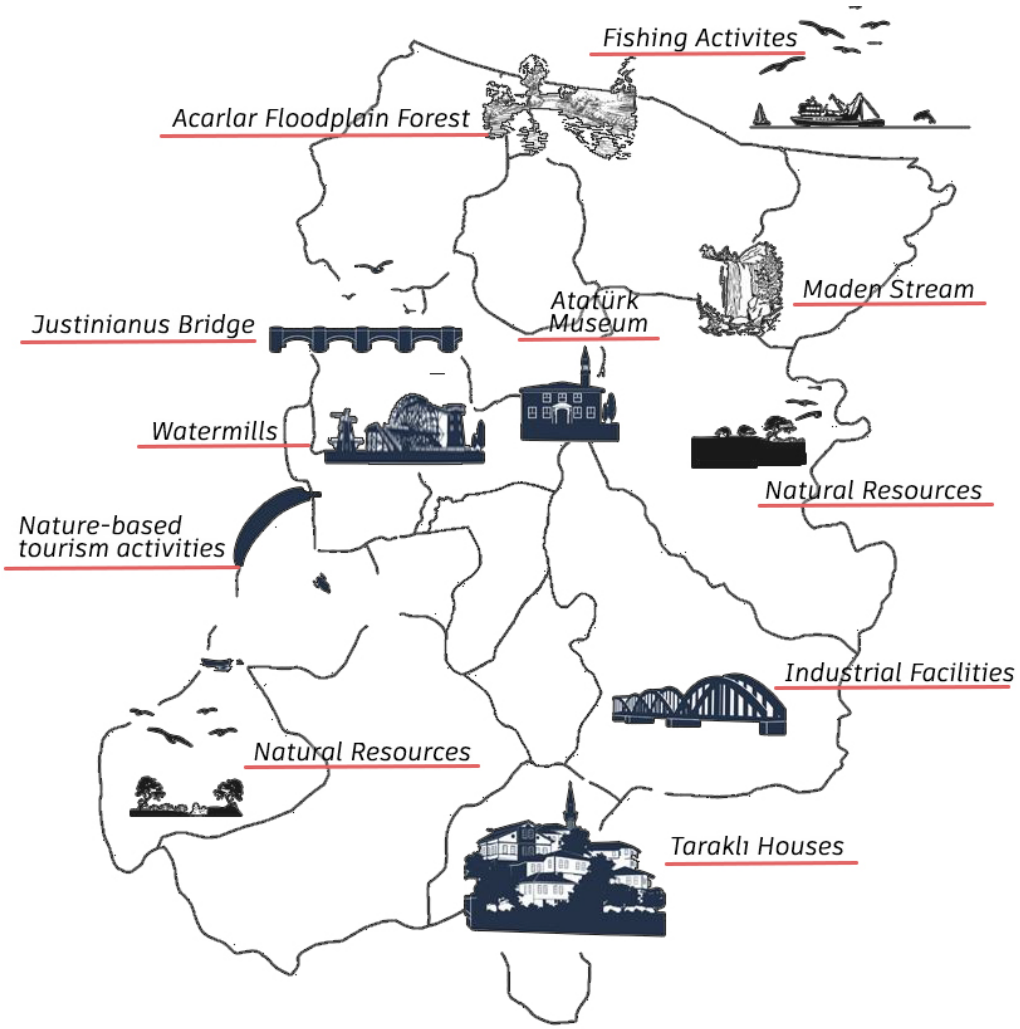


Figure 4 Sakarya's brand values in terms of tourism (Parıldı, 2023)

Logo and Slogan Suggestions: Participants were invited to share perspectives on designing a city logo, emphasizing its role as a key branding element that also reflects Sakarya's tourism potential. Participants recommended that blue and green be featured prominently in the logo to symbolize nature and water resources. Additionally, historical urban landmarks, including the Taraklı Houses, the Sakarya River, and the Çark Watermill, were identified as important visual elements for inclusion. Respondents further suggested integrating various combinations of visual themes, such as Water–Nature–Sports (33.30%), Sea–Nature (33.30%), Sea–Sand–Sun (13.40%), and Nature–Industry (20%), within the logo. For example, participant U-8 stated: *"Our city takes its name from the Sakarya River. I believe the logo should reflect the city's values. Elements such as the Justinianus Bridge, the Sakarya River, the Taraklı Houses, and especially the city's recent identity as a city of bicycles should be reflected in the logo through themes like Water–Sports–Nature."* Similarly, participant U-14 responded: *"If we consider our city and its tourism values, it should include the sea and nature, represented by its shades of blue and green."* Some of the potential brand values are shown in Figure 4.

5.2. The Role of Urban Projects in Advancing Tourism-Oriented City Branding in Sakarya

To assess the contribution of completed or ongoing projects in Sakarya to the city's branding potential, participants evaluated the impact of implemented or planned tourism-related projects based on city branding criteria. A matrix outlining project themes and city branding criteria was provided to participants for this assessment. Project selection for the study considered their potential to contribute to the tourism sector, their implementation within Sakarya or spatial influence on Sakarya and its surroundings, and the extent to which their effects could be evaluated

across social, cultural, economic, and spatial dimensions. The projects included in the study's scope are summarised in Table 2.

Table 2 Urban Projects and Initiatives Related to Tourism in Sakarya

No	Category	Project Title	Institution(s)	Scope / Purpose	Relation to Tourism	Objective	Year
P1	Agricultural Projects	Medicinal and Aromatic Plant Cultivation	Sakarya Metropolitan Municipality	Medicinal plant production, beekeeping, nature walks; rural development	Agro-tourism, gastronomy tourism	Local development, nature-based production, integration with gastronomy	2019–2023 (Completed)
		Sakarya Ornamental Plants and Greenhouse Excellence Center	Sakarya Metropolitan Municipality, Ferizli Municipality	Ornamental plant production, greenhouse, soil-free agriculture, rural support	Rural and agro-tourism	Rural tourism, economic development, eco-compatible production	2016– (Completed)
P2	Coastal Recreation Project	Karasu Coast Park and Recreation Project	Sakarya Metropolitan Municipality	Recreational use of coastal areas	Coastal tourism, day tourism	Enhancing social life quality, contributing to coastal tourism	2017– (Ongoing)
P3	Blue Flag Beach Project	Karasu-Kocaali Blue Flag Project	Sakarya Metropolitan Municipality	Obtaining blue flag certification for Sakarya's coastline	Marine tourism, ecotourism	Gaining international environmental and tourism certifications	2021– (Completed)
P4	Stream Recreation Project	Maden Stream Recreation Project	Sakarya Metropolitan Municipality	Converting the natural area into a tourism zone	Nature walks, nature tourism	Tourism safety, recreational area development	2021–2024 (Completed)
P5	Historical Structure Restoration Project	Restoration of Justinianus Bridge	Serdivan Municipality	Restoring historical and cultural heritage for tourism	Cultural tourism	Heritage conservation, creating tourism resources, identity building	2021– (Ongoing)
P6	Natural Area Restoration Project	Restoration of Acarlar Floodplain	Sakarya Metropolitan Municipality, Ministry of Agriculture and	Conservation of natural areas, strengthening ecotourism infrastructure	Ecotourism, nature tourism	Ecological awareness, nature-based tourism, enhanced visitor experience	2022– (Ongoing)
P7	Projects for Sports Activities	Sunflower Valley and UCI MTB World Championship	Sakarya Metropolitan Municipality	Improving sports infrastructure, hosting international cycling events	Sports tourism, integrated recreation	Increasing sports tourism potential, creating brand image	2018– (Completed)
P8	Digitizing Tourism	SATBIS – Digital Tourism Guide	Sakarya Governorship	Digitization of tourism, providing smart tourism guides	Digital tourism, knowledge sharing	Easy access to information, promotion of tourism potential	2018– (Completed)
P9	Lakeside Recreation Project	Sapanca Lake–Çark Stream Walking & Cycling Path	Sakarya Metropolitan Municipality	Cycling infrastructure and access improvement, increasing quality of life	Nature tourism, cycling tourism	Sustainable mobility, eco-city identity, promoting sports tourism	2020 – (Ongoing)

A set of city branding criteria (Table 3) was compiled to evaluate the contributions of the identified projects to city branding. These criteria were developed through a literature review and applied throughout the research process. In the provided matrix, participants were asked to rate each project received a score of 0-3 based on its alignment with the criteria. Specifically, a score of 0 indicates definitely no impact, 1 indicates neither important nor unimportant, 2 indicates important impact, and 3 indicates definitely important impact.

Table 3 Defined City Branding Criteria

	Criteria	References
K1	Improvement of environmental quality	Frey and George (2010), Lóránt and Tünde (2010), Mihalic et al. (2021)
K2	Impact of the competitiveness	Alpar and Erdem (2005), Anholt(2006), Ashworth and Page (2011), Huovari et al. (2001), Ceran (2013), Kasapi and Cela (2017), Seisdedos and Vaggione (2005), Scoffham and Vale (1996), Zeren (2012)
K3	Impact on the improvement of the quality of life	Dinnie (2010), Özsöz (2018), Kasapi and Cela (2017), Zeren (2012), Deffner and Liourius (2005), Lever and Turok (1999), Harvey (2016)
K4	Impact on the improvement of the city's economic structure	Çetinsöz and Temiz (2018), Özsöz (2018), Özdemir (2007), Oppermann(2000)
K5	Impact of the promotion of the city	Ceran (2013), Cevher (2012), Sarı and Kozak (2005), Saran (2005), Risitano (2006), Hillel et al. (2013), Hashimoto and Telfer (2006)
K6	Contribution to the city's sports activities	Kurtzman (2007), Heidary et al. (2016), Gammon and Robinson (2003)
K7	Contribution to the city's cultural and artistic life	Cevher (2012), Başpınar (2015), Saveriades (2000), Morgan et al. (2003)

Among all evaluated projects, P4 (Stream Recreation Project) is expected to have the most significant positive impact on city branding criteria, both in total and average scores, achieving a total of 19 (Table 4). Located in the northern part of the city within the Maden Stream Recreation Area, which is designated as a 'Natural Site' due to historical mining activities from the Ottoman period, the project benefits from a rich natural environment. The area features a living tree museum, a diverse array of bird species, and caves within the rocks, creating an integrated natural landscape. The project provides recreational opportunities, including hiking trails, fountains, resting areas, mountaineering, trekking, and camping. These attributes have enhanced Sakarya's regional ecotourism potential. Consequently, participants evaluated the project favourably.

Table 4 Project Scores by City Branding Criteria

Projects		Criteria K1	K2	K3	K4	K5	K6	K7	Total	Average	Std. Dev.	Varia.
P1	Agricultural Projects	2	2	3	3	3	0	1	14	2,00	1,15	1,33
P2	Coastal Recreation Project	3	2	2	2	3	2	1	15	2,14	0,69	0,48
P3	Blue Flag Project	3	3	2	2	3	2	1	16	2,29	0,76	0,57
P4	Stream Recreation Project	3	3	2	3	3	3	2	19	2,71	0,49	0,24
P5	Historical Heritage Restoration Project	3	2	1	2	3	1	3	15	2,14	0,90	0,81
P6	Natural Area Restoration Project	3	3	2	3	3	2	2	18	2,57	0,53	0,29
P7	Projects for Sport Activites	2	3	2	2	3	3	2	17	2,43	0,53	0,29
P8	Digitalization in Tourism Sector	0	1	1	1	2	2	1	8	1,14	0,69	0,48
P9	Lakeside Recreation Project	3	2	2	2	2	3	1	15	2,14	0,69	0,48
	Total	22	21	17	20	25	18	14				
	Mean	2,44	2,33	1,89	2,22	2,78	2,00	1,56				

K1: Improvement of environmental quality, K2: Impact of competitiveness, K3: Impact on the improvement of quality of life, K4: Impact on the improvement of the city's economic structure, K5: Impact of the promotion of the city, K6: Contribution to the city's sports activities, K7: Contribution to the city's cultural and artistic life.

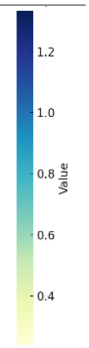
Evaluation of city branding criteria across the projects indicates that all projects, collectively scoring 25 points, have the greatest influence on the 'impact of the promotion of the city' criterion (K5). Projects P1 through P7 are identified as the most effective in promoting the city and are considered to contribute significantly to the city's tourism branding. Expert assessments of projects P8 and P9 highlight the importance of conducting promotional activities not only at local and regional levels but also on national and international platforms, particularly through electronic media such as the internet. Furthermore, expert evaluations suggest that natural and agricultural factors contribute additional value to the city and enhance its recognition.

Analysis of the total criteria scores indicates that the projects are perceived as positively influencing the 'improvement of environmental quality positively' (K1). In cities with significant natural assets, such projects are expected to substantially enhance the city's branding potential. However, regarding the criterion of contribution to the city's cultural and artistic life (K7), all projects received the lowest scores in both total and average evaluations. The Justinianus Bridge, which is included in the UNESCO World Heritage Tentative List, is identified as the project most likely to significantly affect the city's cultural and artistic life through its restoration initiative (P5). Expert evaluations of Project P5 demonstrate consensus that cultural heritage is essential for city branding in tourism, as it ensures preservation for future generations and strengthens urban and regional identity. Additionally, Projects P4, P6, and P7 are considered to have a notable impact on enhancing the city's cultural and artistic life.

According to the criterion of 'the impact on the improvement of the city's economic structure' (K4), projects P2, P3, P5, P7, and P9 are expected to make significant contributions to the development of the city's touristic brand image. Regarding 'the impact on the improvement of quality of life' (K3), agricultural projects (P1) have been identified as the most influential. Project P1 is assessed as having the greatest positive effect on the city's quality of life and, consequently, on the branding process. The anticipated benefits of this project, such as enhanced food security and support for local entrepreneurship, are expected to improve the overall quality of life.

Table 5 Heatmap of the Projects' Score

		Std. Dev.	Varia.
P1	Agricultural Projects	1,15	1,33
P2	Coastal Recreation Project	0,69	0,48
P3	Blue Flag Project	0,76	0,57
P4	Stream Recreation Project	0,49	0,24
P5	Historical Heritage Restoration Project	0,90	0,81
P6	Natural Area Restoration Project	0,53	0,29
P7	Projects for Sport Activites	0,53	0,29
P8	Digitalization in Tourism Sector	0,69	0,48
P9	Lakeside Recreation Project	0,69	0,48



An analysis of standard deviation and variance values across the evaluated projects reveals that P1, P3, and P5 generated the least consensus among experts regarding their contributions to city branding criteria (Table 5). This divergence indicates that, within Sakarya, expert opinions vary significantly concerning the roles of agricultural initiatives, cultural heritage preservation, and Blue Flag-related projects in enhancing the city's brand identity. In contrast, P4 and P6 were associated with the highest level of expert agreement regarding their perceived positive impact on branding. This outcome suggests a prevailing perspective that interventions focused on natural environments and river-based recreation have substantial potential to strengthen the city's brand value. Additionally, these two projects were identified as the most influential in promoting city branding based on their total and average impact scores. Conversely, P8, which received the lowest impact score, is notable for being among the few projects to achieve a strong expert consensus, as indicated by its low standard deviation and variance.

6. Conclusion and Discussion

City branding is widely recognized as a key objective that aligns with broader development strategies. The tourism potential of cities is increasingly conceptualized as a brand, similar to commercial products. Cities can leverage their distinctive resources to enhance their appeal to visitors with varied interests. This study investigates the city branding capacity of Sakarya, a city with considerable potential for urban branding.

Expert assessments indicate that Sakarya's most influential assets in the city branding process are its natural, historical, and cultural values. Previous research demonstrates that cities emphasizing distinctive environmental and cultural characteristics are more likely to establish authentic and competitive brand images, especially within tourism-oriented branding strategies (Başpınar, 2015; Dinnie, 2010). Accordingly, Sakarya's branding potential is consistent with international cases in which place identity is shaped by unique natural landscapes and heritage assets.

City branding relies not only on the existence of urban values but also on effective promotion and institutional collaboration. Accordingly, this study investigates the types of projects that align with the city's tourism values and assesses the extent to which these initiatives meet the criteria for city branding. As highlighted by Dinnie (2010) and Apaydın (2011), city branding is a long-term, multidimensional planning process that necessitates systematic evaluation of urban interventions. The matrix-based evaluation framework utilized in this research reflects multi-criteria assessment methods commonly applied in urban development and branding studies, allowing decision-makers to prioritize projects that most closely align with branding objectives. The results suggest that this approach can serve as a decision-support tool for selecting or comparing alternative projects.

The matrix findings indicate that projects focused on the city's natural areas contribute most significantly to the city's branding process. These projects also excel in criteria that reinforce the city's brand image, including city promotion, environmental quality improvement, enhanced

competitiveness, and the strengthening of the city's economic structure. Consistent with the arguments of Cudny et al. (2020), the results suggest that integrating natural resources into urban branding enhances environmental perception, competitiveness, and long-term brand resilience. Evaluation of the overall impact across all project areas demonstrates that the objective of becoming a branded city aligns with local development strategies for cities and regions.

A key development in Sakarya's city branding process is the municipality's prioritization of bicycle infrastructure, alongside recreational and sports facilities. After receiving the "Bicycle-Friendly City" designation in 2021, the Sakarya Metropolitan Municipality increased investments in this sector and established a continuous bicycle and pedestrian path. This initiative improved sustainable mobility and created new public spaces integrated with nature, thereby enhancing the city's image. Hosting international events such as the UCI Mountain Bike Marathon World Championship has further elevated Sakarya's profile in global sports tourism, promoted healthy lifestyles, and showcased its natural resources. Interviews indicated that most participants associated Sakarya's brand image with the slogan "Bicycle City," underscoring the city's identity. This observation is consistent with research highlighting the importance of creative, lifestyle-oriented, and sustainability-driven urban initiatives in modern city branding strategies (Tomaz & Caldeira, 2021; Kasemsarn et al., 2025).

In this context, Sakarya has significant potential to become a branded city. Accordingly, future objectives for decision-makers and implementing stakeholders should include prioritizing collaboration and coordination within the framework of city branding strategies, leveraging the city's spatial proximity to a global metropolis such as Istanbul by targeting improvements in transportation and infrastructure, developing and implementing region-specific service standards, formulating a city-specific branding vision and executing it through comprehensive spatial planning, and enhancing the promotion of all initiatives through digital and social media tools. The study further demonstrates that Sakarya's brand-building process should adopt a hybrid model that integrates natural landscapes, sports tourism, and short-term tourism flows, rather than relying on a single dominant tourism theme as exemplified by Bergen. Moreover, a context-specific branding process is required, distinct from mass tourism or culture-focused brand-building models.

While this study incorporates an empirical evaluation, its impact assessment relies primarily on estimates and the perspectives of a small group of experts. Subsequent research on tourism-focused city branding could enhance analytical rigor by focusing on specific sub-areas or thematic clusters within cities and by integrating viewpoints from a broader range of stakeholders, including residents, tourists, and local entrepreneurs. Such approaches would facilitate a more thorough identification of target groups, competitive positioning, and branding themes, and would also enable the validation of expert-based assessments through supplementary empirical and spatial data.

CRediT Authorship Contribution Statement

Esra Parıldı: Conception, findings, materials, data collection and processing, analysis, literature review, writing. Güliz Öztürk: Conception, design, supervision, findings, materials, data processing, analysis, literature review, writing, and critical review.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgement

The present study is based on a master's thesis registered with the Council of Higher Education Thesis Centre under registration number 826904.

Data Availability

Data will be made available on request.

Ethics Committee Approval

No ethics committee approval was required for this study, as all datasets and survey instruments used are from a master's thesis and are properly cited in the references.

References

Aaker, J. L. (1997). Dimensions of brand personality. *Journal of Marketing Research*, *34*(3), 347-356.

Ailawadi, K. L., & Keller, K. L. (2004). Understanding retail branding: Conceptual insights and research priorities. *Journal of Retailing*, *80*(4), 331-342.

Akturan, U., & Oğuztimur, S. (2016). Kent markalaşması kavramının içeriği ve gelişimi: Farklı disiplinler farklı yaklaşımlar. *TMMOB Şehir Plancısı Odası Dergisi*, *26*(2), 117-129.

Albayrak, T., & Caber, M. (2008). Tourists' satisfaction and its interaction with loyalty towards a destination. In *Estableciendo puentes en una economía global* (p. 23). ESIC.

Alpar, C., & Erdem, B. (2005). Burdur: Turizmin bölgesel kalkınmaya etkisi çerçevesinde Burdur yöresinde alternatif turizm geliştirme stratejileri. In *I. Burdur Sempozyumu* (Vol. 1, pp. 591-599).

Anholt, S. (2006). The Anholt_GMI city brands index: How the world sees the world's cities. *Place Branding*, *2*(1), 18-31.

Anholt, S. (2010). Definitions of place branding: Working towards a resolution. *Place Branding and Public Diplomacy*, *6*(1), 1-10.

Apaydın, F. (2011). *Şehir pazarlaması* (1. baskı). Nobel Akademik Yayıncılık.

Archer, B. (1977). *Tourism multipliers: The state of art*. University of Wales Press.

Ashworth, G., & Page, S. J. (2011). Urban tourism research: Recent progress and current paradoxes. *Tourism management*, *32*(1), 1-15.

Başaran, İ. (2008). *Kent ve yerel yönetim*. Okutan Yayıncılık.

Başpınar, O. (2015). *Şehir markalaşması ve Ankara örneği* (Uzmanlık tezi). Türk Patent Enstitüsü Markalar Dairesi Başkanlığı.

Begg, I. (1999). Cities and competitiveness. *Urban Studies*, *36*(5-6), 795-809.

Bilgiç, İ. (2007). *Sakarya yaylalarının turizm açısından pazarlanabilirliği* [Yayımlanmamış yüksek lisans tezi, Sakarya Üniversitesi].

Brown, F. (2000). *Tourism reassessed: Blight or blessing*. Butterworth-Heinemann.

Budd, L., & Hirmis, A. (2004). Conceptual framework for regional competitiveness. *Regional Studies*, *38*(9), 1015-1028.

Ceran, Y., (2013). Şehirlerin markalaştırılması ve markanın yönetimi. *Sosyal ve Beşeri Bilimler Dergisi*, *5*(1), 537-547.

Cerisola, S., & Panzera, E. (2021). Cultural and creative cities and regional economic efficiency: Context conditions as catalyzers of cultural vibrancy and creative economy. *Sustainability*, *13*(13), 7150.

Cevher, E. (2012). Kentsel markalaşma süreci: Antalya örneği. *Sosyal ve Beşeri Bilimler Dergisi*, *4*(1), 105-115.

Creswell, J. (2012). *Qualitative inquiry and research design: Choosing among five approaches* (3rd ed.). Sage.

Cudny, W., Comunian, R., & Wolaniuk, A. (2020). Arts and creativity: A business and branding strategy for Lodz as a neoliberal city. *Cities*, *100*, 102659.

Çetinsöz, B. C., & Temiz, G. (2018). *Marka kent stratejileri ve Anamur*. Mersin Büyükşehir Belediyesi Kültür Yayınları.

Deffner, A., & Liouris, C. (2005). City marketing: A significant planning tool for urban development in a globalised economy. In *45th Congress of the European Regional Science Association*. Vrije University Amsterdam.

Dinnie, K. (2010). *City branding: Theory and cases*. Springer.

Emin, N. (2012) *Marka kent oluşturmada sembol yapıların değerlendirilmesi ve bir uygulama* [Yüksek lisans tezi, Gazi Üniversitesi].

Eraydın, Z. (2016). Kentsel markalaşma stratejilerinin kent belleği ve kent imgesi üzerine etkileri: Ankara örneği. *İdealkent*, *7*(20), 830-855.

Ferreia, J., & Estevao, C. (2009). Regional competitiveness of tourism cluster: A conceptual model proposal (MPRA Paper No. 14853).

Frey, N., & George, R. (2010). Responsible tourism management: The missing link between business owners' attitudes and behaviour in the Cape Town tourism industry. *Tourism Management*, *31*(5), 621-628.

Gammon, S., & Robinson, T. (2003). Sport and tourism: A conceptual framework. *Journal of Sport Tourism*, *8*(1), 21-26.

Giritlioğlu, İ., & Avcıkurt, C. (2010). Şehirlerin turistik bir ürün olarak pazarlanması, örnek şehirler ve Türkiye'deki şehirler üzerine öneriler (derlemeden oluşmuş bir uygulama). *Adıyaman Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, (4), 74-89.

Gotham, K. F. (2007). (Re)Branding the Big Easy: Tourism rebuilding in post-Katrina New Orleans. *Urban Affairs Review*, *42*(6), 823-850. https://doi.org/10.1177/1078087407300222

Guest, G., Bunce, A., & Johnson, L. (2006). How many interviews are enough?: An experiment with data saturation and variability. *Field Methods*, *18*(1), 59-82. https://doi.org/10.1177/1525822X05279903

Harvey, D. (2016). *Kent deneyimi*. Sel Yayıncılık.

Hashimoto, A., & Telfer, D. J. (2006). Selling Canadian culinary tourism: branding the global and the regional product. *Tourism Geographies*, *8*(1), 31-55.

Heidary, A., Abdali, T., & Abdali, A. (2016). Sport tourism loyalty revisited: An overview. *International Academic Journal of Business Management*, *3*(2), 43-50.

Helmy, M. (2008). Urban branding strategies and the emerging Arab cityscape: The image of the Gulf city [Doctoral dissertation, Stuttgart University].

Hillel, D., Belhassen, Y., & Shani, A. (2013). What makes a gastronomic destination attractive? Evidence from the Israeli Negev. *Tourism Management*, (36), 200-209.

Hryhorieva, O., Khadartsev, O., & Ivaniuk, A. (2020). Formation of city brand in the ımplementation of the concept of ıntegrated development. *Economics and Region*, *4*(79), 22-27.

Huovari, J., Kangasharju, A., & Alanen, A. (2001). Constructing an index for regional competitiveness. In *The emergence of the knowledge economy: A regional perspective* (pp. 121-138). Springer.

Jansson, J., & Power, D. (2006). *The image of the city: Urban branding as constructed capabilities in Nordic city regions*. Nordic Council of Ministers.

Kapferer, J. N. (2008). *The new strategic brand management: Creating and sustaining brand equity long term*. Kogan Page.

Karasar, N. (2004). *Bilimsel araştırma yöntemi: Kavramlar, ilkeler, teknikler* (13. baskı). Nobel Yayınları.

Kasapi, I., & Cela, A. (2017). Destination branding: A review of the city branding literature. *Mediterranean Journal of Social Sciences*, *8*(4).

Kasemsarn, K., Sawadsri, A., Kritsanaphan, A., & Nickpour, F. (2025). Urban branding through cultural – creative tourism: A review of youth engagement for sustainable development. *Urban Science*, *9*(6), 204.

Kavaratzis, M. (2004). From city marketing to city branding: Towards a theoretical framework for developing city brands. *Place Branding*, *1*(1), 58-73.

Kavaratzis, M., & Ashworth, G. J. (2005). City branding: An effective assertion of identity or a transitory marketing trick? *Tijdschrift voor Economische en Sociale Geografie*, *96*(5), 506-514.

Kavaratzis, M., & Hatch, M. J. (2013). The dynamics of place brands: An identity-based approach to place branding theory. *Marketing Theory*, *13*(1), 69-86.

Kaypak, Ş. (2013). Küreselleşme sürecinde kentlerin markalaşması ve "marka kentler". *Cumhuriyet Üniversit esi İktisadi ve İdari Bilimler Dergisi*, *14*(1), 340-361.

