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CONTACT INFORMATION

Süleyman Demirel University
Deparment of Landscape Architecture, 32260, Isparta/Türkiye.
Phone: +90 (246) 211 3846
dergipark.org.tr/tr/pub/mbud
mbuddergi@gmail.com / atilagul@sdu.edu.tr

@mbuddergi @mbuddergi

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Scenarios for Increasing the Visual Quality of Erzurum City İpekyolu Bridge Intersection with Different Landscape Designs

Kübra GÜRBÜZ [1], Işık SEZEN [2*]

ORCID 1: 0000-0002-0773-2998
ORCID 2: 0000-0003-0304-9072
[1] *Atatürk University, Graduate School of Natural and Applied Sciences Institute of Science, Department of Landscape, 25240, Erzurum, Türkiye.*
[2] *Atatürk University, Faculty of Architecture and Design, Department of Landscape, 25240, Erzurum, Türkiye.*
**** e-mail**: isiksezen@atauni.edu.tr*

Abstract

Landscaping works are needed to eliminate the monotony of concretion caused by bridge intersections, which increases with traffic density in cities. In this study, where the Erzurum city İpekyolu Intersection is the main material, 3 different scenarios have been created to increase the visual quality of the intersection landscape. A total of 4 visual groups consisting of the current situation of the intersection and the scenarios created in the Lumion Program were evaluated. The survey prepared for the analysis was applied to 80 undergraduate and graduate students at Atatürk University Faculty of Architecture. In the analysis, design elements were considered as evaluation criteria. In Scenario 3, which received the highest score, color and color harmony were effective in the side wall visuality. As a result of the research, it was seen that the design scenarios had higher visual quality than the current situations without design.

***Keywords:** Landscape design, İpekyolu bridge intersection, scenario, visual quality analysis, Erzurum.*

Farklı Peyzaj Tasarımları ile Erzurum Kenti İpekyolu Köprülü Kavşağının Görsel Kalitesinin Artırılması Senaryoları

Öz

Kentlerde trafik yoğunluğuyla artan köprülü kavşaklarla oluşan betonlaşmanın monotonluğu gidermek için peyzaj çalışmalarına ihtiyaç duyulmaktadır. Erzurum kenti İpekyolu Köprülü Kavşağı'nın ana materyali oluşturduğu bu çalışmada köprülü kavşağın yan duvar, üst geçit, kavşak peyzaj görselliğini artırmaya yönelik 3 farklı senaryo oluşturulmuştur. Köprülü kavşağın mevcut durumu ve Lumion Programı'nda oluşturulan senaryolardan oluşan toplam 4 görsel grup değerlendirilmiştir. Analiz için hazırlanan anket Atatürk Üniversitesi Mimarlık Fakültesi'nde lisans ve lisansüstü eğitim gören 80 öğrenciye uygulanmıştır. Analizde tasarım unsurları değerlendirme kriterleri olarak ele alınmıştır. En yüksek puanı alan Senaryo 3'de yan duvar görselliğinde renk ve renk harmonisi etkili olmuştur. Araştırmanın sonucunda tasarım senaryolarının, tasarım yapılmayan mevcut durumlardan daha yüksek görsel kaliteye sahip olduğu görülmüştür.

***Anahtar kelimeler:** Peyzaj tasarımı, İpekyolu Köprülü Kavşağı, senaryo, görsel kalite analizi, Erzurum.*

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1. Introduction

Since highways are a structural factor in nature, they need to be harmonized with nature in terms of landscape. Another important reason for this necessity is to ensure the comfort and safety of vehicle drivers in the landscape (Altınçekiç & Altınçekiç, 1996). Landscape arrangements on highways have an effect that arouses curiosity and excitement in drivers (Seçkin, 1997).

The main function of roads and wide boulevards, which determine the direction of development that forms the skeleton of cities, is the comfortable, reliable, easy and comfortable use of pedestrians and vehicles. Especially in planned cities, roads serve as a link between various urban uses and connect urban areas to rural areas (Söğüt, 2005; Yazıcı, 2017).

A bridge intersection is defined as connecting two roads at different levels. The road network that can be used jointly in different directions is called a co-level intersection. According to the research, it has been concluded that 60% of the accidents occurring on the roads inside and outside the city are caused by concurrent intersections. Another negative reason for concurrent intersections is that they increase traffic density and slow down the progress in transportation networks (Yayla, 2011).

Intersections are built at the junction of multiple roads to ensure traffic sustainability. Traffic density can be reduced with interchanges at different levels. Even if the curves at the intersections limit the designs, interchanges provide an excellent result and traffic density control, safety and comfort are supplied by interchanges (Namlı, 2015).

Visual quality has an important effect on the planning and design processes of the elements that make up the landscape. For this reason, determining the possibilities of the landscape structure in determining the visual quality is an important factor in determining the potentials of the elements and components that make up the landscape of the area to be evaluated in terms of visual quality (Ak, 2010).

The use of photography is a very common and valid method for determining aesthetic preferences. This is because it is practical, economical and easily comparable with real natural conditions. According to the studies, it is concluded that there is a link between opinions about real landscapes and opinions about landscape photographs (Kalın, 2004; Kaptanoğlu, 2006; Çakıcı, 2007).

Many national and international studies have been conducted to evaluate the visual quality of urban road landscape and highway landscape. Among these, there are visual quality assessment studies carried out on bicycle paths by Benliay and Soydan (2015), highway by Dere (2017), urban road trees by Sezen et al. (2019), highway route by Yuca and Aşur (2022), bridge junction by Gürbüz and Sezen (2023), and green roads by Zhang et al. (2024).This study aims to create design scenarios to increase the landscape visuality of structures such as side walls, overpasses, bridges and refuges that make up intersections, which are important for solving road networks that have become complex with rapid urbanization and are constantly increasing. In the study carried out in the case of Erzurum City, design scenarios were prepared for the İpekyolu Intersection, which is located in the city and has a high traffic density. The current condition of the intersection and the different scenarios created were evaluated with visual quality analysis, and the most appropriate designs were determined.

2. Material and Method

The main material of this study is the Silk Road Intersection in Erzurum city. The auxiliary materials used in the study are various local and foreign books, theses, articles, etc. The additional materials used in the study are data obtained from multiple local and foreign books, theses, dissertations, articles, etc. and internet search results, photographs obtained by imaging and drone shooting from different angles to define the study area and apply visual quality analysis, Google Earth Pro used to prepare and edit the current site plan of the study area, AutoCAD 2013 used for digitizing the data obtained from Google Earth Pro and transferring the designs in the sketch to the computer, Photoshop CS6 program used to edit the visuals of the scenarios created in line with the data digitized in AutoCAD program, 3Ds Max and SketchUp 2019 used to draw the data digitized in AutoCAD program in a scaled 3D way, Lumion 10.5.1 program, SPSS 20.0 program used for transferring the data of the surveys conducted for the scenarios produced about the study area to the computer and analyzing them.

A total of 32 visual groups were created, consisting of the current status of the intersection and 3 different design scenarios for each intersection. After the current situation photographs and designs were prepared, a visual quality analysis survey form was prepared. The photo and design groups created include 4 images each, including side wall, median, overpass and intersection photos and design scenarios. A total of 128 images were analyzed. Interchange photographs and design scenarios compliance (Güngör, 2005; Karaşah, 2006; Sarı & Karaşah, 2018); balance (Robinson, 2004; Sarı & Karaşah, 2018), emphasis (Uzun, 1999; Sarı & Karaşah, 2018); measure (Booth, 1990; Robinson, 2004; Sarı & Karaşah, 2018) and function, unity (Robinson, 2004; Smith, 2011; Sarı & Karaşah, 2018) and composition, color (Austin, 1982; Booth, 1990; Sarı & Karaşah, 2018), color harmony, naturalness (Bulut et al., 2010), liveliness (Bulut et al., 2010) were scored on a 5-point Likent scale (1 being the lowest to 5 being the highest score).

