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PROF. DR. SERTAÇ GÜNGÖR

PROF. DR. MURAT DAL

SERÜVEN YAYINEVİ

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Chapter 1

CULTURAL TOURS TO CONTEMPORARY ART VENUES AND THEIR CONTRIBUTIONS TO URBAN SUSTAINABILITY[1]

Gökçe Nur Aykaç[2]

1 This study is derived from the paper entitled *'Discussing the Works of Art and Places in The Context of Technical Trips: The Contribution of the Cultural Trips to Quality of Urban Life'* presented at the 2nd International Conference On Sustainable Cities and Urban Landspaces - ICSULA 2023.

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Introduction

In the context of sustainable urbanization requirements, art and culture are at least as important as environmental, economic, and social sustainability at the city scale. According to studies such as the European Urban Charter and the European Declaration of Urban Rights (EUC), the European Environment Agency (EEA), the World Commission on Environment and Development (WCED), and the United Nations Conference on Human Settlements Habitat II (1996), culture, historical heritage, and their preservation are considered integral parts of sustainable urban life. Improving urban life is among the principles of sustainable urbanization. The Stockholm UN Conference on the Human Environment (1972), the first environmental conference to highlight the limited nature of world resources and humanity's need to protect them, contains the first approaches to the concept of sustainable development (URL-1) (Boudes, 2014). According to some principles given in the Conference report, which consists of 26 principles (principles 8 and 15), (UN, 1973), there are principles stating that economic and social development is essential for improving the quality of life, and that planning should be applied to human settlements and urbanization to provide maximum social, economic, and environmental benefits for all.

The agreements prepared at the aforementioned meetings and declarations contain decisions regarding the protection of elements that constitute urban culture. At this point, roles of states, local governments, and finally citizens or urban residents are significant in protecting and developing urban culture (Keleş, 2005). In the context of improving and sustaining urban life, culture is of great importance. Urban culture consists of the totality of values created by the people living there, as well as the city's history and memory, its physical structures and elements, and its socio-economic structure. Tradition, culture, and artistic production are at least as important as the elements mentioned above in the shaping urban culture. Considering the impact of activities carried out within the city on the quality of life of city residents, it has been observed that socio-economic levels and environmental and social developments directly affect this quality.

City and Urban Culture

This research examines the contribution of cultural, artistic, and design spaces to the sustainability of urban quality of life. Given the importance of museums and art centers to urban culture, individual or group city tours shape culture through the experiences of city residents. The contribution of tours to cultural, artistic, and design spaces, undertaken to increase recognition of the urban environment to the sustainability of urban culture, has been investigated. In this context, museums and art centers, which bring art to people, have been identified as the main framework, and the scope has been narrowed to include contemporary art centers.

The evolution of art centers, where art meets people, from the past to the present, and their arrival in contemporary art has been examined. In this context, contemporary art has been a development that restructures past art movements, methods, techniques, and art centers. Along with contemporary art, which gives a new face to art spaces, complexes with individually designed structures have emerged.

The experience, on-site examination, and observation of urban elements by city residents, and their subsequent contributions to necessary improvements and developments, are within the scope of sustainability in urban culture. In doing so, it is important that academia is involved alongside cultural and artistic events, city walks, talks about the city, workshops, and all other municipal activities. Here, it is crucial to participate in these activities within the context of social contributions, beyond the theoretical courses taught at universities, and to encourage students to participate within the scope of their courses. Field trips, which are included in the course curriculum as a field trip method within the teaching principles and methods, serve the purposes of ensuring retention of theoretical knowledge taught in class, on-site learning, and assimilating geography and culture. In this context, field trips within the city are extremely important for contributing to the sustainability of the city and its culture, as they raise awareness of the city and its culture and spread this culture among its residents. The research universe consists of university students, who are an important part of the city's culture. Since the researcher's main area is determined as the main framework, the study conducted within the scope of the research was carried out with students from the Interior Architecture and Environmental Design department.

Interior Architecture and Environmental Design is a discipline that has structured its educational content to produce livable, quality-of-life, safe, comfortable, and prosperous spaces for people, whose most basic need begins with shelter. In addition to application-based courses teaching construction and application theory, interior architecture departments also offer courses focused on art and design, as well as courses that provide technical knowledge and solutions with a theoretical foundation. One of the best ways to make the information conveyed in the courses permanent is through technical field trips and cultural excursions adapted to the course content. These trips are designed to develop urban culture and a sense of belonging to the city.

While local authorities, universities, various organizations play a role in the development of this extremely rich urban culture (Keleş, 2005) -which extends beyond culture and the arts to include the city's own cultural assets -the experiences gained by city residents from these activities also contribute to the sustainability of this culture. It is possible to read the contribution of these aesthetically-minded, well-designed, and high-quality structures (Keleş, 2015a), urban and architectural structures, equipment, and symbols that are part of the city's memory, to the city's culture from the interest and curiosity of the city residents (Hayta, 2016). The structures that have become ingrained in the city's memory and found place in urban culture, with their artistic and aesthetic aspects, are museums, art centers, and art galleries. These buildings, where cultural, historical, traditional, and artistic objects are preserved, stored, and exhibited, along with all the collections kept and displayed within them, and the artists and craftspeople who bring these collections and artworks to life, are all factors that nourish museum and gallery culture (Altıntaş and Eliri, 2012).

Contemporary Art and Venues

In the late 18th and early 19th centuries, there were opinions about rejecting Renaissance and Baroque ornamentation. Art could only be appreciated in the palace, and the strict rules of "École des Beaux-Arts" didn't give a chance to the artist whose work of art was not appropriate for the École. This classical antiquity was going to change with the going through some circumstances in Europe, such as the French Revolution, the Enlightenment, the Scientific Revolution, the development of intellectual thought, and individualism (Little, 2013; Turani, 2019; Gombrich, 2019). Moreover, Rationalism and Classicism merged the antiquity and modernity. This movement would later be named Neo-Classicism. The society answered these changes of ideas rapidly, resulting with the emergence of Realism and Romanticism. Contemporary art draws deeply on this transformation and has continued to thrive today, since the 19th century. These periods had started to change the boundaries and traditions of Academism. Some artists had qualified for admission to the academy with their works that were different from the works before.

Realists conveyed the realities of society by taking their subjects step outside the palace. The subject and methods used by the Realists, 'impressed' some artists to leave the studios and imitate nature with the rules of sunlight rather than describing it. After the beginning of the 19th century, the subjects of art shifted away from antiquity towards everyday life and social events, whilst production techniques took on a more hasty and experimental dimension (Turani, 2019; Gombrich, 2019).

Artists, completely broke away from academicism and antiquity, experimenting with different subjects and materials. They produced new movements using a wide variety of ideas and methods; their ideas crossed European borders and encountered new cultures. The outbreak of WW2 changed many things. Many artists migrated to North America and achieved American prosperity, pushing the boundaries of art beyond the ocean. This migration of artists, architects, and scientists in the 1940s was an escape from the inhumane dimension of the war and fascist rulers. The monopolized art of France transformed into the American Art. Artists were provided with a pleasing environment and art spaces where they could exhibit their works. MoMA and the Guggenheim Museum were first venues for artists to exhibit the works of European artists (Guilbaut, 2008; Turani, 2019, p. 704-710).

It could be said that the initial idea for museums originated from sculpture. A statue in any space gives meaning to the point where it is located (Aktimur, 2009), and where the statue is positioned can monumentalize it. The buildings of antique style, have some limitations I interiors because of their exceedingly gilded, ornamented and decorated inside. Considering the spatial context, sculptures can serve as a part of the historical building (church, cathedral, etc.) where it was exhibited in. Based on this idea, a work of art can transform the space itself in which it is placed (Karaaslan, 2005).

After the WW2 and the Cold War, there was a new understanding of art in 1960's. When the use of conventional materials of art is denied or replaced by the newer ones, many other methods and tools used for the new art media (Karaçalı, 2018). These individual characteristics of works of art have begun to require spaces with flexible surfaces or spaces (Kurt, 2019; Utkan Özden, 2020). For instance, these changes can be seen in the conceptual art of El Lizzitsky, Marcel Duchamp, and Kurt Schwitters, and others' works, the early examples of installation art. In a conceptual context, a work of art requires an art space in order to be recognized as such.

Tate Modern, MoMA, the Guggenheim are the most important ones of the venues all around the world. In addition to these state-supported venues, world-famous luxury brands and banks, etc. have established their own foundations and transformed contemporary art venues and the contemporary art market (Whitham & Pooke, 2013, p. 266). It is possible to examine the contribution made by MoMA (The Museum of Modern Art) in New York -one of the earliest examples of a contemporary art museum- to the urban environment through the lens of the demographic and cultural changes that took place in the area during the 1960s and thereafter (Utkan Özden, 2020). In the 1900s, as financial centres and factories moved out of the city, artists began to make use of abandoned buildings and, at the same time, developed a new culture of spatial and urban living (Zukin, 1989).

As a conclusion, art museums and centers play a significant role in the sustainability of urban culture and life. In this context, contemporary art museums and galleries are introduced to the city dwellers with a huge contribution to urban life.

In the 1950's, modernization movements in sculpture started in Türkiye, after Kurt Schwitters' ready-made technique in the 60s, new trends were followed. In the 70s, the tendency of inspiring from the artists such as Marcel

Duchamp was followed. The works that established a relationship between the art and space were studied. At that time, the majority of contemporary art exhibitions were produced in Istanbul (Aktimur, 2009). It took about a decade for this approach and innovation to develop in Türkiye (Kurt, 2019).

Morphological Genesis of the Selected Area: Ulus District

Within the trajectory of Ankara's urban development, the initial organizational phase was heavily influenced by the 'city beautiful movement' of the 1920s and 1930s. During this period, the Ulus district was conceptualized as the urban core, characterized by expansive boulevards, public parks, and central squares (Keleş, 2015, p. 118). The district's spatial identity was further solidified through the integration of diverse functions, including the headquarters of major financial institutions, commercial bazaars, cultural venues such as theaters, and residential buildings.

As an urban fragmentation and functional displacement, the spatial integrity and foundational values established during the Early Republican Era -which positioned Ulus as the heart of the city -underwent significant disruption due to the architectural interventions of the 1950s and 1960s (Tunçer, 2013). The subsequent migration of the city center toward the Kızılay district led to a socio-spatial detachment, stripping Ulus of its former prominence. Nevertheless, contemporary architectural contributions in the area have recently begun to re-establish a functional dialogue with 'old Ankara', effectively reintegrating modern utility into the historical fabric of the current Ulus district.

The revitalizing influence of contemporary art centers is particularly evident in the Ulus vicinity, where industrial heritage has been reclaimed for cultural consumption. A primary example is the adaptive re-use of the traction workshops situated along the Ankara Train Station railway -a landmark of Republican Era- infrastructure (Aslanoğlu, 2010, pp. 227-229). Originally constructed in 1926 and rendered obsolete by 1995, these idle structures were redesigned by *Uygur Architects*. The transformation of these hangars into the Cermodern Arts Center has not only preserved a significant industrial legacy but has also injected new vitality into the urban landscape. By activating the strategic axis between *Anıtkabir* and *Ankara Castle*, this intervention has reaffirmed the region's historical and cultural significance within Ankara's broader urban plan.

After the construction of the newly built CSO Ada Presidential Symphony Orchestra (1992-2020) on the land adjacent to the Cermodern Art Museum, it contributed to the urban memory of Early Republican Ankara (Figure 1-2). Despite its contemporary architectural approach, it did not forget to salute the eternal resting place of the Ancestor of the Turks, *Anıtkabir.* Cermodern has enabled the revitalization of structures that have served the city and the arts, such as Gençlik Parkı (Youth Park), the former Presidential Symphony Orchestra Historical Stage Building, and Ankara State Theatre - Small Theatre (II. Evkaf Apartment) and Ankara State Opera and Theater buildings, reminding the people of Ankara of their sense of belonging to the city.

Figure 1: Cermodern Arts Center Before-After Its Adaptive Reuse
Photography by: Cemal Emden, uygurarchitects.com

Figure 2: Axial Placement of Anıtkabir, CSO, Cermodern and Ankara Castle googlemaps

Objectives and Methods

During the study, an application was carried out within the scope of art venues that make significant contributions to urban culture. The application was organized within the framework of art and design courses in Interior Architecture Education. As part of technical trips, which are an important part of the education, students are expected to experience their city in the context of culture, art, and design. This research on student trips was completed with the results collected within the framework of students' observations, analyses, and evaluations.

This study was prepared as part of the 'Contemporary Art Movements' course included in the curriculum of the Department of Interior Architecture and Environmental Design at the Faculty of Fine Arts, Design and Architecture, Atılım University. The aim of the course is to enable students to understand the historical process and transformation in art and design, spanning from the second half of the 19th century in Europe to the Americas. By understanding and analysing these art movements, which have shaped today's design world, students will be able to draw upon them. Students are expected to utilise this knowledge when developing and refining design concepts in their projects (Course Syllabus, URL-2).

Within the scope of the course, students are expected to reread the information they have learned about the city, to feel and learn about the city, to participate in urban life, and in this way to increase the city's recognition and to emphasize the importance of art in cultural life and in the city. Fulfilling these steps, which constitute the objectives of the assignment, made it possible to monitor the contribution of the student and the university to the sustainability of urban life. The most important factor determining the students' choice of venue was the proximity of the art venue to their living environment. Generally, contemporary art content was followed; in this sense, the Ankara Capital Culture Route Festival, organized by the Turkish Ministry of Culture and Tourism, was an excellent guide. The most preferred destination for students was Cermodern Art Center, due to its current and successful content, followed by CSO Ada, due to its proximity to Cermodern and its intriguing architecture (Table 1).

114 students participated in the research. They are expected to first examine the art venues they visited in the context of their structural and interior layouts. Afterwards, they were asked to see the exhibitions in the buildings they visited, and expected to obtain information about the contents of these exhibitions: the type of art, the period, the artist, and former works and similar information. Finally, they reported their experiences, impressions and opinions.

	Exhibition	Artists	Venue	Semester
1	Göbeklitepe		Cermodern	2019-2020
2	Samimiyet	Orkide Akkoç	Cermodern	2020-2021
3	Stilstand	Murat Cem Baytok	Cermodern	2020-2021
4	Tezhip Sanatı		Ankara Sanat Galerisi ve Müzayedecilik Evi	2020-2021
5	Sesler ve İzler Sergisi	Ahmet Yeşil	Galeri Soyut	2020-2021
6	Paçavraların	Venüsü Arte Povera	Cermodern	2021-2022
7	Takım Yıldızlar	Pietro Ruffu	Cermodern	2021-2022
8	Titan	Luigi Mainolfi	Cermodern	2021-2022
9	Çökelmeler	Paolo Grassino	Cermodern	2021-2022

10	Anlatılmayan Öyküler	Zehra İşpiroğlu	Cermodern	2021-2022
11	Senin Olan Bizim Olacak	Fabio Viale	Cermodern	2021-2022
12	Estetica dell'Apocalisse	Pamela Diamante	Cermodern İpek Yolu. İtalya'dan Çağdaş Sanat ve Sanatçılar	2021-2022
13	AŞKLA.ngoz Sergisi	Gülsima Baykal	Galeri Soyut	2021-2022
14	Frida ve Diego		Doğan Taşdelen Çağdaş Sanatlar Merkezi	2022-2023
15	Maria Kılıçoğlu Baraz Heykel Sergisi	Maria Kılıçoğlu Baraz	Ziraat Bankası Çukurambar Sanat Galerisi	2022-2023
16	Bir zamanlar denizin olduğu yer	Julia Bornfeld, Aron Demetz, Arnold Maria Dall'o Will-Ma Kammerer, Hubert Kostner, Sissa Micheli, Robert Pan, Peter Senoner, Barbara Tavella, Gustav Willeit	Cermodern Başkent Kültür Yolu Festivali	2023-2024
17	Sonsuz Kat VII Soyutlamaya Saygı	Sissa Micheli		2023-2024
18	Arttırılmış Gerçeklik Augmented Reality	Olivia Babel, Soraya Abu Naba'a, Ana Ratkovic Sobota, Areen Hassan	CSO Ada Başkent Kültür Yolu Festivali	2023-2024
19	Rönesans Rüyaları Renaissance Dreams	Refik Anadol	CSO Ada	2023-2024
20	Warhol'un Dünyası Warhol's World	Andy Warhol	CSO Ada	2024-2025
21	Pablo Picasso: Resimden Seramiğe Bir Serüven Pablo Picasso: Adventure from Painting to Ceramic	Ankara Devlet Resim ve Heykel Müzesi Koleksiyonu	Ankara Devlet Resim ve Heykel Müzesi	2024-2025
22	Kelime Müzesi Koleksiyonu		Kelime Müzesi	2025-2026
23	Rahmi Koç Müzesi Koleksiyonu		Rahmi Koç Müzesi	2025-2026

Table 1: Museums and Art Venues Visited by the Students

Findings and Results

In the field trips conducted so far within the scope of the course, the art venue that students have most enjoyed visiting and where they have spent a lot of time is Cermodern Art Center. One of the reasons for this is that this art center has constantly updated, high-quality content, and in addition to successful artists in its field, it also includes student and amateur activities in collaboration with universities. In this period, which started from 2019, mostly contemporary artworks have been seen, and students have experienced paintings and sculptures produced with mixed media, as well as multimedia for digital works. It has been possible to observe examples of important movements of contemporary art, such as installation art, that establishes a relationship with the building itself. After their field trips, students were asked to focus on exhibition methods, the relationship established with the space in terms of discussing the space, the artists, the exhibited elements, and production methods, and the spatial context. They were expected to convey these in a way grounded in research, observation and interpretation. Below, the interpretations of students that the researcher determined were the best conveyed observations and analysis.

Göbeklitepe: The Gathering

Cermodern and ReoTek Collaboration

Cermodern, 2019-2020 Fall (URL-3)

Produced in 2019 as a digital and three-dimensional experiential exhibition, this multimedia exhibition showcases an archaeological site from the Neolithic era discovered within the borders of Şanlıurfa province in Türkiye's Southeastern Anatolia Region (Figure 3). Its significance in reshaping the history of civilizations has garnered significant attention worldwide. Through multimedia systems, large projections, and interactive approaches, visitors experience the site in an artistic way (URL-4).

> Student-1: The exhibition consisted of three sections. The "Alone in Nature" section featured areas that offered an experience of hunter-gatherers' lives in the wild. The separated corridors by curtains leading to this section were narrow, dimly lit by blue light, dark, and eerie. The second section, "First Gatherings," I believe, alluded to evolution. Here, images projected onto curtains, combined with sounds, offered a glimpse into the lives of people who lived during that period. The final section, "Roads to Gathering" was a 360-degree enclosed space with digital images projected onto it. This digital experience was also a visual, auditory, and tactile experience that recreated Göbeklitepe. The exhibition was extremely impactful in its portrayal of solitude (Figure 4).

Figure 3: Göbeklitepe: The Gathering Poster (URL-5)

Figure 4: Göbeklitepe: The Gathering (URL-5)

Samimiyet/Sincerety

Artist: Orkide Akkoç

Cermodern, 2020-2021 Fall (URL-6)

This exhibition, held in 2020, was the artist's fifth solo exhibition. The works were designed with semantic interpretations of the concept of *sincerity*. Here, students encountered sculptures produced within the framework of contemporary art. It was possible to observe the innovations that contemporary art brought to materials and construction. Students discussed the relationship between the artist's starting point and the materials that sculptures made of: fiberglass, fabric, and metal. The most notable analyses and comments after the trip experience are stated below.

> Student 2 and 3:
>
> The exhibition of the context coincided with the pandemic period. People were physically separated from each other, and this exhibition inspired us by telling about the integrity and sincerity of souls despite all physical distances.
>
> Orkide Akkoç wanted to emphasize the dominance of the heart by

revealing its connection with all emotions by placing the sculpture, which she defined as a heart, in the center of the space with the help of a steel rope. An intimate feeling was wanted to be created by using fabric and polyester. Around the venue, sculptures interpreting concepts such as freedom and courage were exhibited on metal pedestals in smaller sizes than the main heart installation (Figure 5a, 5b, 5c).

For example, I think she wanted to reflect the emotions in the works by simply changing the materials and dimensions, while adding emotions and facial expressions to the work.

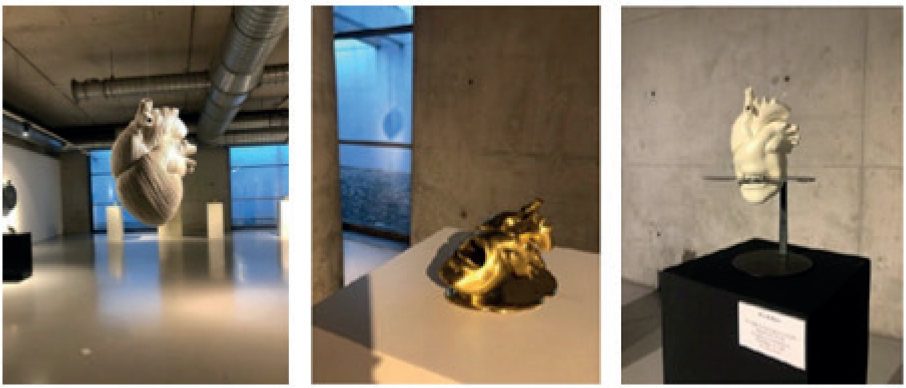

Figure 5a - 5c: Orkide Akkoç, Sincerety Exhibition, Cer Modern, 2020 (Photographed by student 3)

***Il vostro sarà il nostro* - What Is Yours Will Be Ours**

Artist: Fabio Viale

Cermodern, 2021-2022 Fall (URL-7)

"The Silk Road" exhibition is a group exhibition featuring many artists. The exhibition showcases Italian contemporary art from the 1960s to the present day.

Student 4:

Each of the works were exhibited on separate panels in the area where the works were located. The whiteness of the panels and the location of the lighting allowed me to focus entirely on that work when I wanted to examine it. In addition to the works on canvas, there were also sculptures. The work that caught my attention There was sculpture named Il vostro sarà il nostro - What Is Yours Will Be Ours, made by

Fabio Viale, Italian marble sculptor. It was a fist-shaped piece made of white marble, adorned with tattoos. Viale explores sculpture as a means of representing a continuous relationship with the ancient, establishing a form of direct communication with the viewer. He invites reflection on the relationship between ourselves and the other, a relationship increasingly seen as an enemy to be confronted. (Figure 6a, 6b).

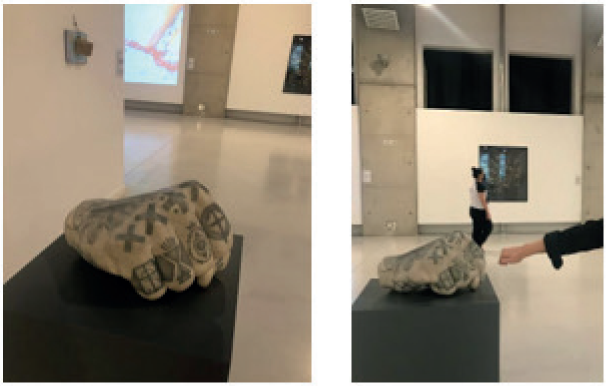

Figure 6a, 6b: Fabio Viale, "The Silk Road" Exhibition, Cermodern, 2021 (Photographed by student 4)

Maria Kılıçlıoğlu Baraz Sculpture Exhibition

TC. Ziraat Bank Art Gallery, 2022-2023 Fall (URL-8)

The Ziraat Bank Art Gallery, where the works of Bulgarian-born artist Maria Kılıçlıoğlu Baraz are exhibited, displays sculptures by the artist produced in various sizes and materials.