Keller, K. L. (2013). Strategic brand management: New approaches to creating and evaluating brand equity. *Journal of Marketing*, *58*(3).

Koç, E. (2018). *City branding/image building as a new paradigm: The case of Eskişehir* [Doctoral dissertation, Middle East Technical University].

Kotler, P. (2000). *Kotler ve pazarlama* (1. basım). Sistem Yayıncılık.

Kotler, P. T., & Lee, N. R. (2009). *Up and out of poverty: The social marketing solution*. Pearson Prentice Hall.

Köseoğlu, Y., & Dursun, T. (2015). *Sakarya ili sosyo-ekonomik ve sosyo-demografik göstergeleri*. Sakarya Ekonomik ve Sosyal Araştırmalar Merkezi (SESAM).

Kurtzman, J. (2007). Economic impact: Sport tourism and the city. *Journal of Sport and Tourism, 10*(1), 47-71.

Kültür ve Turizm Bakanlığı. (2007). *Türkiye turizm stratejisi 2023 eylem planı*.

Lever, W. F., & Turok, I. (1999). Competitive cities: Introduction to the review. *Urban Studies*, *36*(5-6), 791-793.

Lóránt, D., & Tünde, A. (2010). Responsible tourism and tourism ecology. In *Forum geografic* (Vol. 9, pp. 191-196).

Mason, M. (2010). Sample size and saturation in PhD studies using qualitative interviews. *Forum Qualitative Sozialforschung/Forum: Qualitative Social Research*, *11*(3).

Merriam, S. B. (2013). *Nitel araştırma: Desen ve uygulama için bir rehber*. Nobel.

Mihalic, T., Mohamadi, S., Abbasi, A., & David, L. D. (2021). Mapping a sustainable and responsible tourism paradigm: A bibliometric and citation network analysis. *Sustainability*, *13*(2), 853.

Morgan, N. J., Pritchard, A., & Piggott, R. (2003). Destination branding and the role of the stakeholders: The case of New Zealand. *Journal of Vacation Marketing*, *9*(3), 285-299.

Oppermann, M. (2000). Tourism destination loyalty. *Journal of Travel Research*, *39*(1), 78-84.
Orman ve Su İşleri Bakanlığı. (2016). *Acarlar Gölü Longoz Ormanı sulak alan yönetim planı* (2016-2020). Doğa Koruma ve Milli Parklar Genel Müdürlüğü.
Özdemir, G. (2007). Destinasyon pazarlamasında internetin rolü. *Yaşar Üniversitesi E-Dergisi, 2*(8), 889-898.
Özsöz, F. M. (2018). Şehir pazarlamasında bir marka şehir olarak Eskişehir'in incelenmesi. *USOBED Uluslararası Batı Karadeniz Sosyal ve Beşerî Bilimler Dergisi*, *2*(1),12-34.

Parıldı, E. (2023). *Markalaşma sürecinde turizmin planlama açısından ele alınışı: Sakarya örneği* [Unpublished master's thesis, Gebze Technical University].
Risitano, M. (2006). *The role of destination branding in the tourism stakeholders system: The Campi Flegrei case* [Doctoral dissertation, University of Naples Federico II].
Sakarya Büyükşehir Belediyesi. (2022). *Faaliyet raporu*.
Sakarya Valiliği. (2020). *Sakarya il çevre raporu*.
Salihoğlu, G., & Gezici, F. (2018). Geography of suppliers in the hospitality sector: The case of Alanya. *Tourism Management*, *65*, 41-54.
Saran, M. (2005). Kent pazarlaması: Güçlü bir kent imajı ve kent markası oluşturmak. In *Marka Yönetimi Sempozyumu*. TMMOB Makine Mühendisleri Odası.
Sarı, Y., & Kozak, M. (2005). *Turizm pazarlamasına internetin etkisi: Destinasyon web siteleri için bir model önerisi*. *Akdeniz İİBF Dergisi*, *5*(9), 248-271.
Saveriades, A. (2000). Establishing the social tourism carrying capacity for the tourist resorts of the east coast of the Republic of Cyprus. *Tourism Management*, *21*(2), 147-156.
Scoffham, E., & Vale, B. (1996). How compact is sustainable – How sustainable is compact?. In *The compact city: A sustainable urban form* (pp. 66-73).
Seisdedos, G., & Vaggione, P. (2005). The city branding processes: The case of Madrid. In *41st IsoCaRP Cong ress* (pp. 47-56).
Şahin, G. (2010). *Turizmde marka kent olmanın önemi: İstanbul* örneği [Yayımlanmamış yüksek lisans tezi, Ankara Üniversitesi].
Tek, M. (2009). Kamu yatırımlarında turizmin yeri: Türkiye turizm stratejisi 2023'te marka kentler projesi üzerine eleştirel bir değerlendirme. *Anatolia: Turizm Araştırmaları Dergisi, 20*(2), 169-184.
Tezcan, S. (2011). *Kentler arası rekabet, kentsel pazarlama ve markalaşmanın planlama açısından değerlendirilmesi: İzmir örneği* [Yayımlanmamış yüksek lisans tezi, Dokuz Eylül Üniversitesi].
Tomaz, N., & Caldeira, E. (2021). The interplay between culture, creativity, and tourism in the sustainable development of smaller urban centres. In *Small cities: Sustainability studies in community & cultural engagement*.
Ward, S. (2005). *Selling places: the marketing and promotion of towns and cities 1850-2000*. Routledge.
World Tourism Organization. (2012). *Global report on city tourism: Cities 2012 project*. UNWTO.
Yavuz, M. C. (2007). *Uluslararası kent markası oluşturulmasında kimlik geliştirme süreci: Adana örneği* [Yayınlanmamış doktora tezi, Çukurova Üniversitesi].
Yeoman, I. (2009). *Tomorrow's tourist: Scenarios & trends*. Routledge.
Yılmaz, Y., & Çizel, B. (2000). Türk turizminde günü kurtarmak değil marka yaratmak. In *1. Ulusal Türkiye Turizm Sempozyumu Bildiriler Kitabı*. Türkiye Turizm Araştırma Enstitüsü.
Zengin, B., Şen, L. M., & Ökçüm, O. (2023). Karasu'da alternatif turizm türlerinin geliştirilmesine yönelik bir araştırma. *Türk Turizm Araştırmaları Dergisi*, *7*(3), 535-553.
Zenker, S., & Braun, E. (2017). Questioning a "one size fits all" city brand: Developing a branded house strategy for place brand management. *Journal of Place Management and Development*, *10*(3), 270-287.
Zeren, H. E. (2012). Kent markalaşması sürecinde iç girişimcilik faktörü. *Kahramanmaraş Sütçü İmam Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi, 2*(1), 95-104.

Resume

Esra Parıldı graduated from the Department of Landscape Architecture at Istanbul University in 2007. Following graduation, she gained experience in both academic and applied projects in environmental and urban planning. In 2023, she completed her M.S. in City and Regional Planning at Gebze Technical University. Her academic interests are sustainable urban development, tourism planning, green infrastructure, and ecological design. She has been working within the Sakarya Metropolitan Municipality since 2022.

Güliz Öztürk received her B.S. in City and Regional Planning from Dokuz Eylul University in 2005. She completed her M.S. at Gebze Technical University and Ph.D. at Istanbul Technical University. Since 2007, she has been affiliated with the Department of City and Regional Planning at Gebze Technical University. Her research focuses on tourism and local economic development.

JOURNAL OF DESIGN FOR RESILIENCE IN ARCHITECTURE & PLANNING

Research Article
Online: www.drarch.org
Volume 7, Issue 1 (126-143), 2026
DOI: 10.47818/DRArch.2026.v7i1207

The importance of local materials in sustainable rural planning: Case of Gelemiç

Figen Altıner*
Ayşegül Ağan**

Abstract

Studies carried out for sustainable and low carbon emission rural area design and planning are important in minimising the effects of climate change and protecting the ecology. Especially in rural areas, the choice of local materials plays an important role in ensuring environmental sustainability within the scope of landscape planning studies, creating the identity and aesthetic values of the region. In recent years, the traditional building materials used in traditional buildings in rural settlements and the fact that the structures in which these materials are applied do not harm the nature and are suitable for user comfort have been effective in bringing these structures back to the agenda. Traditional buildings were constructed with the most appropriate materials and components depending on the climatic characteristics. In addition, designing and planning studies by taking into consideration the natural, climatic, cultural, social and economic factors of rural settlements contributes to the success of the low carbon target in these areas. In this study, adobe buildings in village settlements within the scope of low carbon rural areas in Gelemiç rural settlement within the borders of Bursa province were evaluated in terms of sustainability and also examined within the scope of climatic and ecological parameters. The construction technique of traditional architectural structures was observed and analytical methods were used to analyse adobe, which is the original and local building material. In addition, the climatic characteristics (precipitation and temperature data between 2004-2024) and geological structure (seismicity, rock structure and soil structure) of the study area were examined and maps were produced using Geographic Information Systems. In line with the information on the produced maps, construction techniques and material properties used in traditional buildings were analysed. As a result of the study, the adobe building material used in traditional houses in Gelemiç rural settlements adapts to the climatic and ecological structure of the region and contributes to the sustainability of the cultural landscape. According to the laboratory tests, the strengths of adobe, which is the main building material used in the timber frame system in the study area, are similar to the values specified in the literature. In addition, the intensive use of adobe material in the study area, the fact that the raw material used in adobe production is supplied from the location close to the settlement, the CO2 emission that may occur in the logistics process is low and the adobe material used is suitable in terms of sustainability.

Keywords: adobe, geographic information systems, rural architectural heritage, rural landscape planning, sustainable planning

1. Introduction

Climate change is defined as 'changes in the average state and/or variability of the climate over decades or longer, regardless of the cause'. According to the Intergovernmental Panel on Climate Change (IPCC) reports, excessive use of fossil fuels is shown as the first degree responsible for the increase in the amount of carbon emissions in the atmosphere (Koçak & Bozyurt, 2021). It is accepted that most of the fossil fuel-based energy use, which causes the rapidly increasing greenhouse gas emission rate in Turkey, originates from residential buildings, which constitute 75% of the existing buildings. For this reason, it is predicted that making the existing construction energy efficient and using sustainable building materials will be effective in reducing carbon emissions (Kocabaş, 2012; Bostan, 2014; Koçak & Bozyurt 2021; Chen et al., 2021).

*(Corresponding author), Department of Architecture, Balıkesir University, Balıkesir, Türkiye altinerfigen@gmail.com
** Department of Architecture, Balıkesir University, Balıkesir, Türkiye aysegul.agan@balikesir.edu.tr
Article history: Received 20 June 2025, Revised 16 January 2026, Accepted 10 February 2026, Published 30 April 2026

The selection of local and low-energy building materials is an important issue in landscape planning studies, as well as supporting environmental sustainability and protecting the identity and aesthetic values of the region (Morel et al., 2001; Şahin, 2006; Görmüş & Oğuz, 2013; Balta & Atik, 2019; Wang & Prominski, 2020; Elagöz Timur & Asiliskender, 2024). Despite being locally producible, concrete is the most widely manufactured man-made material globally, exceeding 1 m^3 per capita annually, and its cradle-to-gate CO_2 emissions vary significantly by region (Orhon, 2012; Hammond & Jones, 2008; Nielsen, 2008; Purnell, 2013). In this context, Çümen and Sarıkaya (2023) reported that a ready-mixed concrete plant in Uşak, Turkey emitted 250.891 tCO_2e annually, with CO_2 accounting for 98.611% of total greenhouse gas emissions, highlighting the substantial carbon footprint of conventional construction materials. These findings indicate that the environmental impact of building materials extends beyond the construction phase and must be evaluated through a comprehensive perspective encompassing production, transportation, and use. Materials reliant on energy-intensive and industrialized production processes, such as concrete, represent a substantial share of carbon emissions within the building sector. This situation has prompted a critical reassessment of material choices and increased interest in alternatives that require significantly lower energy inputs.

Within this context, traditional and locally sourced building materials have regained importance due to their minimal production energy, local availability, and capacity to provide thermal comfort largely through passive means. Materials commonly employed in traditional architecture—including timber, stone, brick, adobe, lime plaster, plant-based materials, and glass—are therefore increasingly recognized as key components of sustainable and energy-efficient building practices (Damluji, 1999; Varum et al., 2015).

Within this framework, earthen construction materials—particularly adobe—have emerged as a critical focus in sustainable building research. Among traditional materials, adobe occupies a distinctive position due to its widespread historical use, low embodied energy requirements, and strong compatibility with local environmental conditions (Fathy, 1986; Morel et al., 2001).

Adobe material is an environmentally friendly and important material for human health that has been used globally since the Neolithic period. According to some international reports, hundreds of millions of people worldwide still live in earth and mud-brick structures (Houben & Guillaud, 1994; Minke, 2022).

The widespread preference for adobe can primarily be attributed to its economic affordability, ease of access, and reliance on locally available raw materials. Its low embodied energy, high energy and cost efficiency during use, and biodegradability make adobe particularly advantageous in achieving low-carbon construction targets (Ziegler et al., 1998; Bui et al., 2009; Christoforou et al., 2016; Reyes et al., 2018; Costa et al., 2019; Salih et al., 2020; Akbaş et al., 2022). Due to these characteristics, adobe has maintained its significance over centuries, especially in rural areas where the absence of industrial production facilities, low construction costs, and favourable thermal performance support passive indoor comfort conditions (Silveira et al., 2007; Özgünler & Gürdal, 2012; Illampas et al., 2023; Christoforou et al., 2016; Yue et al., 2022). In this respect, promoting the use of low-carbon building materials within the existing building stock necessitates comprehensive investigations that extend beyond urban contexts to include rural settlements. Understanding the natural, climatic, and cultural characteristics of rural environments and aligning material selection accordingly is therefore essential for achieving long-term sustainability goals (Royer, 2011; Christoforou et al., 2016; Cavé et al., 2022; Aras Gaudry et al., 2023).

Within the Turkish context, a significant portion of academic research on adobe structures has focused primarily on the physical and mechanical properties of the material, its energy performance, and its environmental impacts. The low embodied energy of adobe, its compatibility with locally sourced raw materials, and its evaluation as a climate-responsive building material are among the key attributes frequently emphasised in the literature on sustainable and low-carbon construction (Acun & Gürdal, 2003; Çavuş et al., 2015; Akbaş et al., 2022; İsak, 2023). However,

most existing studies tend to confine their assessments to the material or building-component scale; the role of adobe structures within broader low-carbon cycles and their relationship with climatic and environmental parameters remain insufficiently addressed in a holistic manner.

In this context, there is a need for holistic studies that evaluate the sustainability of adobe buildings not only at the material or individual building scale, but also within the framework of settlement patterns and environmental and climatic relationships. In this study, it is aimed to evaluate the adobe structures in village settlements within the scope of low carbon rural areas in Gelemiç rural settlement located within the borders of Bursa province, which is among the important industrial centres of Turkey, in terms of sustainability. The ecological sustainability of the adobe material was investigated by examining the relationship of the traditional settlement texture of Gelemiç settlement with the climatic and geographical structure. In addition, traditional construction technique and material properties were analysed.

The originality of this study lies in its holistic evaluation approach, which assesses the sustainability of adobe structures in rural Turkey not solely through architectural or material characteristics, but by considering climatic, geological, and spatial parameters together. The literature review conducted reveals that mudbrick and other earth-based structures have mostly been examined through individual analysis layers in the context of architectural typology, material performance, or environmental impacts. In this context, the study conducted on the example of the Gelemiç rural settlement aims to reveal the multi-layered ecological adaptation potential of traditional building knowledge by evaluating geographical information system-supported climatic and geological data, on-site architectural observations, and limited laboratory analyses together.

2. Material and Methods

The Gelemiç rural settlement was selected as the study area due to its high representational value, as it allows for the interpretation of the compatibility between adobe production techniques based on local soil resources and the prevailing climatic and geological conditions, while enabling the integrated evaluation of different stages of the low-carbon building cycle.

Gelemiç, a village of Keles district within the borders of Bursa province, is located between 39°53’28”-39°53’36” north parallels and 29°16’45”-29°16’74” east meridians. Gelemiç (Figure 1) is located 70 km from Bursa city centre and 10 km from Keles district centre and has an altitude of 780. According to Turkish Statistical Institute (TSI) 2024 population data, 378 people live in the village. The main source of livelihood of the people is agriculture and animal husbandry (Yıldız & Çobancaoğlu, 2019).

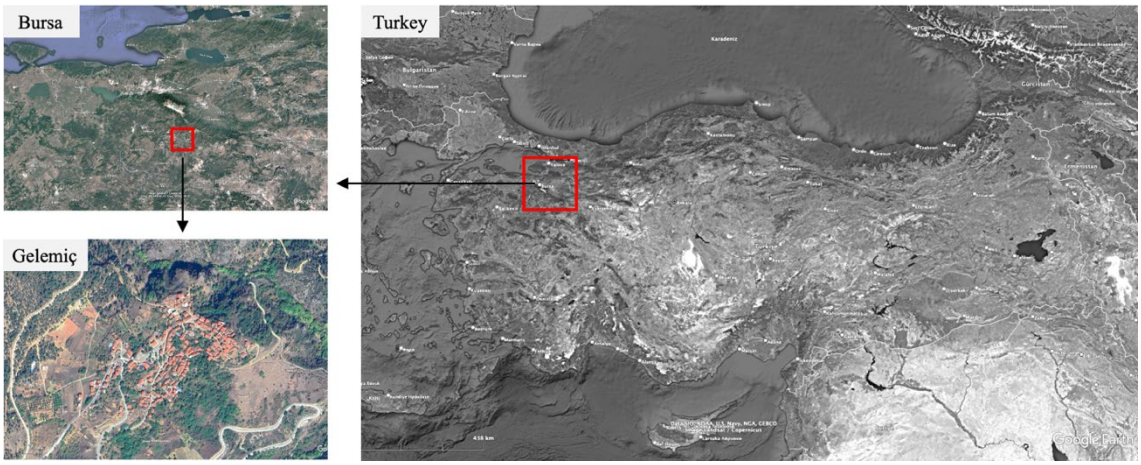


Figure 1 Location of Gelemiç (Google Earth, accessed on 25 December 2024)

2.1. Physical Characteristics of Settlement Fabric

Gelemiç has an organic settlement pattern that closely harmonises with the local topography. Within the settlement, approximately 330 parcels contain buildings serving various functions, excluding gardens and agricultural fields. The settlement has largely preserved its traditional character, with residential buildings constituting the dominant architectural typology rather than monumental structures. Haylofts and storage buildings also form integral components of the settlement fabric.

The housing layout follows the natural slope of the valley, with buildings generally oriented in response to topographic conditions. While recent development has expanded towards the south and southwest, the historic core remains largely intact. Due to the sloping terrain, most buildings benefit from open views towards surrounding forested and mountainous areas.

A defining characteristic of the settlement is the extensive use of adobe as the primary building material. The majority of traditional dwellings and ancillary structures are constructed using adobe, predominantly within timber-framed systems. Importantly, these adobe buildings are not abandoned heritage remnants; rather, many continue to be actively used for residential and agricultural purposes, demonstrating the material's ongoing functional relevance.

The street network has developed organically under the combined influence of topography, climate, and socio-cultural practices. Narrow streets, stone-paved surfaces with central drainage channels, and soil-stabilised paths are characteristic of the historic core, while newer areas feature asphalted main roads and concrete-paved side streets. The settlement includes three main communal spaces: the village square at the southwestern entrance, the threshing floor along the northern boundary, and a large open area at the eastern edge of the settlement (Figure 2).

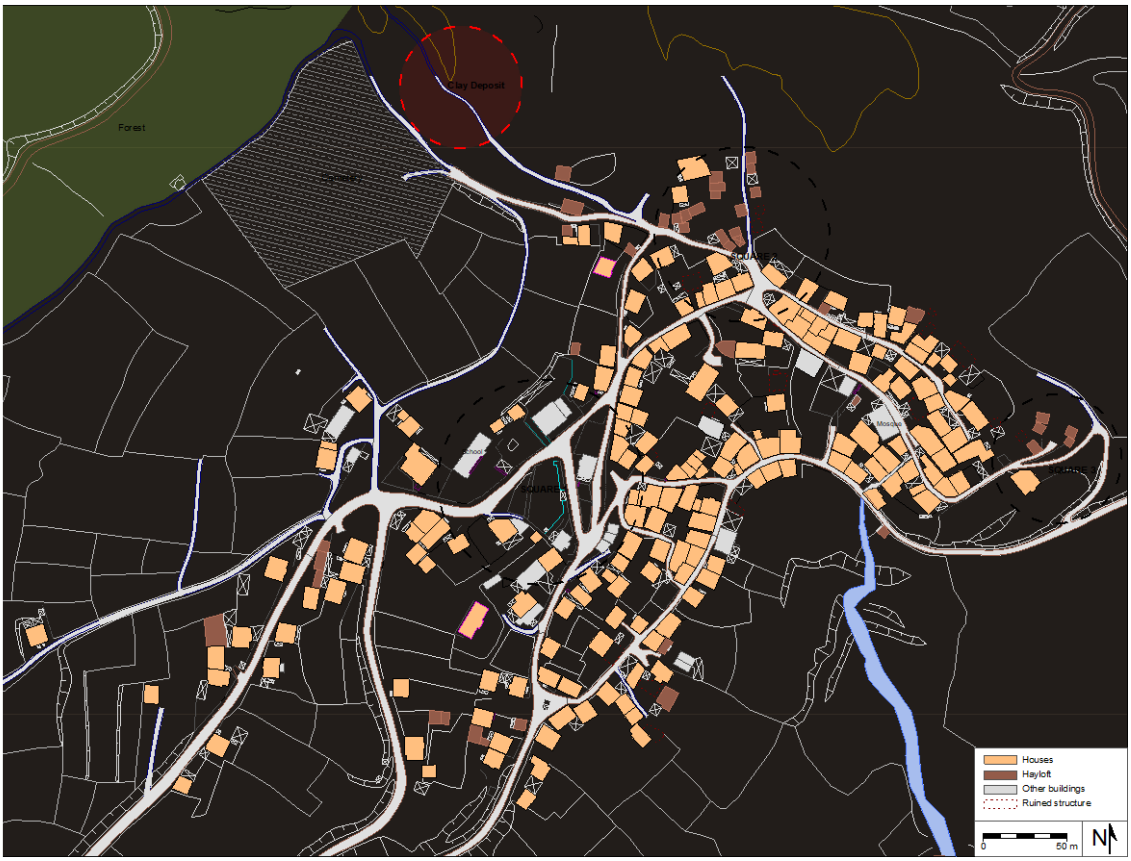


Figure 2 Gelemiç settlement pattern map (Developed by authors)

2.2. Methods

The methodology of this study is structured within an integrated mixed-methods framework designed to evaluate the sustainability of adobe structures in the Gelemiç rural settlement by relating architectural, environmental, and material dimensions within a unified analytical structure (Figure 3). Rather than treating each analytical step independently, all methods are systematically linked to the central research objective: to assess ecological sustainability potential of adobe in its local context. The methodological framework consists of four interrelated stages, each addressing a specific research dimension while informing and supporting the others.

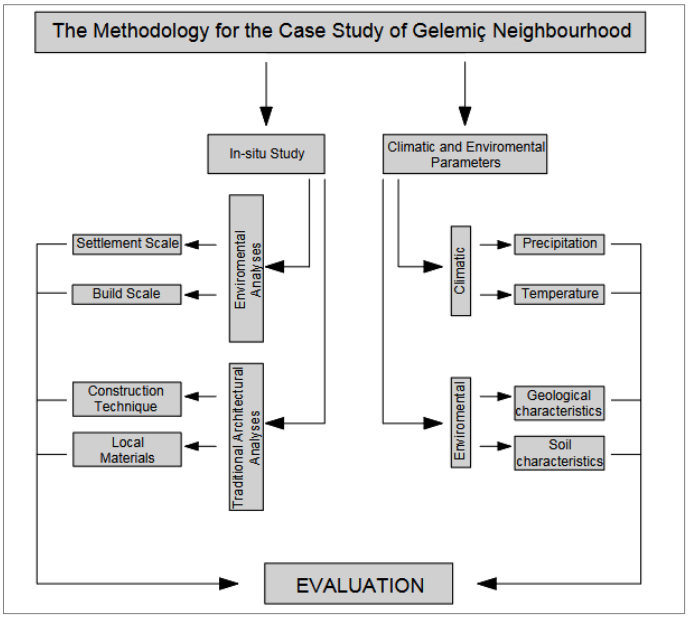


Figure 3 Method flow chart

The first stage comprises fieldwork, which forms the empirical basis of the study and supports all subsequent analyses. Certain examinations and observations were made in order to realise the environmental, socio-cultural, economic and architectural structure of Gelemiç rural settlement in detail. In addition, interviews with local people, public institutions and organisations constitute the first stage of the study.

The second stage focuses on the physical and architectural analysis of the settlement and its traditional building stock, directly addressing the research question related to how adobe is spatially and structurally embedded within the rural fabric. The construction technique of the traditional architectural structures was observed and the principle of the carrier system was schematised by on-site measurements. In addition, adobe, which is the original and local building material, was analysed using analytical methods. The adobe brick samples taken on site were tested in the laboratory. After macroscopic observations, mechanical and mineralogical properties were determined. TS EN 2514 standard was used to determine the mechanical properties. Before the compressive strength test, the brick samples were cut into 7x7x7 cm cubes as specified in the standard. ZWICK /Roell compression test device was used to measure the compressive strength of the cube samples. XRD (X-ray diffraction) was used to characterise the clay and other mineral phases used in adobe brick production and to obtain semi-quantitative data. Philips X'Pert Pro was used for this analysis. The analyses were performed on finely ground samples with grain size <125 µm. Scans were performed in the range of 5-80°2θ at a scan rate of 0.04° per second. The data were interpreted using the 'highscore plus' software and the International Centre of Diffraction Data database.

The third stage investigates climatic and environmental parameters to examine the ecological compatibility of adobe material with its natural context, addressing the question of environmental suitability and climatic adaptation. Using Geographic Information Systems (GIS), rainfall,

temperature, geology, and soil maps were produced to analyze the relationship between local environmental conditions and the use of adobe. ArcGis 10.8 programme was used to produce these maps. In the study, after the necessary coordinating process of the data obtained from the Earth Sciences Database of the General Directorate of Mineral Research and Exploration of Turkey, geological times and stratigraphy information were processed and a geological map was created. The data obtained from Bursa Provincial Directorate of Agriculture and Forestry were used to create the soil map. In the creation of the temperature and precipitation map, the average temperature and precipitation data obtained from the General Directorate of Meteorology Station Data Database were used and the Inverse Distance Weighting (IDW) method was applied. Digital Elevation Model (DEM) data used in obtaining temperature and precipitation maps were downloaded from the USGS- Earthexplorer programme.

In the IDW method, cell values are determined for each non-sampled point according to the distance increase. It is an interpolation technique used to determine the cell values of non-sampled points with the help of the values of known sample points. The cell value is calculated by considering various points moving away from the cell of interest and depending on the increase in distance. The estimated values are a function of the distance and size of the points in the neighbourhood, and the importance and impact on the cell to be estimated decreases with increasing distance (Chen & Liu, 2012; Ajaj et al., 2018; Khouni et al., 2021). In this method, properties such as general distribution, trend, anisotropy and clustering are examined. In recent years, its usage areas have expanded with Geographic Information Systems. The role of Geographic Information Systems in scientific studies on increasing the resolution of meteorological parameter maps and climate model outputs is quite large (Daly et al., 2002; Demircan et al., 2011; Altıner & Kelkit, 2021; Huang et al., 2023; Bingöl et al., 2023).