The reason for choosing İpekyolu Intersection as the subject of the study is to bring movement to its dense, monotonous surfaces and to create awareness. At the same time, it is aimed to contribute to increasing the amount of green space per capita. Within the scope of the intersection used in the study, various written sources and computer programs were used, and alternative scenarios were produced in accordance with the natural and cultural structure of the research area.

In order to evaluate the scenarios created to improve the visual quality of İpekyolu Intersection in Erzurum city with different landscape designs, Daniel (2001), Arriaza et al. (2004), Güngör & Arslan (2004), Önder & Polat (2004), Karahan & Yılmaz (2004), Müderrisoğlu & Eroğlu (2006), Bulut & Yılmaz (2008), Acar & Güneroğlu (2009), Sezen & Yılmaz (2010), Irmak & Yılmaz (2010), Elinç (2011), Turgut et al. (2012), Özhancı & Yılmaz (2013), Sezen (2015), Sezen et al. (2015), Özgeriş & Karahan (2015), Güneroğlu (2017), Sezen et al. (2019) used the Visual Quality Analysis Method in their research.

In the 2020-2021 academic year, the total number of undergraduate students enrolled in Atatürk University Faculty of Architecture and Design and graduate students studying in the departments of the faculty is 1390. In this case, the population size was determined as 1390. A simple random sampling method was used to determine the sample size for the survey study (Karasar, 1982; İslamoğlu, 2003; Özdamar, 2003; Büyüköztürk, 2008; Yazıcıoğlu, 2004). The following formula used by Özdamar (2003) was used to determine the sample size.

Formula 1:

$$n = \frac{N \cdot P \cdot Q \cdot Z_{\alpha}^{2}}{(N-1) \cdot d^{2}}$$

N: Number of population units, n: Sample size
P: Observation rate of X in the universe
Q: (1-P): Unobserved rate of X
$Z\alpha$: 1.96 for α= 0.05
d: Sampling error
For α = 0.05 (d = 0.10) with sampling error (p = 0.3; q = 0.7), the sample size for Atatürk University Faculty of Architecture and Design with a population unit number of 1390;
N=1390*0.3*0.7*(1.96)^2 :(1390-1)*(0.10) =80

The sample size was found to be 80, and the questionnaires of 80 people were evaluated. The SPSS 20.0 Package program was used for the statistical evaluation of the questionnaires. Visual quality analysis was performed using the T-test and ANOVA test. As a result of the analysis, 58,75% of the respondents were between the ages of 25-35, 41,25% between the ages of 18-25, 68,75% female, 31,25% male, 75% Landscape Architecture, 16,25% Architecture, 8,75% Urban and Regional Planning undergraduate and graduate students.

3. Findings and Discussion

İpekyolu intersection is located at the intersection of Fatih Sultan Mehmet Boulevard, Refik Saydam Street and Yenişehir Street. It was constructed by Highways in 2008. Figure 1a and b show the location of the İpekyolu Interchange Interchange. It is located on one of the busiest streets of the city and in a location where the central administration buildings are located. It is also located on the airport road route.

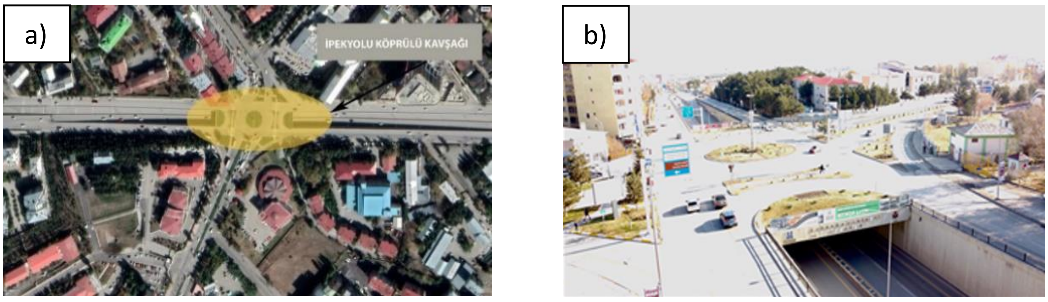


Figure 1. a. Location of the İpekyolu Bridge intersection, **b.** General view of the İpekyolu Bridge Intersection (Gürbüz, 2021)

Figure 2a, b, c, d, e and f show İpekyolu bridge intersection scenarios on vertical garden design and plantation.

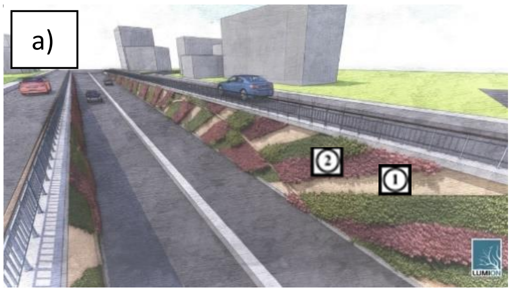


Figure 2.a. İpekyolu bridge Intersection scenario 1 vertical garden design

b. İpekyolu bridge Intersection scenario 1 vegetative design

c. İpekyolu bridge Intersection scenario 2 vertical garden design

d. **İ**pekyolu bridge Intersection scenario 2 plantation

Figure e. İpekyolu bridge Intersection scenario 3 vertical garden design

f. İpekyolu bridge Intersection scenario 3 plantation

As can be seen in Figure 2a and 2b, *Begonia semperflorens* L. (1) and *Juniperus sabina* 'Tamariscifolia' (2) were combined with solid wood in the side wall design in scenario 1 of the İpekyolu interchange. Modular (potted) system from vertical garden systems was preferred in the design. The design principles of rhythm, movement and contrast were utilized. *Robinia pseudoacacia* 'Umbraculifera' (3) *Philadelphus coronarius* L. (4) were used in the intersection design.

In the side wall design of İpekyolu bridge intersection scenario 2, a combination of composite wood and *Begonia semperflorens* L. (1) and *Juniperus sabina* 'Tamariscifolia' (2) was designed. A modular (potted) vertical gardening system was preferred in the design. *Robinia pseudoacacia* 'Umbraculifera' (3) and *Berberis thunbergii* "Atropurpurea" (5) were used in the intersection design (Figure 2c and 2d).

Parthenocissus quinquefolia L. (6) species plants were preferred as living material in the side wall design in scenario 3 of the İpekyolu bridge intersection. A modular (potted) system from vertical garden wall systems was used. The design principles of pattern and rhythm were used. The inanimate materials used in the design are solid wood, and colored insulation felt. A 3-dimensional appearance was aimed to be achieved. In the intersection design, *Prunus cerasifera* 'Pissardii nigra' (7) was used in the central refuge, *Juniperus sabina* 'Tamariscifolia' (2) and *Pinus mugo* 'Mops' (8) were used at the intersection (Figure 2d and 2f). Figure 3a, b, c and d show the existing condition images of the İpekyolu bridge Intersection that were evaluated.

Figure 3.a. Side Wall Visuality -1 (Gürbüz, 2021)

b. Side Wall Visuality -2 (Gürbüz, 2021)

c. Overpass Visuality (Gürbüz, 2021)

d. Central Median Visuality (Gürbüz, 2021)

Table 1 shows the average scores of the side wall, overpass, center median and intersection visuals of the bridge intersection according to the evaluation criteria.