Student 5 and 6:

One of my initial thoughts upon entering the exhibition space was that the lack of an entrance fee was a motivating factor for people to see the artworks. Examining the relationship between the space and the works, I noticed the gallery was positioned in a well-lit area, and I thought the lighting could have been used better to highlight the sculptures. The disconnected and unrelated placement of the sculptures was also a negative aspect. Looking at the sculptures, I observed that they were generally bronze with silver plating and chrome paint, or resin casting with chrome paint. The piece that affected me most was "Hybrid" created in 2004. The human body was depicted with materials that were as smooth and shiny as possible, while the fish was depicted as damaged. In the other works, I felt that the artist explored how the seasons and nature affect people, how she defined the Garden of Eden, and how she depicted many living creatures with colors and textures (Figure 7a-7d).

The *Ziraat Bank Art Gallery*'s location inside the shopping mall was a poor choice. Having the art gallery on the upper floor, where the food court is located, seemed a bit odd to me. I think it would have been better placed on the lower floors, allowing more people to see and explore.

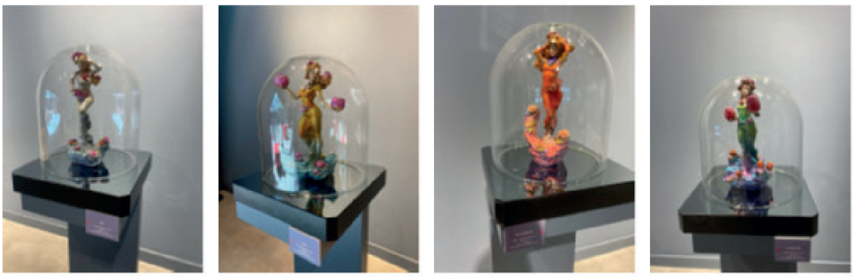

Figure-7a-7d: Maria Kılıçlıoğlu Baraz Sculpture Exhibition,
5a: Winter Garden of Eden, 5b: Summer Garden of Eden, 5c: Fall Garden of Eden, 5d: Spring Garden of Eden, Ziraat Bank Art Gallery, 2022, (Photographed by students 5 and 6)

Arttırılmış Gerçeklik/Augmented Reality

Artist: Soraya Abu Naba'a

CSO Ada 2023-2024 Fall (URL-9)

Student 7:

In this building, which was created through an architectural competition, the architects designed it as a stopover between the past and the future. Ankara Castle, which tells the story of the past, and Anıtkabir, which tells the story of the future, are positioned on the same plane.

If I were to interpret the building, I would see that different geometric shapes are used together on the facades. The building's triangular prismatic mass, with its entirely glass facade and high glass ceiling, creates an exceptionally bright and airy environment. Except other oval concert halls, this part is used for public exhibition area, where

Augmented Reality exhibition was held. The artwork, created by Palestinian-Lebanese artist Soraya Abu Naba'a, is composed of shapes made from what I believe to be ropes of varying shapes and sizes, spatially connected between two surfaces and arranged in an interwoven and spatial manner (Figure 8).

Figure-8: Soraya Abu Naba'a Arttırılmış Gerçeklik/Augmented Reality CSO Ada, 2023
(Photographed by student 7)

Pablo Picasso: Resimden Seramiğe Bir Serüven

Ankara State Museum of Painting and Sculpture, Fall 2024-2025 (URL-10)

Student-8:

Pablo Picasso is notable for his Cubist works. Cubism is considered one of the cornerstones of abstraction in art and has shaped the direction of modern art. Picasso's art revolves around the human figure and portraits. In his portraits, he depicts both the profile and the frontal view of people. In his Cubist works, Pablo Picasso rearranges objects and figures through geometric forms. My reason for choosing Picasso's "The Taste of Happiness" is his ability to convey emotion through sketching. He painted what he saw with his mind, disrupting the conventional human archetype while expressing the emotion he wanted to convey (Figure 9).

Figure-9: Pablo Picasso: Resimden Seramiğe Bir Serüven
Ankara State Museum of Painting and Sculpture, 2024
(Photographed by student 8)

Rahmi M. Koç Çengelhan Museum

Museum Collection, Fall 2025-2026 (URL-11)

Student-9:

The building, an example of Ottoman commercial architecture, is located in Ankara's Kale neighborhood. Built in the 14th century, it has been transformed and now functions as a museum under the Rahmi M. Koç Museum and Culture Foundation. The small rooms within the building, originally designed as a caravanserai, are now used as exhibition spaces. The restoration of these historical spaces into a museum has ensured the continued life cycle of the building through the preservation of cultural heritage. The chronology of the collection exhibited in the museum has been chosen to be in harmony with the atmosphere of the museum space. The museum plays an educational role by bringing together Ankara's commercial history and the evolution of technology in the same space. In this respect, the museum is an important structure that should be visited by all students studying technology, history, and architecture, offering the opportunity to learn while exploring (Figure 10a-10c).

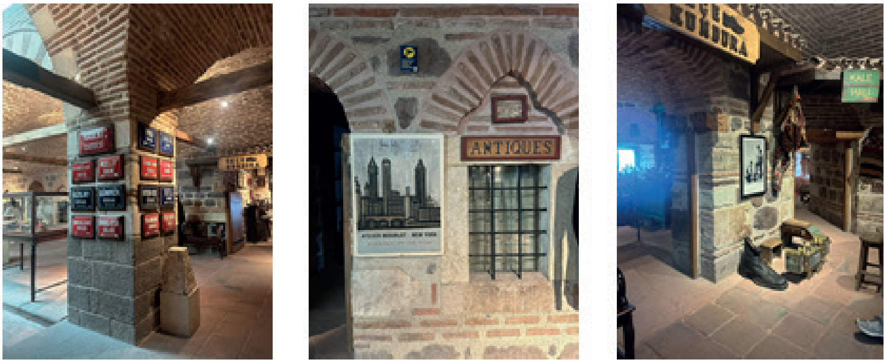

Figure 10a-10c: Rahmi M. Koç Çengelhan Museum
Museum Collection, 2025
(Photographed by student 9)

Results

Based on the discussions and opinions gathered from visit of the places, the results indicate that while this culture is developing in Ankara, it hasn't yet diversified or spread sufficiently. Art venues, which are an important part of the urban identity and life, are generally concentrated along a central axis in Ankara. This is why, despite their relatively small number, their proximity to each other increases their popularity. Despite frequent visits, the Ulus and Sıhhiye districts in Ankara are still considered dangerous, leading to prejudice against visits to these areas. Cermodern, a center where art life is generally more active and continuous, has been the most preferred art center.

All the venues visited are important art points for the city of Ankara. Especially in the development of the Castle and its surroundings, which housed the city's first settlement, preserving the existing culture is a major factor. With the restoration and re-adaptation of some buildings and their surroundings, funded by major companies in Turkey, it has become possible to see the residents of Ankara again in this area, previously suffered from socio-economic decay. Thanks to the significant work being done by local businesses, residents, municipalities, NGOs, and universities within the scope of the sustainability of urban culture, the increasing frequency of visits by city residents is being monitored.

Similarly, within the cultural structures located in the very center of the axis defined as the heart of Ankara, Cermodern art center, transformed from repurposed railway workshops, and the Presidential Symphony Orchestra Building, with its highly contemporary architecture, have become new favorite spots for city residents in recent years. These structures are accompanied by the Ankara State Museum of Painting and Sculpture, with its older history and imposing architecture. The building, which once served as the Turkish Hearth

Building, houses the works of state artists who hold very important places in Türkiye's painting art, thanks to its style from the I. National Architectural Period and its location in the very heart of Ankara (Aslanoğlu, 2010).

Outside of this important axis, it is also possible to see other art centers and smaller galleries in the city. Mostly located in the Çankaya district, these centers offer both temporary and permanent exhibitions by local artists. When all comments on the exhibited works are examined, the general tendency among students, due to their education being heavily focused on practical application, has been primarily to question the techniques and materials used in the production. During this period when they were trying to understand contemporary art, analyzing the artists' conceptual approaches and examining their works in terms of materials and production techniques became an intriguing process for the students.

The student evaluations offer a multifaceted analysis of Ankara's cultural landscape, highlighting the intersection of architectural space, historical narrative, and artistic expression. Their observations range from the immersive, multi-sensory digital recreations of Göbeklitepe and the adaptive re-use of Ottoman heritage in the Rahmi M. Koç Museum, to the symbolic significance of modern structures like CerModern, which bridges the city's past and future. While students praised the emotive power of specific works—such as Fabio Viale's marble sculptures, Picasso's Cubist sketches, and Orkide Akkoç's heart-centered installations—they also provided critical spatial critiques regarding gallery lighting, the placement of art within commercial food courts, and the psychological impact of pandemic-era exhibitions. Collectively, these reflections underscore the vital role of "adaptive re-use" and contemporary art venues in revitalizing Ankara's urban identity, suggesting that the success of an exhibition relies as much on its atmospheric and geographic context as on the artworks themselves.

Students examined the buildings that they visited in a manner of construction and space, the industrial appearance. In Cermodern the use of a large amount of concrete material on the walls was a feature that drawn the most attention and interest of the students. The technical issue on the ceiling was all open to see like plumbing, HVAC and fire systems (Figure 11-12). They are the characteristics of this industrial appearance of Cermodern, which never interrupts the exhibition area itself. Some Student comments below:

· The use of completely exposed concrete in the space has achieved certain simplicity in the space and ensured that the works exhibited there are kept in the foreground.

· Lighting elements were sufficient. My guess is that the pipes on the ceiling were used as design elements.

· The thing that caught my attention was the combination of old and new. It gave me the opportunity to see the architecture of the past and present in the same frame.

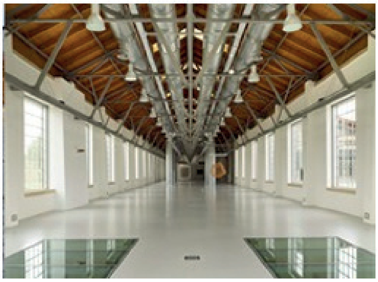

Figure 11-12: Cermodern Structures
Photography by: Cemal Emden, uygurarchitects.com

The more widely known an artist or exhibition is, the more interest it attracts and the more visitors it receives. For these visits to become ingrained in the urban identity as a culture, developing rich and diverse content and offering visitors distinguished works is essential for the sustainability of this culture. These improvements directly influence the behavior of city residents and make these venues, and naturally the surrounding area, more attractive. Enriching the quality of city life and enhancing the sense of belonging to the city, more cultural and art festivals should be organized, and more facilities and structures should be planned. These events are important for the sustainability of art and life in the city by developing a sense of belonging and urban identity. According to the students' personal opinions, art venues such as Cermodern and CSO Ada make significant contributions to the urban culture. Visiting such places increases social interaction and offers opportunities for intellectual enrichment. The exhibited works can be a source of inspiration for aspiring designers. Museum and gallery buildings and interiors provide students with ideas to use in their projects.

These venues instill in students an understanding of art practice and aesthetic thinking. They have already internalized the art spaces and works they interpreted with their own knowledge, intending to use them in their future design careers. Being a city dweller is not just about consuming the resources the city offers, but also about developing and implementing policies to preserve all the structures, traditions, and cultures belonging to the city and to protect them in the city's memory. Consequently, one of the most important things that can be done to enable university students to contribute to the sustainability of urban culture and life is to increase city excursions within the scope of their courses and to teach them how to continue this culture outside of school as well.

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Chapter 2

EXPERIENCING ANKARA IN ENVIRONMENTAL AESTHETICS: WALKING IN THE CITY AND AESTHETIC APPRECIATION

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1 This study is an expansion of the paper titled "A Research on the Aesthetic Appreciation of Cities: The Environmental Aesthetics and Urban Relationship," which was presented at the ICSULA2023 II. International Conference on Sustainable Cities and Urban Landscapes: Re-Thinking the Future of the Cities and Urban Landscapes, held in Konya on October 26-27, 2023, and subsequently published in the conference proceedings:
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Environmental Aesthetics: Theoretical Framework and Development

Environmental aesthetics, as a modern sub-branch of philosophy and aesthetics, has gained scholarly momentum particularly since the late twentieth century. Emerging as a response to the art-centered orientation of traditional aesthetics (Carlson, 2023), the field initially focused on the aesthetic value of natural environments (Carlson, 2010). Today, however, its scope has expanded to include all environments in which human beings interact, as well as the dynamics of everyday life (Parsons, 2008; Maitland, 2010; Jules, 2020; Chambers, 2020). This expansion has generated new tendencies encompassing urban design, everyday activities, and environmental awareness (Carlson, 2023; Carlson, 1979; Sadeghi, 2014).

Over the last two centuries, the aesthetic appeal of the environment has expanded to encompass architecture, interior design, commercial and industrial landscapes. In addition, the field's normative scope has broadened to include negative values. Drawing on numerous disciplines such as philosophy, anthropology, psychology, cultural geography, and architecture, environmental aesthetics is directly related to ontology, ethics, and art theory. This multilayered structure also enables the field to shape government policies and social practices. Particularly since the twentieth century, environmental psychologists and cultural geographers have made significant efforts to ground the field on a scientific basis.

In its most basic sense, aesthetics concerns the apprehension of beauty through emotion, feeling, and perception, as well as the examination of such judgments (Tunçer, 2021b). Environment, by contrast, refers to everything outside the individual's self-consciousness, namely the world perceived by human beings (Perkins, 1999; Erzen, 2006; Berleant, 2013). Because human interaction with the environment encompasses not only physical elements but also cognitive and experiential processes, individual experience plays a central role in environmental aesthetics (Perkins, 1999). The growing scholarly interest in environmental aesthetics reflects the recognition that aesthetic values directly condition not only cultural and artistic life but also economic and political formations (Tunçer, 2021b).

Historically, environmental aesthetics has moved the concept of aesthetics beyond the approaches of thinkers such as Aristotle, Kant, and Hegel, who centered on the concept of "the beauty", and has incorporated new criteria such as order, harmony, wholeness, and purposiveness.

The earliest traces of this discipline date back to cave paintings from 30,000 years ago. Since then, it has evolved from representations of nature and landscape to Renaissance gardens, and from there to contemporary environmental problems (Berleant, 1998). Today, the boundaries of the field have expanded even further, as 'environment' comes to signify not only nature but the entirety of the individual's lived world, including the city, art, architecture, environmental problems, and politics. Within this expanded frame, architectural sustainability, ecological design, the conservation of historic environments, and the interrelated concepts of perception, awareness, and embodied experience constitute the principal research areas of environmental aesthetics. Regardless of whether the environment is natural or built, the quality of the relationship between human beings and their environments is a fundamental element contributing to the development of the field. The principal approaches in environmental aesthetics that summarize human-environment relationship are presented in Table 1.

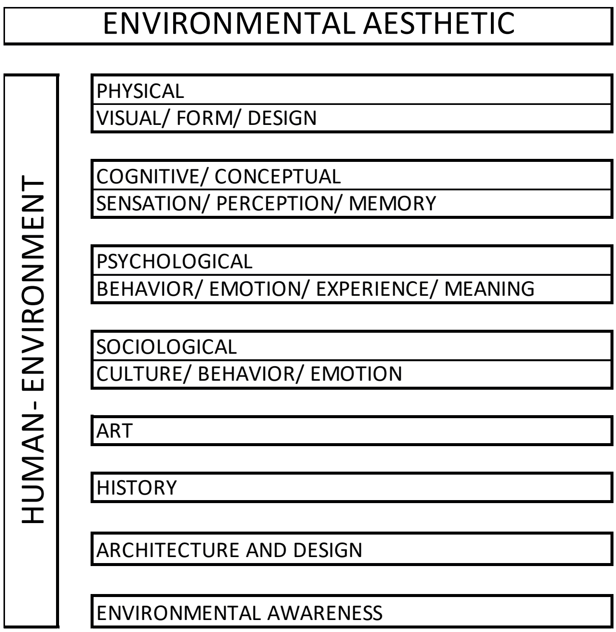

Table 1. *Topics related to the impact areas of environmental aesthetics (prepared by the author)*

As shown in Table 1, the communication and interaction that human beings establish with their surroundings can themselves become the subject of environmental aesthetics (Erzen, 2006). According to Erdoğan (2006), humankind has sought beauty in its surroundings throughout history, shaping living environments to meet this enduring need. Cities, as cultural wholes in which natural and artificial elements are blended, should respond to the physiological, biological, and sociological constitution of the individual. Beyond such adaptation, it is of critical importance that the environment also meets human psychological and intellectual needs within the framework of aesthetic qualities.

Environmental Aesthetics and City Relation

In its broadest sense, environmental aesthetics may be defined as an appreciative mode of participation in the total environmental complex, in which sensory qualities and immediate meanings are internalized by the individual. As an inclusive perceptual system, environmental experience encompasses multidimensional factors such as space, mass, volume, time, movement, color, light, smell, sound, texture, kinesthesia, pattern, order, and meaning. This experience is not merely visual. Rather, it is a holistic process in which all sensory modalities are activated synesthetically, and the participant is drawn into a heightened state of perceptual awareness (Berleant, 1998).

This process also includes a normative dimension that underlies positive and negative value judgments about the environment. Environmental aesthetics, therefore, becomes a discipline concerned with the examination of environmental experience in terms of its immediate and intrinsic value, as expressed in its perceptual and cognitive dimensions (Berleant, 1998). This perspective enables addressing environmental aesthetics alongside the urban scale and analyzing the individual's everyday living environment as a multilayered structure. To frame the dimensions of everyday urban experience, the principal headings are summarized in Table 2.

Layers of the city, urban texture, silhouette, city images
Streets, sidewalks, roads, avenues
Urban furniture, urban plans, stopping points
Buildings, facades, designs
Suitability, harmony, balance, order, proportion
Landscape, nature, landscape designs
Visual harmony, sensation
Historical background
Architectural values, culture, diversity of forms
Enclosure, staging, layering, hospitality
Materials, textures, light and color
Art and its integration into the city
Symbols, signs, directions, wayfindings
Circulation
Socialization and richness of activities
The relationship between memory, city, culture and individuals
Identity, belonging, internalization and character
Perception
Feelings and experiences
Society, politics, economy and collective life

Table 2. *Urban factors affecting the relationship between environmental aesthetics and the city (prepared by the author)*

In parallel with the information presented above, it may be argued that the concept of urban aesthetics is directly related to people's lives in the city and to their healthy physical, mental, and social conditions. Streets, roads, squares, sidewalks, public spaces, social and cultural structures, parks, gardens, and green areas are all part of everyday life, and they are expected to possess aesthetic qualities that respond to human needs. When one considers that cities should embody aesthetic qualities capable of meeting people's physical, cultural, psychological, sociological, and intellectual needs, it becomes clear that certain factors in urban design and everyday life are closely related to environmental aesthetics (Tunçer, 2021a) (Table 2).

Cities have their own fundamental structures. Values such as identity, continuity, form, originality, meaning, and culture shape urban formation. Planning and design play a decisive role in this process. Likewise, these values are directly related to the environment in which urban inhabitants live. In this respect, the qualities of the city affect people's ways of life and aesthetic preferences through their daily interaction with it (Sadeghi, 2014). Researchers working on environmental aesthetics and urban design emphasize that many factors arising from these relationships produce physical, conceptual, cognitive, and psychological effects (Table 3) (Sadeghi, 2014).

Environmental Aesthetic Factors in Urban Design

Theoretician	Visual- form factors	Cognitive-conceptual factors
Jane Jacobs (1961)	Considering street elements	Flexible spaces: The possibility of socializing richness of activities
Kevin Lynch (1984)	Compatibility and Fit	Sense, Vitality
Violich (1983)	Urban forms reminding of the past (cultural heritage)	legibility of the environment, freedom of choice, possibility of a social life
Ian Bentley and Others (1985)	visual intrusion; diverstity of forms; visual compability	legibility, flexibility, customizability
Ragger Trancik (1986)	Enclosure of the spaces, fusion of edges, controlling point of views and perspectives	compatibility of interior and exterior spaces
Coleman (1987)	Historical conservation and urban restoration, architectural values	cultural environments, delightfulness and variety of functions
Allen Jacobs and Appleyard (1987)	delightfulness (visual dviversity)	originality and meaning, collective life, identity and dominance
Prince Charles (1989)	Hierarchy, scale, harmony, enclosure, materials, decorations, art, symbols, sighns and lights	position, local community (genius loci, sense of place and belonging)
Michael Southworth (1989)	structure, form, view and landscape	legibility, genius loci, identity, human scale (passerby)
Francis Tibbalds (1988-92)	learning from the past, respecting the present texture	considering places before buildings, human scale, legibility
Greene (1992)	order includes, coherence, clarity, continuation. Appeal includes: scale, visual coordination, harmony	Identity includes: centre, unity, caharacter, delightfulness
Brian Goodesy (1993)	coordination with the current context, diversity	delightfulness, human scale, customizability, legibility, richness of activities
LPAC, (1993)	intensity of texture, visual richness	structure, legibility and identity, human scale, public and specific places
Haughton and Hunter (1994)	diversity, concentration, proper scale, creative corelations	_
Nelessen (1994)	The core (concentration center), street landscape, diversity, use of design terminolgy	human scale
PMUDTF (1996)	Considering the context and local character, beholding capability	_
Punter and Carmona (1997)	Objective urban landscape, artificial form, ground landscape	Public perception, quality evaluation, functions and perceived appeals, reminder of cultural concepts, legibility
Richard Rogers (1999)	Character, considering sights and positions, context, scale	_
Department of environment, transportation and regions in Britain (2000)	Character, continutity and enclosure, structure of urban space, urban divisions, i.e., street decoration patterns, (blocks, pieces, and buildings); natural landscape, scale, altitude, scale: building, exterior: details, exterior: materials	Identity, legibility
Summary	The quality of natural landscape and its factors, the quality of urban buildings and their elements, the quality of public spaces and their elements, continuity, enclosure, diversity of forms, the quality of views and vistas and coordination with the context	Identity, legibility, concept, perceptibility, coherent mental image, customizability, cultural and social environment, richness of activities

Presantation of environmental aesthetic factors by urban design scholars.
Sources: the authors using diverse sources

Table 3. Presentation of environmental aesthetic factors by urban design scholars (Sadeghi, 2014:508).

The table above summarizes, based on contributions from multiple researchers, the factors related to environmental aesthetics that are effective in urban design. It also serves as a summary supporting the developments mentioned regarding the expansion of the scope of environmental aesthetics and its connection to cities. As noted earlier, the cities in which people live, the natural and built environments that compose them, the historic environments within them, certain fields of study or approaches resulting from physical or political interventions, the incorporation of art into life, the climate crisis and the environmental awareness it has generated, and the relationship between design, environment, and people have all contributed to the expansion of the field of environmental aesthetics; thus, making it possible to transform the field into the context of cities and, consequently, into everyday life.

Aesthetic Engagement and Aesthetic Appreciation in Everyday Life

Saito (2001) argues that art is not the sole object of aesthetic interest. Everything perceived, felt, conceptually imagined, or produced through imagination during experience may be considered an object of aesthetic interest. The aesthetic appropriateness of the environment runs parallel to this argument. Arnold Berleant rejected the classical conception of aesthetics, especially the Kantian notion of disinterested admiration for the artwork, that is, the distance the viewer maintains from the art object. Instead, he advocated a holistic approach. He argues, in this context, for a mode of awareness in which all the senses are active, emphasizing the significance of experience in this process. Thus, through the term "aesthetic engagement," he extends aesthetic understanding beyond debates limited to art or nature and relocates it within the broader framework of environmental aesthetics (Berleant, 2013).

Appreciative participation is a multilayered experiential process in which the individual internalizes meanings through cognitive and sensory qualities. In this process, the environment should be understood not merely as a physical setting, but as a socio-physical context in which visual, auditory, and semantic factors converge. Drawing attention to this inclusive structure of environment, Berleant (1998) states that, depending on the situation, physical elements such as mountains and rivers, or social dynamics such as activities and groups, may assume dominant roles in aesthetic appreciation. In this respect, environmental aesthetics involves the active participation of both the individual and the social group across a wide range of settings, from buildings to neighborhoods and from rural landscapes to wilderness.