At the final stage of the methodology, the architectural, material, and environmental data obtained within the scope of the study were synthesized; through these data, the potential of adobe as a low-carbon, climate-responsive, and sustainable building material was discussed from a holistic perspective, specifically in the context of the rural settlement of Gelemiç.

3. Results and Discussions

3.1. Finding of the Traditional Settlement Texture

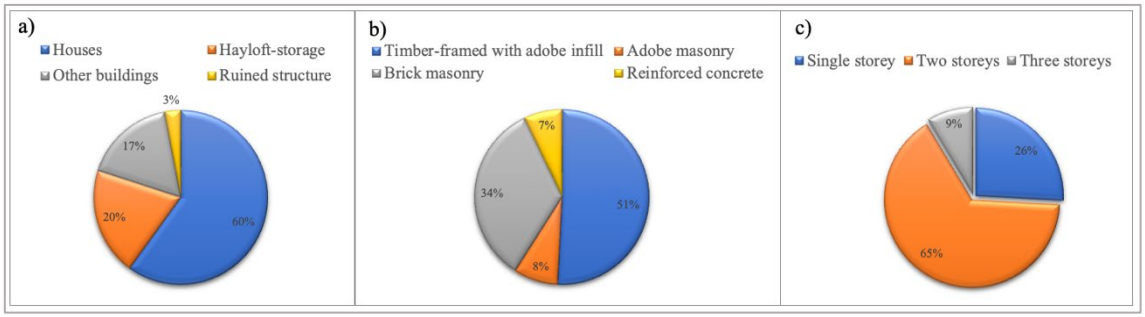
The functions of the buildings in Gelemiç can be listed as residential, haystack, warehouse, shop-commerce, residential, religious and public buildings. The most dominant building types of the settlement texture are dwellings and haylofts that preserve their original character (Figure 4). Of the buildings in the settlement, 60 per cent are residential buildings, 20 per cent are haystacks and 17 per cent are other buildings. The other 3% are the ruins of the houses in ruins (Graph 1a).

Figure 4 Traditional houses and haylofts

The traditional construction systems in the settlement and the use of adobe as the main building material stand out. Almost all of the traditional residential buildings were constructed with adobe-filled timber frame construction system on rough masonry rubble stone body walls with wooden

beams on the ground floor. There are also buildings constructed with masonry adobe technique. Until the 1980s, traditional building craftsmen continued to produce adobe and carried out repairs and new building construction. However, in the last 40 years, since the knowledge and skills of the craftsmen could not be transferred to the new generations, the masonry brick system has been mostly preferred in the partial repair of traditional buildings or in the construction of another building completely. Reinforced concrete system is preferred in today's constructions. As for the haystacks, which are one of the important elements of the settlement texture, it is possible to see examples with adobe filling or adobe masonry technique in the wooden frame system on rough masonry rubble stone body walls with wooden beams. Of the buildings analysed in the settlement, 51% were built with infilled timber frame, 34% with masonry brick, 8% with masonry adobe and 7% with reinforced concrete construction system (Graph 1b).

The majority of the wooden carcass buildings built with the traditional method within the settlement texture of Gelemiç have two storeys. The masonry residential buildings built after the 1960s were generally built as three storeys. When the haystack structures, which are one of the remarkable features of the settlement, are examined, almost all of them were built as two storeys on sloping slopes in order to provide loading from the upper level and access from the lower level when necessary. The buildings built in reinforced concrete or masonry brick system with concrete beams have 3 storeys. Buildings with more than 3 storeys are rarely seen. Sixty-five per cent of the buildings in the settlement are two-storey, 26 per cent are one-storey and 9 per cent are three-storey (Graph 1c).



Graph 1 a) Percentages of building types in the settlement; b) Percentages of buildings in the settlement according to their construction systems; c) Percentages of buildings in the settlement according to the number of storeys

3.1.1. Construction Techniques and Material Properties

The environmental compatibility of traditional adobe structures is not limited to their location or number of storeys, but is closely related to material properties, production methods, and construction techniques. In rural settlements, the sustainability potential of such structures can only be assessed through an integrated evaluation of material performance, structural configuration, and adaptation to local environmental conditions.

The settlement of Gelemiç exhibits a hillside settlement pattern shaped by sloping topography, where buildings are constructed with different level solutions in response to terrain conditions. Within this context, the traditional construction system is predominantly based on adobe-filled timber-framed structures erected on rubble stone foundations and load-bearing walls. According to local master builders, construction begins with rubble stone foundations and body walls, followed by the placement of timber beams and the erection of a timber frame composed of vertical posts and diagonal braces. The spaces between the timber elements are then filled with adobe blocks, and wall surfaces are finished with earthen plaster.

On-site investigations indicate that the ground floors of buildings are formed by rubble stone walls with a thickness of approximately 60–70 cm, reinforced with timber beams. Above these walls, timber-framed systems are installed on wooden bases with cross-sections ranging between 10×10 cm and 15×15 cm. Main posts are carefully positioned on larger stones, particularly at the corners, and in some cases supported by diagonal braces placed at angles of 30° and 45° (Figure 5-

6). The infill of the timber frame consists of adobe bricks measuring 15×7×27 cm, 16×8×28 cm, and 17×8×30 cm. While upper-storey surfaces are generally covered with earthen plaster, the stone masonry surfaces of ground floors are mostly left unplastered.

Figure 5 In-situ measurements

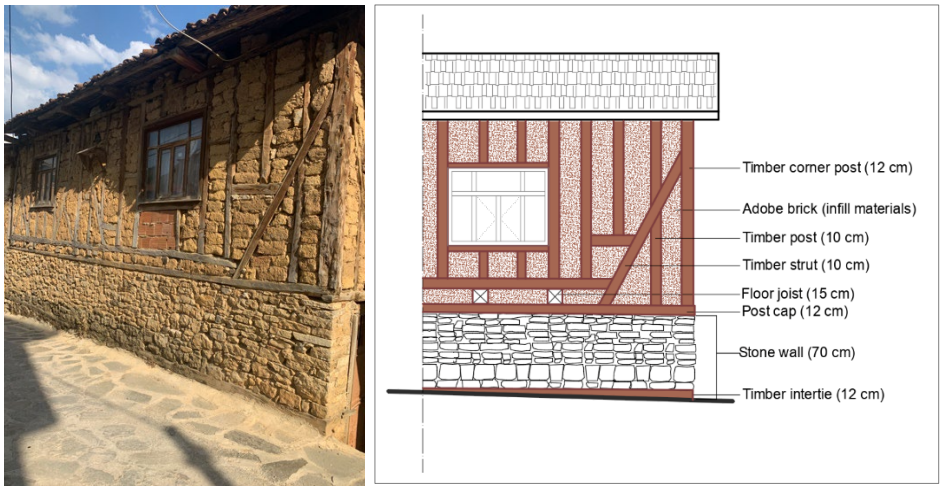


Figure 6 Construction technique-principle of load-bearing system

Adobe is the principal building material used in the settlement, functioning both as an infill material within the timber-framed system and as a plaster on wall surfaces. The clay and soil used for adobe production were sourced locally, primarily from the area surrounding the cemetery located to the north of the settlement. The material analyses conducted in this study were carried out for empirical reasons, aiming to evaluate the mechanical performance of adobe structures based on experimental data and to obtain results comparable with those reported in the literature. For this purpose, two adobe brick samples taken from different traditional houses were subjected to laboratory analyses. The bricks were produced by pouring a mixture of clay, sand, and water into wooden moulds and drying them under the sun, and they contain organic fibres such as straw to enhance strength.

Compression tests (Figure 7) revealed strength values ranging between 0.58 and 0.81 MPa for sample 1 and between 0.50 and 0.69 MPa for sample 2. These values fall within the range of compressive strength values for adobe bricks reported in the literature, which generally vary between 0.6 and 8.3 MPa (Walker et al., 2005; Coroado et al., 2010; Miccoli et al., 2014; Illampas

et al., 2011; Scalisi &Sposito, 2015). Variations in the measured values are considered to be related to the heterogeneous distribution of aggregates and fibre inclusions within the samples.

XRD analyses indicated that freitalite, quartz, and calcite are the dominant minerals in sample 1, while luogufengite, quartz, kaolin, and calcite are predominant in sample 2. This mineralogical composition demonstrates a strong relationship between adobe material and local soil characteristics and shows clear similarities with findings reported for traditional adobe structures in Anatolia and the Mediterranean Basin (Heathcote, 2011; Hall & Djerbib, 2004).

Figure 7 Adobe brick samples and compressive strength test

3.2. Investigation of Gelemiç Houses in Terms of Climatic and Ecological Parameters

3.2.1. Climatic Parameters

The shape of the building envelope, the ratio of transparent and deaf surfaces, material, orientation directly depend on climatic factors. In this context, the comfort environment in buildings should be provided as naturally as possible through climatic effects (Yüceer, 2011). The most important feature of adobe, one of the traditional materials, is that it is natural and healthy. With the help of the additives it contains, it provides thermal insulation without using an external thermal insulation material. Therefore, it keeps the environment warm by keeping the cold air inside in winter and keeps the environment cool by keeping the hot air outside in summer. Adobe, which is a soil-based material, is resistant to fire as it hardens at high temperatures. Walls made of adobe material, which are also used in humid climate zones, should be protected from moisture (Özgünler, 2017; Yalçın et al., 2022).

Gelemiç has a climate with hot summers and cold and rainy winters. Climatic factors, as an important design criterion, also guided the plan schemes during the design phase of the houses. In Gelemiç houses, space organisation, use of direction (orientation towards south), use of building elements and materials were planned and detailed according to the climatic parameters of the region. The houses, which are generally located close to the parcel boundary and/or forming the boundary of large gardens, are generally located in the north-south direction.

3.2.1.1. Material Properties Average Annual Precipitation

Site selection is very important for adobe structures. It is suitable for use in arid regions with little rainfall (Acun & Gürdal, 2003). One of the negative effects of climatic conditions on earthen houses is the destruction of adobe by rainwater and physical dissolution (Şahinalp, 2012). As can be seen in Figure 8, Gelemiç receives a high rate of precipitation (605-626 mm) in terms of annual precipitation averages.

Considering the rainfall conditions based on the last 20 years of data given in Table 1 and Table 2, it is seen that Gelemiç receives rainfall in an amount that can destroy the mud obtained by the addition of straw and salt used as adobe and plaster material in a short time and the monthly total rainfall average is highest in December and lowest in August. In Table 1, the long years (2004-2024) annual average of total monthly precipitation in millimetres is given in Table 2.

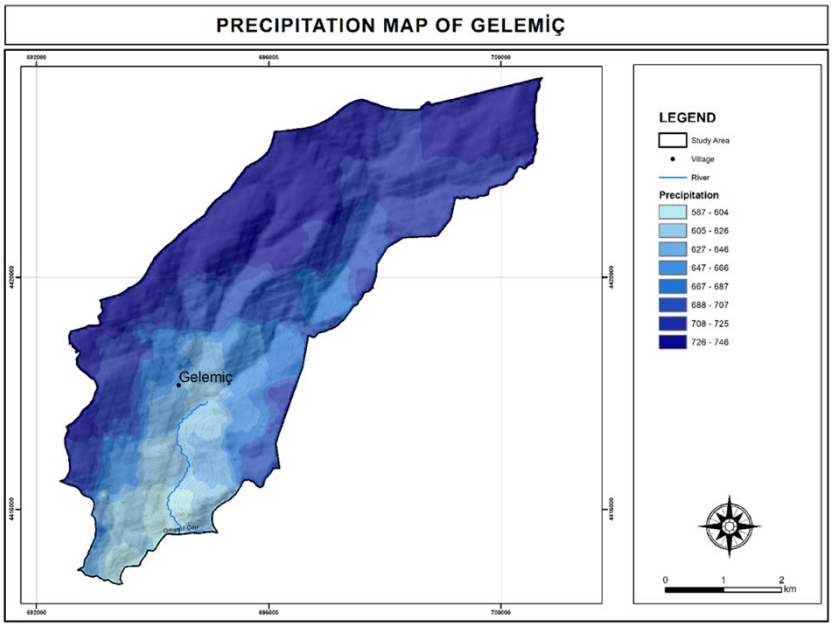


Figure 8 Annual average precipitation map of Gelemiç

Adobe can be quickly affected by moisture and water and may disintegrate after a while. Buildings should be protected especially in areas with flood risk and areas that may be exposed to ground water, and materials such as stone that are less affected by water should be preferred until the sub-base level. When the houses in Gelemiç are evaluated in terms of precipitation, although the precipitation rate is above the average of Turkey, the rate of negative impact is low because the foundations, foundation and basement walls of the buildings are stone up to the subbasement level. In adobe buildings, elements such as foundation, subbasement or basement floor below the ground level are made of suitable sized and durable stones. Stones that are large enough to exceed the thickness of the wall to be built or small enough to cause collapses in the foundation were not used. The construction was carried out below the minimum frost level of the ground.

Table 1 Long Years (2004-2024) of Gelemiç Rural Settlement Area (General Directorate of Meteorology Bursa Branch, 2024)

Years	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Average precipitation	846.3	815.4	488.6	575.4	587.4	783.2	1121.8	619.6	745	709.6	802	670.6	766.6	591.2	788.2	527.6	552.6	821.8	577.0	986.2	488.4

Table 2 Monthly Average Total Precipitation (mm=kg÷m²) of Gelemiç Rural Settlement Area (General Directorate of Meteorology Bursa Branch, 2024)

Month	January	February	March	April	May	June	July	August	September	October	November	December
Average total precipitation	96.5	69.7	85.2	61.1	67.4	51.7	16	11.7	30.8	56.8	73.8	80

3.2.1.2. Average Annual Temperature

According to Goldstein et al. (2010), temperature, like other climatic factors, is one of the factors that contain versatile solutions in architectural design. According to Yezioro (2009), temperature, like other climatic factors (wind, humidity, etc.), creates a temperature difference between indoor and outdoor spaces, causing heat transfer and accumulation in building components and materials

such as windows, walls and roofs. Undesirable temperature increase or heat loss in buildings adversely affects both indoor comfort. Based on temperature maps with the help of Geographical Information Systems, the average temperature of the village (Figure 9) is between 10.8 °C - 11.10 °C. Table 3, the monthly average temperature values of Gelemiç rural settlement area between 2004 and 2024, the annual average temperature values between 2004 and 2024 in Table 4, the monthly average maximum and minimum temperature values between 2004 and 2024, the highest and lowest temperature values are shown in Table 5.

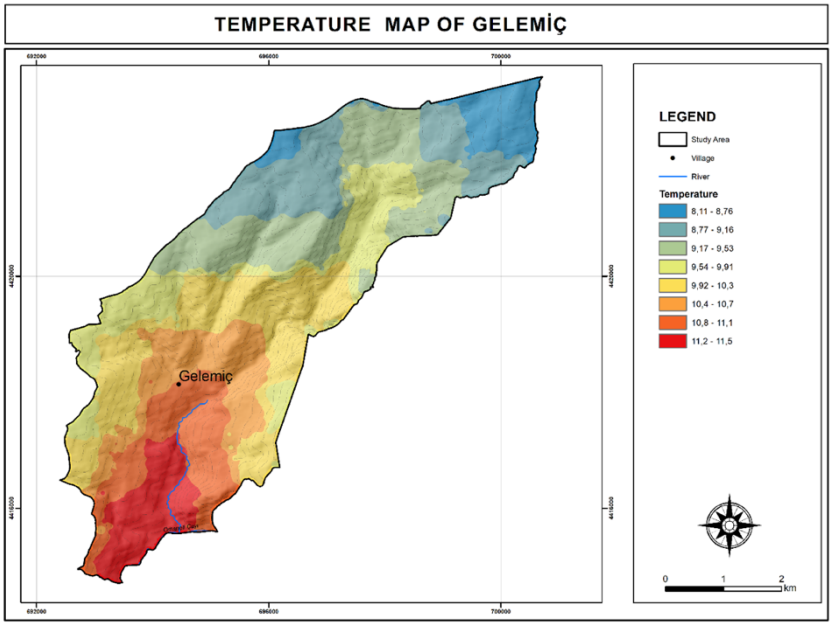


Figure 9 Annual average temperature map of Gelemiç

Adobe reacts slowly to temperature changes but does not heat up or cool down quickly, which helps to buffer sudden temperature changes. Adobe structures are generally used in hot and dry climates. Adobe has a high thermal mass. This allows the material to absorb heat and then release it slowly, absorbing heat from the sun during the day and keeping the interior cool, and releasing it back at night, stabilising the temperature of the interior. Adobe generally retains its structural properties at outdoor temperatures up to a maximum of 45-50°C. At higher temperatures, especially if exposed to direct sunlight for a long time, water loss and cracking may occur. When the monthly average maximum temperature values of Gelemiç were analysed, the average of July was measured as 41 °C, indicating that the adobe is ideal for maintaining its structural properties at outdoor temperatures.

When the monthly rainfall and temperature averages for the rural settlement of Gelemiç are evaluated together, it is concluded that the moisture formed in the wall during the winter period increases the possibility of freezing. However, it was determined that the void ratios on the wall surface in the building envelope in Gelemiç houses were not too high.

Table 3 Monthly Average Temperature Values (°C) of Gelemiç Rural Settlement Area Between 2004-2024 (General Directorate of Meteorology Bursa Branch, 2024)

Month	January	February	March	April	May	June	July	August	September	October	November	December
Average total precipitation	0.65	2.2	4,6	9.4	13.8	17.9	21	21.5	17.2	12	7.4	3.2

Table 4 Annual Mean Temperature Values (°C) of Gelemiç Rural Settlement Area Between 2004 and 2024 (General Directorate of Meteorology Bursa Branch, 2024)

Years	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Average precipitation	9.5	9.1	9.5	10	10	9.9	10.9	9.2	10.4	10.4	11.1	10.3	10.7	10.3	11.4	11.5	11.1	10.5	11.1	11.2	12

Table 5 Monthly Average Maximum and Minimum Temperature Values and Highest and Lowest Temperature Values (°C) of Gelemiç Rural Settlement Area Between 2004 and 2024 (General Directorate of Meteorology Bursa Branch, 2024)

Years	January	February	March	April	May	June	July	August	September	October	November	December
Average Maksimum temperature	9.6	10.9	13.8	19	24.9	31.9	32	28	22.1	16.6	11.7	3.2
Average Minimum temperature	1.7	2.2	3.6	7.2	11.4	15	17.3	17.3	13.8	10.2	6.4	3.6
Highest temperature	8.4	21.3	27.8	31.6	34.4	37	41	40.5	39.1	33.2	24.7	41
Lowest temperature	-24.9	-24.2	-19.1	-7.2	-1.6	3.8	4.4	5.5	-1.5	-9.8	-17.5	-24.9

3.2.2. Ecological Parameters

In addition to many positive aspects of adobe material, it also has negative aspects such as low compressive strength and weak resistance to earthquake effects. The lack of earthquake resistance of the structures produced with adobe material is not only due to material defects, but also due to problems related to the structure of the structure as a result of not applying the necessary details. In this study, geological factors and soil structure are examined.

3.2.2.1. Seismicity and Rock Structure

The major faults of Bursa, the province to which Gelemiç rural settlement is connected, are Iznik-Mekece, Gemlik, Gençali, Zeytinbağı, Inegol, Oylat, Bursa, Uludag, Mustafakemalpaşa, Orhaneli, Karacabey, Barakfaki, Sogukpinar and Kaymakoba. Among these fault lines, Soğukpınar at a distance of 7.1 km and Orhaneli at a distance of 11.9 km are the closest live fault lines to Gelemiç.

When the destructive earthquakes in the region are examined, the earthquake centred in Mustafakemalpaşa on 28 February 1855 occurred with a magnitude of 7.5 and caused great destruction all over Bursa and neighbouring provinces. In 1964, Manyas earthquake occurred with a magnitude of 7.0 and caused loss of life and property. The most recent earthquake centred in Gölcük on 17 August 1999 occurred with a magnitude of 7.6 and caused many damages. The information received from public institutions and organisations as well as the people living in Gelemiç emphasised that Gelemiç and its immediate surroundings were not affected by the major earthquakes that occurred in Bursa province (Bursa Provincial Directorate of Disaster and Emergency-AFAD, 2024).

Considering the regulation on adobe buildings to be built in earthquake zones, the walls should be continuous and the axis directions should follow each other and forms that do not have too many recesses and protrusions should be used. The void ratios in the building envelope of the houses in Gelemiç are as stipulated in the earthquake regulations as required by the construction technique of adobe material. In order to ensure horizontal stability, the use of beams in the

masonry is very important. Wooden material was used as beams in the houses in the village. The local thatch covering material used in the ceiling coverings is a natural and ecological material other than adobe used in Gelemiç houses. It also provides a lightness on the roof. As seen in the map in Figure 10 produced with the help of Geographical Information Systems, the geological infrastructure of Gelemiç, which has an altitude of 780 m, consists of rocks such as schist, granitoid, marble, sandstone, alluvium. When Gelemiç is analysed in terms of soil properties, rocks such as sandstone, marble and granite are found in places where settlements are dense. Since hard rocks such as granite transmit earthquake waves with less magnification, it increases the possibility of less damage to the structures on them. Marble and sandstone, on the other hand, are earthquake resistant because they have a good bearing capacity. Although there has not been a devastating earthquake in recent years, since the region is an earthquake zone, a number of suggestions for improving the adobe used in buildings have been brought by various studies. The use of stabilisers and additives to improve the properties of the soil against earthquakes is suggested in some studies. Various substances added to the soil in order to improve and develop the adobe are cement, lime, gypsum or lime + gypsum, bitumen, binding industrial wastes, straw, flax fibre, cotton stalks etc. (Binici et al., 2010).

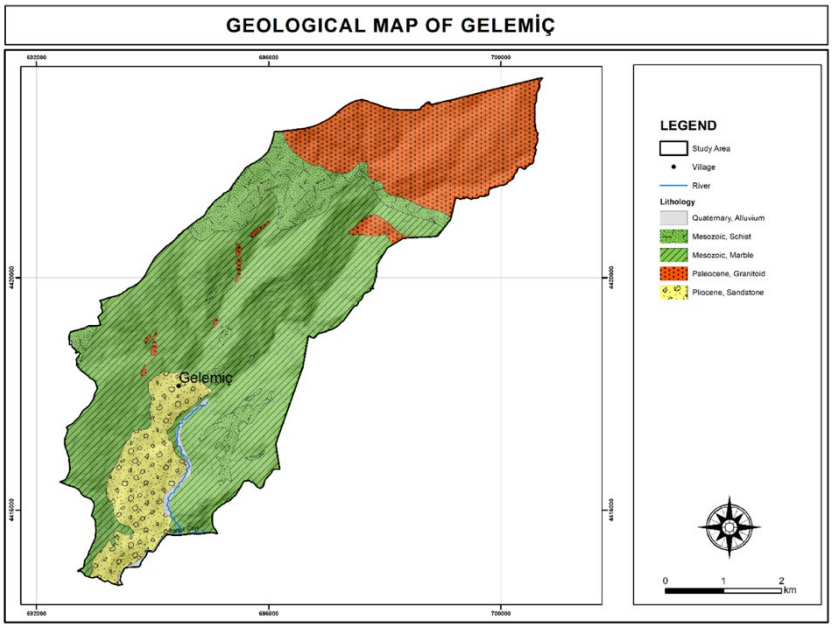


Figure 10 Geological map of Gelemiç

3.2.2.2. Soil Structure

In order to produce good adobe as a building material, it is important to select the appropriate soil type for this work. It is possible to find sufficient and good quality soil for adobe in many regions of our country (Koçu & Korkmaz, 2004). When the soil structure in Gelemiç was analysed, it was seen that it has brown forest soil, alluvium and non-calcerous brown forest soil structure (Figure 11).

Brown forest soils, which are among the large soil groups, consist of clays with calcareous clay or shale clay and limestone interlayers. Thanks to the clay contained in the brown forest soil group, the clay, which is one of the main components of the adobe material, is obtained from the foundation land called 'Clay deposit' (Figure 2) located in the village area, which provides certain advantages for the local people. These advantages are;

- Economic advantage: Elimination of the costly transport element for the supply of clay material
- Temporal advantage: The short supply of material provides advantages in terms of time in adobe structures to be built or requiring certain restorations and

- Spatial advantage: Providing clay material from an area belonging to the same ecosystem increases the resistance capacity of the material to environmental conditions.

The fact that the building material can be obtained from the immediate surroundings provides an advantage as it reduces the transport costs that may occur and accelerates the production process of the buildings (Ağan, 2024). The clay soil, which is the main material of the adobe buildings in Gelemiç, is obtained from the village and its immediate surroundings. The people living in the village stated that they supply the clay soil, which is the main material of the adobe structures they have built, and that they do not have any problems in transport.

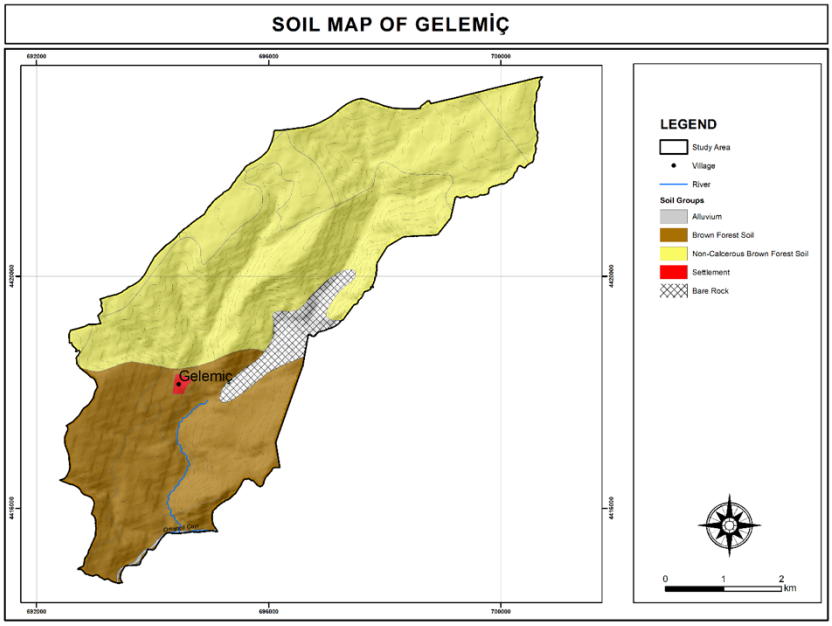


Figure 11 Soil map of Gelemiç

4. Conclusions

The World Bank states that if carbon dioxide emissions continue at the current rate of increase, the average temperature increase in the world will reach 4 ^{0}C in 2060 (World Health Organization, 2025). Climate change, which has become one of the most important problems of the whole world in recent years, shows its effects at an increasing rate. When analysed in the case of Gelemiç, the fact that the buildings are made of adobe releases less CO_2 into the atmosphere compared to concrete and brick structures in terms of climate change. When the issue of materials is examined within the scope of sustainable design and planning, the role of materials in climate change is known by everyone.

In this study, the physical characteristics of the rural settlement of Gelemiç and the architectural features of traditional buildings were investigated. In addition, adobe, which is an original and local building material, was analysed using analytical methods. As a result of laboratory tests, the compressive strength of adobe brick samples was found to be within the ranges specified in the literature. In order to ensure the ecological sustainability of the adobe material, the climatic characteristics of the study area (long years monthly average precipitation and temperature) and geological structure (seismicity, rock structure and soil structure) were examined. It has been observed that heavy rainfall, which is perhaps the most important of the climatic factors in the region, affects the spatial organisation and development of these structures and some measures have been taken by the local people against this.