Table 1. Average scores of the bridge intersection according to the evaluation criteria

Bridge Intersection	Evaluation Criteria	The number of participants	Sig. (P)	Average Score	
Side Wall Visuality (SWV)	Technic	80	**0,001****	2,088	**1,911**
	Harmony	80		2,076	
	Balance	80		2,088	
	Emphasis	80		1,763	
	Size and Function	80		2,125	
	Unity and Composition	80		1,975	
	Color and Color Harmony	80		1,675	
	Naturalness	80		1,663	
	Vividness	80		1,750	
Overpass Visuality (0V)	Technic	80	**0,202**	2,225	**2,028**
	Harmony	80		2,250	
	Balance	80		2,038	
	Emphasis	80		1,938	
	Size and Function	80		2,075	
	Unity and Composition	80		1,925	
	Color and Color Harmony	80		1,888	
	Naturalness	80		1,913	
	Vividness	80		2,000	
Central Median Visuality (CMV)	Technic	80	**0,869**	2,050	**1,953**
	Harmony	80		2,038	
	Balance	80		1,988	
	Emphasis	80		1,888	
	Size and Function	80		2,038	
	Unity and Composition	80		1,863	
	Color and Color Harmony	80		1,950	
	Naturalness	80		1,900	
	Vividness	80		1,863	
Intersection Visuality (IV)	Technic	80	**0,033***	2,013	**1,846**
	Harmony	80		1,813	
	Balance	80		1,950	
	Emphasis	80		1,638	
	Size and Function	80		2,125	
	Unity and Composition	80		1,763	
	Color and Color Harmony	80		1,750	
	Naturalness	80		1,788	
	Vividness	80		1,775	
General Average		**80**		**1,935**	

*Significant (p<0.05) **Very Significant (p<0.01)

As can be seen in Table 1, the highest average score in the visual quality assessment of the bridge intersection was given to the OV (2,028). The most influential evaluation criterion in the average score given to the OV is harmony (2,250). IV received the lowest average score (1,846). Emphasis (1,638) are the evaluation criteria that are effective in such a low average score of IV. Among all evaluation criteria, harmony (2,250) received the highest score in OV and emphasis (1,638) received the lowest score in IV. The overall average score for the bridge intersection is 1,935. There are very significant ($p<0.01$) differences between the scores given by the respondents to the evaluation criteria to determine the SWV. The difference between the scores assigned to the evaluation criteria to determine the IV is significant ($p<0.05$). The difference between the scores given to the evaluation criteria to assess (OV) and (CMV) is insignificant ($p>0.05$). Figure 4a, b, c and d show the evaluated images of the İpekyolu Bridge Intersection Scenario 1 (S1).

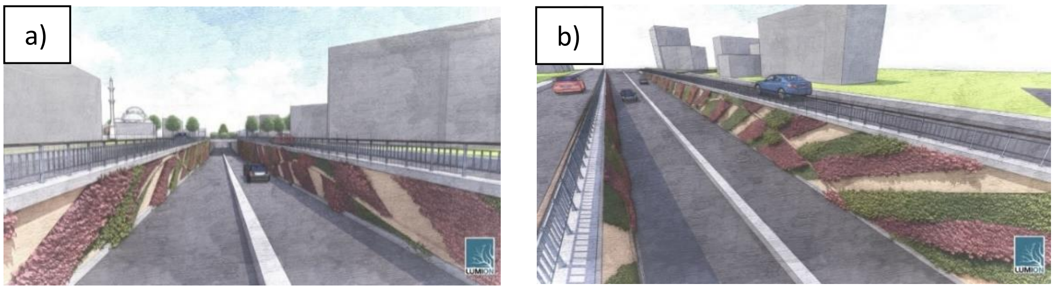
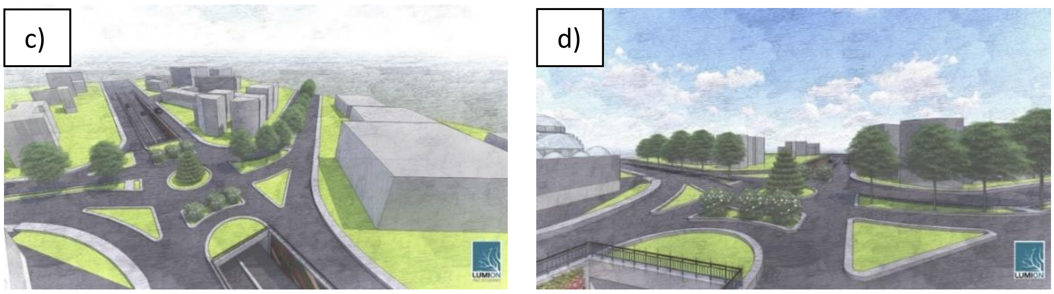


Figure 4.a. Side wall visuality -1 **b**. Side wall visuality -2



c. Overpass visuality **d**. Central median visuality

Table 2 shows the average scores of S1's side wall, overpass, center median and intersection visuality according to the evaluation criteria.

Table 2. Average scores of the S1 intersection according to the evaluation criteria

Bridge Intersection		Evaluation Criteria	The number of participants	Sig. (p)	Average Score	
S1	**Side Wall Visuality (SWV)**	Technic	80		3,775	
		Harmony	80		3,750	
		Balance	80	**0,906**	3,788	**3,760**
		Emphasis	80		3,750	
		Size and Function	80		3,663	
		Unity and Composition	80		3,750	
		Color and Color Harmony	80		3,838	
		Naturalness	80		3,650	
		Vividness	80		3,875	
	Overpass Visuality (0V)	Technic	80		3,888	
		Harmony	80		3,625	
		Balance	80	**0,713**	3,838	**3,750**
		Emphasis	80		3,613	
		Size and Function	80		3,775	
		Unity and Composition	80		3,763	
		Color and Color Harmony	80		3,750	
		Naturalness	80		3,775	
		Vividness	80		3,725	
	Central Median Visuality (CMV)	Technic	80		3,888	
		Harmony	80		3,725	
		Balance	80	**0,564**	3,900	**3,750**
		Emphasis	80		3,588	
		Size and Function	80		3,838	
		Unity and Composition	80		3,700	
		Color and Color Harmony	80		3,725	
		Naturalness	80		3,713	
		Vividness	80		3,675	
	Intersection Visuality (IV)	Technic	80		3,913	
		Harmony	80		3,775	
		Balance	80	**0,723**	3,813	**3,803**
		Emphasis	80		3,646	
		Size and Function	80		3,850	
		Unity and Composition	80		3,825	
		Color and Color Harmony	80		3,750	
		Naturalness	80		3,813	
		Vividness	80		3,838	
	General Average		**80**		**3,766**	

* Significant (p<0.05) **Very Significant (p<0.01)

As seen in Table 2, IV (3,803) received the highest average score in the visual quality assessment of S1. Technic (3,913) was the most influential evaluation criterion in the average score given to IV. OV and CMV received the lowest average score (3,750). The evaluation criteria that were effective in such a low average score for OV and CMV were emphasis (3,588) for CMV and emphasis (3,613) for OV. Among all evaluation criteria, technique in IV received the highest score (3,913), and emphasis in CMV received the lowest score (3,588). The overall average score for S1 is 3,766. The difference between the scores given by the respondents to the evaluation criteria for determining SWV, OV, CMV and IV in the Interchange Scenario 1 (S1) is insignificant (p>0.05). Figure 5a, b, c and d show the evaluated images of the İpekyolu bridge intersection scenario 2 (S2).