In conceptualizing the understanding of environment and the relationships formed within it, Sparshott defines the interaction between self and environment through pairs such as *"I/Thou, thinker/problem, user/used, traveler/scene, subject/object, and self/setting* (as cited in Carlson, 2006:79)". Within this relational network, knowledge, causality, and experience come together to generate perceptual differences. According to Carlson (2006), the principal distinction between the inhabitant and the traveler lies precisely in this mode of perception. While the traveler focuses only on what is temporary and visually noteworthy, the inhabitant who experiences the city as part of everyday life responds in accordance with the world of meanings already formed in the mind.

Experiencing the city by walking is one of the most fundamental forms of this aesthetic engagement and environmental appreciation. De Certeau (2011) defines the city as a spatial field in everyday life where the effects of power are distorted, and various tactics are enacted. Walking offers multiple perspectives that an aerial view can never provide, enabling pedestrians to create new spaces, new perspectives, and new stories. In this sense, walking is a mode of producing space in which the experiencing subject is actively involved in the process and an open field of use and freedom is made available to the individual (De Certeau, 2011; Yılmaz, 2018).

METHOD

This research is structured around a study designed to enable students receiving design-oriented education, and thus already possessing a degree of aesthetic awareness, to perceive their environment holistically by drawing on that education and to articulate their aesthetic appreciation as active participants. Within this framework, the Environmental Aesthetics course in the Department of Interior Architecture and Environmental Design, Faculty of Fine Arts, Design and Architecture, Atılım University, together with the course process and the outputs produced by students enrolled in the course, constitute the basis of the research.

About Environmental Aesthetics Course

The Environmental Aesthetics course has been developed with the developmental trajectories outlined in the previous sections in mind. Beginning from the human being as constituted by body and spirit, the course adopts a broad conceptualization of environment that includes everything outside the individual's self-consciousness. Environment, environmental wholeness, aesthetics, the components of the environment, and environmental aesthetics form the core of the course. While treating every environment with which the individual communicates and interacts as a subject of environmental aesthetics, the course addresses environmental aesthetics primarily through the lenses of the city and design. It examines the factors that enable individuals to understand their environment through perception, sensation, experience, and memory. It focuses on environmental aesthetics through its historical background and addresses natural and built environments, design, art, historic settings, landscape, interiors, and cities. Cities are interpreted through their textures, settlement patterns, silhouettes, architecture, buildings, environmental awareness, and all the elements that constitute urban aesthetics. The course aims to develop students' aesthetic perception and environmental awareness, helping them understand the environment and engage in aesthetic processes.

The research consists of an analysis of end-of-term outputs produced in the course between 2021 and 2026, together with evaluations of aesthetic appreciation generated through students' experiences of the city in which they live as active participants. Students were regarded as inhabitants of the city in which they live, and studies were conducted in which they experienced selected urban areas by walking. In this way, the aim was to move students beyond the scenic views they encounter and admire through social media and toward a deeper engagement with the environment they inhabit. It was observed that students generally travel by vehicle in daily life and often fail to pay attention to the routes they use every day. In this context, recognizing that mere observation or habit is insufficient for students to understand their surroundings and that this does not foster awareness, efforts have been made to ensure that students become active participants in the aesthetic engagement process.

The course topics and the expected outcomes for students upon completing the course are summarized in the table below:

Subjects:	Expected Outputs
Environmental and aesthetic integrity, approaches in environmental aesthetics	Analyze the relationship between people and aesthetics by understanding the environment and its qualities.
Definition of the environment and components of the environment	Provide examples within the framework of environmental aesthetics by comparing the relationships and qualities between the city, the individual, and design.
Perception and aesthetics; The relationship between perception, memory and environment	Explain the relationship between art and aesthetics in both natural and built environments.
Relationship between environment, nature, structure and design	Recall the information about environmental awareness and consciousness.
Relationship between space and landscape	Understand the phenomena of environment, individuality, meaning, aesthetics and perception
Environmental awareness	
Environmental aesthetics, historical background	
Historical Environment Perception and city relations	
Urban aesthetics, environment and art	

Table 4. The topics and expected outcomes of the course (Prepared by the Author)

While aesthetic taste is a profound subject worthy of discussion, it evokes emotional responses and can generally be explained by questioning the value of beauty and pleasure. Aesthetic taste can vary from person to person. Similarly, it can also be shaped by shared interpretations or customs (Tunalı, 1983).

Urban aesthetics, on the other hand, reflects the perceptual processes that underpin environmental experience, and it is not possible to separate the city's social and historical layers from its sensory dimension. Within this framework, aesthetic value exceeds the mere concept of "beauty" by encompassing the holistic experience produced by traditions, spatial familiarity, and contrasts. Therefore, both positive and negative elements may be included within the scope of urban aesthetics. Pause points in a city that allow people to breathe, such as parks, gardens, scenic overlooks, and recreational areas; urban plans that secure order and accessibility; buildings designed in harmony; or interventions carried out with environmental awareness in mind can be considered positive elements. By contrast, noise, overcrowding, the failure to preserve historic environments, poor-quality construction, the degradation of traditional urban fabric, unsafe social environments, and uncontrolled urbanization may be regarded as negative examples. The incorporation of aesthetic concerns into urban planning not only plays a key role in evaluating a city's character but also transforms it into a living environment that serves the fundamental values of civilization and humane goals. In this respect, it is important, both for future generations and for the future development of cities, that students develop an aesthetic perception of the environments in which they live, gain awareness, and experience the process directly.

Expectations from the Analysis

Students were asked to select certain routes and/or areas in Ankara, the city where they live and conduct their daily lives. The most critical aspect of the analysis, which was expected to be conducted as group work, was that the selected area should be visited and evaluated on foot by the students themselves. In this way, students were expected to convey their affective evaluations alongside all other forms of assessment. The selected areas were examined within the framework of environmental aesthetics and urban design. Students were expected to experience the process as aesthetic participants and to communicate their aesthetic appreciation of the elements they observed in the environment. A set of parameters was defined to establish a common framework and procedural guide for these field trips (Table 5 and Table 6).

Location analysis
General information about the building/area
The reason-context relationship in your selection of the structure/area
Analysis of the environment where the building/ area is located
Physical environment and nature relationship analysis
Prominent factors and features that are effective in the perception of the building/ area
Aesthetic and intellectual evaluation of the building
The design of the building/ area and its relationship with its environment
Evaluation of the landscape/ nature in the immediate surroundings of the building
Perceptual evaluation of both the exterior and interior spaces, mass, form and surroundings of the building/ area
Within the scope of environmental awareness, the building, its design, the experience of the building and its environment should be examined and evaluated.
Individuals, art, life, feelings, experiences considered in personal evaluations, analyses based on aesthetic appreciation

Table 5. Topics to be analyzed in the aesthetic evaluation of the selected area (prepared by the Author).

Subject
Reason for selection
Location Analysis
Historical Background
Structures and areas located next to/inside/on the surrounding area
Story
Meaning
Analysis
Transport
Comparison and evaluation between routes/roads
Aim
Function
Socio-economic context
Factors affecting perception
Emotional evaluation
Highlights
Environmental awareness
Art
Staging
Hospitality

Table 6. Factors to be evaluated in field study (prepared by the Author).

In addition to the predetermined questions, several factors were also established for students to examine during the field trip (Table 6). In this context, the aim is for students to comprehensively discuss the area they are analyzing and make aesthetic evaluations. The findings of the field trips will be shared in the next section.

FIELD TRIPS

1. Kuğulu Park, Ankara:

Kuğulu Park is a city park located in Kavaklıdere, Çankaya/Ankara. The park is located between Tunalı Hilmi Street, Atatürk Boulevard, Iran Avenue, and Poland Avenue (Figure 1). The park is famous for its swans, geese, and ducks in the park's pond. Besides the pond in the park, there are many seating elements, urban furniture, trees, artworks, a children's playground, and a cafeteria on the side facing Atatürk Boulevard. The park can be reached via various routes. Artworks, pedestrian walkways, natural elements, structures, and facades are prominent at the park's different entrances. Each sculpture in the park has its own story (Figure 2). The students stated that they had visited Kuğulu Park many times before but had never paid attention to the artworks there. This result reveals that the students are unaware of the aesthetic values in their environment, indicating a lack of environmental awareness.

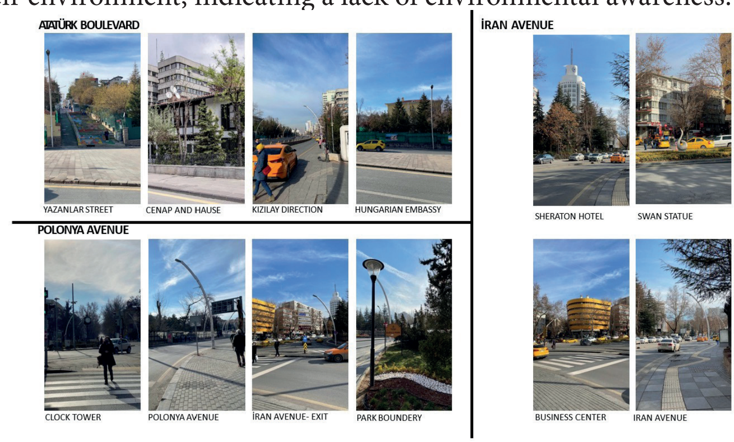

Figure 1. Streets and avenues around Kuğulu Park (Photographed by the students).

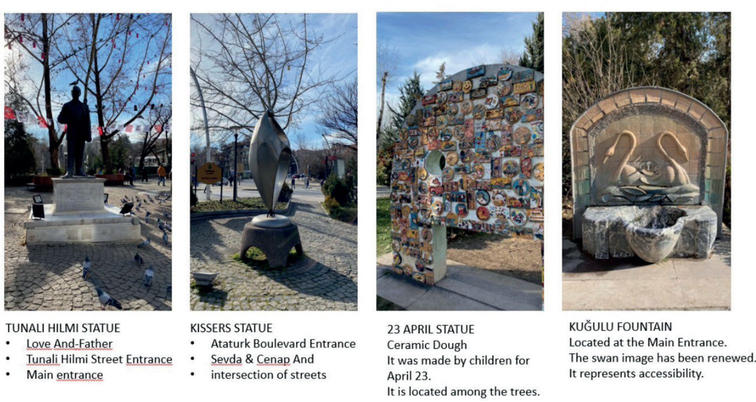

Figure 2. Evaluations of works of art in Kuğulu Park (Photographed by the students).

The natural elements, urban furniture, and park designs that students noticed in their experiences and commented on in terms of their aesthetic appreciation are presented in Figure 3.

Figure 3. Evaluations of urban elements and designs in Kuğulu Park (Photographed by the students).

The conclusions regarding these elements and the students' thoughts are as follows:

• The colorful stairs are interpreted as attractive for the visitors (Positive)

• The bridge over the water which supports the connections of the two lands (Positive)

• Seating elements which were designed by using the natural environment, without interfering with nature (Positive)

• The pond located in the center of the park, which complements the natural environmental elements, has become the guiding and focal point of the social environment (Positive)

• Playgrounds for children (Positive)/ design of that playground (Negative)

• Play areas for pets (Positive)

Some of the positive and negative opinions highlighted in the aesthetic evaluation of Kuğulu Park can be followed in the table below (Table 7):

Positive Opinions:	Negative Opinions:
Appealing to everyone	
Use of artistic elements	
Preserving the integrity of nature in design	There are neglected areas. There are practices that cause pollution, such as brochures.
It can meet the needs of visitors such as resting, sitting, relieving stress and viewing.	Lack of indoor seating areas
Easy access/ Located near areas such as shopping malls, accommodation, hospitals and business centers.	Too many vehicles at the entrance of Tunalı Hilmi Street/ Traffic pollution
Having different entry points creates pleasant transition points between streets.	Bicycle, skating, etc. -Lack of suitable ground for mobile vehicles

Table 7. Positive and Negative opinions about the park

Figure 4 presents images of elements that evoke positive feelings, including the park and its surroundings, along with positive and negative opinions, as well as elements considered to ensure environmental integrity and provide a social space that allows the city to breathe. The inclusion of the natural environment in the design, its protection, and the relationship between urban furniture and nature are highlighted as elements that ensure environmental integrity.

Figure 4. *Elements That Ensure Environmental Integrity (Right) (Photographed by the students).*

Figure 5. *Elements That Disrupt Environmental Integrity (Left) (Photographed by the students).*

However, environmental pollution, differences in facades, carelessly hung brochures and posters, garden tools left scattered in the open, and pollution of the water where swans live have been assessed as visual factors that disrupt environmental integrity (Figure 5).

2. Bahçelievler, Ankara:

Bahçelievler is a neighborhood located in Çankaya/Ankara. As one of Ankara's important social hubs, the neighborhood is home to numerous shops, restaurants, cafes, and bars. It is significant for being one of Ankara's major residential neighborhoods, for its central location, and for the presence of social venues catering particularly to young people along its streets and avenues. In addition to social venues, it also houses many shopping venues.

The side streets are lined with many row houses used as residences and workplaces. The site visit included the streets and avenues of Bahçelievler, as well as the routes of the National Library and Rainbow Public Market, located on one of Ankara's main axes. Rainbow Public Market was designed as an attraction center with the vision of becoming a recreation area that would house many social and commercial venues, adding to the intense social life in

Bahçelievler. However, after failing to meet expectations, it is now used as the Rainbow Public Market, which consists of commercial venues affiliated with the Municipality (Figure 6).

Figure 6. Gökkuşağı Public Market (Photographed by the students).

The group members wanted to draw attention to side streets, sidewalks, environmental awareness, and circulation rather than focusing on the main social streets in this neighborhood. Interventions on trees, facades, and walls along the walking paths were found to be interesting. Although not considered successful or beautiful, these applications were noted to influence perception. Obstacles and neglect on walking paths and sidewalks were cited as negative factors affecting environmental aesthetics (Figure 7).

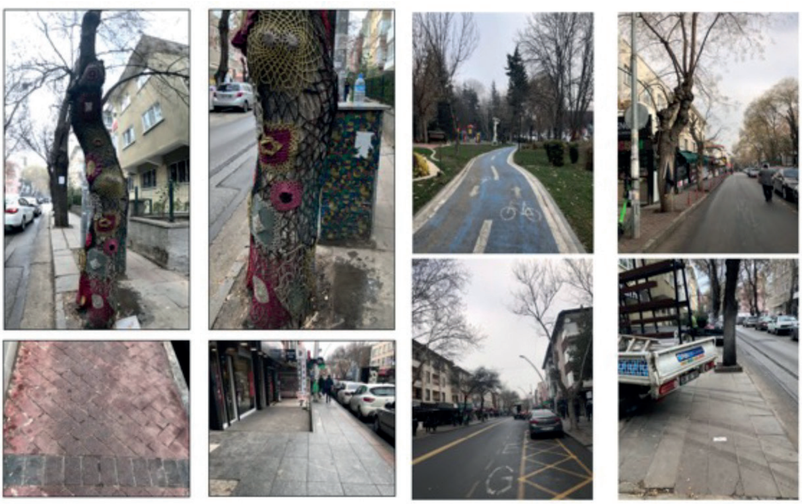

Figure 7. Street elements & views from Bahçelievler (Photographed by the students).

Attention has been drawn to the applications and textures used on sidewalks, as well as to the occupation of sidewalks by vehicles. The presence of trees arranged in rows has been found to be soothing. The layout and colors of the facades, along with the graffiti and decorations used, have been evaluated. The presence of mobile vehicles and parking spaces, along with recycling bins, has been selected as examples of environmental awareness and noted as positive approaches (Figure 8).

Figure 8. Street elements & views from Bahçelievler (Photographed by the students).

3. Hamamönü, Ankara:

Hamamönü is one of the oldest historical settlements in Ankara, dating back to the Roman period and gaining importance during the Seljuk and Ottoman periods. The settlement's name comes from the double bathhouse built by Karacabey, a chieftain of the Bayındır clan of the Oghuz Turks. Hamamönü is in the Altındağ district of Ankara. The park right next to it is named Mehmet Akif Ersoy Park. The park also contains a house where the Turkish National Anthem was written. With this and many similar stories, and its traditional residential architecture and settlement, the region has high value in terms of collective memory, history, and meaning.

Figure 9. Viewpoints of Hamamönü (Photographed by the students).

Hamamönü is home to many historical and registered buildings, businesses, shops, cafes, and restaurants. In these respects, it is an important historical, social, and commercial area. Due to its location, it offers viewpoints from which the city skyline and landscapes can be observed (Figure 9). It is a tourist area that has been revitalized for the city and its inhabitants through a restoration project. The houses from the Ottoman period are entirely decorated with Turkish motifs, and visitors can feel as if they are in the 19th century while strolling through the streets (Erdal, 2013).

Figure 10. Historical texture- harmony: Facades, urban furniture, streets and square views from Hamamönü (Photographed by the students).

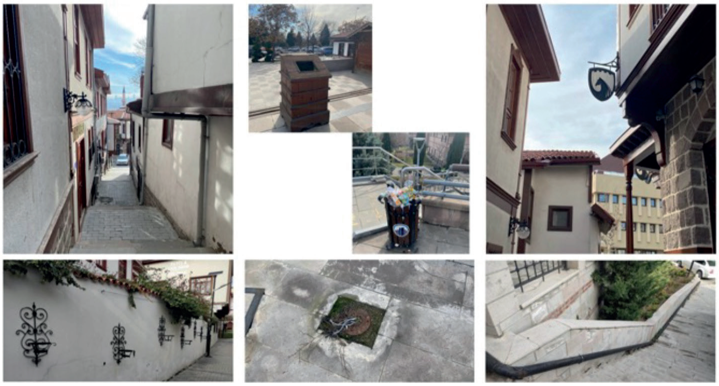

Figure 11. Historical texture- harmony: Facades, urban furniture, streets and square views from Hamamönü (Photographed by the students).

The perception of the historical environment has enhanced the legibility of the past, the nostalgic atmosphere has enriched the emotional experience, and the importance of urban collective memory and historical preservation has been highlighted once again through the area's restoration. The unity in materials, textures, motifs, and street elements, even the uniqueness of the facades, has allowed for holistic harmony in the environment and aesthetic appreciation. (Figure 10 and Figure 11).

Figure 12. *Affecting perception/ Negatively affecting environmental integrity/ Incompatible disruptive items (Photographed by the students).*

Materials that are incompatible with the historical texture are very noticeable because they disrupt the environmental integrity within this atmosphere. In terms of pedestrian experience, irregularities in the roads are negatively evaluated (Figure 12).

Figure 13. Historical texture- harmony: Facades, urban furniture, streets and square views from Hamamönü (Photographed by the students).

Street signs, store signs, telephone booths, and urban furniture being designed in a common language are considered important factors in environmental aesthetics (Figure 13).

4. Dikmen Valley, Ankara

Dikmen Valley Park, located in the Dikmen district of Ankara, close to the city center, is a living space created on Dikmen Valley. The area, which was previously a shantytown, has been transformed into a green space and has become a living center with social facilities, dining venues, walking paths, playgrounds, pet-friendly areas, and a relaxation area. Housing units surround the park, which preserves the valley's natural topography. The park serves as an important breathing space within the city, combining its natural and built environments. It is also known for its cherry blossom trees, which offer city dwellers natural scenery.

As the visitor approaches the area, the transition from dense urban development to the natural valley landscape and landscape becomes apparent. The difference in scale between the surrounding high-rise residential blocks and the green spaces is noticeable. While some parts of the park have a quieter, greener texture, the city's noise can be felt in others. The transitions between artificial hard surfaces and the natural landscape are sometimes sharp, sometimes soft (e.g., bridge crossings and other transition elements).

Figure 14. *Photographs from the Valley (Photographed by the students)*

Moving away from noise and crowding in the city and encountering nature interwoven with everyday life produces feelings of relief and spaciousness. Water elements, the preservation of planted landscapes and natural components, and the presence of scenic viewpoints all recall nature's importance in the environment. Being in the valley, seeing people exercising and walking, and watching children play has a calming effect. The sky and the green texture become more perceptible. The sculpture located in the park symbolizes a meaningful gesture toward the coexistence of nature and art, while its historical reference also carries significance (Figure 14). There are many places to sit and rest, including benches, lawns, and shaded areas under trees.

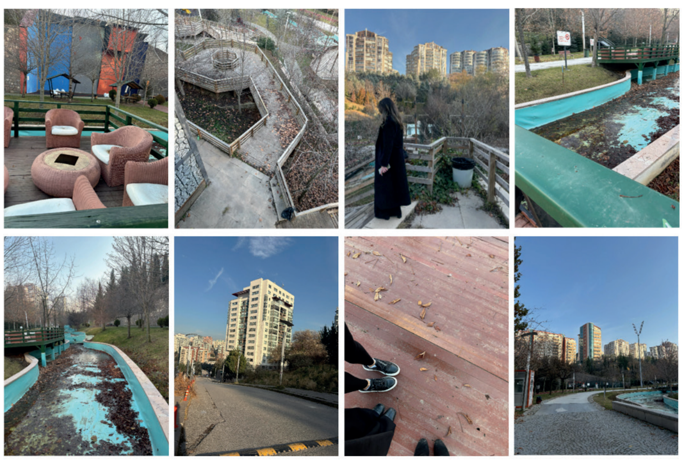

Figure 15. Photographs from the valley (Photographed by the students)

While the sloping topography, dense vegetation, and the use of water elements lend the site a natural texture, pedestrian paths, bridges, and residential structures accompany this texture as hard and artificial surfaces. Artistic elements are limited in number. The aesthetic effect is read primarily through the organization of the landscape. The continuous movement of users throughout the site gives the space a dynamic and active character.

In Dikmen Valley, both positive and negative conditions related to environmental awareness and consciousness can be observed. The preservation of green areas, the arrangement of walking paths in harmony with the natural texture, and the openness of the site to pedestrian use are positive examples in terms of environmental awareness. By contrast, litter accumulations in some areas, irregular patterns of use, and wear from intensive use indicate that environmental awareness has not been equally internalized by all users.

The dominance of the surrounding high-rise, multi-story buildings over the valley's structure negatively affects the relationship between the built environment and nature, producing moments of disjunction and disruption in the texture of the built environment. The lack of maintenance identified on the park paths, around the water element, and in the seating areas disrupts environmental integrity. Although Dikmen Valley and its surroundings constitute an important green area and everyday-use space within the city, they also pose certain problems regarding spatial and aesthetic integrity. While the natural landscape and pedestrian-oriented use are among the site's strongest aspects, structural irregularities, maintenance deficiencies, and visual clutter weaken perceptual continuity (Figure 15). The valley stands out, from the perspective of environmental aesthetics and integrity, as a place experienced through functional and everyday use.

5. Gölbaşı Atatürk Coastal Park, Ankara

Located on the shore of Lake Mogan in the district of Gölbaşı, Ankara, Gölbaşı Atatürk Coastal Park is a recreational area designed as a natural living environment where one can withdraw from the complexity and noise of the city. As one of Ankara's limited natural water resources, it is valuable for enabling urban residents to spend quality time, rest, socialize, and connect with nature in their daily lives. The route used in the study began at the entrance gate located on Konya Road, one of Ankara's principal arterial roads (Figure 16). The aesthetic evaluation of this gate was also incorporated into the study, and before arriving at the analysis area, students identified several remarkable elements and places within the framework of environmental aesthetics. The Central Square Project shown in the image is one of these elements (Figure 16).