When the 20-year monthly and annual average maximum and minimum temperature values are analysed, it is concluded that the adobe structures in the region are ideal for maintaining their structural properties at outdoor temperatures. Thanks to the clay contained in the brown soil group, which constitutes a large part of the area, the use of adobe material has become easier. This

situation provides economic, temporal and spatial benefits to the users. The void ratios in the building envelope of the houses in Gelemiç are made as stipulated in the earthquake regulations as required by the construction technique of the adobe material and the construction on a geologically earthquake-resistant ground reduces the risk of earthquake damage. However, despite all these, since the region is an earthquake zone, more scientific studies on the improvement of adobe used in buildings should be increased. In this regard, the studies to be carried out by public institutions together with scientists are very important. In rural dwellings where local materials are used, measures or suggestions to ensure the sustainability of these structures should be developed by taking into account the climatic and geological conditions of the environment.

Adobe is used as the building material with the least energy consumption during the manufacturing phase. In addition, since they also act as insulation, the energy consumption required for heating the space is low. In other words, adobe structures are a material that has been used for many years in terms of economic, functional, healthy and thermal comfort. Adobe material has a great role in the emergence of ecologically sustainable planning in rural settlements in harmony with nature. At the same time, the use of adobe and other local, renewable building materials necessitates an interdisciplinary collaboration in rural planning among landscape architecture, architecture, urban and regional planning, civil engineering, environmental engineering, and sociology, thereby enabling the development of holistic and sustainable settlement models that integrate ecological sensitivity with cultural continuity.

CRediT Authorship Contribution Statement

Figen Altıner: Writing – review & editing, Writing – original draft, Methodology, Investigation, Analysis, Data curation, Conceptualization, Data visualization. Ayşegül Ağan: Writing – review & editing, Writing – original draft, Methodology, Investigation, Analysis, Data curation, Conceptualization, Data visualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

Data will be made available on request.

Ethics Committee Approval

Ethics committee permission is not required.

References

Acun, S., & Gürdal, E. (2003). Yenilenebilir bir malzeme: Kerpiç ve alçılı kerpiç. *Türkiye Mühendislik Haberleri*, *427*, 71-77.

Ağan, A. (2024). Investigation of the use of local materials in historical buildings: The case of Ayvalık. In Ö. Parlak Biçer (Ed.), *Researches and evaluations in the field of architecture,* (pp. 26-39). Gece Kitaplığı.

Ajaj, Q. M., Shareef, M. A., Hassan, N. D., Hasan, S. F., & Noori, A. M. (2018). GIS based spatial modeling to mapping and estimation relative risk of different diseases using inverse distance weighting (idw) interpolation algorithm and evidential belief function (EBF) (Case study: minor part of Kirkuk City, Iraq). *International Journal of Engineering and Technology*, *7*(4), 185-191.

Akbaş, M. F., Aslan, M., & Arpacıoğlu, Ü. (2022). Yeşil malzeme bağlamında kerpiç. *Eksen Dokuz Eylül Üniversitesi Mimarlık Fakültesi Dergisi*, *3*(2), 72-88.

Altıner, F., & Kelkit, A. (2021). Land use cover change analysıs (1985-2020) of Ayvalık district Balıkesir Turkey using geographic information systems and remote sensing. *Fresenius Environmental Bulletin*, *10*(11), 8275-8290.

Aras Gaudry, A., Fronteau, G., & Hamard, E. (2023). Rediscovering raw earth heritage of champagne area (France): Cartography and typology of a specific adobe vernacular architecture. *Materials Today: Proceedings*. https://doi.org/10.1016/j.matpr.2023.08.310

Balta, S., & Atik, M. (2019). Köy tasarım rehberlerinin hazırlanmasında kırsal peyzaj karakterlerinin yeri: Antalya Elmalı örneği. *Mediterranean Agricultural Sciences*, *32*(1), 1_9. https://doi.org/10.29136/mediterranean.475220

Bingöl, F., Altıner, F., & Kelkit, A. (2023). Analyzing the most eligible site selection for biomass energy facilities through weighted overlay analysis: Case of Balikesir (Turkey) province. *Ege Üniversitesi Ziraat Fakültesi Dergisi*, *60*(1), 19-35. https://doi.org/10.20289/zfdergi.1136651

Binici, H., Durgun, M. Y., & Yardım, Y. (2010). Kerpiç yapılar depreme dayanıksız mıdır? Avantajları ve dezavantajları nedir? *KSÜ Mühendislik Bilimleri Dergisi*, *13*(2), 1-10.

Bostan, Z. (2014). *Düşük karbonlu kentsel gelişme bağlamında korunacak kültür varlıklarının yeniden ele alınması* [Unpublished master dissertation]. Mimar Sinan Güzel Sanatlar Üniversitesi.

Bui, Q. B., Morel J. C., Venkatarama Reddy, B. V., & Ghayad, W. (2009). Durability of rammed earth walls exposed for 20 years to natural weathering. *Built Environment*, *44*(5), 912-919.

Bursa Provincial Directorate of Disaster and Emergency-AFAD. (2024). (Retrieved January, 20, 2025) https://bursa.afad.gov.tr/bursa-ilinin-afet-tehlike-ve-riskleri

Cavé, M., Sindonino, S., & Groetembril, S. (2022). Exemples d'habitats aristocratiques sur les sites des rues Eugène_Desteuque et Ponsardin à Reims/Durocortorum. *Gallia*, *79*(1), 169_194. https://doi.org/10.4000/gallia.6589

Chen, F. W., & Liu, C. W. (2012). Estimation of the spatial rainfall distribution using inverse distance weighting (idw) in the middle of Taiwan. *Paddy and Water Environment*, *10*, 209_222. https://doi.org/10.1007/s10333-012-0319-1

Chen, R., Zhang, R., & Han, H. (2021). Where has carbon footprint research gone? *Ecological Indicators*, 120, 106882. https://doi.org/10.1016/j.ecolind.2020.106882

Christoforou, E., Kylili, A., Fokaides, P. A., & Ioannou, I. (2016). Cradle to site life cycle assessment (LCA) of adobe bricks. *Journal of Cleaner Production*, *112*, 443_452. https://doi.org/10.1016/j.jclepro.2015.09.016

Coroado, J., et al. (2010). Mechanical characterization of adobe bricks. *Materials and Structures*, 43, 1183-93.

Costa, C., Cerqueira, Â., Rocha, F., & Velosa, A. (2019). The sustainability of adobe construction: Past to future. *International Journal of Architectural Heritage*, *13*(5), 639_647. https://doi.org/10.1080/15583058.2018.1459954

Çavuş, M., Dayı, M., Ulusu, H., & Aruntaş, H. Y. (2015). Sürdürülebilir bir yapı malzemesi olarak kerpiç. In *II. Uluslararası Sürdürülebilir Yapılar Sempozyumu bildiriler kitabı* (pp. 10-15).

Çümen, U., & Sarıkaya, H. (2023). Hazır beton santralinin karbon emisyonlarının belirlenmesi. *Bingöl Üniversitesi Teknik Bilimler Dergisi*, *4*(2), 27-36.

Daly, J. W., Kaneko, T., William, J., Garratto, H. M., Spander, T. F., Espinosa, A., & Donnel, M. A. (2002). Bioactive alkaloids of frog skin: Combinatorial bioprospecting reveals that pumiliotoxins have an arthropod source. *Proceedings of the National Academy of Sciences of the United States of America*, 99 (22), 13996-14001

Damluji, S. A. (1999). *Yemen Reality-Architecture sculptured in mud and stone*. Garnet Publishing.

Demircan, M., Alan, İ., & Şensoy, S. (2011). Coğrafi bilgi sistemleri kullanarak sıcaklık haritalarının çözünürlüğünün artırılması. *TMMOB Harita ve Kadastro Mühendisleri Odası Yayını*, *13*, 18-22.

Elagöz Timur, B., & Asiliskender, B. (2024). Kırsal peyzaj mirası çalışmalarının habitus üzerinden değerlendirilmesi. *Milli Folklor*, *36*(141). https://doi.org/10.58242/millifolklor.1129209

Fathy, H. (1986). *Natural energy and vernacular architecture: Principles and examples with reference to hot arid climates*. University of Chicago Press.

General Directorate of Meteorology Bursa Branch. (2024). (Retrieved March, 20, 2025). https://eskisehir.mgm.gov.tr/

Goldstein, E. R., Ziegenfuss, T., Kalman, D., Kreider, R., Campbell, B., Wilborn, C., Taylor, L., Willoughby, D., Stout, J., Graves, B., Wildman, R., Ivy, J. L., Spano, M., Smith, A. E., & Antonio, J. (2010). International society of sports nutrition position stand: Caffeine and performance. *Journal of the International Society of Sports Nutrition*, *7*, 5. https://doi.org/10.1186/1550-2783-7-5

Google Earth. (2024). (Retrieved December, 25, 2024). https://earth.google.com/web/

Görmüş, S., & Oğuz, D. (2013). Kırsal yerleşim ve korunan alan arasındaki etkileşimin değerlendirilmesinde peyzaj karakter analizinin rolü: Kapısuyu Havzası örneği. *Tarım Bilimleri Dergisi*, *19*(4), 310-322.

Hall, M., & Djerbib, Y. (2004). Moisture ingress in rammed earth: Part 1-The effect of soil particle size distribution on the rate of capillary suction. *Construction and Building Materials*, *18*(4), 269-280.

Hammond, G. & Jones C. (2008). *Inventory of carbon & energy (ICE), version 1.6a*. University of Bath.

Heathcote, K. (2011). *The thermal performance of earth buildings*. Routledge.

Houben, H., & Guillaud, H. (1994). *Earth construction: A comprehensive guide*. Intermediate Technology Publications.

Huang, F., Jiang, S., Zhan, W., Bechtel, B., Liu, Z., Demuzere, M., … & Chen, J. (2023). Mapping local climate zones for cities: A large review. *Remote Sensing of Environment*, *292*, 113573. https://doi.org/10.1016/j.rse.2023.113573

Illampas, R., Ioannou, I., & Charmpis, D. C. (2011). A study of the mechanical behaviour of adobe masonry. *Construction and Building Materials*, *40*, 105-116.

Illampas, R., Ioannou, I., & Charmpis, D. C. (2023). Overview of the pathology, repair and strengthening of adobe structures. *International Journal of Architectural Heritage*, *7*, 165_188. https://doi.org/10.1080/15583058.2011.624254

İsak, S. (2023). *Pişmemiş toprak (kerpiç) duvarların enerji korunumuna etkisi ve çağdaş uygulama örneklerinin incelenmesi* [Yüksek lisans tezi, Karadeniz Teknik Üniversitesi].

Khouni, I., Louhichi, G., & Ghrabi, A. (2021). Use of GIS based inverse distance weighted interpolation to assess surface water quality: Case of Wadi El Bey, Tunisia. *Environmental Technology and Innovation*, *24*, 101892. https://doi.org/10.1016/j.eti.2021.101892

Kocabaş, A. (2012). The transition to low carbon urbanisation in Turkey: Emerging policies and initial action. *Habitat International*, *37*, 80-87. https://doi.org/10.1016/j.habitatint.2011.12.016

Koçak, H., & Bozyurt, O. (2021). Küresel iklim değişikliğine yönelik çözüm odaklı yaklaşımlar. *Journal of Social, Humanities and Administrative Sciences*, *7*(47), 2468-2479. http://dx.doi.org/10.31589/JOSHAS.831

Koçu, N., & Korkmaz, Z. (2004). Kerpiç malzeme ile üretilen yapılarda deprem etkilerinin tespiti. In *2. Ulusal Yapı Malzemesi Kongresi bildirileri*. TMMOB Mimarlar Odası İstanbul Büyükkent Şubesi.

Miccoli, L., Müller, U., & Fontana, P. (2014). Mechanical behaviour of earthen materials: A comparison between earth block masonry, rammed earth and cob**.** *Construction and Building Materials*, *61*, 327-339. https://doi.org/10.1016/j.conbuildmat.2014.03.009

Minke, G. (2022). Building with earth: Design and technology of sustainable architecture (2nd ed.). Birkhäuser.

Morel, J. C., Mesbah, A., Oggero, M., & Walker, P. (2001). Building houses with local materials: Means to drastically reduce the environmental impact of construction. *Building and Environment*, *36*(10), 1119-1126.

Nielsen, C. V. (2008). Carbon footprint of concrete buildings seen in the life cycle perspective. In *NRMCA 2008 Concrete Technology Forum: Proceedings*.

Orhon, A. V. (2012). Tasarımdan yapıma, sürdürülebilir beton yaklaşımları. *2. Proje ve Yapım Yönetimi Kongresi bildiriler kitabı* (pp. 700-706).

Özgünler, M. (2017). Kırsal sürdürülebilirlik bağlamında geleneksel köy evlerinde kullanılan toprak esaslı yapı malzemelerinin incelenmesi. *Journal of Architectural Sciences and Applications*, *2*, 33-41.

Özgünler, S., & Gürdal, E. (2012). Dünden bugüne toprak yapı malzemesi: Kerpiç. *Restorasyon ve Konservasyon Çalışmaları Dergisi*, *9*, 29-37. https://izlik.org/JA49DF52GM

Purnell, P. (2013). The carbon footprint of reinforced concrete. *Advances in Cement Research*, *25*(6), 362-368. https://doi.org/10.1680/adcr.13.00013

Reyes, J. C., Yamin, L. E., Hassan, W. M., Sandoval, J. D., Gonzalez, C. D., & Galvis, F. A. (2018). Shear behavior of adobe and rammed earth walls of heritage structures. *Engineering Structures*, *174*, 526-537. https://doi.org/10.1016/j.engstruct.2018.07.061

Royer, C. (2011). Les carreaux de terre crue en champagne-ardenne. In *Les cultures constructives de la brique crue: Échanges transdisciplinaires* (Vol. 3). Éditions Espérou, ENSAM.

Salih, M. M., Osofero, A. I., & Imbabi, M. S. (2020). Critical review of recent development in fiber reinforced adobe bricks for sustainable construction. *Frontiers of Structural and Civil Engineering*, *14*, 839-854.

Scalisi, F., & Sposito, C. (2015). Earth construction: The mechanical properties of adobe with the addition of laponite.

Silveira, D., Varum, H., & Costa, A. (2007). Rehabilitation of an important cultural and architectural heritage: The traditional adobe constructions in aveiro district. *WIT Transactions on Ecology and the Environment*, *102*.

Şahin, Ş. (2006). Kırsal peyzaj: Peyzaj karakter analizi, peyzaj planlama ve peyzaj yönetimi, Türkiye'deki peyzaj uygulamaları ve avrupa peyzaj sözleşmesi. *Eğitim uygulama programı*.

Şahinalp, M. S. A. (2012). Type of rural houses or a cultural heritage that tending to disappear: Beehive houses of Suruç. *Gaziantep University Journal of Social Sciences*, *11*(3), 881-916.

Turkish Statistical Institute. (2024). *Population and demography*. (Retrieved January, 3, 2025) https://data.tuik.gov.tr/Kategori/GetKategori?p=Nufus-ve-Demografi-109

Varum, H., Costa, A., Fonseca, J., & Furtado, A. (2015). Behaviour characterization and rehabilitation of adobe construction. *Procedia Engineering*, *114*, 714-721. https://doi.org/10.1016/j.proeng.2015.08.015

Walker, P., Keable, R., Martin, J., & Maniatidis, V. (2005). *Rammed earth: Design and construction guidelines*. BRE Press.

Wang, F., & Prominski, M. (2020). Landscapes with locality in urban or rural areas. *Indoor and Built Environment*, *29*(8),1047-1052. https://doi.org/10.1177/1420326X209383

World Health Organization. (2025). (Retrieved January, 3, 2025) https://www.who.int/data/#highlights

Yalçın, Ç., Kavut, İ. E., & Bingöl, K. (2022). Kerpiç malzemenin Anadolu'da geleneksel yapılarda kullanımı. *8gen-ART*, *2*(1), 82-96.

Yezioro, A. (2009). A knowledge based CAAD system for passive solar architecture. *Renewable Energy*, *34*(3), 769-779. https://doi.org/10.1016/j.renene.2008.04.008

Yıldız, F., & Çobancaoğlu, T. (2019). Bursa-Keles ilçesi Gelemiç kırsal yerleşmesi geleneksel mimari dokusunun incelenmesi ve koruma amaçlı değerlendirilmesi. *TÜBA-KED Türkiye Bilimler Akademisi Kültür Envanteri Dergisi*, *20*, 143-174. https://doi.org/10.22520/tubaked.2019.20.009

Yue, J., Zhang, Y., Li, P., Zhang, J., Huang, X., Yue, Y., & Han, Z. (2022). Experimental study on the mix ratio of restored heritage building adobe. *Materials*, *15*(11), 4034. https://doi.org/10.3390/ma15114034

Yüceer, S. Y. (2011). Mimari tasarımlarında iklim çözümleme: İstanbul üzerine bir deneme. *Mimarlık Dergisi*.

Ziegler, S., Leshchinsky, D., Ling, H. L., & Perry, E. B. (1998). Effect of short polymeric fibres on crack development in clays. *Soil and Foundation, 38*(1), 247-253.

Resume

Figen Altıner is a landscape architect and Assistant Professor at the Faculty of Architecture, Balıkesir University. She completed her PhD in Landscape Planning at Çanakkale Onsekiz Mart University in 2022. Her academic and professional work centers on sustainable landscape planning, ecological planning, and the modeling of future land-use patterns and spatial change processes. Her research aims to support the sustainable management of natural and cultural landscapes by integrating ecological principles into planning and decision-making processes. She has produced numerous scientific publications in national and international journals, contributing to the development of sustainable landscape planning approaches in both urban and rural contexts. Through her interdisciplinary research, she seeks to enhance landscape resilience, environmental quality, and long-term sustainability.

Ayşegül Ağan is an Assistant Professor at the Faculty of Architecture, Balıkesir University. She received her Bachelor's and Master's degrees in Architecture and completed her PhD in Architecture–Restoration at Istanbul Technical University in 2024. Her academic and professional work focuses on cultural heritage, architectural conservation, and traditional–historic building materials. She has conducted research on architectural heritage, defensive structures, and industrial heritage, and her recent studies concentrate on rural settlements and local building materials.

JOURNAL OF DESIGN FOR RESILIENCE IN ARCHITECTURE & PLANNING

Research Article
Online: www.drarch.org
Volume 7, Issue 1 (144-160), 2026
DOI: 10.47818/DRArch.2026.v7i1208

From rural landscapes to urbanized shores: Rurbanization and second-home dynamics in the Lake Van region

Berfin Karabakan Gökhan*
Yelda Mert*

Abstract

In recent years, in rural areas, rurban processes where rural and urban characteristics are intertwined and have attracted attention. In these areas, especially second homes, new second infrastructure investments and population movements cause socio-spatial transformations. These transformations result in rural areas gaining a new identity. This study investigates how second housing shapes the rurban process in Van/Mollakasım and its surroundings by focusing on the transformation of land use and changing settlement morphology. Within the scope of the study, changes in land use were analyzed using satellite images for the years 2000-2012-2024. In addition, a series of spatial analysis techniques such as Kernel density maps and Average Nearest Neighbor test were used. According to the analysis findings, it is seen that second housing in Mollakasım and its surroundings has increased over time and spatial clusters have formed especially in areas close to the coast. In addition, it is observed that second homes spread over agricultural areas and natural areas and this pressure exhibits a growth pattern that spreads to the inland areas. Within the framework of the research outputs, it is necessary to spatially define coastal and agricultural areas that are open to second home development, to determine the regions under construction pressure as priority monitoring areas and to develop planning strategies that will direct construction in these regions. In addition, it is important to implement spatial policy tools at the local level that limit the use of agricultural areas for non-production purposes and protect coastal areas in terms of public access.

Keywords: agricultural areas, land use changes, rurban, second home

1. Introduction

In recent years, rural areas have transformed from areas defined by agricultural production dynamics into spaces where different functions are intertwined. This trend is increasing especially in coastal areas with natural environments and makes it difficult to explain spatial boundaries with the classical urban-rural distinction. In this context, as rural areas acquire various urban functions, these areas have been reshaped and have caused the formation of rurban areas. The concept of rurban is generally defined as hybrid areas where rural and urban features coexist (Kolhe & Dhote, 2016; Malek & Baharudin, 2019; Delgado-Viñas & Gómez-Moreno, 2022; Keskin, 2024, pp. 9). Many dynamics have played a role in the emergence of these areas that combine urban and rural features. Especially the increasing demand for second homes is an important indicator in the transformation of rural areas. When evaluated in the context of Türkiye, rurban developments are observed in rural areas with scenic features such as coasts and lake surroundings; Second homes, fragmented construction and infrastructure pressure are becoming prominent elements of this process (Ceylan & Somuncu, 2020). Such transformations are mostly evaluated within the framework of urban sprawl in the literature, and the spatial patterns and dynamics of rurban areas are not sufficiently examined. In this context, the study conducted investigates the second housing trends in the rural areas around the Van Mollakasım coastline and whether these developments create a rurban pattern. While studies on second-home development in Türkiye largely focus on social, economic,

*(Corresponding author), Dr., Independent Researcher, İskenderun, Türkiye bkarabakan66@gmail.com
**Department of City and Regional Planning, Iskenderun Technical University, İskenderun, Türkiye yelda.mert@iste.edu.tr
Article history: Received 20 July 2025, Revised 28 November 2025, Accepted 12 March 2026, Published 30 April 2026

or demographic aspects, there are very few studies that holistically examine the spatial formation of these processes, the dynamics of morphological change, and land-use transformation. In particular, the paucity of studies analyzing long-term spatial changes in coastal settlements using remote sensing data points to a significant literature gap in this area. This gap highlights the need for spatial and analytical approaches to understand how rural areas undergo morphological transformation under the pressure of second-home development. For this purpose, Mollakasım, located on the shores of Lake Van, was selected as a typical rural transition area that is losing its rural identity and acquiring urban characteristics under increasing construction pressure. Mollakasım location was determined as the study area because it is an area where the spatial pressure on rural areas can be concretely observed and the spatial spread of second homes can be clearly observed. In line with the stated purpose, the methodological infrastructure of the study was designed to allow the analysis of the spatial dimensions of the transformation of second homes. In the study, a temporal comparison of the changes in the space was made using satellite images from the years 2000, 2012 and 2024. In addition, the direction, density and morphology of the construction trends were analyzed. The Kernel Density Analysis (KDA) method was chosen because it allows for the numerical mapping of spatial concentration trends of buildings. This method is critical for revealing whether second-home projects along the coastline are shaped by random or directed dynamics. Thus, the urbanization process can be assessed not only conceptually but also as a measurable spatial pattern. After the introduction, the study explains the conceptual framework, includes the analyses and dataset in the method section, evaluates the spatial analysis results within the framework of the concept of rurban in the findings section, and finally discusses the findings based on the literature.

2. Literature Review

2.1. Second Home

Second homes are usually located in rural and coastal areas away from the city and are primarily used for seasonal and recreational purposes rather than as primary residences (Hall & Müller, 2004). The concept is often used in the literature with different terms such as “second home”, “recreational dwelling”, “seasonal residence”, “leisure home” (Figure 1). Paris (2014) defines second homes not only as recreational areas related to tourism but also as mixed-quality recreational areas that include investment and consumption aspects. Another approach is defined by Hiltunen and Rehunen (2014) as a mobile lifestyle in second home tourism. Hall (2015) emphasizes that second homes emerged in Western Europe and North America in the second half of the 20th century in parallel with the increasing income and leisure time of the urban middle class, and evaluates the concept as ‘multi-space lives’. In particular, the development of transportation opportunities and the increase in private car ownership have facilitated access to second homes located in rural areas. The studies conducted investigate different dynamics such as the frequency of use of second homes, their legal framework, the residence of the owner, investment motivations, and the socio-spatial transformations they create.

Second homes are generally concentrated in coastal, lakeside and natural beauties (Kılıçaslan, 2006; Hall, 2015; Okuyucu & Somuncu, 2016; Ceylan & Somuncu, 2020; Usun, 2023). These preferences vary depending on criteria such as being in touch with nature, accessibility and being an investment vehicle. However, the increasing number of second homes over time has brought up complex questions regarding changes in land use, housing affordability and rural transformations. (Paris, 2014; Skak & Bloze, 2016; Ceylan & Somuncu, 2020).

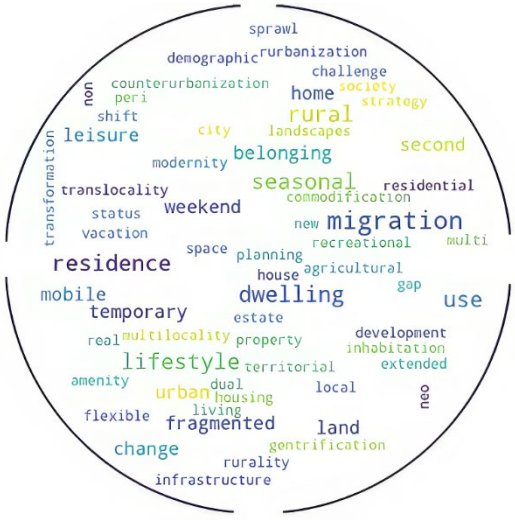


Figure 1 Concept cloud related to second home

In the current context where the boundaries between rural and urban areas are being redefined, spatial practices and ways of life are also undergoing significant transformation. Tacoli (1998) emphasizes that interactions between rural and urban spaces are not merely spatial but also economic, social, and cultural, and that the traditional dichotomy between the two is increasingly blurred. Especially in developing countries, livelihood strategies, migration patterns, and settlement preferences are forging stronger links between urban and rural spheres. In this respect, the development of second homes around Lake Van similarly reflects the transfer of urban lifestyles into rural settings, while simultaneously transforming rural productive landscapes into consumption-oriented environments. This transformation is not merely a matter of physical expansion; it represents a multifaceted socio-spatial restructuring process that clearly illustrates the local expressions of rurbanization (Tacoli, 1998).

The construction that started with the use of summer areas in rural and natural areas has spread over time and turned into spatial pressure. In particular, the increase in second home tourism in fertile agricultural areas has had a negative impact on food production, water resources and agricultural culture (Ceylan & Somuncu, 2020). In addition, this pressure on coastal areas produces inequality in terms of spatial justice and makes access to coastal areas possible only for a certain group.

With the discovery of coastal tourism in Türkiye, a large part of coastal settlements have been exposed to construction pressure and a new form of housing, second homes, has spread (Kılıçaslan, 2006; Okuyucu & Somuncu, 2016; Usun, 2023). Although second homes in Türkiye first appeared on the Aegean and Mediterranean coasts in the 1950s, they have developed intensively on the coasts of Istanbul. (Gökdeniz, 2014; Okuyucu & Somuncu, 2016). During the process, second homes are also observed in the Eastern Black Sea plateaus and around Lake Van in the Eastern Anatolia Region, which have various natural features of the country.

The lack of a comprehensive legal framework for second homes in Türkiye leads to flexibility in practices. For this reason, flexibility in the implementation of legislation such as natural protected areas, coastal law and agricultural land protection laws facilitates this housing (Kılıçaslan, 2006; Usun, 2023). In this context, the Coastal Law No. 3621, which supports the protection of coastal areas and a use that prioritizes public interest in Türkiye, came into force in 1990. This law aims to restrict construction and property uses that are contrary to public interest in coastal areas. However, these restrictions are not effective enough in terms of tourism practices and second homes. Therefore, the phenomenon of second homes in Türkiye has become a practice that contradicts both spatial and environmental sustainability goals due to existing legal gaps, lack of control and the spread of unplanned practices (Kılıçaslan, 2006; Usun, 2023). This emerging

phenomenon leads to problems such as both the transformation of public spaces into private property areas and the disruption of spatial justice in terms of planning. Similar governance and planning difficulties are observed in Southern Europe. In this context, Barke (1991) examines the spatial spread of second homes in Spain during the 1970s and clearly demonstrates how, in the case of Málaga Province (Costa del Sol), inadequate planning and governance mechanisms led to uncontrolled second home development. A similar study conducted in Portugal focuses on the economic and governance impacts of second home projects in the Oeste Region, located in the northwest of the Lisbon Metropolitan Area. Fieldwork by de Oliveira et al. (2015) shows that second homes in this region increase local incomes, but institutional deficiencies in planning and service delivery exacerbate spatial imbalances.