Figure 5.a. Side wall visuality -1 **b.** Side wall visuality -2

c. Overpass visuality **d.** Central median visuality

Table 3 shows the average scores of S2 according to the evaluation criteria of the side wall, bridge (overpass), center median and intersection visuality.

Table 3. Average scores of the S2 intersection according to the evaluation criteria

Bridge Intersection		**Evaluation Criteria**	**The number of participants**	**Sig. (p)**	**Average Score**	
S2	**Side Wall Visuality (SWV)**	Technic	80		3,763	
		Harmony	80		3,613	
		Balance	80	**0,978**	3,738	**3,734**
		Emphasis	80		3,713	
		Size and Function	80		3,800	
		Unity and Composition	80		3,700	
		Color and Color Harmony	80		3,775	
		Naturalness	80		3,763	
		Vividness	80		3,738	
	Overpass Visuality (0V)	Technic	80		3,788	
		Harmony	80		3,688	
		Balance	80	**0,948**	3,763	**3,730**
		Emphasis	80		3,663	
		Size and Function	80		3,825	
		Unity and Composition	80		3,663	
		Color and Color Harmony	80		3,738	

	Naturalness	80		3,675	
	Vividness	80		3,763	
Central Median Visuality (CMV)	Technic	80	**0,828**	3,750	**3,681**
	Harmony	80		3,763	
	Balance	80		3,763	
	Emphasis	80		3,663	
	Size and Function	80		3,775	
	Unity and Composition	80		3,600	
	Color and Color Harmony	80		3,625	
	Naturalness	80		3,625	
	Vividness	80		3,563	
Intersection Visuality (IV)	Technic	80	**0,993**	3,900	**3,836**
	Harmony	80		3,850	
	Balance	80		3,875	
	Emphasis	80		3,838	
	Size and Function	80		3,813	
	Unity and Composition	80		3,863	
	Color and Color Harmony	80		3,763	
	Naturalness	80		3,833	
	Vividness	80		3,788	
General Average		**80**		**3,745**	

* Significant (p<0.05) **Very Significant (p<0.01)

As seen in Table 3, IV (3,836) received the highest average score in the visual quality assessment of S2. The most influential evaluation criterion in the average score given to IV was technique (3,900). CMV received the lowest average score (3,681). The most effective evaluation criterion for CMV to have such a low average score was vividness (3,563). Among all evaluation criteria, technique (3,900) received the highest score in IV and vividness (3,563) received the lowest score in CMV. The overall average score for S2 was 3,745. As seen in Table 3, the difference between the scores given by the respondents in Scenario 2 (S2) and the evaluation criteria for determining the SWV, OV, CMV and IV is insignificant (p>0.05).

Figure 6a, b, c and d show the evaluated photographs of the İpekyolu Interchange Scenario 3 (S3).

Figure 6.a. Side wall visuality -1 **b.** Side wall visuality -2

c. Overpass visuality

d. Central median visuality

Table 4 shows the average scores of S3 according to the evaluation criteria of side wall, bridge (overpass), median and intersection visuality.

Table 4. Average scores of the S3 intersection according to the evaluation criteria

Bridge Intersection	Evaluation Criteria	The number of participants	Sig. (p)	Average Score	
Side Wall Visuality (SWV)	Technic	80		4,088	
	Harmony	80		4,050	
	Balance	80	**0,770**	4,150	**4,104**
	Emphasis	80		4,100	
	Size and Function	80		4,113	
	Unity and Composition	80		4,125	
	Color and Color Harmony	80		4,238	
	Naturalness	80		3,925	
	Vividness	80		4,150	
Overpass Visuality (0V)	Technic	80		3,950	
	Harmony	80		3,963	
	Balance	80	**0,999**	3,988	**3,974**
	Emphasis	80		3,938	
	Size and Function	80		3,988	
	Unity and Composition	80		3,988	
	Color and Color Harmony	80		4,025	
	Naturalness	80		4,000	
	Vividness	80		3,925	
Central Median Visuality (CMV)	Technic	80		3,988	
	Harmony	80		3,925	
	Balance	80	**0,916**	3,938	**3,917**
	Emphasis	80		3,813	
	Size and Function	80		3,975	
	Unity and Composition	80		3,975	
	Color and Color Harmony	80		3,938	
	Naturalness	80		3,900	
	Vividness	80		3,800	
Intersection Visuality (IV)	Technic	80		4,013	
	Harmony	80		3,913	
	Balance	80	**0,902**	4,000	**4,020**

	Emphasis	80	3,963
	Size and Function	80	4,088
	Unity and Composition	80	4,075
	Color and Color Harmony	80	4,125
	Naturalness	80	3,975
	Vividness	80	4,025
General Average		**80**	**4,004**

* Significant (p<0.05) **Very Significant (p<0.01)

As can be seen in Table 4, the highest average score in the visual quality assessment of S3 was given to SWV (4,104). Color and color harmony (4,238) was the most influential evaluation criterion in the average score given to the SWV. CMV received the lowest average score (3,917). The most influential evaluation criterion for ORG to have such a low average score was vividness (3,800). Among all evaluation criteria, color and color harmony (4,238) received the highest score in the SWV and vividness (3,800) received the lowest score in the CMV. The overall average score for S3 is 4,004. The difference between the scores given by the respondents in Scenario 3 (S3) and the evaluation criteria for determining the SWV, OV, CMV and IV is insignificant (p>0.05).

The ranking of the average scores given to the existing condition and design scenarios of the interchange is shown in Figure 7.

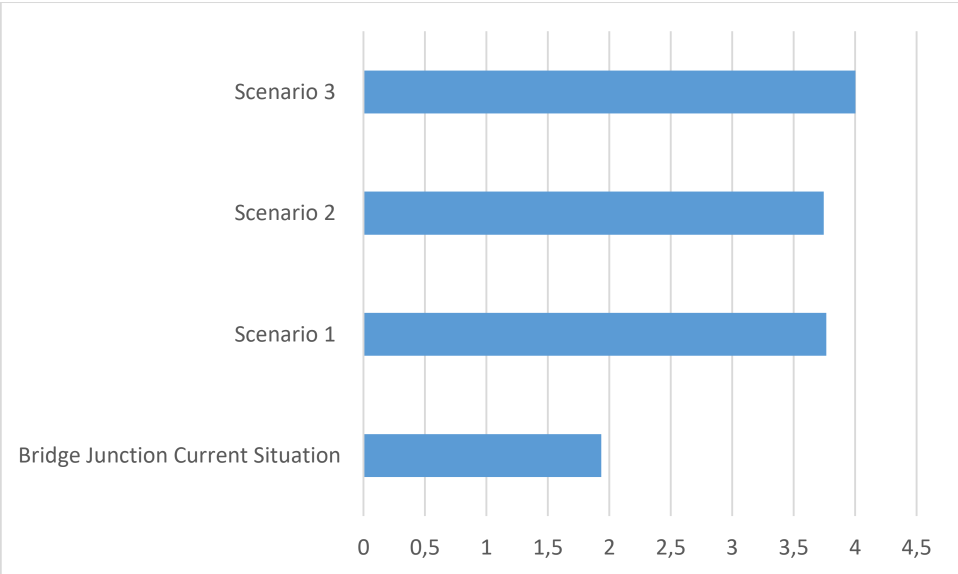


Figure 7. The existing condition of the interchange and average scores given to design scenarios

As can be seen in Figure 7, the scores given to the design scenarios are higher than the scores assigned to the existing condition of the un-designed interchange. Scenario 3 received the highest score among the design scenarios.