Figure 16. Photographs from the gate, Central Square Project and the entrance of Gölbaşı Atatürk Coastal Park (Photographed by the students)

The structure, built as a city gate, is regarded as an oversized intervention incompatible with the general urban fabric and disruption of environmental integrity. Its design, which does not reflect the present and imitates the past, is evaluated negatively. The central project is defined as a space that allows individuals to breathe within the middle of the settlement. The buildings encountered before reaching the park and upon entering it, designed with references to Seljuk and Ottoman architecture, are also evaluated negatively in both artistic and identity-related terms because they do not authentically reflect either identity or period. By contrast, the traditional house encountered upon entering the park, together with the Roman-period stones in its surroundings, is intriguing. However, the failure to preserve these stones is considered contrary to the perception of a historic environment (Figure 17). When the harmony of nature within the city is evaluated, the coexistence, in a landlocked city such as Ankara, of gray buildings and exhaust fumes on one side, and water, reeds, and natural landscape only a short distance away, creates a striking contrast in the environment and is interpreted as a transition from gray to blue (Figure 17).

Figure 17. Photographs from the Park (Photographed by the students)

Seating elements facing the shoreline, benches, and resting pockets are compatible with the park's social potential. However, at certain points, the proximity of these elements to circulation axes is evaluated as disturbing the balance between movement and pause (Figure 17).

Figure 18. Photographs from the Park (Photographed by the students)

The ramps in the park, tactile paving for the visually impaired, wheelchair charging stations, bicycle paths, and parking areas for mobile vehicles and bicycles are evaluated very positively from the perspective of landscape arrangement and universal design. At the same time, applications that raise students' awareness of the significance of these design elements stand out by fostering environmental awareness (Figure 18). Nevertheless, steep ramps obstructed by barriers and manhole covers located in the middle of tactile paving reveal that even sympathetic designs intended to be safe may become dangerous, and these are therefore identified as conditions that disrupt environmental integrity.

CONCLUSION

In the previous section, findings from students' field trips in different districts of Ankara were presented, along with the aesthetic evaluations they produced. During the course, it became apparent that students generally preferred to remain within the comfortable zones they were accustomed to, sought places where they felt good and at ease, and did not carefully examine their surroundings. Taking this into account, the field trips demonstrated that students' prejudices diminished and that combining aesthetic appreciation with walking through the city and with practices that form part of daily life yielded positive results.

Following the trips, students stated that they now approached their surroundings more consciously and viewed the environment holistically. Experiencing the sites by walking helped them notice the elements discussed within environmental aesthetics. For example, although Kuğulu Park was a place they frequently visited, it became apparent that they had only now discovered elements within the park, such as artworks, the bridge, and the stairs. Despite the crowding, noise, and chaos in the surrounding area, emphasis was placed on the park's existence, its artistic components, and the soothing and inviting effect of nature and harmony.

In the evaluations produced by the group that visited Bahçelievler, attention was drawn to the obstacles encountered along pedestrian routes. In such a social and central district, the Gökkuşağı Public Market area was negatively evaluated for its location and use, and attention was drawn to its disruption of environmental integrity. The spillover of commercial elements onto the sidewalks along the main avenue, as well as the poor maintenance of those sidewalks, were also noted. At the same time, the presence of certain installation works and elements related to recycling attracted attention. The variation in building facades, the diversity of signage, and the lack of inviting spatial settings were interpreted negatively.

Hamamönü was evaluated as an area that heightens the perception of the historical environment, and the renewal of the historic fabric so that it could once again function as a living part of the city was regarded as highly positive. Urban elements and designs, selected in harmony with the texture, together with viewing points overlooking the city, were interpreted as aesthetic components that secure environmental integrity. Although this district initially elicited emotional prejudice and unease among students, once they experienced it firsthand, they developed positive feelings and had a nostalgic experience.

Dikmen Valley was identified as a breathing space within the city where one can reconnect with nature. The presence of social activities, resting areas, and sports activities, and their relationship with nature, was found to be highly holistic in terms of environmental aesthetics. At the same time, environmental pollution and lack of maintenance negatively affected the site's environmental integrity.

Gölbaşı Atatürk Coastal Park was interpreted as a space from which one can withdraw from urban intensity, find ease, and remain in close contact with nature. In particular, the presence of water and its integration into both design and circulation were highly praised. Although the spaces and routes designed with universal design principles in mind were highly regarded at the conceptual level, obstacles on the ramps and disruptions along circulation axes elicited negative feelings and interpretations.

The shared findings derived from the field trips are as follows:

• Within the city, there is a greater need for natural areas, parks, recreational zones, and scenic viewpoints where one can withdraw from urban density and remain in contact with nature.

• In areas experienced by walking in the city, circulation should be improved. Roads, sidewalks, and accessible paths should be cleared of obstacles and properly maintained. Steep ramps, stands extending into sidewalks, and similar obstructions should be removed from pedestrian axes and redesigned with appropriate gradients.

•Elements that disrupt environmental integrity should be reconsidered.

• It has been observed that environmental awareness is not yet widespread in the city. Society should be informed about environmental pollution, neglect, and recycling. Environmental consciousness should become more prevalent in the built environment and in architecture. Sustainability and green design should be integrated more fully into all components of urban life, beginning with everyday practices.

It was observed that the most important factor underlying students' prejudicial attitudes toward certain parts of the city, especially among those who did not wish to leave their comfort zones and social circles, was socio-economic and cultural differences. The field trips, by enabling students to experience the process of aesthetic engagement, proved highly effective in breaking down this prejudice.

The need for a greater presence of art within the city was strongly emphasized. Although the artworks in the analyzed areas were positively evaluated for environmental aesthetics, it was emphasized that art should be more fully integrated into everyday life. Criticism was directed not only at the limited presence of artworks but also at the accessibility of cultural events and art centers. It was stated that art could meet spiritual and emotional needs by permeating daily activities, social life, and the routes people take in their everyday lives.

It became clear that aesthetic appreciation is not limited to a conventional notion of beauty. Rather, it encompasses the harmony between nature and human beings, the relationship of the individual with the city and with nature, and all the factors that constitute the environment, especially in the urban context, through a holistic process of harmony, order, understanding, experience, and awareness. From the perspective of the course and of education more broadly, the findings reveal the impact of field experience in transforming aesthetic education into a lived form of consciousness.

The results of the research indicate that evaluating the relationship between environmental aesthetics and the city through certain defined parameters deepens students' aesthetic perception. In terms of educational outcomes, an experience-oriented approach to environmental aesthetics helps students analyze the relationships among the city, art, and nature while also developing their environmental awareness. Experience appears to play a significant role in understanding and interpreting the city's aesthetic integrity and harmony. As Berleant (2013) states, environmental aesthetics lies at the center of the communication and interaction the individual establishes with the environment. In this respect, experiencing the city and engaging in aesthetic practices within everyday life contribute to understanding the significance of the environment and to cognitive and sensory development. It is once again emphasized that the city's relationship with all its elements, and the design of those elements, constitute one of the fundamental domains through which human cognitive and psychological perception is shaped.

Accordingly, aesthetic appreciation is not an autonomous phenomenon independent either of the object itself or of the subject, that is, the individual. Rather, it is the product of a dynamic and holistic perceptual process established among the two and the environment. Therefore, to understand aesthetic appreciation and enable individuals to participate in the process, it is especially important for students to provide direct field-based examples, conduct interpretive evaluations developed through reciprocal interaction, and design frameworks that actively include students in processes of aesthetic engagement. Such efforts will not only generate important data for future studies but will also contribute to aesthetic education by enhancing individuals' ability to perceive and interpret the environment holistically.

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Chapter 3

STRATEGIC APPROACHES TO CLIMATE ADAPTATION AND DISASTER RESILIENCE IN BUILDING DESIGN

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1. Introduction

Building design strategies play a critical role in achieving adaptation and resilience against natural disaster risks caused by climate change. The current literature demonstrates the effectiveness of using disaster-resistant materials, integrating smart sensing systems, performance-based engineering approaches, and community-focused planning strategies in minimizing post-disaster vulnerability and structural damage (Kodur et al., 2020; Gernay, 2023; Papathoma-Köhle et al., 2022; Barua et al., 2025; Luhar et al., 2021; Taccaliti et al., 2023).

The examination of climate change-related disasters and the formulation of design strategies concerning the built environment are fundamental requirements for transforming the relationship between human and nature from a struggle to an integrated harmony. One of the critical areas that concretizes the multidimensional disaster risks triggered by climate change is the destructive effects of this process on fire regimes. Nowadays, these impacts increase the frequency of atmospheric conditions that facilitate the initiation and spread dynamics of fires (Jones et al., 2022). In fragile regions such as the Mediterranean and Amazon basins, extreme fire weather conditions have been observed to exceed historical averages, and this process has accelerated due to anthropogenic warming (Abatzoglou et al., 2019). As a result, thermal and hydraulic imbalances that trigger fire risk are becoming a more systematic threat on a global scale (Fan et al., 2023). This threat is not limited to ecosystem loss and structural damage, but also directly targets public health. Climate-related forest fires and the associated increase in smoke density are causing mortality rates from fine particulate matter (PM2.5) to rise (Park et al., 2024).

Spatial strategies developed to tackle the rise in wildfires caused by climate change aim to minimize disaster risk across a wide range of measures, from building placement and the creation of buffer zones to the use of fire-resistant materials (Aguirre et al., 2024; Guo et al., 2024; Kramer et al., 2019; Tampekis et al., 2023). Furthermore, supporting physical and spatial resilience with technological infrastructure is an integral part of modern disaster management. In this regard, smart monitoring technologies such as Internet of Things (IoT) sensors, legal frameworks, and coordinated management strategies can elevate urban fire resilience and intervention capacity to higher levels (Barua et al., 2025; Chen et al., 2021; Harakan et al., 2025; Talaat & ZainEldin, 2023).

Another critical consequence of climate change is flooding, characterized by the disruption of the global hydrological cycle. These phenomena, which have become more prevalent in recent years, are directly related to global warming, which alters atmospheric dynamics. Findings in the literature indicate that as the atmosphere warms, its capacity to hold moisture increases, and for every 1°C rise in temperature, extreme rainfall events intensify by approximately 6-7%, and in some cases, this rate is significantly higher (Wasko et al., 2021).

This increase in atmospheric humidity is increasing the frequency of "flash floods", particularly in urban areas (Meresa et al., 2022). Globally, humid regions with high rainfall regimes are facing more frequent and severe flooding events due to climate change (Ionno et al., 2024). In this context, flood risk is escalating due to the interaction of multiple factors, including increased heavy rainfall, snowmelt, changes in soil moisture, and rising sea levels (Zhang et al., 2022a). Therefore, short-term extreme rainfall and the sudden floods that develop as a result necessitate the consideration of built environment design and drainage systems within the framework of climate adaptation.

The range of disasters caused by climate change is not limited to changes in the water regime, but also brings destructive thermal anomalies. "Heat waves," listed as a separate category of climate-related events in disaster databases, encompass prolonged periods of extreme temperatures (Tschumi & Zscheischler, 2019). These events have profound effects on health, agriculture, wildlife, and infrastructure systems (Barriopedro et al., 2023).

Global evidence indicates that heatwaves have increased in frequency, intensity, duration, and cumulative heat load since the 1950s, but this trend has accelerated in recent years (Ren & Hu, 2024). The risk of exposure to heat waves, which are among the deadliest natural disasters today, is particularly high for individuals over the age of 65 and vulnerable population groups in low-income countries (Chambers, 2020).

Another natural disaster caused by climate change is storms and hurricanes. Studies predict that a temperature increase of approximately 2°C will increase maximum lifetime wind speeds by 5-10%, rainfall rates by 14%, and the frequency of very severe storms (Knutson et al., 2020). This atmospheric intensification has accelerated academic interest in disaster resilience and climate-responsive building design strategies by increasing the vulnerability of the built environment to wind loads and extreme rainfall (Fatima, 2024).

Residential-scale studies focus on developing non-structural measures, such as landscape-based solutions, and structural measures such as reinforcement of load-bearing systems, by analyzing structural defects caused by floods and storms (Chohan et al., 2024). For instance, Amadi (2024) highlights the critical importance of the concept of "build back better" in post-damage rehabilitation, using historical structures exposed to climate-related flooding as a case study. Recent studies map how resilience parameters such as robustness, redundancy, flexibility, and inclusivity can be integrated into spatial design in the planning of the built environment under climate pressure (Al-Humaiqani & Al-Ghamdi, 2022).

This risk scenario arising from climate change necessitates local design models that are based on a multi-risk approach rather than a one-size-fits-all approach to disaster management, utilize novel technologies, and incorporate building occupants into the system. Therefore, this study addresses climate-sensitive and disaster-resilient design strategies applied in the built environment, focusing on key topics such as multi-risk management, smart systems, social participation, and legal frameworks. Designed through a comprehensive literature review and a multidisciplinary approach, this study aims to present current design paradigms within a holistic framework.

2. METHODOLOGY

In this study, a comprehensive literature review was conducted within the framework of the defined research questions. During the research process, Google Scholar and Web of Science databases were searched to examine building design strategies that minimize natural disaster risks caused by climate change and global warming.

The sources analyzed were selected from studies published within the last 10 years and cited at least once, in order to reflect current design approaches and ensure data reliability. Within the scope of the study, natural disasters were addressed as heat waves, storms, floods, and wildfires, which fall under the category of extreme weather events. The inclusion of wildfires in this category is based on the fact that the initiation and spread dynamics of this disaster are largely controlled by meteorological variables and are classified as a climatological disaster in the literature under the concept of "fire weather." In order to simplify terminology in the remainder of the text, these four specific phenomena analyzed will be referred to as "climate change-induced natural disasters."

The fundamental research questions that form the conceptual framework of the study are as follows:

- What are the building design strategies developed within the framework of integrated multi-hazard management for natural disasters caused by climate change?

- What is the role of smart technologies and socially participatory design strategies in increasing resilience against such disasters?

- What building design strategies should be included in legal frameworks aimed at reducing climate change-related disaster risks?

- What are the trade-offs and gaps in the literature regarding building design strategies intended to reduce climate change-related disaster risks?

Based on the data obtained, building design strategies were evaluated under the headings which are multi-hazard management, smart technologies, community participation, legal framework, and trade offs & gaps (Figure 1).

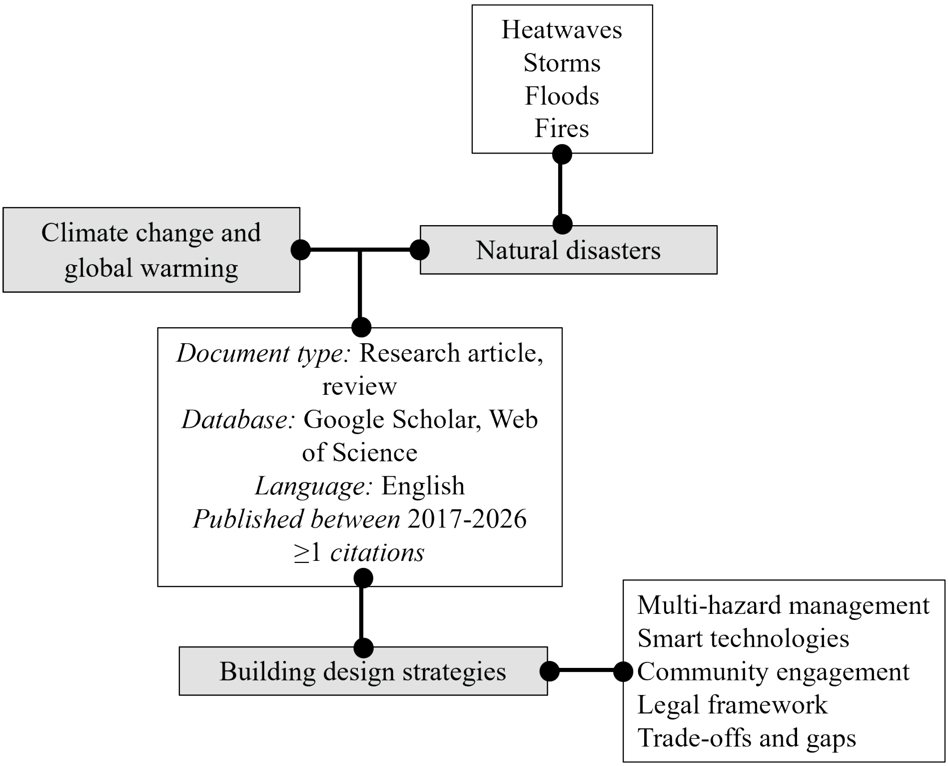

Figure 1. Workflow of the study

Artificial intelligence tools (Google Gemini) were used only for generating schematic illustrations in this study. All scientific interpretation, analysis, and conclusions were conducted solely by the authors.

3. FINDINGS

3.1. Multi-Hazard Management

In enhancing structural resilience against natural disasters caused by climate change, adopting an integrated design approach that combines passive architecture, resilient facade systems, nature-based solutions, and digital risk assessments stands out as an effective strategy (Bianchi, 2023). In this context, rather than focusing on a single type of disaster, multi-risk assessments that combine climate change-induced natural disasters with variables such as social vulnerability, demographic structure, and economic capacity provide a holistic perspective for determining strategic intervention priorities at the neighborhood and building levels (Bixler et al., 2021) (Figure 2).

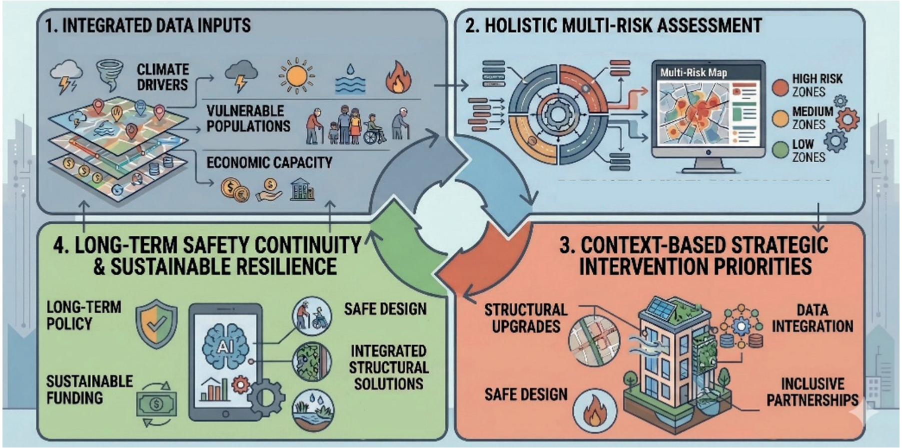

Figure 2. Urban resilience cycle: Integrated multi-risk assessment (Generated using Google Gemini AI and edited by the authors)

Based on findings from the literature, integrated strategies are detailed below:

· *Blue-Green Infrastructure and Urban Form:* Nature-based solutions include urban forests, green structures integrated into buildings, and extensive park areas supported by compact development. These elements provide multidimensional ecosystem services such as reducing the urban heat island effect, flood control, and improving air quality (Felicioni et al., 2025). In this context, strategic plant selection and placement not only prevent fire spread but also directly increase thermal comfort by mitigating the effects of heat waves through shading and transpiration processes (Lin & Li, 2025; MacLeod et al., 2019).

· *Surface Runoff and Integrated Flood Control:* Landscape management focused on green infrastructure and vegetation plays a critical role in minimizing flood risk by controlling surface runoff, as well as preventing fire spread by creating a strategic buffer zone (Felicioni et al., 2025; Zhang et al., 2025). Such nature-based interventions complement structural strategies developed for flood resistance in housing design, such as elevated floors and waterproof barriers (Chohan et al., 2024; Ionno et al., 2024).

· *Wind Loads and Fire Resistance:* Urban vegetation and strategic landscape design contribute to storm resistance by reducing wind speeds and regulating the microclimate. Zhang et al. (2025) emphasize that these landscape elements also play a vital role in fire resistance; plants control fire spread by forming physical barriers and increase fire safety by suppressing combustion processes. Considering that the most destructive fires are wind-driven and that wind directly triggers fire behavior, wind speed control provided through vegetation cover constitutes a critical mechanism for both structural storm resistance and integrated fire safety (Zhang et al., 2025).

· *Thermal Resistance and Fire Safety Integration:* The use of materials with low thermal conductivity and fire resistance in areas with high fire risk not only ensures the safety of buildings against flames but also increases the insulation capacity of structures against heat waves caused by global warming (Pakhira et al., 2025; Aguirre et al., 2024; Kramer et al., 2019). This demonstrates that material selection offers a dual-purpose solution for both thermal comfort and disaster resilience.

3.2. Smart Technologies and Community Engagement

The management of natural disasters caused by climate change is possible not only through physical measures but also through the accurate processing of digital data at the building and neighborhood level. Building Information Modeling (BIM) integration, IoT-based monitoring systems, and artificial intelligence (AI)-supported risk assessments proactively enhance building safety, while social participation mechanisms ensure the long-term sustainability of this resilience (Figure 3).

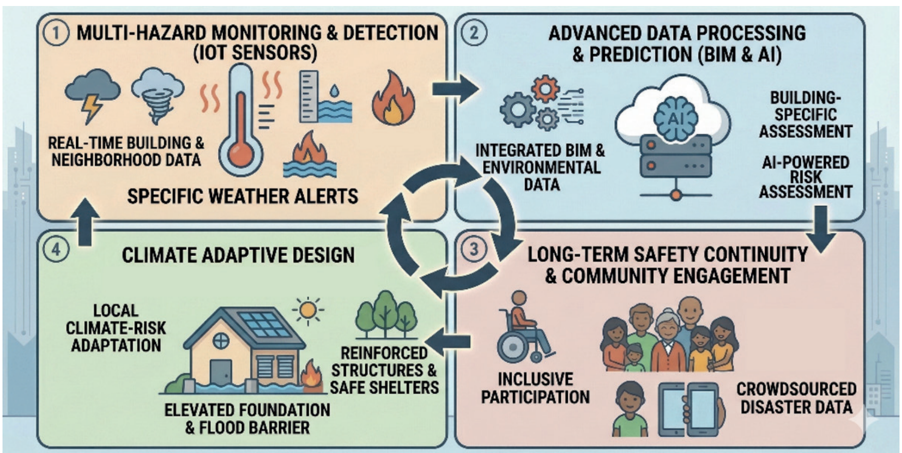

Figure 3. Integration of technology and society in combating climate change-related disasters (Generated using Google Gemini AI and edited by the authors)

Findings from the literature highlight the following strategies for incorporating smart technologies and social participation into the process:

· *Real-Time Monitoring and Early Warning Systems:* IoT sensors measuring temperature, smoke, water level, wind speed, and structural response enable real-time analysis processes against multiple disaster risks (Ojo et al., 2024). When combined with AI-powered digital twins, these systems enable rapid response, particularly in detecting and predicting fires and other extreme weather events in complex structural forms (Talaat

& ZainEldin, 2023; Xie et al., 2025; Zhang et al., 2022b). Furthermore, in strategies that combine smart technologies with social participation, the use of crowdsourced data from citizens creates an important channel for strengthening urban resilience (Kangana et al., 2024).

· *Automation and Data Integration:* Web-based meteorological data should be automatically matched with BIM models and supported by Robotic Process Automation (RPA)-based alert systems. This system optimizes the pre-disaster preparedness process by informing building managers and users in advance about hazardous temperatures, storms, or fire risks (Atencio et al., 2024).

· *Designing Safe Shelters for Vulnerable Groups:* It is recommended to design buildings equipped with passive survival features and backup energy sources, particularly for the elderly and low-income groups, which will function as community centers during disasters (Houghton & Castillo-Salgado, 2020). In smart system designs, approaches focused on trust and cultural sensitivity should be developed to bridge the "digital divide" and prevent the exclusion of groups with limited access to technology (Das & Devadas, 2025; Kangana et al., 2024).

· *Corporate Collaboration and Urban Governance:* In smart urban resilience projects, especially in rapidly urbanizing areas, inter-agency coordination is essential for the successful implementation of technological designs in the field (Harakan et al., 2025).

3.3. Legal Framework

It is necessary to update building regulations and restructure them around multiple hazards within legal frameworks to minimize the structural risks of disasters caused by climate change. In this context, the fundamental principles that the legal framework should include for a resilient and sustainable built environment are as follows (Figure 4).