2.2. Rurban Areas

In recent years, the boundaries between rural and urban areas have become increasingly blurred, and rural areas have gained new functions beyond agricultural, traditional production and lifestyles. This transformation has led to the emergence of new settlement forms where rural and urban features coexist. This emerging settlement form is called rurban. The concept of rural-urban (rurban) was first used by Galphin in 1915 (Azhari, 2021). Rurban areas neither contain completely urban features nor overlap with the traditional rural definition (Shikalgar, 2013; Kolhe & Dhote, 2016; Delgado-Viñas & Gómez-Moreno, 2022). Due to these features, they require special attention in the field of planning.

The background of rurban developments is the urban dwellers' search for rural life, being in touch with nature, acquiring a second home, and increasing transportation opportunities and accessibility. These dynamics bring about the pressure of construction in rural areas, while causing agricultural production to decrease and rural areas to transform into a new morphology (Kolhe & Dhote, 2016). Moreover, many coastal settlements are shaped by more recreational, tourism-oriented demands due to their natural beauties. This transformation experienced in rural areas includes the transformation of socio-economic dynamics beyond physical change (Kolhe & Dhote, 2016; Keskin, 2024). Especially in coastal areas, the increase in second homes, initially built for seasonal use, is becoming a phenomenon affecting the transformation of rural areas (Kılıçaslan, 2006; Okuyucu & Somuncu, 2016; Usun, 2023). This phenomenon causes the original identity of coastal rural areas to erode over time and rural life practices to transform with urban demands. This transformation experienced in coastal areas can be shown as a typical example of rurban developments. In this context, secondary housing in coastal areas is not only the transformation of public space into private property, but also the commodification of rural areas, pressure on agricultural areas, redistribution of natural resources, and socio-spatial changes, and it becomes an important dynamic of the rurbanization process. Secondary housing and settlement practices with demands directed from the city to the countryside move away from randomness over time and form a structural pattern. In addition, rurban developments express a dynamic transformation in which space is reproduced in a multi-layered manner. Rurban patterns emerging in rural areas primarily bring about transformations in property structures, land use, and spatial value production. With second home investments, agricultural areas are turning into residential areas, rural landscapes are gradually fragmenting, and a conflict arises between the local people's usage priorities and external demands (Ceylan & Somuncu, 2020; Kılıçaslan, 2006).

2.3. Planning Policies and Governance Dynamics in Rural Transformation

As rural areas are transformed under increasing pressures, it has become necessary to take rural-urban processes into account in planning practice. (Azhari, 2021; Keskin, 2024). Recent debates on the transformation of rural spaces highlight the increasing relevance of peri-urban dynamics in shaping hybrid settlement forms. As emphasized in the PLUREL project synthesis (Piorr et al., 2011), peri-urban areas have emerged as distinct zones where urban and rural functions intermingle, producing fragmented landscapes and complex governance challenges. These zones are not merely transitional fringes but multifunctional territories under intense development

pressure due to economic restructuring, lifestyle changes, and land speculation. The study identifies that peri-urban expansion in Europe is occurring at a rate 3–4 times faster than core urban areas, often without adequate spatial planning and regulatory oversight. This has led to increasing land consumption, habitat fragmentation, and erosion of agricultural land, especially in regions with weak planning regimes. In this context, rural areas like those around Lake Van are also experiencing similar dynamics, where second-home developments function as vectors of rurbanization, contributing to the restructuring of rural morphologies along urban lines. Addressing such transformations requires integrated planning approaches at the rural–urban interface that go beyond the traditional urban-rural dichotomy and instead prioritize territorial cohesion and sustainable land governance (Piorr et al., 2011).These transition areas taking shape between rural and urban areas exhibit a complex character not only spatially but also in terms of demographic, economic and social structures. For this reason, rurbanization should not be considered as a mere construction problem, but as a multi-dimensional planning issue. The fact that planning approaches are still structured with an urban-centered and hierarchical logic causes rurban areas to not be fully managed either by rural development policies or urban planning tools. However, in such transition areas, flexible, local context-sensitive planning strategies that take into account dynamics such as seasonality and multi-space living, where different forms of use can coexist, should be developed. Otherwise, these new spatial patterns formed in rural areas spread uncontrollably and lead to irreversible environmental, social and economic problems. In this context, the inclusion of rurban processes in the planning framework is not only in terms of protecting the countryside; it is also critical to ensuring spatial justice, sustainability and sensitivity to local needs.

In the context of Türkiye, one of the fundamental challenges in managing rurban transformations is the inadequacy and fragmentation of spatial planning tools. Although several legislative frameworks exist—such as the Zoning Law (No. 3194), the Coastal Law (No. 3621), and laws aimed at the protection of agricultural lands—these are typically implemented in a disconnected and uncoordinated manner. This issue becomes particularly evident in rural and semi-rural areas. Furthermore, with the enactment of the Metropolitan Municipality Law (No. 6360), rural villages were reclassified as urban “neighborhoods,” which brought them under the jurisdiction of urban planning without ensuring adequate planning attention, service provision, or control mechanisms. As a result, areas like Mollakasım have experienced a proliferation of second-home developments that are often parcel-based, informal, and lacking in overall planning coherence. Thus, the core issue in the Turkish context is not merely the absence of appropriate technical tools but also the lack of a comprehensive rural planning paradigm that is capable of addressing hybrid geographies like rurban zones, and that responds to the multifunctional nature of rural territories with flexibility and contextual sensitivity.

2.4. The Conceptual Position of Rurbanization

In the broader spectrum of rural-urban transformation theories, the concept of rurbanization intersects with but remains distinct from related terms such as peri-urbanization, exurbanization, and counter-urbanization. Peri-urbanization typically refers to transitional zones at the edge of cities where rural and urban functions coexist, often characterized by fragmented land use and governance complexity (Piorr et al., 2011). Exurbanization, on the other hand, describes the process of high-income urban dwellers relocating to more distant rural areas while maintaining urban economic ties, often driven by lifestyle preferences and enabled by mobility (Nelson & Sanchez, 1999). Counter-urbanization involves a more demographic-driven shift, where population decline in urban areas is accompanied by growth in rural or smaller towns, often interpreted as a reaction against urban congestion and cost of living (Champion, 1989). Unlike these models, rurbanization places emphasis on the coexistence and hybridization of rural and urban elements within the same territorial and morphological context, resulting in a spatial form that defies traditional dichotomies. In this sense, rurban areas are not merely extensions of urban sprawl nor purely outcomes of population redistribution; they represent a distinct socio-spatial process of hybridization and

reinterpretation of rural space under urban logics. On the other hand, the concept of "urban oasis" expresses the effort to reclaim space and re-establish livability in spaces lost and wasted during the process of modernization and homogenization (Shirazi & Falahat, 2015). Similar to the rural phenomenon, this concept emphasizes the ability of areas where rural and unique characteristics intertwine to create a unique spatiality.

The dynamics observed in Mollakasım also resonate with what Nelson and Sanchez (1999) describe as exurbanization—where urban residents relocate to peripheral rural zones, maintaining urban economic ties while seeking lifestyle advantages. Although the case of Lake Van is not a textbook example of exurban migration, the seasonal and investment-driven nature of second homes indicates a parallel logic of spatial consumption.

Considering the conceptual discussions on rurban transformation and the planning challenges specific to the Turkish context, the following section presents the selected case study area in detail to observe how these processes materialize spatially. The conceptual differences discussed here demonstrate that rural-urbanization is not merely a temporary process but a distinctive socio-spatial formation. The following section examines how this transformation occurred around Lake Van, using the example of Mollakasım.

3. Study Area

This paper examines the coastal strip of Mollakasım Neighborhood in Tuşba district of Van province (Figure 2). Mollakasım is a neighborhood in the Tuşba district of Van province, located 30 km away from the Van city center. Mollakasım was updated as a neighborhood when Van province gained the status of a Metropolitan Municipality with the law numbered 6360 in 2012. With the Metropolitan Municipality Law, these villages, which were rural in nature, became neighborhoods affiliated to the central districts. Mollakasım Neighborhood is a settlement area that draws attention with its natural areas and lake view. Although the area falls within the jurisdiction of metropolitan planning, no comprehensive zoning plan or rural development strategy has been implemented at the local scale. In this context, due to its features, the increase in second home construction areas in recent years has created spatial transformations in these areas with high rural quality. In addition to physical transformations, the area has recently experienced changes in land ownership patterns and seasonal population flows, which further intensify development pressures.

Mollakasım and its surroundings were generally a rural settlement where agricultural production was carried out in the past, but after the 2000s, it entered a rurban process with increasing construction. In this context, the study area is transforming into a transition area that both continues its rural characteristics and has morphological urbanization tendencies. The region under analysis is a qualified sample worth examining, especially in terms of investigating the pressure of construction on the coastline, second housing and structural transformation of natural areas.

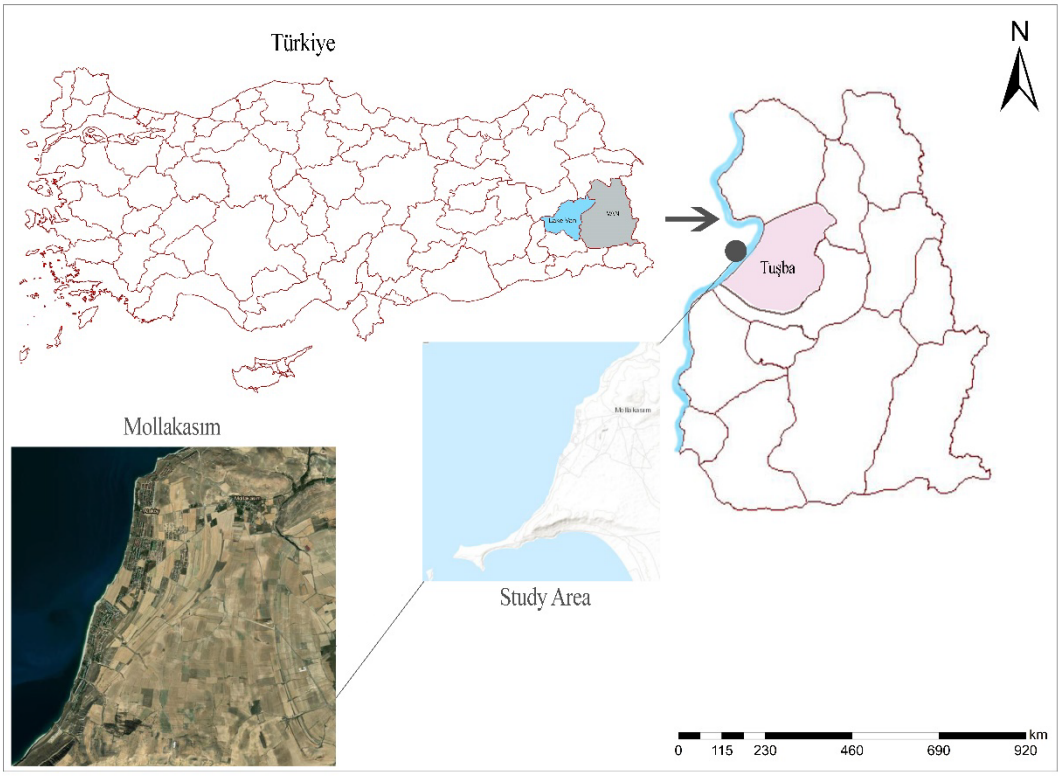


Figure 2 Study area / Mollakasım Van

4. Data and Method

This section provides detailed information on the method flow and data sets used in the study. In the first stage of the method, spatial changes in construction were analyzed using satellite images from Google Earth Pro for the years 2000, 2012 and 2024. In addition, satellite images from 2012 and 2024 were examined, buildings were manually counted and the percentage of change over the years was calculated. Satellite images from 2000 were examined, and due to the absence of any construction along the coastline, this year was used as the starting point for the analysis. Building numbers were evaluated using a zero reference point at this stage. Kernel density analysis was performed to strengthen this analysis method. This method was applied to reveal the spatial densities of building densities. The analysis based on point data allows understanding how construction trends change over the years. In the second stage of the method, Average Nearest Neighbor (ANN) analysis was performed to investigate whether the construction trend was random or had a specific spatial pattern. In the final stage of the method, CORINE land use data for the years 2000 and 2018 were analyzed and the impact of second home development on agricultural areas was evaluated by making spatial comparisons. The scope of the datasets used in this study presents some limitations. Because CORINE land use data has not been updated since 2018, assessments conducted after this date were supplemented by manual building counts from satellite imagery. In this process, images from different years were compared and verified using specific control points to improve the spatial accuracy of buildings. However, this visual interpretation-based method cannot completely eliminate human error and data sensitivity. Therefore, the findings for the post-2018 period focus on identifying spatial trends and distribution patterns rather than quantitative accuracy. Data from different years were transferred to ArcGIS software and processed with comparative spatial analysis methods. In this context, both spatial and numerical transformations were presented using tools such as raster calculators and reclassification.

5. Finding

This section describes the main empirical findings, paying special attention to the spatial features and transformation patterns identified in different land use categories.

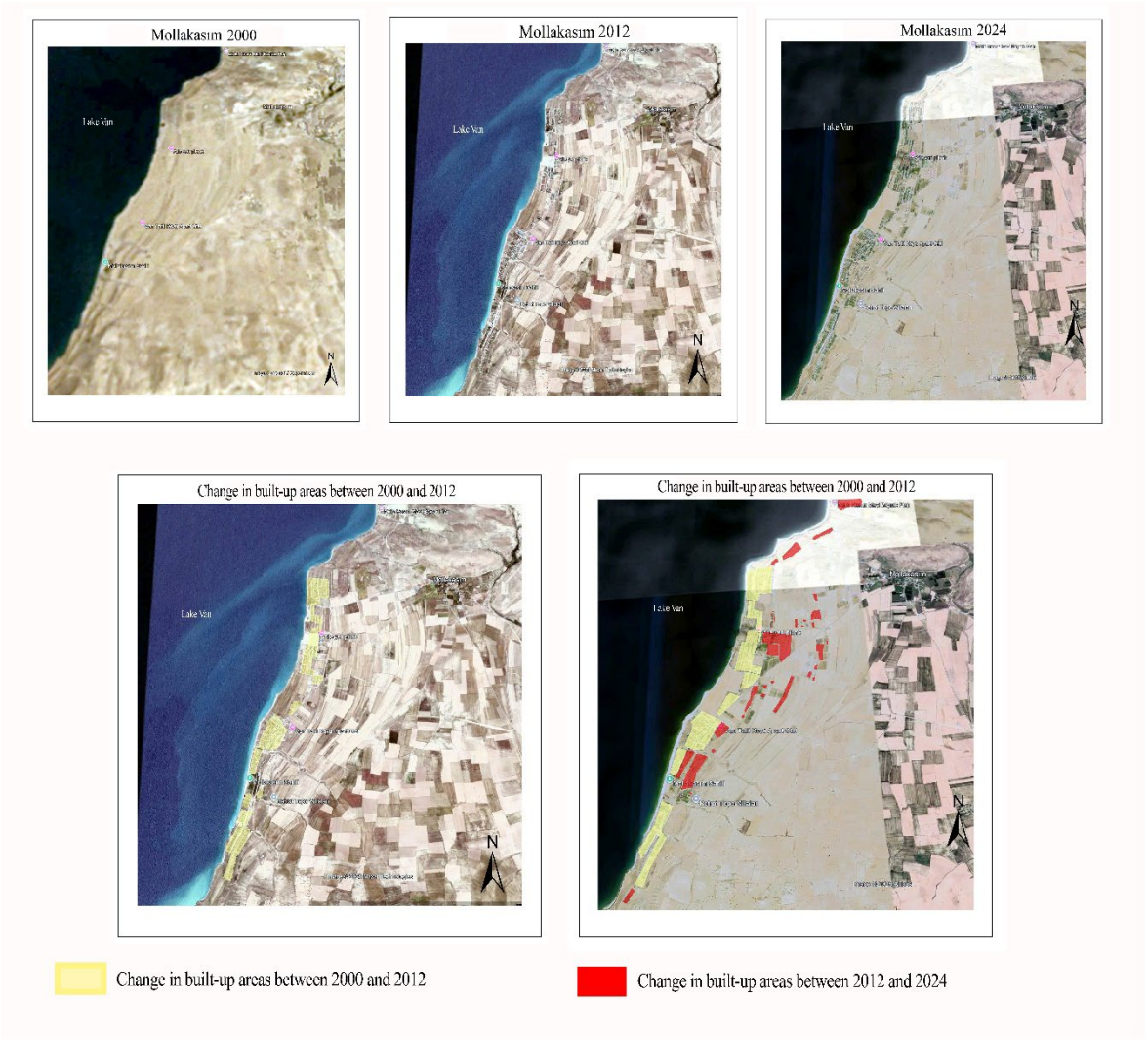


Figure 3 The changes in the construction of the Mollakasım district coastline between 2000 and 2024 (Analyzed with satellite images obtained from google earth pro)

Table 1 Number of Buildings Identified on the Coastline of Mollakasım Neighborhood Between 2000-2024

Year	Number of buildings	Increase %
2000	0	-
2012	549	-
2024	1149	%109

When the temporal development of construction trends is examined, traces of a typical rurbanization process are clearly seen in Mollakasım Neighborhood (see Figure 3). In this coastal area, which was characterized by agricultural production in the 2000s, clusters of construction suitable for second home use emerged in the period after 2012; and by 2024, it was observed that these constructions had spread from the coast to the inland areas (Table 1). This form of development indicates a rurban settlement pattern in which the rural texture is transformed by urban forms.

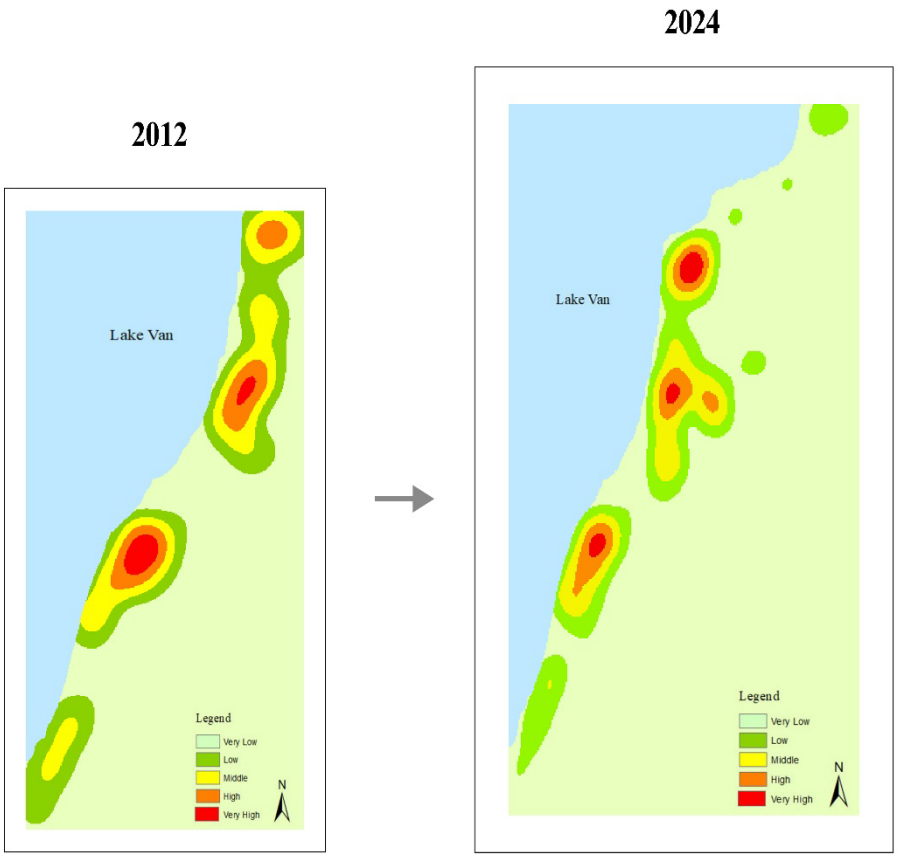
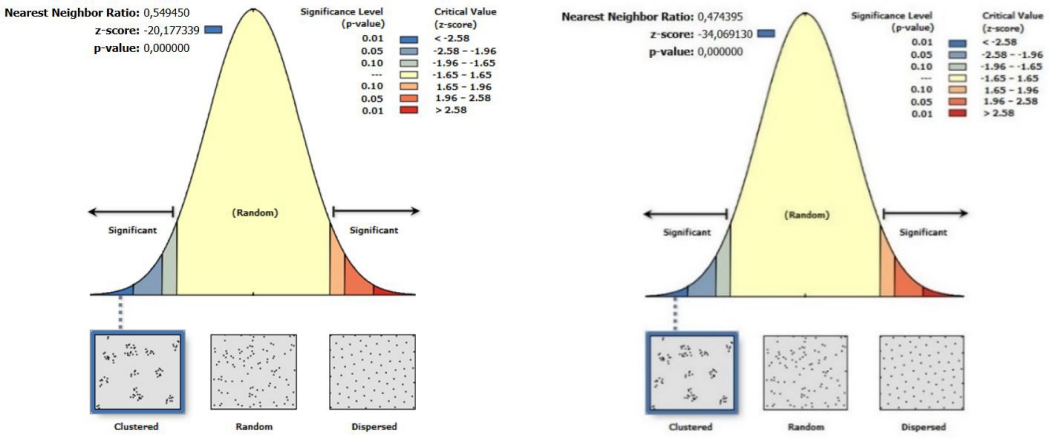


Figure 4 Second housing cluster density (Kernel density analysis): 2012-2024 comparison (Produced from google earth pro KML building points)

Density analysis results show that while construction was observed only in certain areas with limited to moderate density in 2012, this pattern appears to have changed significantly by 2024 (see Figure 4). Not only has density increased, but the area covered by construction has also expanded significantly. This expansion, particularly observed in coastal areas, indicates that construction pressure is spreading more strongly, both horizontally and spatially, clustering at specific focal points. In other words, construction has not only spread into new areas, but also central pressure areas have formed as density increases around existing construction.



(a) 2012 (b) 2024

Figure 5 Normal distribution graphs of the average nearest neighbor analysis for the years 2012 and 2024

Table 2 ANN Analysis Results on Secondary Housing Development in the Coastal Strip of Mollakasım Neighborhood

	2012	2024
Number of Input Points	549	1149
Actual Average Distance	0,0002 Meters	0,0002 Meters
Expected (Random) Distance	0,0004 Meters	0,0004 Meters
Z-score	-20,177	-34,069
p-Value	0.000000	0.000000
Distribution Comment	Clustered	Clustered

The Average Nearest Neighbor (ANN) analysis, which was conducted to analyze the spatial pattern of construction, revealed that secondary residences do not show a random distribution in rural areas (Figure 5). As a result of the measurement made on point data, a significant difference was detected when the observed average distance was compared to the expected value. The obtained Z-score (-34.069) was found to be negative and the p-value (0.00000) was found to be statistically significant, as shown in Table 2. The resulting Z score (-34.069) was negative, and the p-value (0.00000) was statistically significant. The number of building points increased from 549 in 2012 to 1,149 in 2024; however, the actual average distance remained the same (0.0002 m) and was lower than the expected distance (0.0004 m). This suggests that the average distance between building points was shorter than the random distribution, and therefore, buildings were placed closer together. These findings indicate that secondary residences were concentrated in certain areas and exhibited a spatially clustered building pattern. Furthermore, the higher absolute value of the Z-score in 2024 compared to 2012 (-34.069) indicates that clustering has strengthened over time. In other words, construction both increased in number and tended to be spatially concentrated around certain centers of attraction. These findings indicate that secondary residences were concentrated in certain areas and exhibited a spatially clustered building pattern.

Figure 6 Satellite images of the second housing cluster on the coastline of Mollakasım neighbor (2024)

In the field visual, different villa complexes positioned parallel to the coastline are placed side by side with similar plan schemes. These second housing developments, especially concentrated on the Mollakasım coastline, exhibit a striking pattern not only in terms of physical spread but also in terms of architectural similarity, plot order and morphological character. As seen in Figure 6. The

settlement units in question have become defined by being organized in certain spatial clusters, homogeneous building typologies, similar plot sizes in terms of scale and repetitive mass organizations.

The CORINE-based land use distribution for 2000 is shown in Figure 7, while the distribution for 2018 is shown in Figure 8.