In cities with rapid urbanization, the connection with nature is broken due to activities such as rapid population growth and urban transformation. The rate of destruction of nature increases with the effect of variables such as climate change, rapidly developing technology and consumption habits in the area where urban people engaged in trade, industry and service management live. Therefore, landscape architecture studies with urban afforestation, lighting, planting, and water basins have gained importance. Green walls on the sides of highways in big cities are also included (Güleç, 2019).

Cities have to adapt to a constantly developing and changing world and people. For this reason, planning and design processes in cities never end. New designs and plans must be continuously produced in order to meet the increasing and changing demands, population, requirements of the modern age, spatial growth and similar needs. Accordingly, planners and designers must constantly produce new things and renew and improve themselves. In order to create solutions to continually changing needs, many experts from different professional disciplines, designers and planners can work together. For example, landscape architecture, which is a professional discipline that takes into account ecological needs and is carried out as a whole with nature, has long taken its place as one of the important actors of urban studies, especially in developed countries. Urbanization, but also respect, longing and needs for nature, require collaborative work with landscape architects (Bulut & Atabeyoğlu, 2010).

When the scores given are examined, it is seen that the lowest average score is given to the IV in its current condition (1,846), and the evaluation criterion that is effective in the IV having such a low average score is color and color harmony (1,638). It is seen that the effect of color and color harmony is important in visual quality evaluations. As a matter of fact, Şekerci et al. (2016) also stated that color is one of the most important elements of design and that all forms and surfaces in the space are perceived with color differences. According to Akoğlu and Akten (2022), visual perception color is an important factor for its realization. The respondents gave the highest average visual quality score (4,004) to the 3rd scenario (S3) designed for the Silk Road Interchange (Figure 8).

Figure 8. Highest scoring ınterchange among the designed scenario

Parthenocissus quinquefolia L. plant was preferred as living material in the side wall design of İpekyolu interchange scenario 3. As a matter of fact, according to Aslan and Akan (2019), the leaves of *Parthenocissus quinquefolia* L. first turn yellow, orange, then copper and red, and during shedding, they turn into red and red, offering a feast of visual colors in parks and gardens. According to Sağlık et al. (2020), it is a suitable plant for covering walls, trees or structures.

The design principles are based on the principles of pattern and rhythm. The inanimate materials used in the design are solid wood, and colored insulation felt. A 3-dimensional appearance was aimed to be achieved. In the intersection design, *Prunus cerasifera* "Pissardii nigra" plants were used in rows in the central refuge. According to Aslan and Akan (2019), the flowers of *Prunus cerasifera* "Pissardii nigra" bloom in pink, white and red colors in late winter and early spring. This species, which is widely grown for fruit and ornamental purposes, is used in landscaping for its flowers and sometimes for its bark and leaves.

Juniperus sabina 'Tamariscifolia' and *Pinus mugo* ''Mops'' were used at the intersection. According to Özcan (2022), *Juniperus sabina* 'Tamariscifolia' is a suitable plant for highways, squares, parking lots, refuges and avenues. According to Yücel (2012), *Juniperus sabina* 'Tamariscifolia,' an evergreen shrub, is resistant to cold climates; *Pinus mugo* 'Mops' is an evergreen, young shoots yellow, bark grayish-black, needle leaves dark green, used singly or in groups, used on roadsides, has high aesthetic and decorative value, has different forms.

A potted system was used among vertical garden wall systems. The inanimate materials used in the design are solid wood, and colored insulation felt. Color and color harmony (4,238) is the most effective evaluation criterion in the average score given to the SWV. As a matter of fact, Gürbüz and Sezen (2023) concluded that color and color harmony increase the visual quality in the design scenarios they created for Erzurum City Mecidiye Bridge Interchange.

In the visual quality assessment of the İpekyolu Interchange, the highest average score was given to the OV (2,028). The most influential evaluation criterion in the average score given to the OV is harmony (2,250). As a matter of fact, according to Gülgün & Türkyılmaz (2001), harmony between human and environment is an important factor in design. IV (1,846) received the lowest average score. The evaluation criteria that are effective in IV having such a low average score are color and color harmony (1,638). As a matter of fact, Şekerci et al. (2016) also stated that color is one of the most important elements of design and that all forms and surfaces in the space are perceived with color differences.

4. Conclusions and Suggestions

As a result of the research, when the landscape design scenarios created for the intersections and intersections of Erzurum city were evaluated with the visual quality analysis method, it was seen that the design scenarios were given much higher scores than their current state without design. These data show that the side walls, overpasses, central refuges and intersections of the bridge intersections in Erzurum City are in need of landscape design. The landscape quality of urban road routes, road connections, and intersections is very effective in enhancing the high visual quality of a city's landscape. For this reason, the local administrations of Erzurum city should not ignore the landscape visuals as well as the design and implementation of intersections. Landscaping work to be carried out in the sections forming the interchanges will not only increase the visual quality value of the city but also improve the ecology of the city and increase the amount of green space per capita. With this study, urban aesthetics and visual quality evaluations are taken into consideration in the concept of sustainable landscaping for the future and a database that can serve as a resource for local governments is provided.

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All authors contributed equally to the article. The first author contributed 50% and the second author contributed 50%. The authors declare no conflict of interest.

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Analysis of the Impact of Urban Building Blocks Orientation on Outdoor Thermal Comfort in Winter Cities Using ENVI-met

Başak ERTEM MUTLU [1*], Sevgi YILMAZ [2]

ORCID 1: 0000-0002-0394-4950
ORCID 2: 0000-0001-7668-5788
[1] *Atatürk University, Faculty of Architecture and Design, Department of Landscape Architecture, 25240, Erzurum, Türkiye.*
[2] *Atatürk University, Faculty of Architecture and Design, Department of Landscape Architecture, 25240, Erzurum-Türkiye*
**** e-mail**: basakertem_14@hotmail.com*

Abstract

The increase in urbanization, building density in cities, and the excess of hard surfaces exacerbate the urban heat island effect, negatively impacting outdoor thermal comfort. It is anticipated that not only the abundance of structures but also the orientation of building blocks in space affects thermal comfort. In this study, four different orientation scenarios "0°, 45°, 90°, 135°" were analyzed using the ENVI-met 5.6.1 software model. The newly developed settlement area Yıldızkent, located in the development axis of the city center of Erzurum, was chosen as the study area. The study concluded that the street orientation at a 45° angle was the most suitable scenario in terms of thermal comfort for both winter and summer months. In this scenario analysis, a 1.0°C PET improvement for winter months was determined, positively affecting thermal comfort. It was determined that the orientation of building blocks has an impact on thermal comfort.

Keywords: *Building blocks, orientation, ENVI-met 5.6.1, cold climate, outdoor thermal comfort.*

Kış Kentlerinde Yapı Bloğu Yöneliminin Dış Mekân Termal Konfor Üzerine Etkisinin ENVI-met ile Analizi

Öz

Kentleşmenin artması kentlerdeki bina yoğunluğu, sert zemin fazlalığı kentsel ısı ada etkisini arttırmakta ve bu da dış mekan termal konforu olumsuz yönde etkilemektedir. Sadece yapı fazlalığı değil aynı zamanda yapı bloklarının mekandaki yönlenmesinin de termal konforu etkilediği öngörülmektedir. Yapılan bu çalışmada ENVI-met 5.6.1 yazılım modeli kullanılarak 4 farklı açıda yönelim senaryosu "0°, 45°, 90°, 135°" çalışılmıştır. Çalışma alanı olarak Erzurum kent merkezinde gelişme aksında yer alan, yeni yerleşim yeri Yıldızkent tercih edilmiştir. Çalışma sonucunda 45° açılı cadde yöneliminin hem kış hem yaz ayı için termal konfor açısından en uygun senaryo olduğu tespit edilmiştir. Bu senaryo analizinde kış ayları için 1.0 C°'lik bir PET iyileşmesi olduğu ve termal konforu olumlu yönde etkilediği belirlenmiştir. Yapı bloğu yönlenmesinin termal konfor üzerinde etkisi olduğu belirlenmiştir.