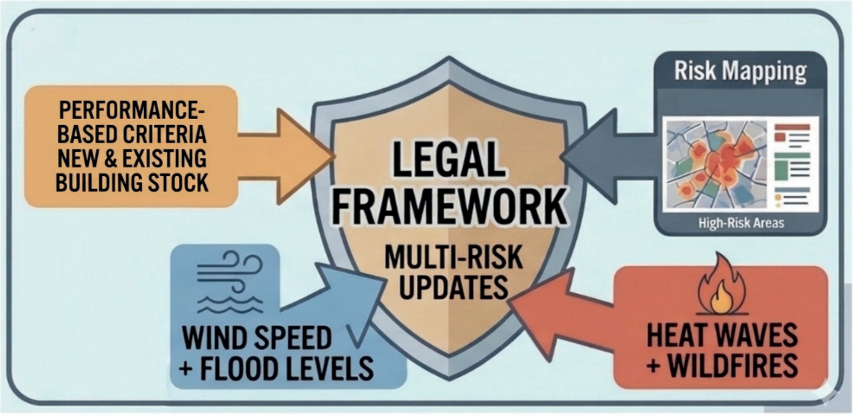

Figure 4. Legal framework for climate-resilient building design (Generated using Google Gemini AI and edited by the authors)

· *Risk-Based and Dynamic Standards:* Countries should adopt "risk-based" approaches that base building standards not on historical climate averages that have lost their reliability, but on projected climate extremes such as flood levels, extreme wind speeds, heat waves, and wildfire risk (Hong et al., 2023).

· *Performance-Based Engineering Approach:* Legal regulations should include not only minimum structural safety criteria but also performance-focused and integrated resilience criteria for natural disasters related to climate change. Particularly in wildland-urban interface (WUI) areas, performance-based fire engineering frameworks and specific risk assessments should be mandatory (Tampekis et al., 2023).

· *Fairness and Inclusivity:* Legal frameworks should cover not only new buildings but also the existing building stock. Protective measures, voluntary metrics, and incentive mechanisms should be used to ensure fairness in implementation, based on a fair application model (Hong et al., 2023).

3.4. Trade-offs and Gaps

Resilience efforts against natural disasters require an approach that balances mitigation and adaptation strategies, manages climate uncertainties, and prioritizes social justice. The current literature is still in the process of development in terms of standardized resilience criteria and evidence-based data based on multiple hazard scenarios. The main challenges encountered in the implementation process can be seen in Table 1.

Table 1. Strategic balances and areas for growth in combating climate change-induced disasters

Trade offs and shortcomings	Highlights
Systemic Conflicts and Secondary Risks	Measures developed against one type of disaster may indirectly weaken another risk factor. For instance, while high-performance insulation system reduces energy consumption which is a positive strategy to cope with climate change, it can lead to overheating indoors and increased cooling demand during heat waves combined with power outages (Hong et al., 2023). Similarly, some flood-resistant building materials increase embodied carbon emissions, while fire-resistant material choices can reduce overall energy efficiency (Balasbaneh et al., 2019).
Cost and Adaptability Constraints	Although nature-based solutions are effective in reducing flood and heat island risks, they remain limited in adaptation to existing building stock due to high initial costs and maintenance requirements (Chohan et al., 2024). Furthermore, strategies optimized based on the current climate data may prove inadequate in future extreme scenarios, increasing the need for flexible and adaptable design paradigms (Krelling et al., 2024).

Sustainability and Safety Balance	Sustainability-focused solutions such as wood building systems or building-integrated photovoltaic (BIPV) panels can pose risks if proper fire safety management is not ensured. To strike a balance between these objectives, it is imperative to adopt integrated management frameworks such as Resilience, Sustainability, and Smartness (ReSuSm) (Barua et al., 2025; Yang et al., 2023).
Typological Gaps in the Literature	Existing resilience studies largely focus on high-rise and general-purpose buildings. The disaster safety needs of unique typologies such as healthcare facilities, historic structures, and informal settlements are not yet adequately represented in the literature (Varolgunes, 2025).

4. DISCUSSION

The effects of climate change are becoming increasingly apparent. Consequently, natural disasters associated with global warming can cause significant damage to the built environment. The advance planning of natural disaster risks is of vital importance for the built environment and its users. The discipline of architecture is responsible for identifying such risks in advance during the design phase of buildings. Building design strategies must be approached from various perspectives and in a holistic manner, considering the disaster risks that may prevail in the relevant region.

This study examines approximately 40 recent studies conducted over the past decade within the framework of the role of building design strategies in natural disasters associated with climate change. The four main natural disasters identified are wildfires, floods, heat waves, and storms. These natural disasters, whose frequency and impact are increasing due to climate change, are addressed in the built environment under four main headings. The first of these involves the comprehensive management of natural disaster risks. Developing strategies for a single type of disaster risk in buildings can lead to negative consequences when other disaster risks are ignored. For instance, choosing a fire-resistant building material may reduce the thermal performance of the building envelope, which may cause to stay behind in the struggle against global warming due to increased energy consumption.

On the other hand, some design strategies can contribute to reducing multiple disaster risks simultaneously. For instance, blue-green infrastructure, which is part of nature-based solutions, can reduce the heat island effect through landscape planning and reduce flood risk by decreasing surface runoff.

Another topic is the integration of smart technologies into buildings and the use of these systems to predict disaster risks in advance. In ensuring urban disaster resilience, it is necessary to process data collected from users, plan safe shelters for users in vulnerable groups, and include those in this group in advanced technology systems. Thirdly, it was discussed that legal regulations should include criteria related to natural disaster risk management. Multifaceted disaster risk assessment, the preparation of risk maps, and the adoption of a performance-oriented risk approach rather than historical averages can have positive effects on natural disaster risks. Solutions suitable for existing and new building stocks should also be evaluated.

The literature reveals a lack of comprehensive approaches addressing multiple disaster risks. Furthermore, as many disaster management strategies target new buildings, it is imperative to develop more alternative scenarios specifically for the existing building stock. The acceleration of climate change may cause measures planned for the current climate to lose their effectiveness in the future. Therefore, flexible and adaptable solutions for future scenarios should be considered. In the current climate, where climate change has major impacts, it is inevitable to address resilience, sustainability, and smart technologies in the built environment together.

5. CONCLUSION AND RECOMMENDATIONS

Natural disasters triggered by climate change have become a serious structural security problem that directly threatens human life, cultural heritage, and social welfare. This study aims to evaluate the effectiveness of design strategies used to enhance the resilience of buildings against multiple disaster risks such as fire, flood, heatwave, and storm. Within the scope of the research, multiple-hazard management, smart systems, community engagement processes and legal regulations were examined in a holistic manner. By analyzing gaps in the existing literature and strategic balancing factors that may arise during implementation, this study is significant in that it offers interdisciplinary recommendations for building disaster-resilient environments.

The analysis demonstrates that aligning structural reinforcement, smart detection systems, landscape management, and community preparedness processes with legal regulations significantly enhances disaster resilience at both the building and community levels. A robust building design approach that integrates technology, policy, and social action with physical measures has been found to be the most effective defense mechanism against climate uncertainties. However, the success of these strategies should not be limited to designs on paper; they must be expanded to encompass emerging hazards and different socio-economic contexts at the global level and supported in the field.

Future research and application models are recommended to focus on the following three main axes:

• Typology-Specific Strategies: Rather than relying solely on general design rules, customized resilience protocols should be developed for building types with unique needs, such as healthcare facilities, historic heritage sites, and informal settlements.

• Optimization and Balance: “Green and safe” design models that minimize potential conflicts between sustainability goals and disaster safety on a global scale should be optimized.

• Scaling Hybrid Systems: Scalable and cost-effective models that integrate advanced smart technologies, traditional passive protection methods, and community participation should be developed.

In conclusion, adopting an integrated resilience vision enables the risks caused by climate change to be made manageable and paves the way for building safe living spaces for the future.

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Chapter 4

COMPARATIVE EVALUATION OF FACADE SYSTEMS IN DIFFERENT CLIMATES USING BIM-BASED ENERGY AND CARBON ASSESSMENT

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1. Introduction

The building sector remains one of the primary contributors to global energy consumption and carbon emissions. Both operational energy use and the embodied carbon associated with construction materials and processes significantly affect the overall environmental footprint of buildings (IEA, 2019; UNEP, 2020). Within this context, facade systems play a critical role, as they regulate thermal exchange, solar radiation, daylight penetration, and material intensity. Decisions taken at the facade level therefore have long-term implications for both energy demand and life-cycle carbon performance (Tzempelikos & Athienitis, 2007; Pomponi & Moncaster, 2016).

While earlier research largely focused on reducing operational energy consumption, recent studies emphasize the necessity of integrating life cycle perspectives into building design. Evaluating operational energy without considering embodied carbon may lead to unintended environmental trade-offs, where improvements in thermal performance result in increased material-related emissions (Cabeza et al., 2014; Röck et al., 2020). A balanced assessment requires simultaneous consideration of both dimensions.

Facade performance is also strongly influenced by climatic conditions. Mediterranean climates, such as Izmir, are characterized by hot summers and relatively mild winters, leading to cooling-dominated energy profiles. In contrast, continental climates, such as Erzurum, experience long and cold winters, where heating demand becomes the primary concern. As a result, facade systems that perform efficiently in one climate may not yield similar outcomes in another.

This study presents a comparative evaluation of five facade scenarios (S1–S5) applied to a representative office building located in two distinct climatic contexts: Izmir and Erzurum. Using BIM-based energy simulation combined with life cycle–oriented carbon assessment, the study investigates how different facade typologies influence annual heating and cooling energy demand as well as embodied carbon. By examining operational and embodied impacts together, the research aims to support more informed and climate-responsive design decisions during early project stages.

2. Research Problem & Questions

Buildings account for a substantial share of global CO_2 emissions, and facade systems significantly influence both operational energy demand and material-related embodied carbon (IEA, 2019; Cabeza et al., 2014). Despite growing awareness of life cycle–based assessment methods, many studies continue to evaluate operational energy and embodied carbon separately. This fragmented approach limits the ability of designers to understand trade-offs between thermal performance improvements and material-related environmental impacts.

Moreover, facade performance cannot be generalized independently of climate. A glazing-dominant facade that enhances daylight and transparency may increase cooling loads in warm regions, while insufficient insulation may lead to excessive heating demand in colder climates. Therefore, climate-specific evaluation becomes essential for optimizing facade strategies in a meaningful way.

The research problem addressed in this study is the lack of integrated, comparative assessments that evaluate multiple facade alternatives across different climatic contexts using a unified BIM-based framework. In response, this study seeks to answer the following questions:

· How do the five facade scenarios (S1–S5) affect annual heating and cooling energy consumption in Mediterranean (Izmir) and continental (Erzurum) climates?

· How do these facade alternatives differ in terms of embodied carbon (A1–A3 stages) when applied to the same building model?

· What trade-offs emerge between operational energy demand and embodied carbon in each climate?

· To what extent can BIM-based simulation tools support early-stage, climate-responsive facade decision-making?

By addressing these questions, the study aims to bridge the gap between energy-focused and carbon-focused analyses within a comparative and climate-sensitive framework.

3. Literature Review

Facade systems constitute one of the most critical components of the building envelope, mediating the interaction between interior and exterior environments. Beyond their architectural expression, facades regulate heat transfer, solar radiation, air infiltration, and daylight penetration, thereby directly influencing indoor thermal comfort and energy consumption (Tzempelikos & Athienitis, 2007; Pomponi & Moncaster, 2016). As buildings transition toward lower carbon targets, the environmental performance of facade systems has become a central topic in sustainable design research.

In recent years, the integration of digital design tools has significantly transformed environmental assessment processes. Building Information Modeling (BIM) enables the coordination of geometric, material, and performance-related information within a single parametric environment. Rather than treating energy analysis and material assessment as separate post-design evaluations, BIM facilitates their incorporation into early design stages, where strategic decisions regarding envelope composition, glazing ratios, and shading systems can still be optimized (Soust-Verdaguer et al., 2017). This integration reduces uncertainty and enhances the ability of designers to compare alternative facade systems under consistent modelling assumptions.

When BIM models are connected to dynamic simulation engines such as EnergyPlus or OpenStudio, annual heating and cooling demands can be evaluated based on climate data, occupancy patterns, and envelope properties. Studies indicate that such digital workflows improve the reliability of comparative analyses, particularly when assessing the thermal implications of varying insulation levels, glazing types, cavity systems, and external shading devices (Gervasio & Dimova, 2018; Simonen et al., 2017). Importantly, BIM-based simulations also support scenario-based design exploration, allowing multiple facade configurations to be tested within the same building geometry.

While operational energy analysis has long been the primary focus of facade research, the importance of embodied carbon has gained increasing attention. Life Cycle Assessment (LCA) provides a systematic method for quantifying environmental impacts associated with material extraction, manufacturing, and transportation (A1–A3 stages), as well as operational energy use during the building's service life (B6) (Zabalza Bribián et al., 2011; Anand & Amor, 2017). Integrating LCA with energy simulation enables a more holistic understanding of environmental performance, preventing the unintended consequence of reducing operational energy at the expense of increased material-related emissions.

The embodied carbon of facade systems varies considerably depending on material selection and structural complexity. Highly glazed systems, particularly curtain walls, often involve aluminium framing, multi-layer glazing units, sealants, and support systems that are energy-intensive to produce. Research shows that such systems typically exhibit higher embodied carbon compared to masonry or insulated opaque wall assemblies (Azari & Abbasabadi, 2018; Ibn-Mohammed et al., 2013). Although glazing-dominant facades may enhance daylight availability and architectural transparency, their environmental performance must be evaluated in relation to both operational cooling loads and material impacts.

In contrast, masonry walls combined with External Thermal Insulation Composite Systems (ETICS) are widely recognized for providing balanced thermal performance with relatively moderate embodied carbon (Dixit et al., 2010; Cuce et al., 2019). The effectiveness of ETICS depends on insulation thickness, material density, and climatic conditions, but such systems are generally associated with lower material complexity compared to fully glazed facades. When complemented by passive solar strategies such as fixed or movable shading devices, opaque envelope systems can significantly reduce cooling demand without substantially increasing embodied emissions (Olgyay, 1963; Al-Tamimi & Fadzil, 2011).

Double-skin facades represent a more technologically complex alternative, incorporating ventilated cavities intended to reduce cooling loads and improve indoor comfort. However, their performance is highly sensitive to design parameters such as cavity depth, ventilation strategy, and orientation (Saelens, 2002; Gratia & De Herde, 2007). While operational energy savings may be achieved under certain conditions, the additional material layers required for double-skin assemblies may increase embodied carbon. Consequently, the environmental advantage of such systems cannot be assumed universally and must be assessed within specific climatic contexts.

Climate has consistently been identified as a decisive factor in facade performance. In Mediterranean regions characterized by high solar radiation and extended cooling seasons, strategies such as controlled glazing ratios, shading devices, and reflective materials are particularly effective in reducing cooling energy demand (Grynning et al., 2013; Ascione et al., 2016). Conversely, in continental climates with prolonged and severe winters, thermal insulation becomes the dominant performance parameter, and opaque, well-insulated facade systems often outperform highly glazed alternatives in terms of both operational energy and life-cycle carbon (Pomponi et al., 2017).

Despite these insights, the literature reveals certain limitations. Many studies examine facade typologies within a single climatic context, which restricts the comparability of results across regions. Additionally, operational and embodied carbon impacts are frequently evaluated separately rather than within an integrated framework. Although BIM-based workflows have the potential to bridge this gap, relatively few studies systematically apply identical facade scenarios across multiple climates using a unified energy and carbon assessment methodology (Simonen et al., 2017).

These limitations highlight the need for comparative, climate-sensitive analyses that simultaneously address operational energy and embodied carbon within the same modelling environment. Such an approach can provide clearer guidance for designers seeking to balance transparency, insulation, material intensity, and environmental performance across different climatic conditions.

Table 1. *Summary of Key Literature on Facade Performance Using BIM and LCA*

Study	Research Focus	Climate Context	Methodological Approach	Key Contribution
Dixit et al., 2010	Embodied energy of building materials	Not climate-specific	Review of embodied energy assessment methods	Highlights variability and uncertainty in embodied energy calculations; emphasizes material-stage impacts.
Cabeza et al., 2014	Life cycle assessment in buildings	General (multiple building studies)	Review of LCA applications in buildings	Demonstrates growing importance of embodied impacts in low-energy buildings.
Pomponi & Moncaster, 2016	Embodied carbon in construction	General	Critical review of embodied carbon accounting	Calls for integration of operational and embodied carbon in early design stages.
Röck et al., 2020	Global embodied carbon trends	Global	Meta-analysis of international LCA data	Shows embodied carbon represents a significant share of total building emissions worldwide.
Azari & Abbasabadi, 2018	BIM-integrated LCA workflows	USA (case-based)	BIM-based LCA case study	Demonstrates benefits of integrating LCA into BIM-supported design processes.
Simonen et al., 2017	Embodied carbon benchmarking	USA	Database-based benchmarking approach	Provides embodied carbon benchmarks to support early-stage design decisions.
Ibn-Mohammed et al., 2013	Life cycle energy assessment	Not climate-specific	Review of lifecycle energy studies	Emphasizes significance of embodied energy in overall building sustainability.
Saelens, 2002	Double-skin facade performance	Belgium (temperate continental)	Dynamic thermal simulation	Shows climate-dependent performance of double-skin facade systems.
Gratia & De Herde, 2007	Thermal behavior of double-skin facades	Temperate European climate	Energy simulation study	Identifies operational trade-offs and design sensitivity of DSF systems.
Olgyay, 1963	Climate-responsive facade principles	Climate-responsive theory (conceptual)	Passive design framework	Establishes foundational principles of shading and climate-based envelope design.
Al-Tamimi & Fadzil, 2011	Shading devices in hot climates	Hot-humid climate (Malaysia)	Energy simulation study	Demonstrates cooling reduction through effective shading strategies.
Grynning et al., 2013	Glazing ratio and facade performance	Cold climate (Northern Europe)	Energy simulation study	Indicates increased cooling loads with high glazing ratios; importance of solar control.

Study	Research Focus	Climate Context	Methodological Approach	Key Contribution
Ascione et al., 2016	Envelope retrofit strategies	Mediterranean climate (Italy)	Energy simulation-based study	Shows combined insulation and shading improve operational energy performance.

Gap and Contribution of This Chapter

As summarized in **Table 1**, existing research has made significant progress in evaluating facade performance using energy simulation and life cycle assessment tools. However, two limitations remain evident. First, many studies focus on a single climatic context, which restricts the transferability of findings to regions with different heating and cooling profiles. Second, operational energy and embodied carbon are frequently examined separately rather than within an integrated comparative framework.

Although BIM-based workflows increasingly enable the simultaneous analysis of thermal performance and material-related impacts, relatively few studies apply identical facade scenarios across contrasting climates under consistent modelling assumptions. As a result, it remains unclear how the same facade configuration may shift in relative environmental performance when exposed to different climatic demands.

This chapter addresses this gap by systematically evaluating five facade scenarios (S1–S5) applied to the same office building model in two distinct climatic conditions: Mediterranean (Izmir) and continental (Erzurum). By maintaining consistent building geometry, occupancy assumptions, and modelling parameters, the study isolates the effect of climate and facade configuration on both operational energy demand and embodied carbon (A1–A3).

Rather than privileging a specific facade typology, the objective is to identify performance tendencies and trade-offs across climate contexts. The integrated assessment enables a clearer understanding of how insulation strategies, glazing ratios, and shading configurations influence annual heating and cooling loads while simultaneously affecting material-related carbon emissions.

The contribution of this chapter can therefore be summarized in three aspects:

1. It provides a climate-comparative evaluation of identical facade scenarios under Mediterranean and continental conditions.

2. It integrates operational energy simulation with embodied carbon assessment within a unified BIM-based workflow.

3. It supports early-stage design decision-making by revealing energy–carbon trade-offs in different climatic contexts.

By bridging the methodological separation between energy modelling and carbon accounting, and by explicitly comparing facade performance across two climate types, this study contributes to more climate-responsive and environmentally balanced facade design strategies.

4. Materials and Methods

Case Study Description

The study is based on a representative mid-scale office building model developed to evaluate the environmental implications of alternative facade configurations under different climatic conditions. In order to ensure methodological consistency and allow controlled comparison, the overall building geometry, floor plan organization, internal loads, and occupancy assumptions were kept constant across all scenarios. By fixing these parameters, the analysis isolates the impact of facade composition and climatic context on environmental performance.

The building was defined as a single-zone office volume with a total floor area of approximately 500 m^2 and a floor-to-ceiling height of 3 meters. The primary facade orientation is south-facing, allowing the study to examine solar exposure and shading effects in a consistent manner. Other facades remain exposed to outdoor conditions but are not characterized by extensive glazing in order to reduce confounding variables.

While the overall building mass and spatial configuration remain unchanged, window-to-wall ratios vary between scenarios in accordance with the logic of each facade system. Glazing-dominant configurations naturally incorporate higher transparency levels, whereas insulation-oriented alternatives adopt more opaque surface proportions. Window modules were defined with dimensions of 1.5 m × 1.5 m and a sill height of 0.9 m above finished floor level. These variations in fenestration were intentionally integrated into the design scenarios to reflect realistic facade compositions rather than artificially uniform glazing ratios.

To evaluate climate sensitivity, the same building model was simulated under two distinct climatic contexts: Mediterranean (Izmir) and continental (Erzurum). This dual application enables a comparative assessment of how identical facade strategies respond to different heating and cooling demands.

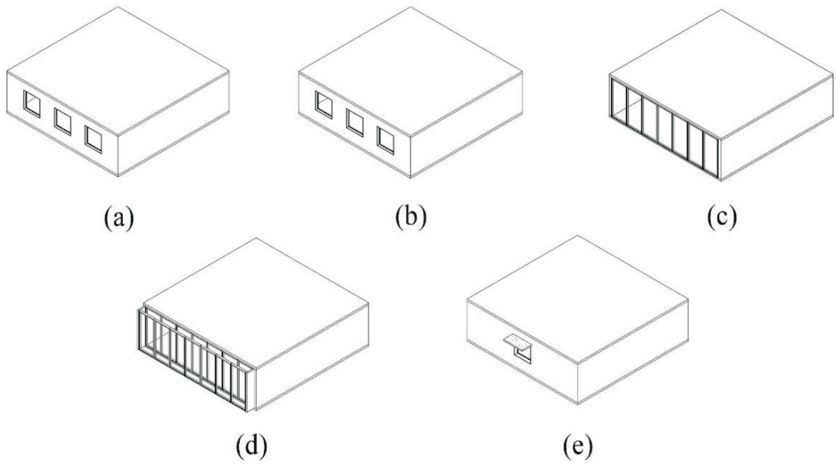


Figure 1. *Architectural models of the analysed facade scenarios: (a) S1 – base masonry wall, (b) S2 – externally insulated masonry wall (ETICS), (c) S3 – curtain wall facade, (d) S4 – double-skin facade with ventilated cavity, and (e) S5 – enhanced ETICS with reduced glazing ratio and external shading devices.*

Five facade scenarios (S1–S5) were developed to represent commonly applied envelope strategies in contemporary office design. These include a base masonry wall, externally insulated masonry (ETICS), curtain wall configuration, double-skin assembly, and an enhanced ETICS solution integrating improved insulation and fixed external shading. The scenarios differ in material composition, insulation thickness, glazing proportion, and shading integration, while maintaining the same structural framework and interior conditions.