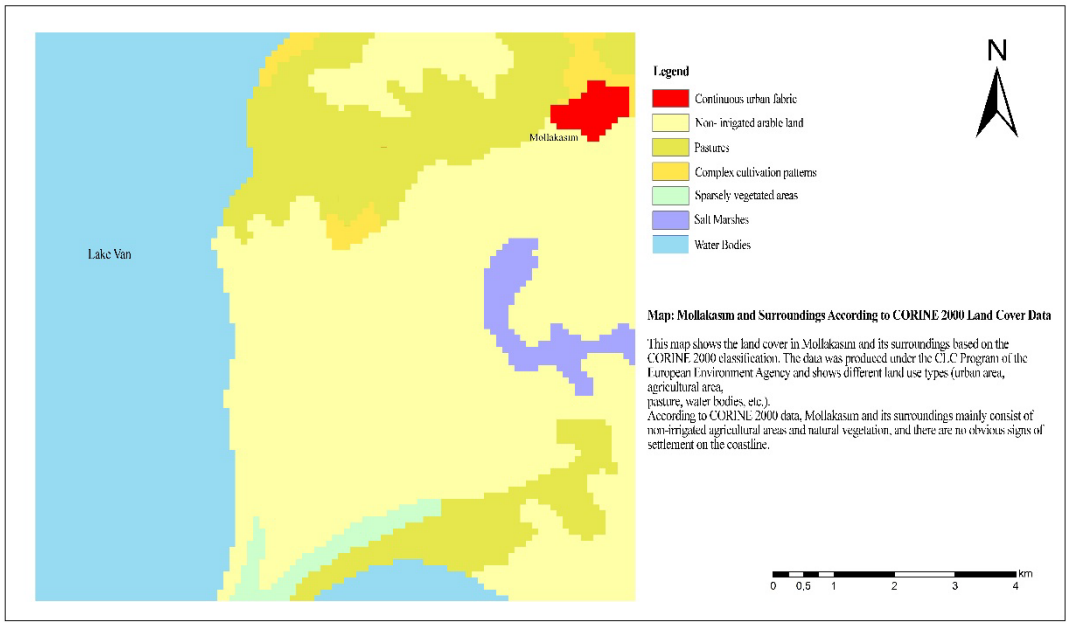


Figure 7 CORINE land use in 2000

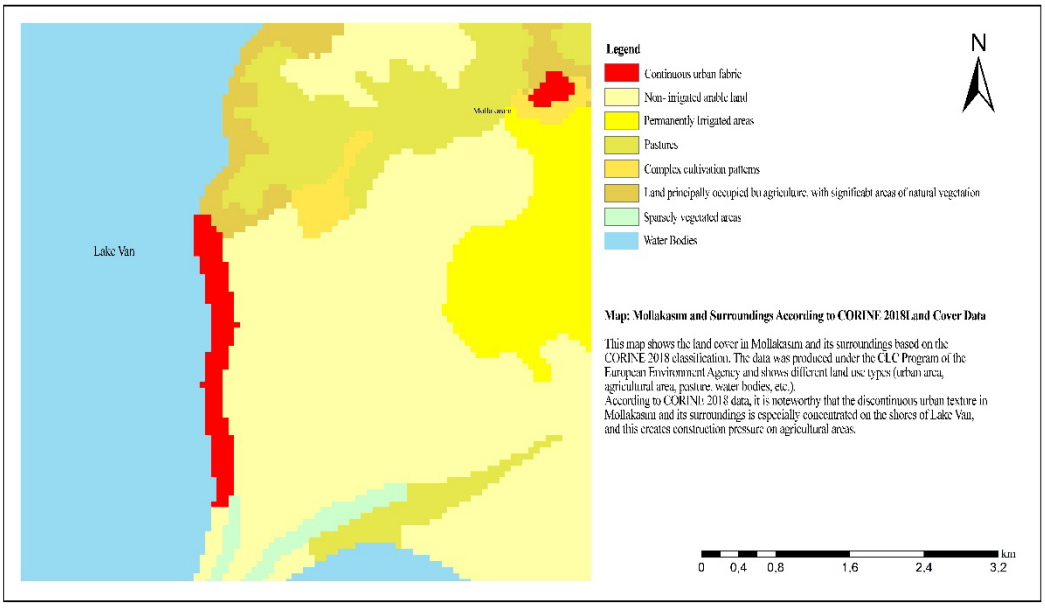


Figure 8 CORINE land use in 2018

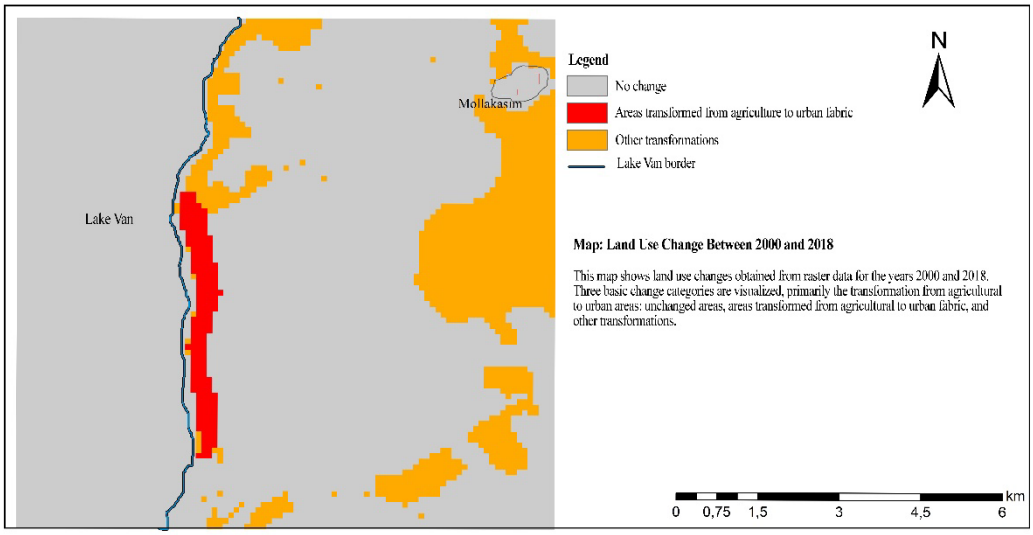


Figure 9 CORINE land use change 2000-2018

(Although the year 2024 was taken as a reference in the analysis, the most up-to-date Corine map (2018) was used to evaluate land use due to the lack of data for this year.)

According to the land use change analysis between 2000 and 2018 (Figure 9), approximately 11.8 hectares of non-irrigated arable land in the study area was directly converted to urban uses. This transformation is not only a physical land change; it is also a concrete indicator of the spatial pressure that rural areas are exposed to. The transformation of non-irrigated lands in particular reveals that lands considered to have lower agricultural production value are more easily opened to construction and that planning policies do not prioritize rural sustainability. This change trend shows that settlement pressure in rural areas is becoming more systematic and that urban demands are strengthening the transformative effect of rural areas. Although the magnitude of the transformation seems limited in absolute terms, such changes can be evaluated as the starting point of expansionist construction trends that threaten the unique landscape, production methods and ecological integrity of the countryside. Moreover, this transformation indicates not only a spatial shift; it also indicates that the rural area has begun to disintegrate in terms of identity and functionality. Therefore, such land transformations are not merely technical data in the planning process; It should also be considered critically important in terms of protecting rural areas, the future of agriculture and ensuring spatial justice.

Although the Van Lake area was registered as a “Sustainable Protection and Controlled Use Area” in 2022, the extent to which this status is reflected in the Mollakasım Neighborhood and the coastline is quite controversial. The construction trends observed on the coastline largely contradict the said protection decisions; the density of buildings, especially in parcels close to the coast, is significantly increasing. These structures are mostly built for second homes and are largely based on unplanned, individual initiatives developed solely on a parcel basis. Another particularly striking situation is the gradual decline in public use in coastal areas and the de facto transformation of these areas into private property. Despite the public interest principles stated in the Coastal Law and the regulations that the coastline should be open to everyone, access to the coasts is restricted in many areas with wire fences, private entrance gates and personal use areas; the natural coastline is largely under pressure from construction. This situation has negative effects not only on the physical environment but also on social equality and the right to access space. In this respect, Mollakasım presents a concrete example of the unplanned transformation and conservation-use contradiction experienced in the transition areas between the city and the countryside. This divergence between conservation decisions and the actual situation on the field is a sign of a larger-scale ecological and spatial degradation around Lake Van.

This transformation process not only alters spatial patterns but also entails long-term risks for the sustainability of the rural economy. The conversion of agricultural land into built-up areas reduces local production capacity and threatens traditional rural livelihoods. Moreover, in these hybrid areas where the boundaries between rural and urban are increasingly blurred, natural assets such as public spaces and coastal zones are progressively subject to privatization. This raises serious concerns in terms of spatial justice, as capital-owning groups gain access to second-home opportunities, while local residents become increasingly disadvantaged due to rising land values and limited access to resources.

6. Discussion

The findings of this study reveal that second home development in the rural coastal areas of Lake Van is not a random or isolated spatial phenomenon, but rather part of a broader and systematic rurbanization trend. The temporal progression of construction pressures reveals not only the physical spread of this change but also the speed and intensity of socio-spatial transformation. Increasing construction disrupts the continuity of natural areas, deepens the pressure on agricultural lands and coastal ecosystems, and demonstrates the inadequacy of local planning tools to combat this pressure. In this context, the period 2012-2024 is notable for demonstrating the increasingly systematic intensification of construction and the re-creation of space based on user profiles. Furthermore, the conversion of agricultural land into seasonal settlements, often outside of formal planning mechanisms, demonstrates the increasing urban impact on rural areas. Similar trends are observed in the European context (Piorr et al., 2011).

In this regard, Tacoli's (1998) assertion that the rural-urban dichotomy is no longer adequate to explain the complexity of contemporary settlement dynamics proves to be highly relevant. This demonstrates that structures opened for residential use in rural areas are shaped not only by individual preferences but also by specific spatial trends. Clustering, particularly in areas close to the coastline, with scenic views, or with high accessibility, can be considered spatial traces of rural transformation. This clustering of second homes reinforces trends in unplanned or uncontrolled plot-based construction, thus creating a fragmentation in the structural identity of rural areas. Spatial clustering reflects not only increased density but also the changing nature of spatial production. In this context, ANN analyses demonstrate the development of a new settlement model with urban characteristics in rural areas, demonstrating that the process of rural urbanization creates a measurable pattern not only at the sociological but also at the spatial level. In the case of Lake Van, second homes have become more than leisure spaces; they represent a mobile, consumption-oriented lifestyle that reflects changing socio-economic values among urban middle classes, similar to those observed in Western Europe (Hall, 2015; Gallent et al., 2005).

Moreover, the study confirms that rurbanization in this region is largely shaped by informal and opportunistic land use, facilitated by weak enforcement of legal frameworks such as the Coastal Law No. 3621. This aligns with the findings of Paris (2014), who highlights that second home development frequently occurs in regulatory grey zones, leading to increased environmental risks, spatial injustice, and rural commodification. This regularity reveals that these structures are shaped not only by individual preferences but also by a specific spatial logic and market-driven mode of production. The uniform building character reveals the physical traces of the rural morphology that emerged with the transfer of urban lifestyles to rural areas, and distances itself from the subjective morphology of the countryside. Therefore, this structural pattern demonstrates that the transformation undergone by rural areas is not merely pervasive but also reproduced with urban values at formal and semantic levels. In other words, this pattern reveals that the spatial traces of the rural-urban process are now visibly fixed.

The process around Lake Van, by granting access privileges to high-income groups, deepens spatial inequalities, threatening agricultural sustainability and cultural continuity. These results

echo similar tensions observed in peri-urban areas across Europe, where multifunctionality and fragmentation challenge traditional land uses (Piorr et al., 2011; Skak & Bloze, 2016).

Recent discussions on rural transformation emphasize the need to integrate spatial resilience and morphological continuity in areas undergoing informal second-home development. As highlighted by Demiroğlu İzgi (2022), the fragmentation of rural landscapes without ecological sensitivity weakens the adaptive capacity of these environments. Similarly, Mamunlu Kocabaş, (2025) study on water-sensitive planning underlines that increasing accessibility and land speculation in lakeside districts, such as those around Van Lake, directly contributes to the loss of agricultural lands and the privatization of public spaces. Consequently, the morphological homogenization of second homes around Mollakasım reflects a restructuring that challenges environmental and spatial justice.

In the case of Mollakasım, the rurbanization process is significantly shaped by institutional shortcomings and the limited capacity of local authorities to anticipate and manage spatial transformation. Although the region officially fell under the jurisdiction of the Van Metropolitan Municipality after the enactment of Law No. 6360, no comprehensive zoning or rural development plan was implemented at the neighborhood level. This governance vacuum has led to the proliferation of parcel-based, unregulated second-home development. The disconnect between metropolitan-scale planning imperatives and local-scale realities has left neighborhoods like Mollakasım in a marginal position, subject to urban planning controls without the necessary institutional support or infrastructure investment. Local administrations often lack the technical expertise, data infrastructure, and legal tools to monitor morphological change or enforce land-use regulations. In this context, alternative planning scenarios that integrate flexible zoning overlays, participatory land-use mapping, and seasonal population management strategies may offer more adaptive governance solutions. Furthermore, strengthening cross-scale coordination among provincial, district, and neighborhood administrations, particularly through institutionalized spatial monitoring tools such as remote sensing or cadastral inspections, can help reduce fragmented urbanization. Therefore, managing rural-urban transformation in Van requires redesigning local governance models beyond technical planning tools.

Thus, the case of Lake Van contributes to the broader theoretical discourse on rurbanization by illustrating how second homes act as spatial agents of urbanisation in rural settings, both materially and symbolically. These dynamics necessitate a new planning approach that prioritizes environmental sustainability and equal access in rural policies.

7. Conclusion

This study examined the spatial expansion and transformation of second homes in the coastal rural areas of Lake Van, focusing on the village of Mollakasım. Using spatial analysis techniques such as Kernel Density and Average Nearest Neighbor analysis, along with CORINE data, the research has revealed a significant shift in land use patterns driven by informal planning dynamics and increasing second-home demand.

The spatial analyses conducted in the study reveal that second housing projects in Mollakasım, on the shores of Lake Van, do not exhibit a random distribution but rather a systematic rurbanization process. According to the core density analysis results, construction observed in limited and medium-density areas in 2012 increased significantly by 2024, with construction along the coastline both expanding into new areas and tending to concentrate around existing settlements. Average Nearest Neighbor (ANN) analysis also supports this finding, showing that the construction pattern is not random but concentrated in specific attraction areas. These results reveal that the construction pattern in coastal areas is increasingly forming distinct clusters and that spatial pressure has intensified over time. According to the land use change analysis, approximately 11.8 hectares of non-irrigated agricultural land was directly converted to urban use between 2000 and 2018. This finding suggests that lands considered to have low agricultural

production value are more easily opened to development and that sustainability priorities in rural areas are not adequately addressed.

Second homes, initially perceived as seasonal and leisure-oriented units, have evolved into permanent or semi-permanent presences in rural zones, contributing to urbanization pressures and the commodification of nature. In the case of Mollakasım, this trend has produced clear morphological homogenization, fragmented agricultural land use, and limitations in public access to natural resources such as lakefronts. These processes raise critical questions about spatial justice, environmental sustainability, and the resilience of rural landscapes in the face of informal and unregulated development.

The findings of this study underscore the necessity for integrated rural planning approaches that transcend short-term individual land-use decisions. In this context, the main problems identified and corresponding policy recommendations are summarized in Table 3.

First and foremost, there is an urgent need to reconsider land-use policies in rural and semi-rural zones, particularly those experiencing tourism-led growth. The fragmentation of fertile agricultural lands and the commodification of lakeside zones into elite consumption enclaves call for stronger alignment between land protection legislation (e.g., agricultural land conservation, coastal protection) and local development plans. In this regard, spatial planning instruments should be designed to anticipate and guide informal transformation processes, rather than reacting to them retrospectively.

Moreover, the case highlights the critical role of morphological monitoring and participatory governance. The unchecked expansion of second homes has not only undermined the ecological balance but also altered the public nature of commons, such as shoreline access. Thus, planning institutions should integrate morphological change detection tools, such as remote sensing and spatial clustering analysis, into routine monitoring frameworks. Additionally, including local communities in decision-making processes can prevent exclusionary practices and promote adaptive reuse strategies that respect the ecological and social context of the region.

Finally, the rurban transformation evident in Lake Van requires a broader reconceptualization of rurality itself. Rural areas should no longer be seen merely as reservoirs of land for urban consumption but as dynamic and contested spaces where production, habitation, and recreation intersect. Policy frameworks must therefore be capable of managing this hybridity by embracing the multifunctional character of rural landscapes and fostering forms of development that are both equitable and resilient.

Future studies could further explore the concept of rurbanization as an analytical framework for explaining the interaction between rural and urban areas. This approach would contribute to a more comprehensive understanding of the hybrid spatial patterns created by second homes and new lifestyles in rural areas.

Table 3 Problem, Policy and Planning Recommendation

Problem	Policy and planning recommendations
Unregulated second- home development	Special zoning regulations defining density, lot size, and building boundaries should be prepared for second home developments in coastal and rural areas.
Public access problems in coastal areas	Public corridors and access points should be planned in accordance with the public interest access principle of the Coastal Law.
Loss of agricultural land	Planning decisions that protect agricultural production should be strengthened, and practices that allow non-agricultural use should be limited.
Undefined status of *rurban areas*	An intermediate status should be defined for rurban areas and location-specific planning approaches should be developed for these areas and included in the legal framework.

Weakness of local governance	Remote sensing and spatial monitoring systems should be institutionalized at the local scale and participation mechanisms should be activated.
Ecological and Spatial Justice Issues	Environmental controls in coastal, agricultural and natural areas should be strengthened; spatial justice should be supported through public access policies.

CRediT Authorship Contribution Statement

Berfin Karabakan Gökhan: Writing – review & editing, Writing – original draft, Methodology, Investigation, Analysis, Data curation, Conceptualization, Data visualization. Yelda Mert: Writing – review & editing, Writing – original draft, Methodology, Investigation, Conceptualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

Data will be made available on request.

Ethics Committee Approval

Ethics committee permission is not required.

References

Azhari, M. (2021). *Planning approachies for rurban areas as new dimension of urbanization: In case of aceh (Indonesia) region* [Master thesis, Konya Technical University].

Barke, M. (1991). The growth and changing pattern of second homes in Spain in the 1970s. *Scottish Geographical Magazine*, *107*(1), 12-21.

Ceylan, S., & Somuncu, M. (2020). Pressure on agriculture resources of second homes tourism: Case of Pelitköy Village. *Turkish Geographical Review*, *75*, 41-56.

Champion, T. (1989). *Counterurbanization: The changing pace and nature of population deconcentration*. Edward Arnold.

Delgado-Viñas, C., & Gómez-Moreno, M. (2022). The interaction between urban and rural areas: an updated paradigmatic, methodological and bibliographic review. *Land*, *11*(8), 1-21.

Demiroğlu İzgi, B. (2022). Resilience of rural settlement morphology dynamics: The case of Kargalı district (village) *Journal of Design for Resilience in Architecture and Planning*, *3*(1), 112_126. https://doi.org/10.47818/DRArch.2022.v3i1047

de Oliveira, J. A., Roca, M. N. O., & Roca, Z. (2015). Economic effects of second homes: A case study in Portugal. *Economics and Sociology*, *8*(3), 183-196. https://doi.org/10.14254/2071-789X.2015/8-3/14

Gallent, N., Mace, A., & Tewdwr-Jones, M. (2005). *Second homes: European perspectives and UK policies*. Ashgate.

Gökdeniz, A. (2014). *Ev turizmi Ayvalık ve Danimarka Navasol örnekleri*. Detay Yayıncılık.

Hall, C. M. (2015). Second homes planning, policy and governance. *Journal of Policy Research in Tourism, Leisure and Events*, *7*(1), 1-14. https://doi.org/10.1080/19407963.2014.964251

Hall, C. M., & Müller, D. (Eds.). (2004). *Tourism, mobility and second homes: Between elite landscape and common ground*. Clevedon: Channel View.

Hiltunen, M., & Rehunen, A. (2014). Second home mobility in Finland: Patterns, practices and relations of leisure oriented mobile lifestyle. *Fennia*, *192*, 1-22.

Keskin, Ö. (2024). *Kent çeperlerindeki kırkent 'r-urban' yerleşim örüntülerinin diyalektik bir okuması: İstanbul-Çekmeköy*. [Yüksek lisans tezi, Özyeğin Üniversitesi].

Kılıçaslan, Ç. (2006). İkinci konutların deniz kıyılarına etkisi. *Süleyman Demirel Üniversitesi Orman Fakültesi Dergisi*, *7*(1), 147-156.

Kolhe, N. P., & Dhote, Dr. K. K. (2016). Rurban centres: The new dimension of urbanism. *Procedia Technology*, *24*, 1699-1705. https://doi.org/10.1016/j.protcy.2016.05.198

Malek, J. A., & Baharudin, R. A. (2019). *Smart city (SC)-smart village (SC) and the 'rurban' concept from a Malaysia Indonesia perspective*. African Journal of Hospitality, Tourism and Leisure, GCBSS Special Edition.

Mamunlu Kocabaş, H. (2025). The importance of water-sensitive planning and design approaches for resilience to flood disaster risk in Istanbul: Evaluation of examples in Çatalca and Beykoz districts. *Journal of Design for Resilience in Architecture and Planning*, *6*(1), 71_101. https://doi.org/10.47818/DRArch.2025.v6i1158

Nelson, A. C., & Sanchez, T. W. (1999). Debunking the exurban myth: A comparison of suburban households. *Housing Policy Debate*, *10*(3), 689-709.

Okuyucu, A., & Somuncu, M. (2016). İkinci konut sahipliliğinde motivasyon, sosyo-demografik özellikler ve seyahat karakteristikleri arasındaki ilişkiler: Yalova-Çınarcık örneği. *Coğrafi Bilimler Dergisi*, 14(1), 39-56. https://doi.org/10.1501/Cogbil_0000000172

Paris, C. (2014). Critical commentary: Second homes. *Annals of Leisure Research*, 17(1), 4_9. https://doi.org/10.1080/11745398.2014.890511

Piorr, A., Ravetz, J., & Tosics,I. (2011). *Peri-urbanisation in Europe, towards European policies to sustain urban-rural futures*. Sythesis Report.

Shikalgar, R. S. (2013). Geographical analysis of rurban centers in Yerala river basin. *Online International Interdisciplinary Research Journal*, 152-158.

Shirazi, M. R., & Falahat, S. (2015). Urban oasis, towards a prototype for sustainable urbanity: The case of Tehran. *International Journal of Society Systems Science*, 7(4), 334. https://doi.org/10.1504/IJSSS.2015.073227

Skak, M., & Bloze, G. (2016). Owning and letting of second homes: What are the drivers? Insights from Denmark. *Journal of Housing and Built Enviroment*, *32*(4).

Tacoli, C. (1998). Rural-urban interactions: A guide to the literature. *Environment and Urbanization*, *10*(1), 147-166. https://doi.org/10.1177/095624789801000105

Usun, Ç. F. (2023). Türkiye'de ikinci konut sayısının tespiti mümkün mü? *Ege Coğrafya Dergisi*, 32(Cumhuriyet'in 100. Yılı Özel Sayısı) 143-165. https://doi.org/10.51800/ecd.1357133

Resume

Berfin Karabakan Gökhan received her PhD in City and Regional Planning from İzmir Institute of Technology (İzTech). She holds a bachelor's degree in City and Regional Planning and a master's degree in Landscape Architecture. During her doctoral studies, she conducted research on regional economic resilience using GIS-based spatial analysis and spatial econometric methods. Her research interests include regional economic resilience, spatial planning, urban–rural dynamics, and land-use change. Her recent studies focus on rurban transformation processes and post-disaster reconstruction and their spatial implications for regional development and planning in Türkiye.

Yelda Mert is currently an Assoc. Prof. Dr. at İskenderun Technical University. She received her bachelor's, master's, and PhD degrees from İzmir Institute of Technology (İzTech). Her research mainly focuses on disasters and earthquakes from the perspective of spatial planning and regional development. Her recent studies examine post-earthquake reconstruction processes, rurban transformation, rural change, and related policy frameworks.

JOURNAL OF DESIGN FOR RESILIENCE IN ARCHITECTURE & PLANNING

Research Article
Online: www.drarch.org
Volume 7, Issue 1 (161-181), 2026
DOI: 10.47818/DRArch.2026.v7i1209

Cost analysis and feasibility of green building adaptation in low-rise residential housing: Evidence from Türkiye

Merve Hasözhan Bıyıklı[*]
Zübeyde Özlem Parlak Biçer[**]
Nurbanu Şahin[***]

Abstract

This study evaluates the cost implications of green building practices in low-rise residential housing by analyzing three sample houses in Kayseri, Türkiye. It compares traditional construction systems with green alternatives, focusing on water efficiency, energy-saving technologies, and sustainable materials. The findings reveal that green buildings incur higher upfront costs, particularly due to photovoltaic systems and certified materials. However, when compared with traditional structures, they demonstrate clear long-term benefits in energy savings, environmental performance, and operational efficiency. Water-related costs were mainly driven by sanitary fixtures and appliances, while insulation dominated material expenses. By offering a localized cost comparison between traditional and green construction, this study fills a gap in the national literature and highlights the feasibility of sustainable housing in Türkiye. These insights aim to inform both policy development and practical applications, providing a valuable foundation for integrating green certification systems into future low-rise residential projects.

Keywords: green buildings, construction cost analysis, energy efficiency, b.e.s.t-residential certification, Türkiye, low-rise residential buildings

1. Introduction

Industrial and technological advances, while providing significant benefits, have also led to major environmental challenges such as climate change, ecological degradation, and pandemics (İmert, 2017; Zengin & Yamaçlı, 2023). In response, global and local initiatives, from international agreements to municipal regulations, have been developed to restore ecological balance.

The construction industry is a major contributor to carbon emissions across material production, construction, and operation phases, accounting for 34% of global energy consumption and 37% of total emissions (UNEP, 2022). The sector also relies heavily on cement and steel (Wang & Zhang, 2008). Due to its environmental impact, the sector faces increasing pressure to adopt sustainable practices. In this context, green buildings have become a key solution (Hwang et al., 2017; UNEP, 2022; USEPA, 2016).

Green buildings, often defined as high-performance or sustainable buildings, lack a universally agreed-upon definition. The EPA defines them as resource-efficient structures operating across their life cycle (Circo, 2007; Dania et al., 2013; Kibert, 2007; Olubunmi et al., 2016; USEPA, 2016; Yudelson, 2007). ASTM emphasizes performance standards, minimized environmental harm, and ecosystem support (ASTM, 2023). These buildings integrate environmental, economic, and social objectives and play a key role in the circular economy (Burnett, 2007).

Green buildings differ from traditional structures by prioritizing minimal resource use in design and operation (Guo et al., 2021; Hwang et al., 2017; Wedding, 2008; Zigenfus, 2008). They reduce environmental impact, improve worker productivity, lower absenteeism, and cut operational costs

[*]*Independent Researcher, Kayseri, Türkiye* mervehasozhan@gmail.com
[**]*Department of Architecture, Erciyes University, Kayseri, Türkiye* parlako@erciyes.edu.tr
[***]*(Corresponding author) Department of Architecture, Erciyes University, Kayseri, Türkiye* nurbanuatmaca@erciyes.edu.tr
Article history: Received 17 December 2025, Revised 31 March 2026, Accepted 22 April 2026, Published 30 April 2026

(Kats, 2003; Mozingo & Arens, 2014; Ries et al., 2006). Some studies report up to a 25% increase in productivity and significant reductions in water use and waste generation. However, some studies question energy efficiency claims; for example, 30% of LEED buildings may consume more energy than conventional ones (Newsham et al., 2009).

Recent studies indicate that although green buildings may involve higher initial costs, they provide long-term economic benefits by reducing operational and maintenance expenses (Dong, et al., 2025). In addition, the decreasing cost of renewable energy technologies, particularly photovoltaic (PV) systems, has improved the economic feasibility of green building applications (Wang et al., 2020). Recent research also highlights the importance of life-cycle assessment (LCA), considering both embodied carbon and operational energy in evaluating building sustainability (Taseer et al., 2025).

To assess sustainability performance, various green building rating systems have been developed worldwide. Türkiye has increased its interest in green buildings in response to both global pressures and local challenges (ÇŞB, 2020; Ramakrishnan et al., 2023) (Figure 1).

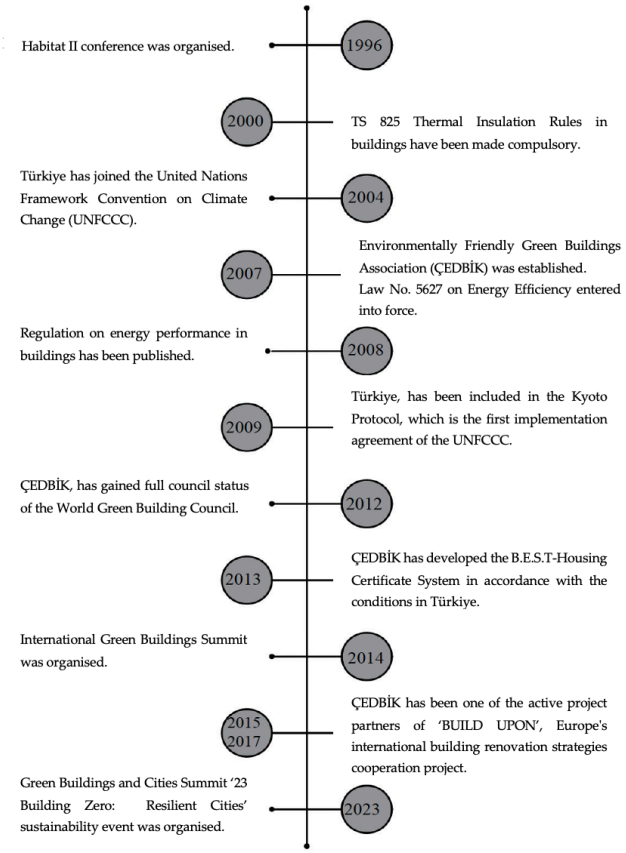


Figure 1 Historical development of green buildings in Türkiye

Rating systems provide sustainability benchmarks using data across design, construction, and operation stages (Ade & Rehm, 2019; Mateus & Bragança, 2011). These systems are adapted to local climatic, cultural, and regulatory conditions (Mattoni et al., 2018). Prominent global systems include BREEAM (UK), LEED (USA), CASBEE (Japan), and Green Star (Australia) (Portalatin et al., 2010) (Table 1).