Anahtar kelimeler: *Yapı blokları, yönelim, ENVI-met 5.6.1, soğuk iklim, dış mekân termal konfor.*

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1. Introduction

Climate change has become a crisis manifesting itself globally today. In addition to climate change, cities also experience the urban heat island (UHI) effect, a localized increase in air temperature (Oke, 2002; Oke et al., 2017; He et al., 2021; Menteş et al., 2024). The urban heat island is defined as the temperature difference between urban and rural areas (Salvati & Kolokotroni, 2023). The rise in temperature is more pronounced in urban areas due to factors such as building density, the prevalence of hard surfaces, the placement and orientation of buildings, the direction of wind, and the lack of green spaces (Yılmaz et al., 2018; Yılmaz et al., 2022; Potchter et al., 2022). Especially in summer, the absorption and reflection of heat on hard surfaces make the urban heat island effect more noticeable (Salvati et al., 2019). Global warming has led to more frequent and intense extreme heat events, with prolonged heat waves threatening the sustainable development of urban areas and human societies. Between 2001 and 2020, global surface temperatures increased by 0.99°C compared to the period from 1850 to 1900 (IPCC, 2021). Global warming has become a major issue for cities (He et al., 2021; Yılmaz et al., 2023).

There are numerous studies and software developed to improve outdoor thermal comfort. Since 2017, a total of 165 thermal indices have been developed to address this issue (De Freitas & Grigorieva, 2017). A review study determined that in the last five years, simulation software was used in 77% of studies aimed at improving outdoor thermal comfort, with Physiological Equivalent Temperature (PET)-ENVI-met being the preferred choice (Tsoka et al., 2018). Alternative scenario applications have shown that outdoor thermal comfort conditions can be improved with designs that consider the natural features of the space (Blazejczyk et al., 2012; Santamouris, 2020; Jamali et al., 2021).

Urban environments also affect wind speed and direction. The roughness of the urban surface reduces wind speed by 20% to 30% and increases turbulence intensity by 50% to 100% when moving from rural to urban areas (Ghiaus et al., 2005). By changing the free-flow speed over buildings, the reduction in average wind speed at pedestrian level is even higher, reaching up to 60% in densely urban areas (Orme et al., 1998; Palusci et al., 2022). The shape of the building and the geometric features of its surroundings (i.e., the ratio of street width and length to the height of buildings), street designs (Yılmaz et al., 2017) affect the airflow around buildings in cities, altering the potential for natural ventilation in buildings (Mei et al., 2017; Xie et al., 2020). The varying solar radiation depending on street and avenue orientation was tested in simulations with a 12° southeast orientation. The results showed that, particularly in high-rise east-west oriented buildings, the orientation resulted in a temperature increase on the northern façades, with the orientation increasing the ambient temperature by an average of 0.5°C during the winter period (Yavaş & Yılmaz, 2019).

The thermal environment of a street block is influenced by factors such as the Sky View Factor (SVF), street orientation, street aspect ratio, and other factors (Watson & Johnson, 2010). SVF explains the impact of the spatial pattern of urban street canyons on the urban physical environment from an energy transfer perspective; it is an important quantitative index for defining urban geometry. Today, scientists generally agree that SVF is a significant parameter affecting the microclimate, night heat island effect, thermal comfort, and air pollution in urban areas (Li et al., 2020; Cui et al., 2023). Various simulations using the ENVI-met software have analyzed alternative street canyon structures (Ali-Toudert & Mayer, 2006-2007; Acero et al., 2021; Sun et al., 2022), the relationship between building block orientations within urban spaces and thermal comfort (Song et al., 2023; Salameh et al., 2024; Sadeghian et al., 2024), and the impact on energy consumption (Peng et al., 2020).

From the studies related to street angles and ENVI-met: Ali-Toudert & Mayer (2006) investigated both the aspect ratios and orientations of streets in Algiers, which has an arid climate, to determine which are more suitable for thermal comfort. The study found that higher street height-to-width ratios and orienting the street in a NE-SW or NW-SE direction provided better thermal comfort conditions. Achour-Younsi & Kharrat (2016), in their study using the ENVI-met model in Tunisia, examined the impact of street canyon geometry and orientation on outdoor thermal comfort in the city. They determined that having the street oriented NW not only aligned with the prevailing wind direction but also facilitated air flow through the street, making it the most suitable orientation for thermal comfort.

Yılmaz et al. (2016), in their study in Dadaşkent, Erzurum, investigated the impact of different street orientations on thermal comfort during the winter months. They found that the NE-SW oriented street was the most suitable for winter outdoor thermal comfort, while the NS oriented street was the least suitable. Mutlu et al. (2018) examined the impact of street angles on thermal comfort in an area with various orientations in Erzurum. They analyzed angles of 0°, 22.5°, 45°, and 67.5° separately for the winter months and determined that the 45° oriented street provided the best thermal comfort.

The research area in Erzurum, located in a cold climate region according to the Köppen and Flee (1954) criteria, experiences extremely harsh winter conditions (Kottek et al., 2006). Erzurum has the potential to become a significant brand city due to its historical background and winter tourism opportunities. The city, which hosted the 2011 Winter Olympics, has substantial infrastructure facilities for winter tourism. With its two universities and a large number of students, outdoor thermal comfort is crucial in the city. Erzurum has approximately 650 hectares of urban renewal and transformation areas. Therefore, studies conducted for each micro-area are considered highly valuable.

In Erzurum, known for its cold climate, residential fuel consumption is the primary source of pollutant gas emissions. The heavy reliance on fossil fuels during the winter months exacerbates air pollution (Yılmaz et al., 2021). According to the 2020 World Air Quality Report, Turkey ranked 46th out of 106 countries, and Erzurum was highlighted as one of the top three cities with the highest air pollution levels in Turkey (WAQR, 2020).

These studies aim to develop design criteria that will improve outdoor thermal comfort and facilitate the creation of more comfortable living spaces. In this context, a neighborhood in the Yıldızkent area, which began developing after the 2000s, was selected. Within this neighborhood, a regular building block with existing structures was identified. Microclimate data from the study area were recorded using a device. The ENVI-met 5.6.1 software, used for simulation analyses in thermal comfort studies, was employed to analyze this building block. The study investigated the optimal orientation angle for building blocks in cold climate regions. Thus, the research sought to answer the question, "What orientation angle should building blocks have to improve outdoor thermal comfort conditions in cold climate cities?"

2. Material and Method

The city of Erzurum, one of the coldest cities in Turkey and situated at the highest elevation, was selected as the study area. Green space system scenarios with various proposals were implemented at the urban scale in the chosen study area. The coordinates of the study area are 39°54'19.77"N and 41°15'57.29"E. The selected study area is located in the Hüseyin Avni Ulaş neighborhood, specifically the Zabıta unit, which is part of the Palandöken district. Palandöken Municipality has a total population of 175,920, while the population of the neighborhood encompassing the study area is 46,118 (Anonymous, 2023).

The Zabıta station is located in the Yıldızkent area of Palandöken Municipality. A 514m x 480m area within this region, which includes residential complexes, was selected as the study area. The Zabıta station was chosen to be in the exact center of this area (Figure 1).