Table 2. *Layer composition and material thickness for each scenario*

Scenario	Facade system description
S1 – Base	Internal plaster (15 mm) + Brick masonry (190 mm) + External render (20 mm)
S2 – ETICS	Internal plaster (15 mm) + Brick masonry (190 mm) + External insulation (50 mm) + External render (20 mm)
S3 – Curtain wall	Aluminium-framed curtain wall with double glazing
S4 – Double-skin facade	Inner aluminium-framed curtain wall with double glazing + 600 mm ventilated cavity + outer aluminium-framed curtain wall with double glazing
S5 – Enhanced ETICS + shading	Internal plaster (15 mm) + Brick masonry (190 mm) + External insulation (100 mm) + External render (20 mm) + low-emissivity double glazing + fixed external shading

BIM-Based Energy Simulation

Operational energy performance was evaluated through a BIM-based workflow. All facade configurations were modeled in Autodesk Revit and exported to OpenStudio for dynamic energy simulation. The simulation environment was structured to maintain identical assumptions across scenarios, including occupancy schedules, internal heat gains, lighting loads, and HVAC setpoints. This standardization ensures that observed performance differences derive exclusively from facade variation and climatic conditions.

Climate-specific weather files were used for Izmir and Erzurum, allowing annual heating and cooling demands to be calculated under realistic meteorological conditions. Annual energy consumption values (kWh) were extracted separately for heating and cooling loads in order to identify climate-dependent performance shifts.

The results reveal clear distinctions between facade systems across the two climates. In the Mediterranean context, cooling demand becomes the dominant operational parameter, making solar control and glazing proportion critical variables. In the continental climate, heating demand increases significantly, altering the relative performance hierarchy of facade alternatives.

Table 3. *Annual heating and cooling energy consumption per scenario and climate*

	İzmir		**Erzurum**	
Scenario	**Heating (kWh)**	**Cooling (kWh)**	**Heating (kWh)**	**Cooling (kWh)**
S1 – Base	1,886	11,697	6,85	5,55
S2 – ETICS	1,883	11,669	6,833	5,536
S3 – Curtain Wall	2,047	24,417	7,481	17,144
S4 – Double Skin	2,281	20,658	8,078	13,131
S5 – Enhanced ETICS + Shading	1,964	9,344	7,258	3,986

Embodied Carbon Assessment

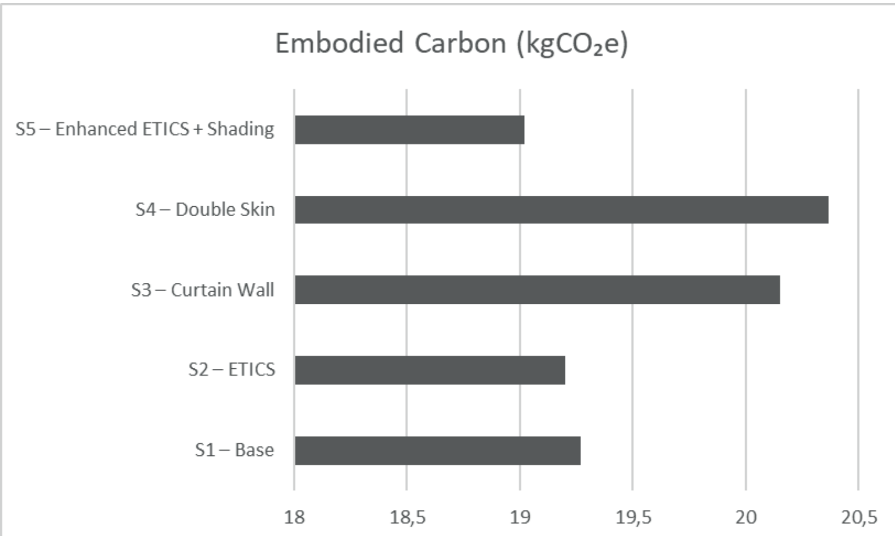
To complement operational energy analysis, the embodied carbon of facade systems was assessed using the Carbon Insights tool. The assessment focused on cradle-to-gate impacts (A1–A3), encompassing raw material extraction, manufacturing, and transportation processes associated with facade components.

Material quantities were extracted directly from the BIM models, ensuring consistency between geometric definition and environmental calculation.

Carbon intensity factors were applied to each material layer, and results were aggregated as total embodied carbon ($kgCO_2e$) per building.

Unlike operational energy, embodied carbon values remain constant across climatic contexts, as they are determined by material composition rather than geographical location. This distinction is critical for interpreting integrated performance results: while operational loads shift according to climate, material-related emissions remain fixed.

Table 4. *Embodied carbon values for all scenarios*



Integrated Energy and Carbon Performance

The environmental performance of the five facade scenarios was evaluated through an integrated assessment combining operational cooling energy and embodied carbon values. Cooling demand was prioritized in the integrated comparison due to its dominance in Mediterranean conditions and its sensitivity to facade transparency and shading strategies. However, the climate-based comparison also allows interpretation of heating impacts in continental conditions.

Table 5. *Integrated Energy and Carbon Performance of Facade Scenarios*

Scenario	**Cooling Energy (kWh)**	**Embodied Carbon ($kgCO_2e$)**	**Overall Performance**
S1 – Base	Izmir: 11,697 Erzurum: 5,550	19,268.77	Baseline reference
S2 – ETICS	Izmir: 11,669 Erzurum: 5,536	19,201.12	Balanced solution

Scenario	Cooling Energy (kWh)	Embodied Carbon ($kgCO_2e$)	Overall Performance
S3 – Curtain Wall	Izmir: 24,417 Erzurum: 17,144	20,150.35	High energy & carbon
S4 – Double Skin	Izmir: 20,658 Erzurum: 13,131	20,367.83	Energy improvement, carbon penalty
S5 – Enhanced ETICS + Shading	Izmir: 9,344 Erzurum: 3,986	19,023.62	Best overall performance

To visualize trade-offs between operational and material impacts, a two-dimensional diagram was developed plotting cooling energy (kWh) against embodied carbon ($kgCO_2e$).

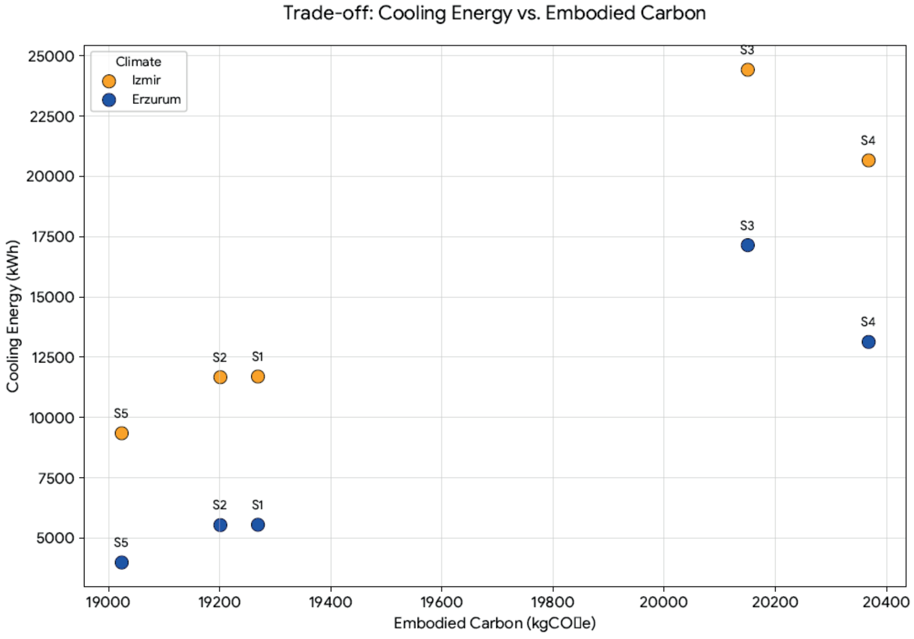


Figure 2. *Trade-off diagram of cooling energy versus embodied carbon across facade scenarios and climates.*

The diagram illustrates how facade systems shift in relative performance across climates. In the Mediterranean climate, configurations with higher glazing proportions demonstrate elevated cooling demands, moving toward less favorable environmental balance zones. Conversely, insulation-oriented solutions combined with shading achieve lower cooling demand without increasing embodied carbon.

Under continental conditions, cooling differences become less pronounced, yet embodied carbon remains a constant parameter. This contrast underscores a key methodological insight: facade performance rankings are climate-dependent and cannot be generalized across geographic contexts.

Importantly, the analysis does not aim to promote a specific facade typology as universally superior. Instead, it reveals performance tendencies and environmental trade-offs within a consistent modelling framework. By integrating operational simulation with embodied carbon assessment, the study supports early-stage design decisions grounded in life-cycle thinking rather than single-metric optimization.

Design Implications and Methodological Contribution

The integrated findings of this study indicate that facade design decisions require careful environmental evaluation across climatic contexts rather than reliance on formal expression or isolated performance metrics. In particular, the results demonstrate that increasing glazing ratios in cooling-dominated regions may substantially elevate operational energy demand. This highlights the necessity of assessing facade transparency in relation to climatic exposure and solar gains rather than treating it as a universally applicable design strategy.

The comparative analysis further shows that envelope configurations emphasizing balanced insulation levels and solar control can achieve competitive environmental performance without increasing material-related impacts. These findings suggest that sustainability is not inherently linked to facade elaboration or intensity of intervention; rather, it depends on how effectively envelope composition responds to climatic demands.

From a methodological perspective, the study demonstrates the value of integrating BIM-based energy simulation with embodied carbon assessment during early design stages. Evaluating operational and material-related impacts within the same analytical framework allows for a more comprehensive interpretation of environmental performance. The trade-off visualization developed in this study provides a clear and accessible means of identifying balanced solutions, supporting iterative and performance-informed design processes.

The comparative application across Mediterranean and continental climates further reveals that facade performance rankings are not fixed. Strategies that perform effectively under cooling-dominated conditions may shift in relative performance when heating demand becomes more prominent. This reinforces the need for region-specific evaluation and challenges generalized envelope prescriptions. By combining climate comparison with integrated carbon analysis, the study contributes to ongoing research advocating context-sensitive and life-cycle-oriented architectural decision-making.

7. Discussion

The findings confirm that facade performance is strongly influenced by climatic conditions and that operational energy optimization alone does not guarantee overall environmental improvement. When operational energy and embodied carbon are evaluated together, facade systems exhibit different performance hierarchies depending on regional context.

In the Mediterranean climate, cooling demand emerges as the primary determinant of environmental impact. Scenarios characterized by higher glazing proportions demonstrate significantly increased cooling loads, supporting existing literature that associates elevated transparency with intensified solar heat gains in warm climates (Attia, 2018; Pacheco et al., 2012). These results reinforce the importance of solar control and balanced envelope composition in cooling-dominated regions.

In contrast, under continental conditions, cooling demand differences become less pronounced, while heating requirements assume greater importance. Although embodied carbon values remain constant across climates due to their material basis, the operational relevance of facade composition changes. This distinction underlines a key insight: environmental evaluation must distinguish between climate-sensitive operational impacts and climate-independent material emissions.

The integrated trade-off analysis further demonstrates that increased facade articulation or additional material layers do not inherently result in improved environmental outcomes. Without proportional reductions in operational demand, added material intensity may diminish overall performance benefits. This finding contributes to broader discussions in sustainable design regarding the balance between envelope configuration and life-cycle impacts.

Another important contribution of the study lies in its methodological approach. By embedding energy simulation and carbon assessment within a unified BIM workflow, the research illustrates how early-stage design decisions can be informed by simultaneous environmental evaluation. This integrated process reduces the likelihood of optimizing one parameter at the expense of another and strengthens the alignment between architectural design and life-cycle thinking.

Limitations and Future Research

Despite its contributions, the study presents certain limitations. The embodied carbon assessment focuses primarily on cradle-to-gate impacts (A1–A3) of facade components and does not extend to maintenance, replacement cycles, or end-of-life stages. Consequently, long-term life-cycle implications may be underrepresented.

In addition, operational simulations are based on standardized occupancy schedules and internal load assumptions. While this approach ensures comparability across scenarios, real-world behavioral variations may influence actual energy performance outcomes.

Future research could expand this comparative framework by incorporating full life-cycle carbon assessment, additional climate zones, and alternative occupancy profiles. Further investigations may also explore dynamic shading strategies, daylighting performance, and multi-criteria optimization models integrating cost, energy, and carbon parameters. Such extensions would strengthen the applicability of BIM-integrated decision-support systems in sustainable architectural design.

8. Conclusion and Recommendations

This chapter presented a comparative evaluation of five facade configurations under Mediterranean (Izmir) and continental (Erzurum) climatic conditions using an integrated BIM-based energy and embodied carbon assessment framework. By combining operational cooling demand with cradle-to-gate carbon emissions, the study aimed to provide a balanced understanding of facade performance across distinct environmental contexts.

The findings demonstrate that facade performance is inherently climate-sensitive. In cooling-dominated conditions, glazing proportion and solar control significantly influence operational energy demand, while insulation-based configurations combined with shading strategies offer a more balanced environmental profile. Under continental conditions, operational priorities shift, emphasizing the importance of heating performance while embodied carbon remains unchanged.

A key insight of the study is that facade optimization cannot rely on universal solutions. Operational performance varies geographically, whereas material-related emissions remain constant; therefore, design strategies must be evaluated within their specific climatic context. The integrated trade-off diagram proved to be an effective tool for identifying balanced environmental outcomes and revealing potential conflicts between operational and embodied impacts.

More broadly, the research underscores the importance of embedding life-cycle thinking into early-stage architectural design processes. By integrating energy simulation and carbon assessment within a BIM-based workflow, designers can move beyond fragmented sustainability metrics toward informed, climate-responsive decision-making.

Design Recommendations

Based on the comparative findings, the following recommendations can be derived:

- In cooling-dominated climates, prioritize solar control and insulation strategies before increasing glazing ratios.
- Evaluate embodied carbon alongside operational energy during early design phases.
- Avoid envelope modifications that increase material intensity without proportional operational benefits.
- Employ BIM-based simulation tools to test facade scenarios under region-specific climatic conditions.
- Develop climate-responsive design guidelines rather than applying generalized performance assumptions.

Final Remarks

Sustainable facade design requires an integrated and context-aware approach. The combination of operational energy analysis and embodied carbon assessment within a consistent modelling environment enables a more comprehensive understanding of environmental performance. By grounding facade decisions in climate-specific evaluation and life-cycle thinking, architectural design can align environmental responsibility with methodological rigor and contextual sensitivity.

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Chapter
5

A COMPARATIVE EVALUATION OF CONTEMPORARY GENERATIVE ARTIFICIAL INTELLIGENCE TOOLS IN ARCHITECTURAL DESIGN AND VISUALIZATION PROCESSES

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1. Introduction

The discipline of architecture has historically been in direct interaction with technological developments, and the tools used in each new era have continuously reshaped design approaches. The progression from traditional drawing techniques to computer-aided design (CAD), from three-dimensional modeling software to building information modeling (BIM), has transformed both the methods of architectural production and the identity of the designer. Today, the most current and influential representative of this transformation is artificial intelligence technologies. In particular, the integration of generative artificial intelligence (generative AI)–based tools into architectural design processes has brought about a new paradigm shift in architectural practice.

In recent years, artificial intelligence has moved beyond being merely a tool for computation and automation, assuming an active role in creative production processes. In disciplines such as architecture, which are shaped by multidimensional and aesthetic decision-making, the use of AI has created a broad sphere of influence extending from the early stages of design to implementation and presentation phases. Today, architects gain significant advantages through AI-supported systems in processes such as concept development, plan organization, generating alternative design scenarios, producing realistic visualizations, and even creating digital models of three-dimensional physical environments. This indicates that architectural design is evolving from an activity based solely on human creativity into a hybrid mode of production grounded in human–machine collaboration.

One of the main reasons generative AI tools are becoming increasingly widespread in architecture is their ability to accelerate design processes and generate a wide range of alternatives. Concept sketches or modeling stages that traditionally require long periods of time can now be produced in various iterations within minutes through AI systems. This supports architects' decision-making, particularly in the early design stages, by enabling the evaluation of a greater number of possibilities. Moreover, AI technologies contribute not only to visual production but also to technical dimensions of architectural practice such as data analysis, project documentation, and workflow management.

This transformation in architectural design processes is also clearly observable through the diversity of AI tools being utilized. Six AI tools compiled by Webrazzi in 2024 (Swapp, Veras, Finch, Luma AI, Maket, and Coohom) offer innovative solutions targeting different phases of architectural projects. For example, systems such as Swapp focus on project management and documentation, whereas Veras and Coohom provide strong alternatives in visualization and rendering. Finch and Maket stand out in conceptual planning and generative design processes, while Luma AI enables advanced technological applications such as transforming physical environments into three-dimensional digital models. This diversity demonstrates that AI does not serve a single task within architecture; rather, it has become a multilayered transformative tool that can be integrated into all components of the design ecosystem.

However, the rise of AI technologies in architecture also brings important debates to the forefront. Issues such as design originality, contextual compatibility, ethical responsibility, copyright concerns, and the preservation of designer control have emerged as critical topics in AI-supported architectural production. The question of whether AI is an element that replaces the designer or a supportive tool that enhances design processes remains widely discussed in both academic and professional contexts. Therefore, maintaining a critical perspective and keeping the designer's role central are essential for the effective use of AI systems in architectural practice.

From a future-oriented perspective, AI is expected to become even more central in architecture. Developments such as intelligent systems integrated with BIM-based processes, the automation of sustainability analyses, the personalization of user-centered experience design, and the widespread adoption of digital twin technologies will further expand the role of AI in architectural production. In this context, AI is evaluated not merely as a design tool but as a technology that restructures the architectural thinking of the future.

This book chapter aims to comparatively examine current AI tools that can be used in architectural projects and to discuss both their potentials and limitations. Thus, the study seeks to contribute to academic literature while also developing awareness of AI integration within architectural practice.

2. Literature Review

In recent years, artificial intelligence (AI) technologies have attained an increasingly central position in architecture due to the creative and technical contributions they provide in conceptual design, automation, and digital visualization processes (Castro Pena et al., 2021; Harapan et al., 2021). Particularly in the early stages of architectural design, generative systems enable designers to develop diverse formal alternatives, thereby expanding creative processes. In this context, it has been emphasized that evolutionary algorithms and deep learning–based methods diversify architectural decision-making processes and enrich design production (Lukovich, 2023). Thus, a significant transformation is occurring in architectural production not only in terms of speed but also in revealing new innovative needs.

With the increasing digitalization of architectural practice, the integration of big data analytics and distributed AI systems into platforms such as BIM and CAD has become noteworthy. This integration accelerates complex structural and environmental evaluations and enables architects to make more comprehensive design decisions. Furthermore, AI-supported visualization tools strengthen conceptual learning and increase student motivation in architectural education (Vergunova, 2024). The enhancement of the aesthetic quality of generative models also enables stronger communication, particularly in client presentations.

Nevertheless, the widespread adoption of AI tools introduces several challenges. Issues such as cost, user experience problems, and ethical concerns are frequently discussed in the literature (Sharma et al., 2023). From an ethical perspective, it has been stressed that interdisciplinary frameworks must be established for the responsible use of AI in architecture, with the protection of creativity and cultural diversity being particularly important (Softaoğlu, 2024). Likewise, developing education and policy models that promote effective and fair AI use is among the key topics highlighted in current research (Park & Kim, 2024).

It has been reported that AI enhances innovation during the conceptual design stage and makes significant contributions to form generation and design analysis (Smith & Jones, 2024). These systems function as decision-support mechanisms in architectural design, increasing design diversity through rapid prototyping (Chen et al., 2024). Similarly, AI-based prototyping systems have been shown to improve user control, contribute to design quality, and enable the rapid testing of alternative solutions (Aslan & Aydın, 2023). These developments provide a theoretical background explaining why tools such as Swapp, Finch, or Maket have become prominent in contemporary design processes.

The role of AI technologies in architecture and interior architecture education is also becoming increasingly evident. It has been observed that text-to-image generative systems often tend toward repetitive forms (such as flower-like visuals), whereas newer versions of Stable Diffusion provide more diverse outputs (Buldaç, 2024). Experimental studies in interior architecture have revealed that AI tools accelerate design processes and increase overall student satisfaction, yet challenges remain in prompt interpretation and technical limitations (Avinç, 2024). Likewise, a study conducted at Istanbul Kent University reported that students perceived increased creativity and speed when using generative tools, although some outputs were not considered sufficiently realistic (Marşoğlu & Özdemir, 2025).

AI-supported tools have been shown to enhance students' creative and analytical skills, support the visualization of complex themes, and facilitate the integration of topics such as sustainability into studio education (Adetayo, 2024). However, it has also been emphasized that this integration is often fragmented rather than holistic within architectural education (Almaz et al., 2024). This indicates the need for more systematic investigation into the potential educational applications of tools such as Coohom or Veras.

Overall, AI offers new opportunities in architectural design processes in terms of efficiency, sustainability, and creativity, supporting data-driven decision-making through generative algorithms and BIM integration (Ploennigs & Berger, 2023). Visualization systems such as ChatGPT, Midjourney, DALL·E, and Stable Diffusion are widely used in conceptual development stages and provide effectiveness in parametric design and client presentations (Sheikh & Crolla, 2023). In addition, the integration of virtual reality technologies into architectural education offers interactive and decision-support solutions, particularly in understanding modeling and construction detailing processes (Cao et al., 2024; Mammadov et al., 2025).

Finally, it has been noted that generative AI systems operating through text-based prompts enable the rapid visualization of abstract ideas; however, human contribution remains necessary for achieving high-quality outputs (Abd El-Maksoud & Ahmed, 2024). Within this framework, emerging AI tools in architecture carry the potential to transfer designers' intuitive production approaches into digital environments, thereby creating more holistic and innovative workflows.

3. Materials and Methods

The purpose of this book chapter is to comparatively examine current artificial intelligence tools that can be used in architectural project processes. The material of the study consists of six AI platforms compiled by Webrazzi (2024) among the prominent applications in the field of architecture: Swapp, Veras, Finch, Luma AI, Maket, and Coohom. These tools were selected because they serve functions at different stages of the architectural design ecosystem, including project management, conceptual design, plan generation, three-dimensional modeling, and interior visualization.

The research methodology is based on systematically evaluating the potential contributions of the selected platforms to architectural design processes. Accordingly, the tools were analyzed comparatively according to specific criteria. The evaluation framework was grounded in Purdue University's "AI Tools Evaluation Criteria" guideline, which provides a contemporary structure for assessing AI systems. This guideline emphasizes that key criteria such as usability, accuracy, integration capacity, ethical dimensions, and cost should be taken into account when evaluating AI tools in professional application fields such as architecture.

Within the scope of this study, the platforms were assessed according to the following criteria:

- **Functionality and purpose of use:** The stage of the architectural design process in which the tool plays a role (concept generation, rendering, planning, documentation, etc.).

- **User experience and accessibility:** Interface usability, learning curve, and practical applicability from the designer's perspective.

- **Integration capacity:** The level of compatibility with BIM/CAD-based software or other digital platforms.

- **Production quality and accuracy:** Consistency of visual outputs, ability to support design decisions, and overall reliability.

- **Ethical and legal dimensions:** Data security, copyright issues, and responsibility debates in content generation.

- **Cost and applicability:** Free or paid access conditions and sustainability of professional use.

Based on these criteria, each AI tool was evaluated in terms of its contributions and limitations within architectural project processes. The findings were presented through a comparative table and interpretive analysis. In this way, the evolving role of AI platforms in the discipline of architecture is discussed from both academic and practice-based perspectives.

4. General Overview of Contemporary AI Tools in Architectural Design and Visualization Processes

The scope of AI-based tools in architectural project production has been expanding rapidly, creating significant transformations across different stages of the design process. Generative AI systems used in processes such as conceptual development, spatial organization, digital modeling, project management, and realistic visualization not only increase speed but also redefine architectural creativity by enabling greater diversity of design alternatives. Particularly in recent years, digital platforms have provided designers with multifaceted solutions ranging from early design decision-making to presentation stages.