Table 1 Green Building Certification Systems Worldwide

Certification System	Country	Certification System	Country
BREAM	England	HQE	France
IISBE	Canada	DGNB	Germany
SBTOOL	Canada	ESTIDAMA	United Arab Emirates

BEAT	Denmark	HK-BEAM	Hong-Kong
Protocollo Itaca	Italy	LEED-MEXICO	Mexico
GREEN STAR	Australia	TERI GRIHA	India
CASBEE	Japan	MINERGIE	Switzerland
NETHARLANDS	Netherlands	B.E.S.T	Türkiye

In Türkiye, institutions such as like the Ministry of Environment, universities, and NGOs have created local certification systems adapted from international models (Erdede & Bektaş, 2018). These systems evaluate design, construction, and operation phases and foster awareness among stakeholders (Table 2). Compared to European countries such as Austria, Germany, and Switzerland, where green building practices are widely implemented, Türkiye remains in a developing phase with increasing but limited adoption (Umaroğulları et al., 2020).

Table 2 Green Building Certification Systems Developed and Implemented in Türkiye

Year	Certification System	Institution
2008	Yeşil Yıldız (Green Star)	Ministry of Culture and Tourism
2013	B.E.S.T-Konut	ÇEDBİK
2013	Güvenli Yeşil Bina Belgesi	TSE
2014	SEEB-TR	YUAM
2019	YeS-TR	Ministry of Environment, Urbanisation and Climate Change

Kahramanmaraş and Hatay earthquakes (February 6, 2023) and the COVID-19 pandemic have further increased the demand for low-rise, resilient, and sustainable housing. In this context, understanding the economic feasibility of green building applications at the local scale is crucial for decision-makers, particularly in rapidly developing urban environments.

Recent studies have focused on the economic evaluation of photovoltaic systems and life-cycle cost analysis in residential buildings, highlighting the importance of energy price fluctuations and investment costs in determining economic feasibility (Wang et al., 2020; Taseer et al., 2025).

While previous studies have extensively examined green building practices at global and large scales, detailed, region-specific cost analyses for low-rise residential buildings remain limited in the Turkish context (Akgül et al., 2020; Bayat & Küçükali, 2022; Yalili Kılıç & Adalı, 2021).

Addressing this gap, the present study provides a localized, case-specific cost analysis in Türkiye, offering a more practical and implementable perspective for sustainable residential development. Specifically, this study examines how green building principles can be applied to low-rise residential buildings in Kayseri, contributing to both economic evaluation and resilience-oriented design approaches.

2. Materials and Methods

In this study, examples of low-rise residential buildings in Kayseri province were evaluated according to common characteristics of residential buildings with green certification both in Türkiye and worldwide, and in alignment with Türkiye's local certification criteria, namely the B.E.S.T-Residential (B.E.S.T-Konut) certificate. For each criterion, a cost analysis was conducted, and the resulting cost data were analyzed considering the hypothetical construction of these residential buildings according to green building standards.

Three residential buildings of varying total construction areas were selected to understand how these differences affect the implementation of green building practices and associated cost calculations. The first residential building has an area of 314.87 m², the second is 449.06 m², and the third is 439.3 m². The first residence was designed entirely independently from the second and third residences and has a smaller scale. Although the second and third residences have similar plan schemas and comparable are close, their facade openings differ depending on their scale. Investigating how these characteristics affect green building practices and the corresponding cost calculations was one of the reasons for selecting these specific residences.

2.1. Case Study Buildings Overview

The residences examined within this study are in two different residential complexes in the Çay Bağları area of Kayseri province and share standard floor plans. Buildings with approximately the same arrangement of floor plans were therefore selected for examination. Green building cost analyses were conducted for three different types of residential buildings.

The complex containing the first residence examined has four buildings. The ongoing construction status of the complex influenced its selection as a case study. It was assumed that green building implementations and cost analyses conducted on the sample building would serve as a reference to the contractor and encourage the application of similar practices. Furthermore, since the surrounding area of the site has a dense residential pattern, it is anticipated that the example could inspire nearby construction. The second and third detached residences are situated within the same site and have similar plan schemes.

These three buildings were examined, and green building practices and cost analyses were conducted. Residences of different sizes within the same site were specifically chosen to determine how size differences would impact construction costs under green building practices.

First building

The structure is positioned in the northeast direction within the plot, with its entrance located on the south facade. The building consists of three floors: basement, ground, and first floor (Figures 2, 3, 4). The basement floor contains a water tank, booster pump room, heating center, and corridor. The ground floor includes an entrance hall, living room-kitchen, a utility area, and a lavatory-WC; while on the first floor, there are showers, a hallway, laundry room, bathroom, dressing room, master bedroom, and children's bedrooms. Technical units are collected on the basement floor at elevation-3.30, while the ground floor at +0.20 elevation is designed for daily living areas. The first floor at +3.70 elevation has four bedrooms, each with a bathroom. Due to the anticipated extensive garden usage and climatic conditions, the building does not include balconies.

Figure 2 Basement floor (S-Line Mimarlık, 2022)

Figure 3 Ground floor (S-Line Mimarlık, 2022)

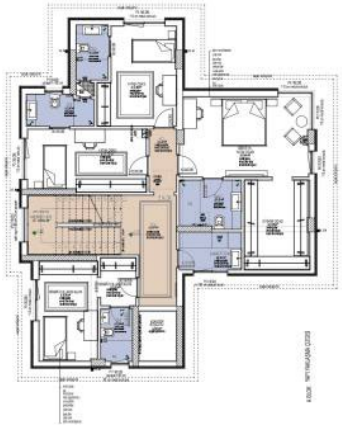


Figure 4 First floor (S-Line Mimarlık, 2022)

Since winters in Kayseri are cold, the building predominantly has large window openings facing south (Figure 5). The structural system is reinforced concrete, and the exterior facade consists of pumice blocks with rock wool insulation, plaster, and paint (Figure 6).

Figure 5 South facade (Author 1, 2024)

Figure 6 East facade (Author 1, 2024)

Second building

The building is oriented northeast to southwest, with the entrance situated on the southwest side. It is accessed through an elevation of 70 cm from ground level. The residence consists of three floors: a basement, a ground floor, and a first floor (Figures 7, 8, 9). The basement (-2.30 m level) contains predominantly storage areas, showers-WC, a boiler room, and a corridor. The ground floor (+0.70 m) includes a hallway, living room, sitting room, kitchen, WC, and terrace areas designed mainly for daily activities. The first floor, at +4.00 elevation, includes bedrooms, a dressing room, bathrooms, and a corridor.

Figure 7 B. floor (Toprak Tasarım Mimarlık, 2022)

Figure 8 G. floor (Toprak Tasarım Mimarlık, 2022)

Figure 9 First floor (Toprak Tasarım Mimarlık, 2022)

The residence has large window openings predominantly oriented to the northeast (Figure 10). Notably, the stairwell window opening enhances natural daylight within the interior spaces (Figure 11). Compared to the first residence, the window proportions are smaller. The structural system is reinforced concrete, and the exterior facade uses XPS insulation, plaster, and paint.

Figure 10 Northeast facade (Author 1, 2024)

Figure 11 East facade (Author 1, 2024)

Third building

The building is oriented in an east-west direction, with its entrance located on the west façade. It consists of three floors: the basement, the ground, and the first floor (Figures 12, 13, 14). The basement floor contains storage areas, a shower-WC, a boiler room, a hallway, and a pantry. The ground floor includes an entrance hall, living room, sitting room, kitchen, WC, and terrace designed primarily for daily living activities. It also includes extensive terrace areas. The first floor at +4.00 m elevation contains four bedrooms and bathrooms.

Figure 12 B. floor (Toprak Tasarım Mimarlık, 2022)

Figure 13 G. floor (Toprak Tasarım Mimarlık, 2022)

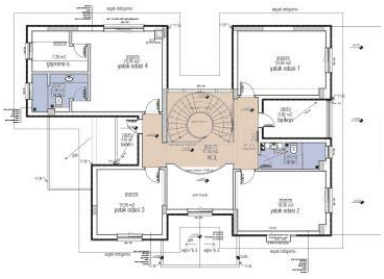


Figure 14 First floor (Toprak Tasarım Mimarlık, 2022)

The building has large window openings, predominantly on the southern façade (Figure 15), enhancing natural daylight intake. The window-to-wall ratio of this building is greater than that of the second building (Figure 16). The structure has a reinforced concrete system, with exterior finishes including XPS insulation, plaster, and paint.

Figure 15 Southern facade (Author 1, 2024)

Figure 16 East facade (Author 1, 2024)

2.2. Methodology

The residential projects in the Çay Bağları region of the Erenköy Neighborhood in Melikgazi District, Kayseri, were evaluated in accordance with Türkiye's local green building certification system, B.E.S.T-Residential. Residential building quality encompasses multiple performance dimensions, including energy efficiency, water conservation, material sustainability, acoustic comfort, and outdoor environmental conditions such as wind and noise control (ÇEDBİK, 2019; Kiraz, 2015). Within this broader framework, the present study focuses on three categories directly addressed by the B.E.S.T-Residential certification system: energy use, water use, and material use. According to the B.E.S.T-Residential certification system, points allocated for each category vary (Table 3).

Table 3 Scoring Table for B.E.S.T-Residential Certification According to Energy, Material, and Water Categories

Evaluation Criteria	Points Available	Design	Construction	Total
Renewable Energy Use	7	2	5	7
Energy Efficient White Goods	1		1	1
Use of Environmentally Friendly Materials	3		3	3
Reducing Water Use	1-6	4		4

According to the B.E.S.T-Residential certification, energy use can achieve up to seven points by utilizing renewable energy sources to reduce carbon emissions. In this study, solar energy was applied as a renewable energy source suitable for residential buildings. Conducting feasibility studies at the project stage awards 2 points, while the actual implementation of the technology awards 5 points. Furthermore, using energy-efficient appliances in homes contributes one additional point due to reduced carbon emissions (ÇEDBİK, 2019).

In the B.E.S.T-Residential certification, material usage is encouraged through the selection of environmentally labeled materials, based on life cycle analyses in construction. Accordingly, products with Environmental Product Declaration (EPD) labels were chosen for the exterior walls and facades of the studied buildings. Meeting these criteria under the B.E.S.T-Residential certification could earn three points (ÇEDBİK, 2019).

For water usage under the B.E.S.T-Residential certification, up to six points can be earned by implementing measures that save water both inside and outside residences. Measures outside residences, accounting for two points, were not considered in this study. Scoring for residential water usage varies between 1 and 4 points, depending on annual water consumption. Therefore, ensuring efficient water usage within residences could achieve up to four points (ÇEDBİK, 2019).

The 2024 (January) unit price lists from the Ministry of Environment, Urbanization, and Climate Change were primarily used. For items not included in this list, prices were obtained directly from relevant companies. Additionally, since certain green building components could only be specified by authorized companies, costs related to green building criteria were acquired from such firms. For instance, photovoltaic panel prices were included in the January 2024 unit price list by the Ministry of Environment, Urbanization and Climate Change. However, the characteristics of selected panels vary according to several factors, such as geographical location, roof area, and the operating time of heating devices in buildings. Therefore, an authorized company was consulted to determine the characteristics and costs of panels used in the buildings.

Based on calculations provided by Solimpeks, a solar thermal energy company operating in Türkiye (personal communication), the monthly electricity consumption was assumed to be 972 kWh for the first residential building and 1100 kWh for the second and third buildings. These assumptions formed the basis for the development of photovoltaic panel layout schemes for each building.

Cost evaluations included photovoltaic solar panels that convert solar energy into electrical energy and triple-glazed thermal insulation windows to minimize heat exchange. Private sector data were utilized to determine current prices and features of photovoltaic solar panels. For window selection, triple-glazed windows with low heat transfer values (U=0.90 W/m²K), providing high thermal insulation, were chosen, and data were sourced from the private sector. Additionally, the B.E.S.T-Residential certification encourages the use of energy-efficient appliances (A-class or higher) to reduce carbon emissions during operation, according to the certification manual.

Energy classes of appliances are indicated by letter notation representing energy efficiency, from A (highest efficiency) to G (lowest). Class A indicates good efficiency, A+ very good efficiency, and A++ high efficiency (Samsung, 2025). Because high-efficiency products are more costly, the most affordable A-class appliances meeting the required standards were chosen to minimize cost concerns. This approach was chosen to reflect realistic user preferences and cost considerations, while ensuring compliance with green certification requirements.

For material use, EPD-certified materials common among national and international green building certifications were targeted for use in construction. Accordingly, ISO 14025 Environmental Product Declarations (EPD)-certified materials were selected for external walls, including rock wool insulation, Probase Matik cement-based plaster, Probase mineral, and silicone-based exterior paints. Since these EPD-certified materials were not listed by the Ministry of Environment, Urbanization, and Climate Change, prices were collected from private sector companies. The total cost for these materials was calculated by multiplying the building's external wall area (g) by the unit price of the materials (h), as shown in Table 4 and Table 5.

Table 4 Calculation of the Quantity of the External Wall of the Building

Formula	Building Height (m)	Building Perimeter (m)	Deduction Quantity (m^2)	External Wall Quantity of the Building (m^2)
(d x e) - f = G	d	e	f	G

Table 5 Cost Calculation of Criteria for Material Utilization

Formula	External Wall Quantity of the Building (m^2)	Unit price (USD)	Total cost (USD)
g x h = M	g	h	M

Water-saving practices recommended by the B.E.S.T-Residential certification include selecting low-water-consuming fixtures, reservoirs, dishwashers, and washing machines, conforming to TS EN 200, TS EN 274, and TS EN 997 standards. Cost calculations were performed separately for each residence, based on the number of sanitary wares and devices used, employing the formula a x b = C (Table 6).

Table 6 Cost Calculation of the Criteria for Water Saving

Formula	Number of sanitary wares used	Unit price including assembly (USD)	Total cost (USD)
a x b =C	a	b	C

Residential projects were compared to conventional construction methods by examining three categories: energy consumption, material usage, and water consumption practices, to facilitate comparisons with green buildings. Traditional construction practices do not require energy or water-saving measures; thus, selections are based on owner or contractor preferences. Therefore, the categories were analyzed under energy and water consumption aspects for traditional practices.

In energy-related practices, photovoltaic solar panels were excluded from the traditional energy category since they are not commonly used in low-rise buildings traditionally constructed in the Çay Bağları area. For windows, double-glazed windows commonly used in traditional buildings were considered, with prices sourced from the private sector. According to the B.E.S.T-Residential certification, A-class or higher appliances are required (washing machine, dishwasher, and refrigerator). However, traditional construction usually overlooks this criterion. Thus, for traditional practices, class C appliances were selected due to their lower costs.

For material usage in traditional buildings, facade materials without any certification (standard plaster, rock wool insulation board, and silicone exterior paint) were employed. Costs were calculated by multiplying external wall measurements (g) by the material unit price (h) (Table 5), using unit prices provided by the Ministry of Environment, Urbanization, and Climate Change.

For water consumption practices, conventional sanitary fixtures and household appliances meeting optimal requirements for daily usage were selected instead of water-saving alternatives. Costs were calculated using the unit price list of the ministry with the formula a x b = C (Table 6).

In the case study, cost analyses for detached low-rise residential buildings in the Çay Bağları area were conducted, comparing green certification system criteria and certified construction materials with traditional construction methods and materials against traditional construction methods and materials. The resulting cost differences were comparatively analyzed.

To evaluate the economic robustness of the proposed photovoltaic systems, a simplified scenario-based sensitivity analysis was conducted. Electricity prices and photovoltaic system costs were varied by ±20% to examine their potential effects on annual savings and payback periods under changing market conditions. This approach allowed the assessment of the sensitivity of payback periods to changes in key economic parameters.

3. Results

3.1. Cost Findings Related to Green Building Practices

Green building measures included water-saving fixtures, efficient appliances, solar panels, insulated windows, and EPD-certified facade materials. Based on these criteria, traditionally constructed low-rise residential buildings were evaluated according to green building practices, and related cost data were generated.

Cost data regarding products, materials, and practices evaluated within the categories of water, energy, and material conservation were obtained through private-sector research. Cost calculations were performed individually for each of the three residential buildings in Kayseri's Çay Bağları area, and comparative analyses between buildings were conducted.

Cost findings related to water saving practices in buildings

For the cost analysis of water-saving practices, sanitary installations with low water consumption, water-efficient faucets, and sanitary wares (wall-mounted toilets, concealed cisterns) meeting green building certifications were selected. Additionally, water-efficient appliances (washing machines and dishwashers) with A-class energy ratings, as recommended in the B.E.S.T-Residential certification guidelines, were selected.

In the first residence, among water-saving practices, washbasin faucets had the lowest unit cost, while sanitary fixtures (wall-mounted toilets, concealed cisterns) had the highest unit cost. When considering the total cost of the building, the sanitary wares significantly influenced the overall expenses due to their quantity. Additionally, due to selecting water-efficient appliances with A-class energy ratings, these products' prices were higher compared to standard appliances (Table 7). Sanitary fixtures accounted for 39.3% of total water-saving costs, followed by the dishwasher (22.0%) and washing machine (17.9%). The kitchen faucet had the smallest share at 3.9%.

Table 7 Cost Analysis for the First Building Water Saving

	Water-Saving Practices	Unit Price (USD)	Quantity	Total Cost (USD)
Water-Efficient Sanitary Wares	**Kitchen Faucet** -With special flow throttling aerator, max. 5 L/min water flow and is in the lowest consumption group. -European Water Labelling Class: Dark Green (0 < Flow rate ≤ 6)	201	1	201
	Washbasin Faucet -With special flow throttling aerator, max. 5 L/min water flow and is in the lowest consumption group. -European Water Labelling Class: Dark Green (0 < Flow rate ≤ 6)	147	6	882
	Sanitary Fixtures **Wall-mounted toilet & concealed cistern)** According to the European Union norms, it is approved as the lowest water consumption toilet bowls that function with 2.5/4 L of water.	408,6	5	2043
Water Efficient Devices	**Dishwasher** -Water consumption 9.5 L -A energy class -Energy consumption 0.503 kWh	1144	1	1144
	Washing Machine -Water consumption 40 L (1 cycle) -A energy class -Energy consumption 34 kWh (100 cycles)	932	1	932

Total: 5202 USD

Water-saving costs were lower in the second and third residences due to fewer installed faucets and toilets. Across all three residences, the kitchen faucet had the lowest contribution to the total cost, whereas the dishwasher had the highest contribution. In the second and third residences, sanitary fixtures represented 36.3% of total water-saving costs, while the dishwasher (25.4%) and washing machine (20.7%) together accounted for nearly half of total expenditure.

Table 8 Cost Analysis for the Second and Third Buildings Water Saving

	Water-Saving Practices	Unit Price (USD)	Quantity	Total Cost (USD)
Water-Efficient Sanitary Wares	**Kitchen Faucet** -With special flow throttling aerator, max. 5 L/min water flow and is in the lowest consumption group. -European Water Labelling Class: Dark Green (0 < Flow rate ≤ 6)	201	1	201
	Washbasin Faucet -With special flow throttling aerator, max. 5 L/min water flow and is in the lowest consumption group. -European Water Labelling Class: Dark Green (0 < Flow rate ≤ 6)	147	4	588
	Sanitary Fixtures **Wall-mounted toilet & concealed cistern)** According to the European Union norms, it is approved as the lowest water consumption toilet bowls that function with 2.5/4 L of water.	408,6	4	1634,4
Water Efficient Devices	**Dishwasher** -Water consumption 9.5 L -A energy class -Energy consumption 0.503 kWh	1144	1	1144
	Washing Machine -Water consumption 40 L (1 cycle) -A energy class -Energy consumption 34 kWh (100 cycles)	932	1	932

Total: 4499,4 USD

Cost findings for energy-saving practices in residential buildings

For the cost assessment of energy-saving measures in residences, photovoltaic solar panels converting solar energy into electricity, insulated windows minimizing heat exchange, and energy-efficient household appliances were considered. As the required data could not be found in the ministry's unit price list, market research was conducted to obtain current data from private sector firms for each item.

To calculate the costs of photovoltaic solar panels, the characteristics and costs of the panels were determined by consulting specialized private sector firms, and relevant project documents were shared with these firms. Annual electricity generation and consumption values for each residence, panel specifications, the proportion of electricity consumption supplied by solar energy, environmental benefits, and the system cost were determined. Panels were designed primarily to meet the internal electricity demand of the residences. A Grid-Connected System (ON-GRID) was arranged to transfer any excess energy back to the grid. Panels with a capacity of 540 Wp are typically preferred in detached residential buildings in Kayseri. For optimal efficiency, panels must primarily be oriented toward south, east, or west directions.

For the cost calculations of insulated windows, windows with triple glazing, 84 mm-wide PVC profile systems, 7-chamber profiles, and low thermal transmittance values (U=0.90 W/m²K) were selected. Window and door measurements of each residence were determined, and total costs were calculated using data from a private company based in Kayseri.

Regarding energy-efficient household appliances, the B.E.S.T-Residential certification guidelines require the selection of refrigerators, washing machines, and dishwashers classified as "A" energy class or higher. In this study, costs were calculated using appliances classified as energy class A.

However, due to the absence of class-A refrigerators during the market research, refrigerators were excluded from the cost assessment. Additionally, since the certification specifies only washing machines, dishwashers, and refrigerators, other household appliances were excluded from the scope of this study.

For the first residential building, photovoltaic solar panel calculations were performed based on assumptions listed in Table 9. A total of 15 panels, each with a power rating of 540.00 Watts and a DC installed power of 8.10 kWp, were used (Figure 17).

Table 9 Assumptions Used in Photovoltaic Panel Calculations for the First Residence

Assumption	Value
Average monthly electricity consumption	972 kWh
Energy purchase price	0.17 USD/kWh
Annual potential electricity price increase	35%

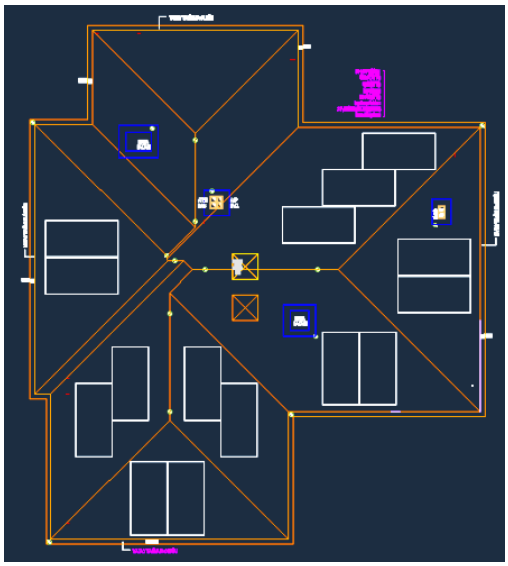


Figure 17 Illustrates the photovoltaic panel layout plan for the first residence (Solimpeks, 2024)

Annual electricity production and consumption values for the residences were calculated automatically based on international databases and regional solar radiation data. According to the calculations, annual solar-generated savings amounted to 1668 USD, electricity purchased from the grid cost 476 USD, and excess electricity sold back to the grid amounted to 104,65 USD. The total savings were thus calculated as 1572,5 USD, with a payback period of 5.25 years (Solimpeks, 2024).

In Kayseri, where the first residence is located, surplus energy produced during summer months is sold back to the grid. While 83% of the building's electricity demand is covered by solar energy, 17% is supplied from the grid. As a result, substantial energy savings were achieved. Additionally, the renewable energy system reduces annual CO_2 emissions by approximately 3.59 tons/year, equivalent to saving around 582 trees (Solimpeks, 2024).

For the second and third residential buildings, a single photovoltaic solar panel analysis was performed since their layouts are similar and roof areas are close in size (Table 10). The roof area of the second building is 213.76 m², while the third building's roof area is 236.22 m². Panel design and calculations were based on assumptions listed in Table 10. In both the second and third buildings, 17 panels with a unit power of 540.00 W and a total DC-installed capacity of 9.18 kWp were used (Figure 18).

Table 10 Assumptions used in Photovoltaic Panel Calculations for the second and Third Residences (Solimpeks, 2024)

Assumption	Value
Average monthly electricity consumption	1100 kWh
Energy purchase price	0.17 USD/kWh
Annual potential electricity price increase	35%

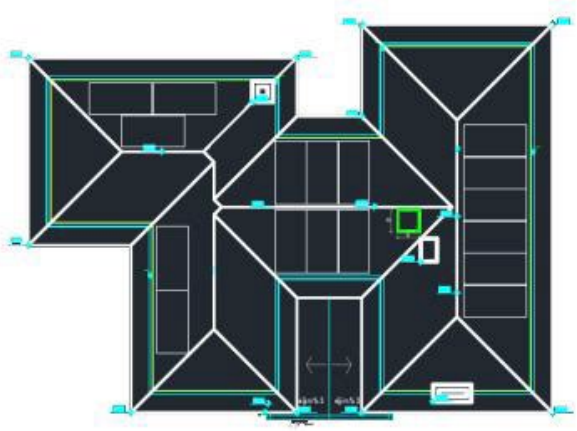


Figure 18 Illustrates the photovoltaic panel layout plan for the second and third buildings (Solimpeks, 2024)

Annual electricity production and consumption values of these residences were automatically calculated based on international solar radiation data specific to the region. According to the calculations, solar energy savings were 1662,5 USD, electricity purchased from the grid cost 537,5 USD, and excess electricity sold back to the grid amounted to 119,5 USD. Total savings were thus 1782 USD, with a payback period of 4.5 years (Solimpeks, 2024).

As with the first building, surplus energy generated during summer months in the second and third residences is sold back to the grid. Approximately 83% of the electricity demand was met by solar energy, with the remaining 17% from the grid, resulting in significant energy savings. Moreover, renewable energy systems reduced CO_2 emissions by 4.07 tons/year, equivalent to approximately 660 trees saved annually (Solimpeks, 2024).

For the window cost analysis, measurements of the three buildings were taken. A detailed cost list was generated for windows characterized by 84 mm wide PVC profile systems, featuring seven chambers, triple glazing, and low thermal transmittance values (U=0.90 W/m²K) (Solimpeks, 2024).

Across all three buildings, the frame casing and the S series triple-glazed window system (4+12+4+12+4) were the primary contributors to total window costs due to their substantial impact on energy conservation. Perimeter locking hardware had the lowest impact on costs. The third building exhibited the lowest total window cost, primarily because fewer windows were used compared to the other two residences. The S series triple-glazed systems substantially reduce heat loss compared to standard glazing, leading to decreased fuel consumption and energy savings.

In the cost study regarding energy-efficient appliances, household appliances with identical features were selected for each of the three residential buildings. According to the B.E.S.T-Residential guidelines, these appliances must be classified at least as energy class "A" or higher. Class-A-rated appliances were therefore selected, and their prices were sourced from the private sector. However, refrigerators were excluded because they were unavailable as class-A products during the market research. Additionally, since the B.E.S.T-Residential guidelines specify criteria only for washing machines, dishwashers, and refrigerators, other household appliances were excluded from this research.