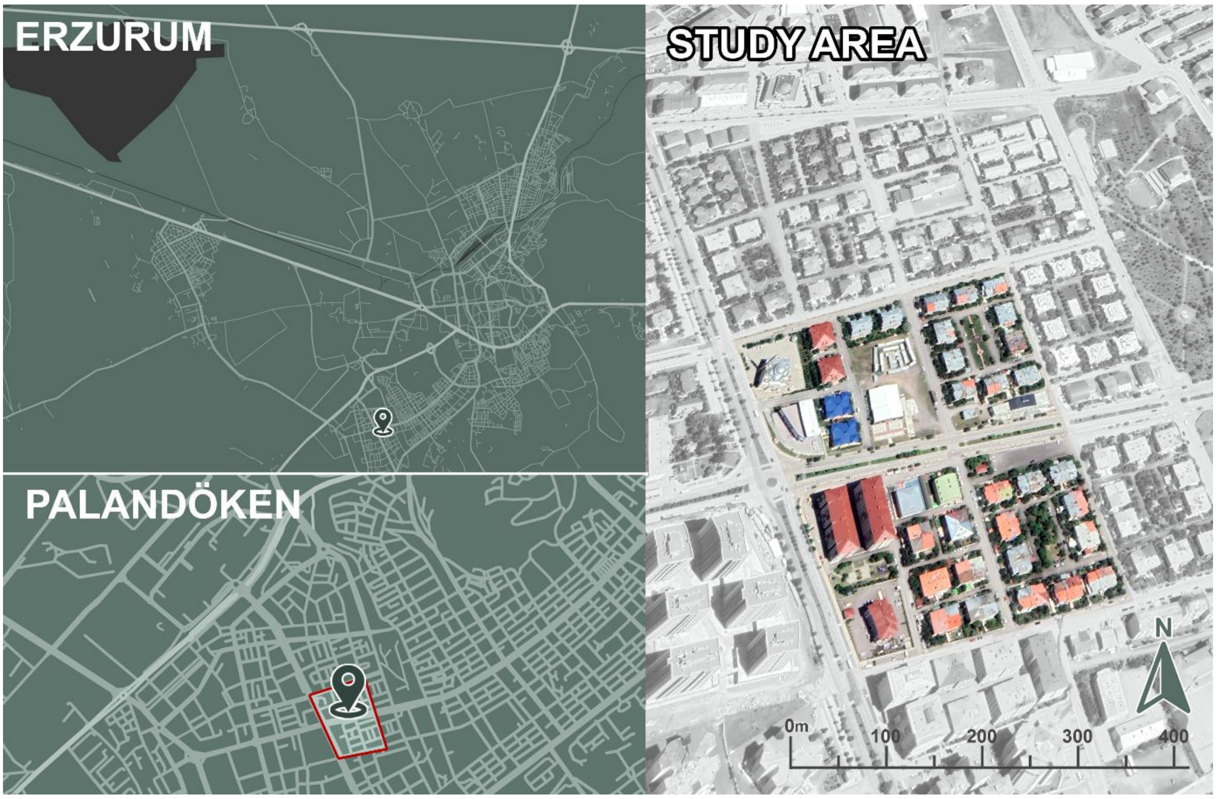

Figure 1. Location of the Yıldızkent study area and visual of the building block

Four different scenarios were created for the study area. The data for the areas positioned at four different angles within this building block were evaluated for both summer and winter months. The data include hourly air temperature (Ta-°C), humidity (RH-%), wind speed (m/s), Mean Radiant Temperature (Tmrt), and Physiological Equivalent Temperature (PET).

2.1. ENVI-met Scenarios

Four scenario designs were produced with different angles of building block orientations. The scenarios generated along with the existing condition are as follows:

Scenario 1: The building block orientation has an angle of 0°.

Scenario 2: The building block orientation has an angle of 45°.

Scenario 3: The building block orientation has an angle of 90°.

Scenario 4: The building block orientation has an angle of 135°.

Microclimate Data Measurement: A measurement device was installed in the garden of the Zabıta Building, which is determined to be publicly owned in the Yıldızkent settlement area. The recording device of this apparatus was placed inside the Zabıta Building and connected to electricity. The device is protected by an iron cage against potential hazards. Its calibration was performed in collaboration with a meteorological engineer from the manufacturing company (established under TÜBİTAK 1001-TOVAG project number 119O479) (Figure 2).

For the study area, the annual climate data collected by the Davis Vantage Pro-2 for the hottest and coldest days of 2021 were first recorded. According to the collected climate data, the coldest day was determined to be January 22, 2021, while the hottest day was July 21, 2021.

Figure 2. Measurement of microclimate data within the study area

The 24-hour climate data for these identified days were obtained and used for analysis in the ENVI-met program (Table 1). The current status of the study area was drawn in the ENVI-met 6.5.1 version program, and analyses at four different angles were conducted for these days.

Table 1. Data used in the ENVI-met 6.5.1 program

Location	Yıldızkent Settlement Area	
Climate Type	Mountain Ecosystem	
Simulation Time	January and July	
Total Simulation Duration	24 hours per alternative	
Spatil Resolution	2m x 2m x 2m	
Area Size	257m x 240m x 36m	
Model Angle	…	
	22.01.2021	**21.07.2021**
Basic Meteorological Inputs	Unshaded	Unshaded
Wind Speed (m/s)	0.18	0.6
Wind Direction (°)	234.37 °	225.0 °
24-Hour Air Temperature	+	+
24-Hour Relative Humidity	+	+
Lowest Air Temperature (°C)/h	-19.7 °C / 07:00	17.1 °C / 05:00
Highest Air Temperature (°C)/h	-10.4 °C / 14:00	32.6 °C / 16:00
Lowest Humidity	%68 / 14:00	%13 / 16:00
Highest Humidity	%84 / 07:00	%58 / 23:00
Sky View Factor	Open	Open

2.2. ENVI-met 5.6.1 Software

ENVI-met is a three-dimensional, non-hydrostatic microclimate model developed to calculate and simulate climate variables in urban areas, with a grid resolution ranging from 0.5 to 10 meters. Developed by Michael Bruse in 1993, it is a small-scale atmospheric adaptation capable of simulating surface air in an urban environment with up to 250 grids from a single building. The model takes into account total radiation, including direct, reflected, and diffuse solar radiation as well as long-wave radiation. By utilizing the laws of fluid dynamics and thermodynamics, it models the evolution of climate variables measured within the study area throughout the day. The ENVI-met model integrates the effects of buildings, orientation angles, vegetation, surface characteristics, soils, and climatic conditions to compute the state of the atmosphere (Bruse & Fleer 1998; Bruse, 1999).

To run a simulation, the user needs to create two files. The first is a field input file in *.INX format that contains all the necessary physical information about the area to be simulated. This file includes information about the dimensions of the simulation, building sizes and placements, materials of various surfaces, roads, vegetation, etc. The second is a *.SIM file that contains the climatic data at the start of the simulation and shows the results on the timeline. Climate data (temperature, humidity, wind speed, and direction) collected from mobile measurements or a fixed meteorological station are required to initiate a simulation in the ENVI-met 5.6.1 software and are stored in a *.SIM file. Practically, the minimum and maximum grid sizes for ENVI-met are 0.5x0.5 meters and 10x10 meters, respectively. The grid size varies depending on the required level of detail (Qaid & Ossen, 2015; Faragallah & Ragheb, 2022; Guo et al., 2023).

In this study, the building block in the area of the station, with dimensions of 514m x 480m, was analyzed using the ENVI-met 5.6.1 model. Each grid in the simulations represents a 2m x 2m area. The model consists of 2m grids in the Z direction, with the model height ending at 36 meters. The field input file (.INX) has 257 x 240 x 36 (x * y * z) grid cells, with a grid size of 514 x 480 x 72 meters and thus an area size of 246,720 m².