The six contemporary AI tools addressed in this study (Swapp, Veras, Finch, Luma AI, Maket, and Coohom) stand out as innovative systems responding to various needs within the architectural project ecosystem. These tools demonstrate that AI in architecture cannot be reduced solely to visual production; rather, it can be effectively employed in broader domains such as project management, analysis, and digital production. In this section, the tools are introduced within a general framework according to their architectural application areas.

Swapp is an AI-based tool focused on process analysis and documentation management in architectural projects. It is used in areas such as organizing project data, tracking workflows during the design process, and supporting coordination within design teams. Swapp highlights that AI in architectural practice offers important potential not only for design production but also for knowledge management and project organization.

Veras is one of the generative visualization tools used in BIM-based modeling environments. By working in integration with software such as Revit and SketchUp, it enables the rapid production of AI-supported renderings and conceptual visuals from an existing design model. In this respect, Veras facilitates the representation of ideas during early design phases and provides a significant time advantage in presentation processes.

Finch is an AI tool focused on generating plan organization and layout alternatives in the conceptual stage of architectural design. It supports rapid decision-making by offering designers various spatial scenarios and constitutes a contemporary example of how generative design approaches can be applied at the beginning of a project. Finch is particularly notable for providing diversity and flexibility in conceptual design processes.

Luma AI is a three-dimensional modeling–based system that enables the transfer of real environments into digital platforms. Through photogrammetry and AI-supported algorithms, it can generate 3D digital models from physical objects or spaces. This constitutes an important innovation area in architecture in terms of digital twin, virtual representation, and augmented reality applications.

Maket is a platform that develops architectural massing and building suggestions using generative AI. Particularly in residential projects, it provides different plan types and formal alternatives, offering automated design recommendations. Maket serves as an example of tools in which AI directly functions in architectural form production and design decision-support mechanisms.

Coohom is an AI-supported visualization platform focused on interior design and rapid rendering production. With its ready-made furniture libraries and automated scene-generation systems, it contributes to the preparation of effective presentations in a short time, especially in interior architecture projects. Coohom demonstrates that AI-based systems can be integrated into design practice more accessibly through user-friendly interfaces.

Overall, these tools clearly reveal the multilayered role of AI in architectural project processes. Systems such as Swapp strengthen project management and analytical dimensions, while Veras and Coohom provide speed and representational power in visualization. Finch and Maket enhance alternative production in early design phases, whereas Luma AI offers innovative solutions for the digital representation of the physical environment.

This diversity indicates that AI technologies have become not merely auxiliary tools in architecture, but strategic transformation elements restructuring the design ecosystem.

The reason Swapp, Veras, Finch, Luma AI, Maket, and Coohom were selected in this study is that these systems stand out among current AI applications usable in architectural projects and provide diverse functions representing different stages of the architectural design process. The selected tools were included because they cover a wide application range—from project management to visualization, from conceptual plan generation to three-dimensional modeling—thus allowing a comparative examination of AI's multifaceted transformation within architectural practice.

5. Comparative Analysis and Findings of Artificial Intelligence Tools

In this section, the platforms Swapp, Veras, Finch, Luma AI, Maket, and Coohom are comparatively evaluated in accordance with the criteria established in the materials and methods section. The fact that these tools specialize in different stages of the architectural design process indicates that artificial intelligence has created a multifaceted transformation within architectural practice. The comparison was conducted based on the criteria of functionality, user experience, integration capacity, output quality, ethical dimensions, and cost.

Table 1. *Criteria-Based Comparison of AI Tools Used in Architectural Design Processes*

Tool	Primary Focus Area	Level of Use in the Architectural Process	Main Contribution Provided	Production Quality and Accuracy	Integration Potential	Key Limitations and Risks
Swapp	Project documentation and process analysis	Implementation and management stage	Organizing architectural data, team coordination, workflow tracking	Accuracy in knowledge management rather than visual production is prioritized	High compatibility with institutional project workflows	Limited direct contribution to design creativity
Veras	BIM-based generative visualization	Concept development + presentation	Rapid AI-supported rendering from existing BIM models	Strong aesthetic output, though technical realism may be limited	Strong integration with Revit and SketchUp	Paid access and copyright/ethical uncertainties
Finch	Generative planning and layout alternatives	Early design stage	Producing multiple spatial scenarios and supporting rapid decision-making	Strong conceptual accuracy, but weak in detailed design resolution	Concept-oriented; additional tools required for transition to implementation projects	Structural and regulatory compliance may remain limited
Luma AI	3D digital modeling from physical environments	Digital representation and modeling	Creating digital twins of real environments through photogrammetry	High representational accuracy, though additional processing is required for project standardization	High potential for VR/AR and digital twin systems	Requires hardware resources and technical expertise
Maket	Generative architectural massing and building suggestions	Concept design stage	Alternative production through automated plan and form recommendations	High diversity, but contextual accuracy remains debatable	Strong in design initiation; limited BIM integration	Risk of incompatibility with local environmental context and cultural originality
Coohom	Interior design and rapid rendering	Interior architecture + client presentation	Fast interior visualization with ready-made furniture libraries	High presentation quality, originality partially limited	Independent platform; outputs usable mainly for presentation purposes	Prone to design repetition and standardization

5.1. Comparison in Terms of Functionality

When the functionality levels of the tools are examined, it is evident that each platform addresses a different need within the architectural project process. Swapp provides a system aimed at organizing architectural workflows by focusing on project documentation and process analysis rather than design production. In contrast, Veras and Coohom offer strong solutions in visualization and rendering, playing an effective role in concept development and presentation stages. Finch and Maket support the initial phases in which design decisions are shaped by generating plan alternatives and generative massing proposals during the early design stage. Luma AI's capacity to produce three-dimensional models from the physical environment reveals new application areas of digital twin and virtual representation technologies in architecture. Therefore, the functional diversity of these tools demonstrates that artificial intelligence has become a multilayered transformative element in architectural production.

5.2. User Experience and Accessibility

In terms of user experience, there are notable differences in accessibility among the tools. Coohom offers a system that is quickly learnable, particularly in interior architecture applications, thanks to its user-friendly interface and ready-made interior components. Although Veras is powerful for architects due to its integration with professional BIM software, it requires a certain level of technical infrastructure and software knowledge. Finch and Maket provide practical solutions focused on early-stage design; however, familiarity with generative design logic is important for their effective use. Swapp, on the other hand, is oriented more toward project management and gains significance in professional environments requiring team coordination rather than direct design production. Luma AI appeals to a more specialized user group in terms of accessibility, as it requires higher technical skills and hardware resources due to its three-dimensional scanning and model generation capabilities.

5.3. Integration Capacity

The integration of these tools with the architectural software ecosystem is a decisive criterion for professional application. Veras is a strong system that can be directly integrated into the design process due to its compatibility with BIM/CAD-based software such as Revit and SketchUp. Swapp also supports workflows by analyzing architectural project data and contributing to documentation processes. Coohom operates independently within its own interface for interior design; however, it provides indirect integration through the usability of its outputs in presentation stages. Finch and Maket are mostly limited to conceptual production and may require additional software support when transitioning into implementation projects. Luma AI supplies data to digital design processes through 3D model production, holding significant integration potential especially for VR/AR and digital twin applications.

5.4. Production Quality and Accuracy

In terms of production quality, tool outputs differ both in visual representational strength and architectural accuracy. Veras and Coohom enhance presentation quality through rapid and aesthetically strong rendering, although these outputs often remain at a conceptual level. The plan and massing proposals generated by Finch and Maket provide designers with alternative scenarios but may contain limitations regarding structural accuracy and local contextual compatibility. Although Luma AI produces higher-accuracy digital representations by generating data from real environments, additional processes are required to adapt these models to architectural project standards. Swapp, rather than producing visual outputs, is significant in terms of accuracy and data consistency in project analysis. Overall, although AI systems provide speed and design diversity, final accuracy and quality control remain dependent on designer supervision.

5.5. Ethical and Legal Dimensions

Ethical and legal debates constitute a major dimension in the use of AI tools within architecture. Copyright issues, transparency of data sources, and concerns of originality become prominent especially in generative visualization tools. In particular, systems such as Veras, Maket, and Coohom, which generate visual content, may create uncertainty regarding the ownership and usage rights of design outputs. Moreover, AI systems must be positioned not as replacements for designers, but as supportive tools. In platforms processing project data, such as Swapp, data security and privacy become important ethical considerations. Therefore, AI use in architecture should be considered not only a technical issue but also a transformation process that must be evaluated in line with interdisciplinary ethical principles.

5.6. Cost and Applicability

The sustainable use of these tools in professional architectural practice is directly related to cost and access conditions. Platforms such as Coohom offer flexible packages targeting broader user groups, whereas BIM-based tools like Veras mostly operate through paid subscription systems. Finch and Maket, while advantageous in early conceptual design stages, may increase costs due to additional software requirements in professional projects. Luma AI's hardware and technical infrastructure needs raise its applicability to a specialized expertise level. Swapp provides institutional-scale project management and thus finds greater economic value in large architectural offices. Accordingly, the applicability of these tools varies not only according to technical capacity but also depending on economic accessibility and usage scenarios.

This analysis demonstrates that AI tools assume different roles within architectural design processes and that each tool provides strong contributions at specific stages. However, issues such as output accuracy, ethical responsibility, and preservation of designer control remain critical discussion areas that must be carefully addressed in the integration of these technologies into architectural practice.

5.7. Findings

The platforms examined in this study—Swapp, Veras, Finch, Luma AI, Maket, and Coohom—demonstrate that the use of AI in architectural design processes extends across different phases of the project cycle. The findings reveal that AI tools provide multidimensional contributions to architectural production beyond visual representation, including planning, documentation, three-dimensional digital modeling, and interior design.

According to the results, the distribution of roles among the tools differs significantly. Swapp strengthens knowledge management and organizational capacity in architectural practice by standing out in project documentation and process analysis rather than design generation. In contrast, Veras and Coohom are evaluated as tools supporting conceptual expression and client presentations through AI-assisted rapid visualization and rendering. Finch and Maket offer notable contributions in the early design stage in terms of producing spatial scenarios and developing generative alternatives. Luma AI's ability to generate three-dimensional digital models from physical environments highlights the growing importance of digital twin technologies in architecture.

In terms of user experience and accessibility, findings indicate that interior design–oriented platforms provide a lower learning curve. While tools such as Coohom are rapidly applicable due to user-friendly interfaces, platforms such as Veras and Luma AI require more advanced technical infrastructure. This shows that widespread adoption of AI tools depends not only on technological capability but also on user access and educational levels.

Regarding integration capacity, the most significant finding is that BIM-based tools can be more directly integrated into architectural workflows. Veras's compatibility with Revit and SketchUp enables AI-supported visualization to be more rapidly adapted to professional design environments. However, the need for additional tools when transitioning Finch and Maket into implementation projects indicates that integration remains limited.

With respect to production quality, findings demonstrate that although AI provides speed and diversity, human supervision remains essential for output accuracy. Visual production tools generate aesthetically strong results but may have limitations in contextual suitability and technical realism. In generative planning and massing systems, issues such as compliance with local regulations and structural accuracy remain uncertain.

Ethical and legal findings indicate that AI use in architectural production must be evaluated alongside copyright, data security, and originality debates. In particular, design ownership and transparency of content sources emerge as key problem areas in generative visualization systems.

Finally, cost and applicability criteria reveal differences in professional accessibility. Subscription-based platforms are more feasible in large offices, while some tools remain limited in individual use due to hardware requirements.

Overall, the findings indicate that AI tools provide significant contributions to architectural design processes; however, issues such as accuracy, ethical responsibility, contextual compatibility, and designer control require more comprehensive future research. The role of AI in architecture is therefore evaluated not as replacing the designer, but as an integrated transformative tool supporting the design process.

6. Conclusion and Recommendations

In this book chapter, contemporary AI tools that can be used in architectural project processes were comparatively examined through six platforms highlighted by Webrazzi (2024): Swapp, Veras, Finch, Luma AI, Maket, and Coohom. The findings demonstrate that AI technologies can be effectively utilized not only for visualization purposes but also in multilayered processes such as conceptual design, planning, documentation, project management, and three-dimensional digital representation. This indicates that architectural production is evolving from traditional human-centered drawing practices toward a hybrid design ecosystem based on human–machine collaboration.

The comparative analysis results show that each tool specializes in a different stage of the architectural design process. Swapp provides institutional contributions in knowledge management and project coordination, while Veras and Coohom stand out as generative rendering systems that enhance presentation and visual representation power. Finch and Maket strengthen the decision-support dimension of generative design by offering alternative plan and massing suggestions in the early design phase. Luma AI emphasizes the expanding role of digital twin and virtual representation technologies through the digital transfer of physical environments. This diversity confirms that AI has become a comprehensive transformative tool in architecture, integrated into all stages of disciplinary production rather than being limited to a single task.

Nevertheless, the findings indicate that despite the speed and alternative production capacity offered by AI-supported tools, fundamental discussions regarding design accuracy, contextual compatibility, and ethical responsibility remain highly relevant. In particular, issues of copyright, design originality, and transparency of content sources create major uncertainties in visual production systems. Furthermore, generative planning and massing tools still require designer supervision in terms of compliance with local regulations and structural correctness. Therefore, AI systems should clearly be positioned not as substitutes for designers but as supportive technologies enhancing the creative process.

Looking ahead, AI tools are expected to become more fully integrated with BIM systems, to automate sustainability analyses, and to expand the use of digital twin applications. In architectural education, these platforms should be considered not only as visual production tools but also as pedagogical instruments supporting critical thinking and design development. Accordingly, the development of ethical principles guiding AI use, the expansion of user training, and the establishment of policy-based regulations are seen as necessary steps.

In conclusion, this study contributes to both academic literature and professional practice by systematically presenting the potentials and limitations of AI tools in architectural project processes. AI is clearly expected to take a more central role in architecture in the future; however, this transformation must be managed through an approach that preserves designer control, ensures ethical responsibility, and places contextual sensitivity at its core.

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Chapter 6

CONTEMPORARY ARCHITECTURAL MATERIAL SYSTEMS: A COMPARATIVE PERFORMANCE AND SUSTAINABILITY ASSESSMENT OF EMERGING BUILDNG MATERIALS*

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1. INTRODUCTION

This study examines advanced material systems that are becoming increasingly influential in contemporary architectural and construction practice through a holistic perspective rather than through isolated technical attributes. Instead of evaluating materials solely in terms of individual properties such as strength or structural capacity, the research considers multiple performance dimensions including mechanical performance, thermal behaviour, acoustic capacity, fire resistance, sustainability, applicability, and life cycle based economic feasibility. Through the assessment of a wide spectrum of materials ranging from carbon fibre reinforced composites and self-healing systems to aerogels, phase change materials, biomaterials, additive manufacturing technologies, nanomaterials, and smart glazing systems, the study demonstrates that material selection can no longer be explained only through load bearing capacity, strength, or structural adequacy. Contemporary architectural production increasingly requires a reconsideration of the relationship between the micro scale composition of materials and their macro scale environmental, structural, and operational performance. In this context, the study proposes an interdisciplinary evaluation framework that integrates material knowledge with building physics, building technology, sustainable design, and performance based architectural decision-making processes.

The primary gap motivating this research lies in the tendency of contemporary architectural material literature to examine advanced materials either through a single performance parameter or within the boundaries of a particular material class. A substantial portion of existing studies focus on limited perspectives such as thermal insulation efficiency, mechanical strength enhancement, or sustainability potential, which restricts the ability to understand the multifunctional role of materials within architectural systems. In the contemporary built environment, materials are no longer merely envelopes or structural components. They operate as active performance regulators that simultaneously influence energy optimization, occupant comfort, maintenance cycles, fire safety, acoustic quality, and environmental impact. Addressing this limitation, the present study comparatively examines diverse material technologies within a unified analytical framework and highlights the necessity of adopting an integrated performance perspective in architectural material selection.

The main objective of the study is to analyse advanced material systems that have gained prominence in contemporary architecture through a multi criteria evaluation framework and to systematically reveal their technical, environmental, and operational potential for architectural applications. Within this framework, the research evaluates mechanical behaviour, thermal and acoustic interaction, fire response, carbon footprint implications, cost, and applicability simultaneously, while also incorporating a critical examination of risks, limitations, and certification challenges. Consequently, the study does not merely attempt to answer the question of which material demonstrates higher performance. It also addresses the more complex question of under which conditions, within which architectural contexts, and according to which life cycle priorities and application constraints a particular material system becomes the most rational option. In this sense, the research establishes an analytical framework that connects material performance with contextual architectural decision-making processes.

The originality of the study lies in the comparative examination of innovative material systems with markedly different characteristics through common performance parameters and in supporting this comparison not only with technical data but also with considerations of architectural applicability, risk, and sustainability. Material systems that are often examined within separate disciplinary domains such as carbon composites, phase change materials, smart glazing technologies, nano enhanced concretes, metal foams, bio-based construction materials, and hydrophobic surface technologies are interpreted here within the same decision space. This approach provides a meaningful contribution not only to material science but also to architectural design and construction practice. In particular, the comparative matrix analysis enables the relative strengths and limitations of different materials to be interpreted in a clear and accessible manner, offering a decision support framework for designers, researchers, building technology specialists, and practitioners. The study therefore transforms material knowledge from a purely descriptive body of information into a strategic form of design knowledge and proposes a distinctive methodological contribution.

The scope of the research is intentionally broad and represents one of its most significant scientific contributions. The study incorporates not only laboratory scale performance data but also documented real world architectural applications, construction techniques, relationships between materials and scale, and potential risks that may arise during implementation. The evaluation therefore encompasses new construction as well as strengthening and adaptive reuse processes, building envelope systems as well as interior components, and both structural and non-structural applications. In addition, the sustainability perspective of the research extends beyond carbon reduction to include life cycle-oriented variables such as operational energy demand, maintenance frequency, service life, resource efficiency, and circular economy potential. Through this approach the study examines the role of advanced materials in architecture in a multilayered manner that considers not only technical suitability but also system integrity, environmental impact, and application strategies.

The significance of the study stems from its proposal of an approach that redefines material selection in response to the increasingly complex performance expectations of the built environment. Climate change, energy efficiency requirements, carbon reduction targets, fire safety regulations, expectations of occupant comfort, and pressures for economic sustainability are collectively directing the architecture and construction sectors toward smarter, more adaptive, and longer lasting material solutions. The findings demonstrate that this transformation cannot be achieved solely through the development of innovative materials. It also requires systematic performance verification, life cycle evaluation, regulatory compatibility, and carefully considered architectural integration strategies. In this respect the study contributes to academic discourse by introducing new perspectives for discussion while simultaneously providing a conceptual and analytical foundation that can guide performance-oriented material decision making in practice. Ultimately the research positions advanced material systems not merely as technological innovations but as essential components of environmental responsibility, structural reliability, and integrated design intelligence within the architecture of the future.

2. METHOODOLOGY

This research is based on a multi stage analytical methodology aimed at holistically evaluating advanced material systems used in contemporary architecture and construction technologies in terms of performance, sustainability, and applicability. The study adopts a systematic research design that combines qualitative literature review, analytical synthesis of performance parameters, and a comparative evaluation approach. Within the scope of the research, contemporary architectural material categories including carbon fibre composites, self-healing materials, transparent concrete, aerogel systems, phase change materials (PCM), biomaterials, additive manufacturing materials (3D printing), graphene and nanomaterials, smart glazing technologies, metal foams, and hydrophobic surface technologies were examined. These materials were selected because they represent material groups that are increasingly used in architectural applications and that influence building performance in multiple dimensions.

In the first stage of the research, a comprehensive literature review was conducted. During this process, scientific articles, technical reports, engineering databases, and application reports published in the fields of architecture, building technology, materials engineering, and sustainable building systems were examined. The literature review particularly focused on the microstructural properties, mechanical behaviour, thermal performance, acoustic characteristics, fire resistance, and sustainability indicators of materials. Through this investigation, the performance parameters of each material system and their modes of use in architectural applications were identified. The collected data were evaluated from an interdisciplinary perspective and systematically classified in a manner that reveals the relationship between architectural design and building technology.

In the second stage of the research, a performance evaluation framework was developed in order to compare the performance characteristics of the examined materials. This framework was structured around five core performance parameters that are critical in architectural applications: mechanical performance, thermal performance, acoustic behaviour, fire resistance, and sustainability indicators. Mechanical performance encompasses properties such as strength, stiffness, load bearing capacity, and structural reliability. Thermal performance includes criteria such as thermal conductivity, energy storage capacity, and contribution to building energy efficiency. Acoustic performance evaluates the effects of materials on sound absorption, vibration damping, and acoustic comfort. Fire resistance reveals the performance of materials in terms of high temperature stability, combustibility characteristics, and fire safety. Sustainability assessment includes criteria such as carbon footprint, energy efficiency, life cycle impacts, and resource efficiency.

In the third stage, the practical applicability of the materials in architectural applications was evaluated. Each material system was analysed through documented examples from real construction applications. The applicability analysis considered criteria such as compatibility with existing construction technologies, ease of integration into construction processes, economic feasibility, maintenance requirements, and impacts on architectural design. In addition, potential application areas of the materials within façade systems, building envelopes, interior applications, and structural strengthening strategies were evaluated. This approach aims to reveal the relationship between laboratory-based material performance data and real architectural implementation.

In the fourth stage of the research, risks and limitations associated with the examined material systems were analysed. This analysis included factors such as technological complexity, production costs, scalability issues, durability uncertainties, environmental sensitivities, and regulatory constraints. The purpose of this stage was to highlight not only the advantages of advanced materials but also the potential technical and economic barriers that may arise in architectural applications. In this way, the study provides a realistic assessment of material technologies and makes visible the decision related risks that may be encountered in architectural design and construction processes.

In the final stage of the research, all examined material categories were evaluated through a comparative analysis matrix. Within this matrix, materials were assessed according to criteria including mechanical performance, acoustic properties, thermal performance, fire resistance, carbon footprint, cost, applicability, and overall architectural potential. During the evaluation process, qualitative performance levels such as low, moderate, and high were used in order to reveal the relative strengths and limitations of each material system. This comparative approach enables the analysis of how different material technologies can be positioned within architectural design processes and provides a structured basis for performance-based material selection.

3. NEXT-GENERATION CONSTRUCTION MATERIALS

3.1. High-Performance Fiber Composites: Carbon Fiber Systems

In the literature, carbon fibres are widely recognized as one of the most important reinforcement elements in advanced composite materials due to their high strength, high elastic modulus, and low-density characteristics (Fitzer & Manocha, 1998; Chung, 2016; Özçakır, 2024). Carbon fibers generally contain more than 92 percent carbon by weight, while fibres with even higher carbon content are commonly classified as graphite fibres (Huang, 2009). Owing to these properties, carbon fibre-based materials are extensively utilized in high performance sectors such as aerospace, automotive engineering, and structural applications within construction engineering. Depending on the precursor materials used in their production, several types of carbon fibres have been developed, including PAN based, pitch based, and bio-based carbon fibres. Among these, PAN based carbon fibres represent the most widely used category due to their superior tensile strength and mechanical performance (Wang et al., 2006; Kjell et al., 2011). In contrast, pitch-based carbon fibres are often preferred in specialized engineering applications because of their high modulus and superior thermal conductivity properties (Yang et al., 2014; Liu et al., 2024). Bio based carbon fibres, which can be produced from renewable resources such as lignin and cellulose, have recently attracted significant attention in sustainable material research due to their potential to reduce reliance on fossil-based precursors (Zamani et al., 2021; Sharma et al., 2025).

Carbon fibres can be combined with different matrix systems to produce a wide variety of composite materials. Carbon fibre reinforced polymer matrix composites are widely employed in the aerospace and automotive industries because of their high specific strength and low-density characteristics (Kessler, 2012; Mallick, 2017). Carbon fibre reinforced metal matrix composites combine the high strength of carbon fibres with the toughness and thermal resistance of metals, making them particularly advantageous for applications in high temperature environments (Shirvanimoghaddam et al., 2017). In addition, carbon fibre reinforced cementitious systems provide higher elastic modulus and enhanced durability compared to conventional steel fibre or glass fibre reinforced concrete systems, thereby offering significant performance improvements in structural engineering applications (Afroughsabet et al., 2016; Raza et al., 2021).