The cost analyses for photovoltaic solar panels, insulated windows, and energy-efficient appliances for each residence are summarized below:

First Building Energy Conservation Cost Analysis:

Among energy conservation practices, photovoltaic solar panel implementation has the most significant influence on total costs, followed by insulated windows, dishwashers, and washing machines, respectively. Energy-saving measures dominated overall green building costs, representing 67.1% of total expenditure for the first building.

A sensitivity analysis was conducted to evaluate the impact of electricity price and photovoltaic system cost on economic performance. The results indicate that increases in electricity prices enhance the economic value of self-generated energy and reduce payback periods, whereas higher photovoltaic system costs lead to longer payback durations (Table 11).

Table 11 Sensitivity Analysis for the First Building

Scenario	Change	Estimated Payback Period (years)
Base Case	**-**	**5.25**
Electricity +20%	Price ↑	4.38
Electricity -20%	Price ↓	6.56
PV Cost +20%	Cost ↑	6.30
PV Cost -20	Cost ↓	4.20

The cost analysis for the second residence indicates that the lowest-cost component among energy-efficient appliances was the washing machine, whereas photovoltaic solar panels had the most significant impact on the total cost. Although less influential than photovoltaic systems, insulated windows also contributed considerably to the overall cost. Energy-saving practices accounted for 59.0% of total green building costs in the second residence.

Third Building Energy Conservation Cost Analysis:

Similarly, in the third building, photovoltaic solar panels represented the highest-cost component, consistent with the findings for the first and second residences, while energy-efficient appliances had the least impact. Despite the third residence having a larger total construction area (537.01 m²) compared to the first residence (328 m²), its total cost related to energy conservation was lower. This suggests that energy conservation costs may not increase proportionally with building size. Energy-related costs constituted 60.2% of total green expenditure in the third building.

To further evaluate the impact of key parameters such as electricity price and photovoltaic system cost on economic performance, a sensitivity analysis was conducted, indicating that increases in electricity prices enhance the economic value of self-generated energy and reduce payback periods, whereas higher photovoltaic system costs lead to longer payback durations (Table 12).

Table 12 Sensitivity Analysis for the Second and Third Buildings

Scenario	Change	Estimated Payback Period (years)
Base Case	-	4.50
Electricity +20%	Price ↑	3.75
Electricity -20%	Price ↓	5.63
PV Cost +20%	Cost ↑	5.40
PV Cost -20	Cost ↓	3.60

The sensitivity analysis indicates that increases in electricity prices significantly reduce the payback period, while increases in photovoltaic system costs extend it. A ±20% variation in electricity prices is lead to noticeable changes in annual savings, whereas variations in PV system costs directly influence initial investment and payback duration. These findings suggest that economic feasibility is more sensitive to energy price fluctuations in the long term.

Although the payback period was calculated for photovoltaic systems, a comprehensive life-cycle cost analysis covering all building components was not included within the scope of this study. Such analyses could provide a more detailed understanding of long-term economic performance and are recommended for future research.

Cost findings related to material usage in residential buildings

Materials with EPD certification, required by major green standards, were chosen for the cost analysis in these residences. The external façade was constructed sequentially using Probase Matik

cement-based plaster, rock wool insulation, Probase render primer plaster, Probase mineral decorative coating plaster, and silicone-based exterior paint. A 7-cm thick rock wool insulation with perpendicular tensile strength of 10 kPa and thermal conductivity of 0.036 W/mK was applied over the cement-based ready-mixed machine plaster (Probase matik). Subsequently, Probase render primer plaster conforming to TS EN 998-1 standards, Probase mineral-based decorative plaster, and EPD-certified silicone-based exterior paint were used (Dalsan, 2025; Dyo, 2025).

To calculate the cost of EPD-certified construction materials for the sample residences, first, external wall measurements were first calculated using the formula (d x e) - f = G, where the building height (d) was multiplied by the perimeter (e), subtracting openings such as windows and doors (f). As the heights and perimeters of ground and first floors were not identical, they were calculated separately. Since prices for these certified products were unavailable from the Ministry of Environment, Urbanization, and Climate Change unit price list, data from private sector companies were utilized. The total material costs (I) were then calculated by multiplying the external wall area of the building (g) by the unit price of each material (h) (Table 13).

Table 13 Cost Analysis of Three Buildings for Material Usage

Building	Total cost (USD)
1st Building	10592,16
2nd Building	14242,5
3rd Building	14792

Across all three buildings, EPD-certified rock wool insulation was consistently the most cost-influential material, owing to both its high unit price and its significant contribution to energy savings through reduced heat loss. Cement-based plaster ranked second in terms of cost impact, while mineral decorative plaster and silicone-based exterior paint had the least influence on total costs. The total costs of decorative plaster and silicone-based exterior paint were relatively close across all residences.

3.2. Cost Findings Related to Traditional Construction Practices

In this section, the costs of three detached residential buildings were calculated and evaluated within the framework of traditional construction practices have been calculated and evaluated. For fair comparison, traditional buildings were analyzed using the same water, energy, and material categories as in the green study. However, the selection of products, materials, and practices for the three residential buildings in the Çay Bağları area does not require compliance with the specific standards mandatory for green buildings. Materials for traditional buildings were chosen based on affordability and local construction norms to reflect typical usage.

Cost findings related to water consumption in residential buildings

While low-flow sanitary fittings and water-efficient appliances are selected in green building practices, traditional construction practices do not specifically consider criteria for water and energy conservation. To enable a direct comparison, while A-class energy-rated appliances were selected for green building practices, class-C appliances were chosen for traditional practices. In traditional construction, medium-class priced products were selected for household appliances, sanitary fittings, and sanitary ware.

Although Çay Bağları is typically home to upper-income residents with diverse and high-end preferences, this study selected traditional construction materials with optimal costs to allow fair comparison with green building practices (Table 14). Top-quality washbasin faucets were therefore not used in the cost calculation for water consumption; only price variations in the product range based on preference were presented (Table 14).

Among practices related to water consumption, washbasin faucets had the lowest unit cost, whereas dishwashers exhibited the highest cost. The share of each product in total costs varied depending on the quantity used in each residence. In the first building, the total costs of household

appliances (washing machine) and washbasin faucets were relatively close. In contrast, the second and third residences had fewer washbasin faucets, resulting in lower total costs compared to washing machines. The first residence had higher total costs than the others, primarily due to the greater quantity of faucets and sanitary fittings installed (Tables 14 and 15).

Table 14 Cost Analysis for the First Building Water Use

	Practices for water consumption	Unit Price (USD)	Quantity	Total Cost (USD)
Sanitary Wares	**Kitchen Faucet**	159	1	159
	Washbasin Faucet	85	6	516
	Top Quality Washbasin Faucet	643	6	3858
	Sanitaryware Elements (Set Toilet)	180	5	900
Devices	**Dishwasher**	819	1	819
	Washing Machine	608	1	608

Total: 6860 USD

Table 15 Cost Analysis for the Second and Third Buildings Water Use

	Practices for water consumption	Unit Price (USD)	Quantity	Total Cost (USD)
Sanitary Wares	**Kitchen Faucet**	159	1	159
	Washbasin Faucet	85	4	344
	Sanitaryware Elements (Set Toilet)	180	4	720
Devices	**Dishwasher**	819	1	819
	Washing Machine	608	1	608

Total: 2650 USD

Cost findings related to energy consumption in residential buildings

In traditional residential construction, windows and household appliances were selected based on conventional specifications without adherence to green certification criteria. Double-glazed windows commonly used in the region were considered, and class C appliances were selected due to their lower costs compared to the A-class appliances required in green building practices.

Among the three residences, the third building had the highest window-related costs, followed by the first and second, indicating that window costs directly correlate with both the number of units and their technical specifications. Although appliances were cheaper per unit, window costs were higher due to their greater quantity. Appliance costs (dishwasher and washing machine) were identical across all buildings, since products with similar specifications were used.

In this context, the main factors influencing energy-related costs in traditional residences include window specifications, the number of window units, and appliance selection. Accordingly, the total energy-related costs for the three buildings are summarized in Table 16.

Table 16 Cost Comparison of Three Buildings for Energy Consumption

Building	Total cost (USD)
1st Building	11050
2nd Building	10448
3rd Building	11592

Cost findings related to material consumption in residential buildings

Residential buildings constructed in the Çay Bağları area are predominantly built using traditional reinforced concrete structural systems. Common external facade finishes include rough plaster, 6 cm-thick insulation, primer plaster, and exterior facade paint, applied sequentially. These local materials were selected for calculating material costs under traditional building practices. Unlike the environmentally certified materials used in green buildings, as specified in global certification systems, the materials selected for traditional construction do not possess any

environmental certification. The unit price list published by the Ministry (January 2024) and private-sector market data were used for cost calculations.

The external wall areas of the three sample buildings were used as a basis for calculating total material costs the external wall measurements are consistent with those previously calculated for the green building cost analyses.

Across all three buildings, rock wool insulation exhibited the highest unit cost among exterior facade materials, followed by rough plaster, mineral decorative plaster, primer plaster, and exterior paint. In the first building, total rock wool insulation costs amounted to 3,621 USD, whereas exterior paint costs amounted to 850 USD, highlighting the significant cost impact of insulation (Table 17). As the external wall area increased across the three buildings, from 314.87 m² (first) to 422.98 m² (second) and 439.3 m² (third), total material costs rose proportionally, from 9,320 USD to 12,520 USD and 13,003 USD, respectively. The unit cost per square meter remained nearly constant at approximately 29.5–29.6 USD/m² across all three buildings. Due to the similar wall areas of the second and third buildings, the cost difference between them was smaller than the difference from the first building (Table 17).

Table 17 Cost Comparison of Three Buildings for the Use of Materials

Building	External Wall Quantity of the Building (m²)	Total cost (USD)	Unit price (USD/m²)
1st Building	314,87	**9320,11**	**29,5**
2nd Building	422,98	**12520,26**	**29,6**
3rd Building	439,3	**13003,36**	**29,6**

Table 18 presents a comparative summary of total green and traditional building costs across all three residences. Energy-saving measures represented the largest share of green building expenditure (59–67%), followed by materials (22–31%) and water-saving practices (9–11%).

Table 18 Cost Comparison of Green and Traditional Building Applications for the Three Residences

	Applications	1st Building (USD)	2nd Building (USD)	3rd Building (USD)
Green Building Applications	Water-saving practices	5,204	4,500	4,500
	Energy-saving practices	32,285	26,958	29,128
	Material usage practices	10,602	14,243	14,792
	Total	**48,090**	**45,701**	**48,421**
Traditional Building Applications	Water consumption practices	3,002	2,651	2,651
	Energy consumption practices	11,050	10,448	11,592
	Material usage practices	9,352	12,565	13,050
	Total	**23,404**	**25,663**	**27,292**
	Difference (Green – Traditional)	24,687	20,038	21,129
	Percentage increase (%)	**105.5%**	**78.1%**	**77.4%**

Although the analysis primarily focuses on initial investment costs, the calculated payback periods for photovoltaic systems indicate long-term economic performance. The findings can therefore serve as a preliminary reference for life-cycle cost evaluations. Despite higher initial costs, certain green building applications, particularly photovoltaic systems, can offer economic advantages over time through reduced operational costs.

4. Discussion

Green buildings are often viewed as more expensive than traditional construction, particularly during the initial investment phase. This perception can hinder the adoption of sustainable practices despite long-term savings. In this study, low-rise residences in Kayseri's Çay Bağları district were examined to assess cost differences between traditional and green systems.

Green cost categories included water efficiency, energy efficiency, and sustainable materials. Although Kayseri lacks certified green housing, this study provides foundational data for future applications. Water-saving strategies featured low-flow faucets, efficient sanitary fixtures, and appliances. Sanitary fixtures and appliances were the most significant cost factors, with fixture quantity impacting cost regardless of unit price.

Energy-saving measures included photovoltaic panels, insulated windows, and efficient appliances. Solar panels had the highest upfront cost, while windows and appliances also contributed substantially to the aggregate. For materials, environmentally certified products such as EPD-labeled cement plasters, rock wool insulation, and eco-friendly paints were used. Rock wool insulation led material costs due to its thermal performance (EPD Türkiye, 2025).

Although initial costs were higher, green elements offer long-term benefits. Variations in roof size impacted photovoltaic installations; the smallest house had the highest unit cost, revealing non-linear cost behavior. Façade material costs increased with building size and were shaped by wall area and design. The smallest building had notably lower external finish costs.

To summarize: sanitary fixtures and appliances drove water efficiency costs; solar panels dominated energy investments; and insulation was the largest material cost. While these factors raise initial expenditure, operational and environmental gains justify the investment.

Prior research supports these outcomes. Çelik (2009) advocated for integrating global green certifications into Turkish construction but lacked practical studies. Yağcıoğlu (2018) explored water-efficient fixtures, paralleling this study's focus. Güzelkokar (2019) examined transitions to green buildings but did not detail cost analyses. Yılmazsoy (2021) emphasized sustainable housing post-COVID, a direction confirmed by this fieldwork (Çelik, 2009; Yağcıoğlu, 2018; Güzelkokar, 2019; Yilmazsoy, 2021).

5. Conclusions and Recommendations

Green building practices resulted in higher initial construction costs across all categories analyzed. The total cost of green building applications was higher than that of traditional construction in all three residences, amounting to approximately USD 48,090 versus USD 23,404 in the first residence, USD 45,701 versus USD 25,663 in the second residence, and USD 48,421 versus USD 27,292 in the third residence, corresponding to increases of approximately 106%, 78%, and 77%, respectively. Photovoltaic systems were identified as the most significant cost contributor. However, these initial expenses are offset by long-term operational savings.

To promote adoption, several stakeholder-specific recommendations are proposed:

Central Authorities: Implement financial incentives, tax reliefs, and technical support mechanisms. Establish municipal green building units and increase public awareness to stimulate demand.

Contractors: Evaluate buildings beyond initial costs by considering long-term savings. Improve awareness and training regarding green building benefits.

Architects: As design decisions influence lifecycle costs, incorporate green building education in professional training. Encourage specializations in sustainable design.

Users: Educate residents about green building benefits, including operational savings, environmental impact, and improved indoor comfort.

Material Manufacturers: Promote awareness of certified materials and their long-term advantages. Address misconceptions about cost through transparent communication and training.

In conclusion, although initial investments in green buildings are higher, these practices offer significant long-term benefits. They improve environmental performance, increase property value, and contribute to broader sustainability goals. Policymakers, practitioners, and users must

collaborate to overcome cost-related concerns and promote the widespread adoption of green buildings in Türkiye.

Although life cycle cost (LCC) is widely recognized as an important parameter in evaluating the long-term economic performance of building systems, a comprehensive LCC analysis was not included within the scope of this study. This is mainly due to the lack of reliable and consistent long-term data, such as maintenance, operation, and replacement costs, as well as appropriate discount rates.

In addition, variability in service life assumptions and the lack of standardized datasets limit the applicability of detailed LCC calculations in this context. A net present value (NPV) analysis incorporating discount rates and the time value of money was also not conducted, due to the limited availability of region-specific discount rates and long-term operational cost data for residential green buildings in Türkiye. Therefore, this study focuses on initial cost comparisons and payback-based evaluations.

Future research should incorporate long-term cost components and develop more comprehensive life cycle cost analyses, including NPV-based investment appraisal methods, to better assess the economic performance of green building applications.

The findings of this study provide practical implications for different stakeholder groups. For policymakers, the results highlight the importance of developing incentive mechanisms and regulatory frameworks to support the adoption of green building applications. For designers and practitioners, the study emphasizes the need to consider not only initial investment costs but also long-term economic benefits when selecting building components and systems. For users and investors, increasing awareness of payback periods and operational savings is crucial for more informed decision-making.

In addition, improving long-term cost awareness requires not only economic evaluation but also the dissemination of technical knowledge and training programs related to energy-efficient systems and renewable energy applications. The lack of accessible and standardized data on long-term costs remains a significant barrier to wider adoption.

Furthermore, the findings indicate that region-specific challenges and implementation gaps still exist, particularly in terms of data availability, technical expertise, and market accessibility. Future studies should focus on field-based analyses and regionally adapted models to better reflect real-world conditions and support the broader implementation of sustainable building practices.

Overall, the study demonstrates that green building applications can be evaluated not only in terms of initial costs but also in relation to their long-term economic potential.

CRediT Authorship Contribution Statement

Nurbanu Şahin: Methodology, Conceptualization, Investigation, Validation, Visualization, Writing – Original Draft. Merve Bıyıklı Hasözhan: Conceptualization, Investigation, Methodology, Formal Analysis, Validation, Visualization, Writing – Original Draft Zübeyde Özlem Parlak Biçer: Supervision, Writing – Review & Editing. All authors have read and approved the final version of the manuscript.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

Data will be made available on request.

Ethics Committee Approval

Ethics committee permission is not required.

References

Ade, R., & Rehm, M. (2019). *The unwritten history of green building rating tools: A personal view from some of the "founding fathers"* (SSRN Scholarly Paper No. 4177291). SSRN. https://papers.ssrn.com/abstract=4177291

Akgül, T., Besken, İ., & Karabıyıkoğlu, O. (2020). BREEAM Sertifikalı Bir Eğitim Binasının Yapım Maliyetinin Geleneksel Yapım Maliyetiyle Karşılaştırılması. *Türk Doğa Ve Fen Dergisi, 9*(1), 49-54. https://doi.org/10.46810/tdfd.707092

ASTM. (2023). *Terminology for sustainability relative to the performance of buildings*. (ASTM E2114-21). ASTM International. https://doi.org/10.1520/E2114-21

Author 1. (2024). *Author 1 photo archive*.

Bayat, F., & Küçükali, U. F. (2022). Sürdürülebilirlik bağlamında yeşil binaların ulusal ve uluslararası örnekler üzerinden incelenmesi. *Anadolu Bil Meslek Yüksekokulu Dergisi, 16*(64), 321_347. https://izlik.org/JA35AC84HW

Burnett, J. (2007). City buildings – Eco-labels and shades of green! *Landscape and Urban Planning*, *83*(1), 29-38. https://doi.org/10.1016/j.landurbplan.2007.09.003

Circo, C. J. (2007). *Using mandates and incentives to promote sustainable construction and green building projects in the private sector: A call for more state land use policy initiatives*. SSRN. https://papers.ssrn.com/abstract=1066982

ÇEDBİK, G. (2019). *B.E.S.T konut sertifika kIlavuzu*. Çevre Dostu Yeşil Binalar Derneği. https://www.cedbik.org/dosyapaylasimi/028a434f-059b-4fe3-9f0c-8dde158d1616

Çelik, E. (2009). *Yeşil Bina Sertifika Sistemlerinin İncelenmesi Türkiye'de Uygulanabilirliklerinin Değerlendirilmesi* [Yüksek Lisans]. İstanbul Teknik Üniversitesi, Fen Bilimleri Enstitüsü.

Çevre, Şehircilik ve İklim Değişikliği Bakanlığı (ÇŞB). (2020). *Yerli yeşil sertifika sistemi YES-TR ile yeşil bina sayısı artacak*. https://agri.csb.gov.tr/yerli-yesil-sertifika-sistemi-yes-tr-ile-yesil-bina-sayisi-artacak-haber-253949

Dalsan. (2025). *Dalsan*. https://dalsan.com.tr/

Dania, A., Larsen, G., & Yao, R. (2013). *Mainstreaming sustainable construction: Case studies of an indigenous and multinational firm in Nigeria* [Konferans bildirisi]. Engineering Project Organization Conference, Colorado, ABD.

Dong, M., Sampene, A. K., Li, C., & Kyere, F. (2025). Innovative pathways to green building development: Integrating technology, policy, and industry collaboration. *Cleaner and Responsible Consumption*, *19*, 100329. https://doi.org/10.1016/j.clrc.2025.100329

Dyo. (2025). *Dyo*. https://dekoratif.dyo.com.tr/

Erdede, S. B., & Bektaş, S. (2018). Türkiye için yeşil bina sertifika sistemi gerekliliği. *SET-SCI Conference Proceedings, 3*, 138-143. http://www.set-science.com/manage/uploads/ISAS2018-Winter_0039/SETSCI_ISAS2018-Winter_0039_0025.pdf

Guo, K., Li, Q., Zhang, L., & Wu, X. (2021). BIM-based green building evaluation and optimization: A case study. *Journal of Cleaner Production*, *320*, 128824. https://doi.org/10.1016/j.jclepro.2021.128824

Güzelkokar, O., & Gelişen, G. (2019). Mevcut Yapıların Sürdürülebilir Yeşil Binalara Dönüştürülmesi. *Ulusal Çevre Bilimleri Araştırma Dergisi, 2*(2), 76–90.

Hwang, B.-G., Zhu, L., & Ming, J. T. T. (2017). Factors affecting productivity in green building construction projects: The case of Singapore. *Journal of Management in Engineering*, *33*(3), 04016052. https://doi.org/10.1061/(ASCE)ME.1943-5479.0000499

İmert, H. (2017). *Konaklama mekânlarında ekolojik biçimleniş ve bir tasarım modeli önerisi* [Doktora tezi, Mimar Sinan Güzel Sanatlar Üniversitesi].

Kats, G. (2003). *The costs and financial benefits of green buildings*. Massachusetts Technology Collaborative.

Kibert, C. (2007). The next generation of sustainable construction. *Building Research and Information*, *25*(6). https://doi.org/https://doi.org/10.1080/09613210701467040

Kiraz, F. (2015). *Toplu konutlarda rüzgâr ve gürültü açısından konforlu açık alan tasarımına yönelik bir yaklaşım* [Doktora tezi, Yıldız Teknik Üniversitesi].

Mateus, R., & Bragança, L. (2011). Sustainability assessment and rating of buildings: Developing the methodology SBToolPT_H. *Building and Environment*, *46*(10), 1962_1971. https://doi.org/10.1016/j.buildenv.2011.04.023

Mattoni, B., Guattari, C., Evangelisti, L., Bisegna, F., Gori, P., & Asdrubali, F. (2018). Critical review and methodological approach to evaluate the differences among international green building rating tools. *Renewable and Sustainable Energy Reviews*, *82*, 950-960. https://doi.org/10.1016/j.rser.2017.09.105

Mozingo, L., & Arens, E. (2014). *Quantifying the comprehensive greenhouse gas co-benefits of green buildings*. eScholarship. https://escholarship.org/uc/item/935461rm

Newsham, G. R., Mancini, S., & Birt, B. J. (2009). Do LEED-certified buildings save energy? Yes, but…. *Energy and Buildings*, *41*(8), 897-905. https://doi.org/10.1016/j.enbuild.2009.03.014

Olubunmi, O. A., Xia, P. B., & Skitmore, M. (2016). Green building incentives: A review. *Renewable and Sustainable Energy Reviews*, *59*, 1611-1621. https://doi.org/10.1016/j.rser.2016.01.028

Portalatin, M., Roskoski, M., Koepke, K., & Shouse, T. (2010). *Sustainability "how-to guide" series: Green building rating systems*. IFMA Foundation. http://cdn.ifma.org/sfcdn/docs/default-source/default-document-library/green-building-rating-systems.pdf

Ramakrishnan, J., Seshadri, K., Liu, T., Zhang, F., Yu, R., & Gou, Z. (2023). Explainable semi-supervised AI for green performance evaluation of airport buildings. *Journal of Building Engineering*, *79*, 107788. https://doi.org/10.1016/j.jobe.2023.107788

Ries, R., Bilec, M. M., Gokhan, N. M., & Needy, K. L. (2006). The economic benefits of green buildings: A comprehensive case study. *The Engineering Economist*, *51*(3), 259_295. https://doi.org/10.1080/00137910600865469

Samsung. (2025). *Beyaz eşya enerji sınıfları nelerdir?* Samsung Türkiye. https://www.samsung.com/tr/explore/brand/what-are-energy-classes/

S-Line Mimarlık. (2022). *Mimari projeler*.

Solimpeks. (2024). *Fotovoltaik güneş paneli çalışmaları-EK 11-12*.

Taseer, A., Aslam, M., Malik, M. S. A., Zahoor, H., & Jadoon, A. A. (2025). Energy efficiency and life cycle cost analysis of residential buildings using sustainable building materials. *Journal of Building Engineering*, *114*, 114243. https://doi.org/10.1016/j.jobe.2025.114243

Toprak Tasarım Mimarlık. (2022). *Mimari projeler*.

Umaroğulları, F., Kartal, S., & Aydın, D. (2020). A comparative study on Turkey's national green building certification system under energy policy developments. *Iconarp International J. of Architecture and Planning*, *8*(1), 187-210. https://doi.org/10.15320/ICONARP.2020.110

UNEP. (2022, September 11). *2022 global status report for buildings and construction*. United Nations Environment Programme. http://www.unep.org/resources/publication/2022-global-status-report-buildings-and-construction

United States Environmental Protection Agency (USEPA). (2016). *Basic information: Green building*. https://archive.epa.gov/greenbuilding/web/html/about.html

Wang, Y., Pang, B., Zhang, X., Wang, J., Liu, Y., Shi, C., & Zhou, S. (2020). Life cycle environmental costs of buildings. *Energies*, *13*(6), 1353. https://doi.org/10.3390/en13061353

Wedding, G. C. (2008). *Understanding sustainability in real estate: A focus on measuring and communicating success in green building* [Master thesis, University of North Carolina at Chapel Hill]. Carolina Digital Repository. https://doi.org/10.17615/HHCS-FW12

Yağcioğlu, M. H. (2018). *An investigation of the water efficiency credits in international green building assessment systems and a roadmap for their implementations in Turkey* [Yüksek Lisans, Boğaziçi Üniversitesi, Fen Bilimleri Enstitüsü]. https://acikbilim.yok.gov.tr/handle/20.500.12812/75509

Yalılı Kılıç, M., & Adalı, S. (2021). Yeşil Bir Villanın Tasarım Maliyetinin Klasik Villa Tasarım Maliyetiyle Karşılaştırılması. *Duzce University Journal of Science and Technology, 9*(2), 822_835. https://doi.org/10.29130/dubited.820515

Yilmazsoy, K. B. (2021). TARİHİ SÜREÇTE SALGIN HASTALIKLAR VE DEĞİŞİM: COVID-19 SONRASI MİMARİ VE KENT. *International Journal of Social Humanities Sciences Research (JSHSR), 8(*66), 425–440. https://doi.org/10.26450/jshsr.2323

Yudelson, J. (2007). *The green building revolution*. Island Press.

Zengin, N., & Yamaçlı, R. (2023). Mimari tasarımda değişen iklim ve küresel ısınmanın rolü. *İnönü Üniversitesi Sanat ve Tasarım Dergisi*, (27), Article 27. https://doi.org/10.16950/iujad.1225133

Zigenfus, G. C. (2008). *Element analysis of the green building process* [Master thesis, Rochester Institute of Technology]. RIT Scholar Works. https://repository.rit.edu/theses/507

Resume

Merve Hasözhan Bıyıklı received her MSc degree in Architecture from Erciyes University in 2024 under the supervision of Prof. Dr. Zübeyde Özlem Parlak Biçer. Her research focuses on green building practices, cost analysis, and sustainable approaches in residential architecture.

Zübeyde Özlem Parlak Biçer is currently a Prof. Dr. at Erciyes University, Faculty of Architecture, Department of Architecture. Her research areas include architecture, building information, project and construction management, and sustainable building practices. She has authored and co-authored several studies on architecture, building technologies, ecological approaches, and cost-related evaluations in the built environment.

Nurbanu Şahin is currently a Res. Asst. at Erciyes University. She received her BArch degree in 2014 and her MSc degree from Erciyes University in 2020. She has been continuing her doctoral studies at Erciyes University since 2021. Her research focuses primarily on structural systems, mass timber and timber structures, while also encompassing studies on sustainability, ecological design and building materials.