3.2. Smart and Self-Healing Construction Materials

Self-healing materials, which are classified within the broader category of smart material systems, have attracted considerable research attention in recent years due to their potential to reduce maintenance requirements and extend the service life of structural systems. These materials are generally defined as systems capable of autonomously restoring their structural integrity to a certain extent after mechanical or environmental damage occurs (Wool, 2008; Hager et al., 2010). Various technological approaches have been developed to enable self-healing functionality, most commonly including microencapsulation, vascular network systems, and microbial mechanisms. In microcapsule-based systems, healing agents are stored within microcapsules embedded in the material matrix and are released when cracks propagate, thereby filling and repairing the damaged region (Liu et al., 2023; Kontiza & Kartsonakis, 2024). In contrast, vascular network systems mimic biological circulatory structures by incorporating interconnected microchannels that transport healing agents toward damaged zones within the material (Lee et al., 2018; Shields et al., 2021).

Microbial concrete technology represents another biologically inspired approach to self-healing materials. In this system, bacteria embedded within the concrete matrix produce calcium carbonate through metabolic processes, which subsequently precipitates within cracks and seals them (De Muynck et al., 2010; Van Wylick et al., 2021). This mechanism has the potential to significantly enhance the durability of concrete structures while simultaneously reducing long term maintenance costs. However, several challenges continue to limit the widespread application of these technologies. High production costs, limited repeat healing capacity, and insufficient effectiveness in repairing large structural cracks remain among the major constraints identified in the literature (Choi et al., 2023).

3.3. Energy-Efficient and Thermal Performance-Oriented Materials

Among next generation materials developed in line with energy efficiency and sustainability objectives, transparent concrete, aerogels, and phase change materials occupy a significant position. Transparent concrete is defined as a construction material capable of transmitting light through the integration of optical fibres within the cement matrix (Palanisamy et al., 2022; Sharma & Gupta, 2018). This technology offers the potential to increase the use of natural daylight in façade and interior applications, thereby contributing to the reduction of energy consumption associated with artificial lighting systems.

Aerogels, on the other hand, are porous materials characterized by extremely low density and exceptionally low thermal conductivity, which makes them highly suitable for high performance insulation applications (Pierre & Pajonk, 2002; Ratke & Gurikov, 2021). Similarly, phase change materials (PCM) regulate indoor temperature fluctuations by storing large amounts of latent heat during phase transitions (Cui et al., 2017; Raoux, 2009). Through this mechanism, PCM systems contribute to thermal stabilization within buildings and are increasingly integrated into passive energy design strategies aimed at improving energy efficiency in the built environment.

3.4. Sustainable Materials: Biomaterials and Circular Material Strategies

In the literature on sustainable building materials, biomaterials are defined as alternative material systems derived from renewable biological resources and characterized by their potential to reduce carbon footprints (Doshi et al., 2018; Santos et al., 2021). Biopolymers such as cellulose and lignin are widely utilized as fundamental structural components in the production of bio composites. These materials offer several advantages, including high renewability, biodegradability, and environmental compatibility, which contribute to their growing relevance in sustainable construction research (Fan et al., 2022).

Fungal and mycelium-based biomaterials, in particular, are considered promising due to their lightweight and thermally insulating properties resulting from porous structures formed through biological growth processes (Pandit et al., 2018; Porta et al., 2022). However, the performance of biomaterials can be influenced by several factors, including variability in raw material characteristics, sensitivity to moisture, and limitations related to large scale production and industrial scalability (Wool & Sun, 2011; Yang et al., 2024). For this reason, the potential of biomaterials in architectural applications is increasingly being examined within the broader frameworks of life cycle assessment and circular economy strategies, which aim to evaluate their environmental performance throughout the entire life cycle of building materials (Carcassi et al., 2022).

3.5. Advanced Materials: Nanotechnology, 3D Printing and Smart Systems

In recent years, nanotechnology and digital manufacturing techniques have introduced significant innovations in the fields of architecture and building technologies. Three-dimensional printing technologies enable the production of complex geometries through layer-based manufacturing processes, thereby improving efficiency in construction while simultaneously reducing material waste (Kerr, 2023; Sandhu et al., 2022). Within this technological framework, a variety of materials including concrete, polymers, metals, and bio-based materials are commonly employed as primary feedstock for additive manufacturing processes.

Nanomaterials, on the other hand, represent an important class of additives used to enhance the mechanical, chemical, and surface properties of construction materials. Nanomaterials such as nanosilica, nano titanium dioxide, and carbon nanotubes have been shown to improve durability and surface performance in concrete and coating systems (Chen et al., 2020; Gogotsi, 2006). In addition, two-dimensional carbon structures such as graphene have gained considerable attention as reinforcement elements in advanced composite materials due to their exceptional strength to weight ratio and superior electrical conductivity properties (Geim & Novoselov, 2007; Li et al., 2016). Furthermore, adaptive material technologies including smart glazing systems and hydrophobic coatings enable building envelopes to respond dynamically to environmental conditions, thereby improving both energy efficiency and occupant comfort in architectural applications (Casini, 2014; Lampert, 2003).

4. Comparative Assessment of Next-Generation Architectural Materials: Performance, Sustainability, Applicability, and Risk Dimensions

4.1. Performance-Based Material Assessment Framework

Contemporary architectural material systems are no longer evaluated solely on the basis of load-bearing capacity or structural adequacy; instead, they are assessed through multi-layered criteria including mechanical performance, thermal regulation, acoustic behaviour, fire resistance, durability, and environmental impact. When advanced composites, bio-based materials, additive manufacturing systems, smart glazing technologies, metal foams, nanomaterials, aerogels, phase change materials, and hydrophobic surfaces are considered collectively, it becomes evident that factors such as microstructural configuration, porosity, phase behaviour, surface chemistry, and interfacial bonding play a decisive role in material selection. Within this framework, architectural materials must be understood not as single-function elements but as multifunctional performance components that actively contribute to the overall behaviour of the built environment.

4.2. Performance Characteristics of Carbon Fiber Composites

Carbon fibre reinforced composites have gained prominence in architectural and engineering applications due to their ability to exhibit high specific strength, high stiffness, fatigue resistance, dimensional stability, and corrosion resistance despite their low density. In particular, polymer matrix systems demonstrate exceptionally high tensile strength, elastic modulus, and impact tolerance, while their near zero thermal expansion coefficients support geometric stability under temperature fluctuations. Carbon fibre reinforced metal matrix composites offer advantages in environments requiring high temperature resistance and enhanced thermal conductivity. Similarly, ceramic and carbon matrix systems demonstrate superior fire resistance and dimensional stability under extreme thermal conditions. However, the fire behaviour of these composites varies depending on the matrix type, and polymer-based systems in particular remain sensitive to elevated temperatures, which represents a significant limitation in high temperature applications.

4.3. Performance Improvements in Cement-Based and Self-Healing Systems

In cement-based composites, fibre reinforcement has demonstrated significant positive effects particularly on crack control, compressive strength, elastic modulus, and long-term durability. Carbon fibre reinforced concrete systems can exhibit higher mechanical performance compared to conventional steel fibre or glass fibre reinforced alternatives. In addition, microbial and capsule based self-healing systems autonomously seal cracks, thereby reducing permeability, improving durability, and extending the service life of structural elements. These systems contribute not only to mechanical performance but also indirectly support thermal stability and material integrity by limiting moisture penetration into the structural matrix.

4.4. Transparent Concrete, Bio-Based Materials, and Additive Manufacturing Systems

Transparent concrete is considered a hybrid material system that combines structural continuity with daylight transmission through the integration of optical fibre reinforcement. Although it may exhibit a limited reduction in mechanical strength compared to conventional concrete, it attracts attention in terms of environmental performance due to its potential to enhance natural lighting within built environments. Bio based materials, on the other hand, derived from cellulose, lignin, fungal, and mycelium structures, offer characteristics such as low density, porosity, sound absorption, and thermal resistance. These properties make them particularly relevant in achieving acoustic and thermal comfort objectives in architectural applications. Meanwhile, materials used in additive manufacturing systems exhibit anisotropic behaviour that varies depending on rheological control, layer bonding, and printing direction. This characteristic indicates that the mechanical performance of such materials is closely linked to the specific production process employed during fabrication.

4.5. Performance Contributions of Nanomaterials, Aerogels, Phase Change Materials (PCMs), and Smart Glass

Nanomaterials such as graphene, carbon nanotubes, nanosilica, and nanoclays enhance mechanical and durability performance in composite matrices by improving stress transfer, increasing crack resistance, and refining pore structures. Aerogels, in contrast, are distinguished by their extremely low thermal conductivity and high porosity, which makes them highly effective insulation materials; silica aerogels in particular also attract attention due to their notable fire resistance. Phase change materials (PCMs) regulate indoor temperature fluctuations through their latent heat storage capacity, thereby reducing overall energy demand in building environments. Smart glazing systems further improve the environmental performance of building envelopes by dynamically controlling solar heat gain and light transmission; however, their acoustic and fire behaviour largely remains dependent on the inherent properties of the base glass material.

4.6. Integrated Performance Characteristics of Metal Foams and Hydrophobic Surfaces

Metal foams are regarded as multifunctional materials that integrate low density, energy absorption capacity, acoustic attenuation, and thermal regulation within a single structural system. Owing to their porous architecture, they provide advantages in terms of lightweight performance and controlled deformation while simultaneously absorbing sound waves and limiting heat transfer. Hydrophobic and superhydrophobic surfaces, in contrast, enhance the durability of construction materials by reducing water adhesion, capillary absorption, and moisture penetration. By preventing moisture related degradation, these surface technologies help maintain insulation performance and improve the self-cleaning capacity of building surfaces. When considered together, these two material systems illustrate how contemporary material design increasingly integrates surface engineering with structural performance in order to achieve multifunctional behaviour in the built environment.

4.7. Carbon Reduction and Life Cycle Assessment in Sustainability

The sustainability contribution of the materials examined in this study is primarily evaluated along three main dimensions: reduction of carbon footprint, improvement of energy efficiency, and the achievement of economic efficiency throughout the life cycle. Bio based carbon fibres reduce dependence on fossil resources by utilizing biomass based raw materials and contribute indirectly to emission reduction through enhanced durability. Self-healing materials, on the other hand, decrease material consumption and associated embodied carbon by reducing the frequency of maintenance and repair interventions. This assessment demonstrates that sustainability is not determined solely by the origin of a material but is also closely related to the continuity of performance it provides throughout its service life.

4.8. Energy-Efficient Materials and the Reduction of Operational Emissions

Certain materials evaluated in this study, particularly transparent concrete, aerogels, phase change materials (PCMs), and smart glazing systems, contribute directly to reducing operational energy demand in buildings. Transparent concrete enhances the transmission of natural daylight into interior spaces, thereby decreasing the reliance on artificial lighting. Aerogels provide superior thermal insulation, which helps reduce heating and cooling loads within buildings. Phase change materials stabilize indoor temperature fluctuations through latent heat storage, consequently lowering dependence on HVAC systems. Smart glazing technologies regulate solar radiation and visible light transmittance, which contributes to reductions in both lighting and cooling energy consumption. A common characteristic of these materials is their ability to strengthen environmental performance by directly reducing operational carbon emissions in the built environment.

4.9. Environmental Potential of Biomaterials, Additive Manufacturing and Nanomaterials

Biomaterials and bio-based composites have gained a strong position among sustainable construction materials due to their derivation from renewable resources, their potential for biodegradability, and in some cases their ability to store biogenic carbon. Additive manufacturing systems further contribute to sustainability by allowing materials to be applied only where structurally required, thereby minimizing waste. In addition, the possibility of localized production reduces carbon emissions associated with transportation and logistics. Advanced additives such as nanomaterials and graphene enhance durability as well as thermal and mechanical performance even when used in very small quantities, enabling higher performance with reduced material consumption. However, the sustainability potential of these materials must be evaluated in conjunction with life cycle assessments and considerations related to production scalability.

4.10. Architectural Applicability: Integration into Real-World Construction Practices

The majority of the materials examined in this study are no longer limited to experimental laboratory developments but have begun to be implemented in real architectural applications. CFRP laminates are increasingly used in the structural strengthening of existing buildings, while self-healing concrete has been applied in durability-oriented infrastructure systems. Transparent concrete is utilized in architectural surfaces that emphasize daylight transmission and visual experience. Aerogel based plasters are applied in conservation practices to improve thermal performance without significantly altering historic fabric, while PCM panels are used to introduce thermal mass in lightweight building structures. Similarly, bio-based construction systems such as straw bale construction are employed in low impact building strategies. These examples demonstrate that advanced materials in architecture possess not only theoretical potential but also practical applicability within contemporary construction practices.

4.11. Risks, Limitations and Barriers to Implementation

Despite the significant advantages associated with each material category, they are also accompanied by notable risks and limitations. The anisotropic behaviour of carbon fibre, its susceptibility to oxidation at high temperatures, and its sensitivity in alkaline environments represent important technical constraints. Self-healing systems, while promising, remain limited by high costs, restricted repeat healing capacity, and insufficient effectiveness in repairing large cracks. Transparent concrete requires highly controlled and precise manufacturing processes, while aerogels suffer from inherent brittleness that restricts their structural use. Phase change materials present challenges related to low thermal conductivity and the risk of leakage during phase transitions. Bio based materials may exhibit variability in raw material properties and sensitivity to moisture, which can affect long term performance. Additive manufacturing systems continue to face regulatory gaps and structural uncertainties due to the absence of comprehensive building codes and standardized guidelines. Graphene and other nanomaterials raise concerns regarding scalability, as well as potential environmental and health implications. Smart glazing systems are often constrained by high costs and maintenance requirements, while metal foams involve relatively high production expenses. Similarly, hydrophobic surface technologies may experience performance degradation over time. Consequently, a considerable gap still exists between the technical potential of these materials and their widespread implementation in real architectural practice.

4.12. Comparative Matrix Approach and Overall Assessment

The comparative matrix approach proposed in the final section of this study aims to systematically evaluate different material systems based on criteria including mechanical performance, acoustic properties, thermal behaviour, fire resistance, carbon footprint, cost, applicability, and overall potential. The use of a qualitative scale ranging from low to very high enables the relative strengths and limitations of each material to be interpreted within a unified framework. This approach demonstrates that material selection should not be understood as a single technical decision, but rather as a multi criteria balance established among performance, environmental impact, economic considerations, and practical applicability. Consequently, the study highlights that the future of advanced architectural materials will be shaped not only by technological innovation but also by life cycle thinking, regulatory compliance, economic feasibility, and integrated design strategies (Table 1).

Table 1. *Comparative Matrix of Advanced Architectural Materials*

Material Category	Material Type	Mechanical Performance	Acoustic	Thermal	Fire Resistance	Carbon Footprint	Cost	Applicability	Overall Potential
Carbon Fiber Composites	Polymer Matrix Composite	Very High	High	High	–	–	High	High	Very High
	Metal Matrix Composite	Very High	–	Very High	–	–	High–Moderate	High	High
	Ceramic Matrix Composite	Very High	–	Very High	Very High	–	–	Moderate	High
	Carbon Matrix Composite	Moderate	–	Very High	–	–	Very High	Moderate	High
	Cement Matrix Composite	Very High	–	–	–	Moderate	Very High	Very High	Very High
Self-Healing Materials	Capsule-Based Systems	Moderate–High	–	–	–	Moderate	High	Very High	Very High
	Vascular Networks	Moderate–High	–	–	–	Moderate–High	High	Very High	Very High
	Microbial Systems	Moderate–High	–	–	Very High	Moderate–High	High	Very High	Very High
Transparent Concrete	Optical Fiber Reinforced	Moderate–High	–	Moderate–High	–	High	Moderate–High	High	High
Aerogels	Silica-Based	Low–Moderate	–	Very High	Very High	–	High	Moderate–High	High
	Carbon-Based	Moderate–High	–	Moderate–High	Moderate–High	–	High	Moderate–High	High
	Polymer-Based	Moderate–High	–	Moderate–High	Moderate	–	High	High	High
Phase Change Materials (PCM)	Organic	Moderate	–	High	Low–Moderate	–	Moderate–High	High	High
	Inorganic	Moderate	–	Very High	High	–	High	Moderate–High	High
	Eutectic	Moderate	–	Very High	High	–	High	High	Very High
Bio-Based Materials	Cellulose-Based	Moderate–High	Moderate	Moderate	Low–Moderate	Very High	Moderate	Moderate–High	Very High
	Lignin-Based	Moderate–High	Low–Moderate	Moderate–High	Moderate	Very High	Moderate	Moderate–High	High
	Fungal-Based	Moderate	High	Moderate–High	Low–Moderate	Very High	Moderate–High	Moderate–High	High
	Mycelium-Based	Moderate	High	Moderate–High	Low–Moderate	Very High	Moderate–High	Moderate–High	High
3D Printing Materials	Concrete	Very High	–	Moderate–High	Moderate–High	Moderate–High	Moderate–High	Moderate–High	Very High
	Polymer	Moderate–High	–	Moderate	Low–Moderate	Moderate	Moderate	Moderate–High	Moderate–High
	Bio-Based	Moderate–High	–	Moderate–High	Low–Moderate	Very High	Moderate–High	Moderate–High	High
	Metal	Very High	–	High	High	Low–Moderate	High	Moderate–High	Very High
Graphene Reinforced Systems	Graphene Composites	Very High	–	Very High	–	Moderate–High	High	Moderate–High	Very High
Nano-Enhanced Concrete	Nano Silica	Moderate–High	–	Moderate–High	–	Moderate	Moderate	Moderate	Moderate–High
	Nano Titanium	Very High	–	High	–	Moderate–High	High	Moderate–High	High
	Nano Clay	Moderate	–	Moderate	–	Low–Moderate	Moderate	Moderate	Moderate

Material Category	Material Type	Mechanical Performance	Acoustic	Thermal	Fire Resistance	Carbon Footprint	Cost	Applicability	Overall Potential
Smart Glass	Electrochromic	–	–	Moderate–High	–	–	High	Moderate	High
	Thermochromic	–	–	Moderate	–	–	Moderate–High	Moderate	Moderate–High
	Photochromic	–	–	Moderate–High	–	–	Moderate–High	Moderate	Moderate–High
Metal Foams	–	Moderate–High	High	Moderate	–	–	High	Moderate	High
Hydrophobic Coatings	–	Moderate	–	–	–	Moderate	High	High	High

Note: Performance levels are evaluated qualitatively using a five-level scale: Low, Low–Moderate, Moderate, Moderate–High, High, and Very High.

5. Conclusions and Recommendations

This research demonstrates that contemporary architectural material systems should no longer be evaluated solely through isolated performance criteria, but rather within a holistic and multi scale performance framework in which mechanical reliability, thermal regulation, acoustic behaviour, fire resistance, sustainability performance, and practical applicability are assessed simultaneously. The findings clearly indicate that microstructural design strategies such as fibre reinforcement, porosity control, interface engineering, phase behaviour, nano scale modifications, and additive manufacturing techniques directly influence architectural performance at the macro scale.

Within this context, when carbon fibre composites, nano reinforced systems, metal foams, aerogels, phase change materials, smart glazing technologies, bio-based materials, additive manufacturing systems, hydrophobic surface treatments, and self-healing mechanisms are considered collectively, a clear paradigm shift in architectural material thinking becomes evident. In this emerging perspective, materials no longer function merely as structural components but rather operate as active performance regulators within the building envelope and structural system. Mechanical performance is shaped through density optimization, reinforcement strategies, and interface bonding, while thermal behaviour is controlled through conductivity management, solar modulation, phase transitions, and moisture regulation. Acoustic performance arises from fibrous and porous micro architectures, whereas fire resistance is largely determined by matrix composition, oxidation stability, and combustibility characteristics.

The sustainability findings of the study reveal a strong relationship between carbon emission reduction, operational energy savings, improved material durability, and life cycle economic performance. The use of renewable raw materials, lightweight design strategies, material efficiency, reduction of manufacturing waste, passive thermal regulation approaches, daylight transmission systems, and adaptive façade technologies collectively reduce environmental impact while maintaining structural and functional performance.

However, the risk and limitation analyses indicate that the widespread application of these materials still faces several technical and economic barriers. High production costs, technological complexity, anisotropic behaviour, uncertainties in long term durability, environmental sensitivities, gaps in regulatory frameworks, and scalability challenges represent the most significant obstacles. Therefore, the advancement of sustainable architectural material systems depends not only on technological innovation but also on the development of regulatory infrastructure, standardization processes, and economic feasibility studies.

The applicability analysis confirms that many of the examined materials have moved beyond laboratory scale experimentation and have begun to appear in real architectural and construction practices. Carbon fiber reinforced composites are increasingly used in structural strengthening strategies, self-healing concrete systems are applied in durability-oriented infrastructure solutions, aerogel-based insulation systems are employed in energy efficient façade upgrades, and phase change materials are integrated into passive thermal regulation systems. Similarly, additive manufacturing technologies and nanotechnology-based materials are becoming increasingly visible within contemporary architectural production processes.

Nevertheless, broader adoption of these technologies requires further progress in areas such as long-term performance reliability, certification procedures, compatibility with existing construction systems, and economic scalability. Consequently, the integration of advanced material technologies into architectural practice is directly related not only to technical performance but also to engineering coordination, regulatory compliance, and economic sustainability. Based on the findings of this research, the following recommendations are proposed:

· *Adoption of Integrated Performance Based Material Selection Frameworks:* Architectural material selection processes should not rely solely on individual performance parameters. Instead, decision making models should be developed based on holistic life cycle analyses that simultaneously evaluate mechanical, thermal, acoustic, fire, environmental, and economic criteria.

· *Prioritization of Durability Based Carbon Reduction Strategies:* Extended service life significantly reduces the total carbon emissions generated throughout the life cycle of building materials. Therefore, self-healing systems, nano reinforced concretes, hydrophobic coatings, and corrosion resistant composite systems should be strategically applied in structurally critical building components.

· *Systematic Verification of Fire and High-Temperature Performance:* Material systems whose fire behaviour depends on matrix composition, such as polymer-based composites and certain bio-based materials, should undergo comprehensive fire performance testing before being integrated into structural or façade applications.

· *Improvement of Interface Engineering and Microstructural Control:* The performance of advanced materials largely depends on interface bonding quality, porosity distribution, and phase stability. Therefore, interface design and microstructural control should be further optimized in fibre reinforced composites, nano enhanced systems, and additive manufacturing technologies.

· *Development of Standardization and Certification Processes:* Regulatory frameworks and standardized testing protocols should be developed for emerging technologies such as three-dimensional printed concrete, graphene reinforced systems, aerogels, phase change material integrations, and self-healing materials.

· *Promotion of Hybrid System Integration:* Phase change materials, aerogels, smart glazing technologies, and hydrophobic coatings may exhibit limited performance when applied individually. For this reason, these materials should be considered as hybrid components within holistic environmental design strategies.

· *Conducting Long-Term Environmental and Health Impact Assessments:* Comprehensive life cycle analyses should be carried out for nanomaterials and advanced composite systems in order to evaluate potential emission risks and environmental impacts.

· *Evaluation of Initial Investment Costs Through Life-Cycle Economic Analysis:* Advanced materials that involve high initial costs should be assessed through life cycle economic analyses that consider operational energy savings, reduced maintenance costs, and extended service life.

In conclusion, advanced architectural material systems offer transformative potential for the built environment. However, their responsible and effective implementation requires interdisciplinary collaboration, performance verification processes, regulatory support, and comprehensive life cycle assessments. When applied strategically, these materials can simultaneously contribute to structural reliability, energy efficiency, environmental responsibility, and long-term economic sustainability.

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