2.3. ENVI-met 5.6.1 Software Model Validation

In the study, the accuracy of the ENVI-met program's scenarios was assessed by comparing the data used in the program with the results obtained. This comparison was performed through accuracy analysis. The accuracy analysis compared the predicted data with observed data using R^2 (coefficient of determination), RMSE (root mean square error), MBE/MAE value, and d (agreement index). This validation method, developed by Willmott (1982), uses specific formulas for analysis. The MBE/MAE value should be between 0 and 1. A value of 1 or close to 1 indicates the accuracy of the model. In the analysis, high values of the agreement index (d) and coefficient of determination (R^2) represent the agreement of the data (Qaid et al., 2016; Yılmaz et al., 2021; Ertem Mutlu & Yılmaz, 2024).

For the current situation, when evaluating the measured and simulated air temperature data for the winter months, the R^2 value was 0.8129. A high R^2 value close to 1 indicates that the data agreement is high. The d value was 0.71, which, being close to 1, indicates the reliability of the simulation (Ertem Mutlu, 2023) (Figure 3).

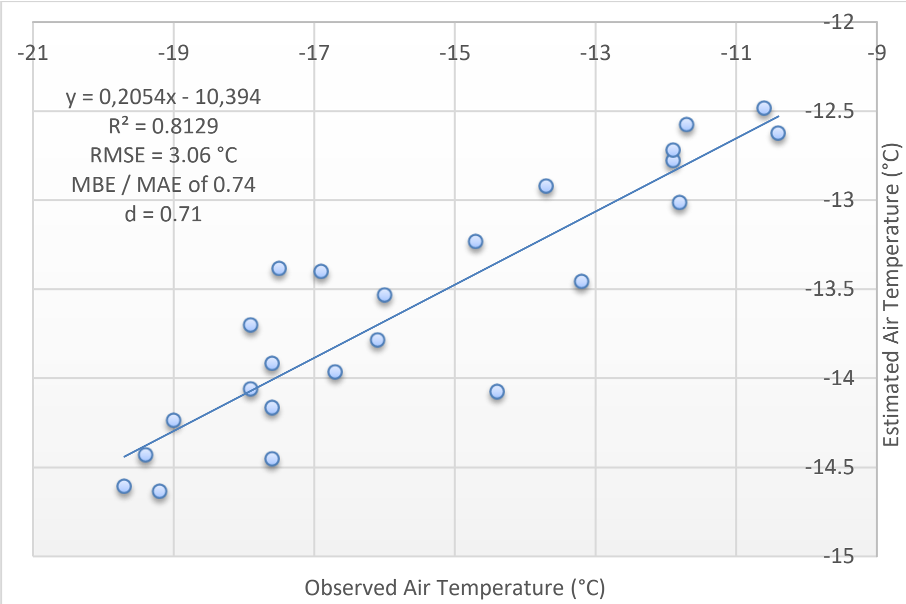

Figure 3. Scatter plot of predicted and observed air temperature data for winter accuracy analysis (Ertem Mutlu & Yılmaz, 2024)

For the summer months, the accuracy analysis of the current situation resulted in an R^2 value of 0.92. This high R^2 value shows that the data agreement is very high. The d value was 0.90, indicating the reliability of the simulation (Figure 4).

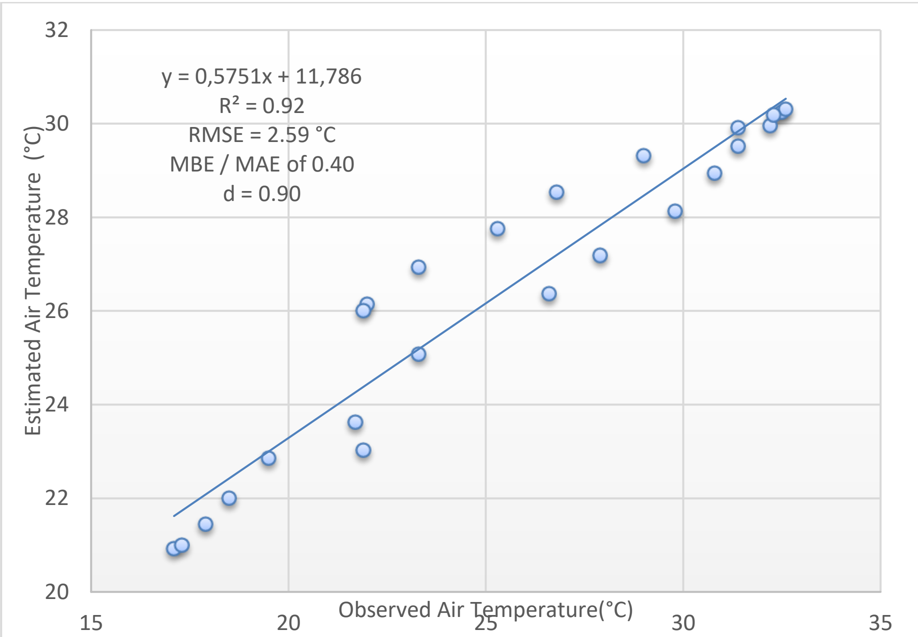

Figure 4. Scatter plot of predicted and observed air temperature data summer month accuracy analysis (Ertem Mutlu & Yılmaz, 2024)

According to the results, the ENVI-met software has been well validated with these data, and the study can be conducted using the software outputs. The meanings of the abbreviations in the formula 1 (Battista et al., 2016) are as follows:

d: Agreement index [–]

MAE: Mean Absolute Error [–]

MBE: Mean Bias Error [–]

ND: Number of data points analyzed [–]

Ō: Mean of the observed variable

Oj: Observed variables for each j instance

Pj: Model-predicted variables for each j instance

$$d = 1 - \left[\frac{\sum_{j=1}^{N_D} \left[(P_j - \bar{O}) - (O_j - \bar{O}) \right]^2}{\sum_{j=1}^{N_D} \left(|P_j - \bar{O}| + |O_j - \bar{O}| \right)^2} \right] \quad (1)$$

$$MBE = \frac{\sum_{j=1}^{N_D} (P_j - O_j)}{N_D}$$

$$MAE = \frac{\sum_{j=1}^{N_D} |P_j - O_j|}{N_D}$$

3. Research Findings and Discussion

Within the Yıldızkent residential area, which extends to the north-northwest of Erzurum city center and the foothills of Mount Palandöken, four different ENVI-met analyses were performed on the identified building block. The analyses, conducted for both summer and winter months, were evaluated separately in terms of air temperature (°C), relative humidity (%), wind speed (m/s), Mean Radiant Temperature (Tmrt), and Physiological Equivalent Temperature (PET) for different orientation angles.

3.1. Analysis of Current Conditions for Summer and Winter Months

For the analysis of the current conditions of the area, the existing trees have been drawn to scale. A total of 868 plant species have been used in the area. Analyses for both summer and winter months have been conducted.

Looking at the winter analysis of the current conditions, the minimum air temperature was -12.5 °C, the maximum was 16.2 °C, and the average air temperature was 1.9 °C. In terms of humidity data, the minimum was 9.7%, the maximum was 144%, and the average was 76.9%. Regarding wind speed, the minimum was 0 m/s, the maximum was 0.15 m/s, and the average was 0.07 m/s. For the Mean Radiant Temperature (Tmrt) data, the minimum was -13.9 °C, the maximum was 20.5 °C, and the average was 3.3 °C. In the Physiological Equivalent Temperature (PET) data for winter, the minimum temperature was 2.6 °C, the maximum temperature was 13.9 °C, and the average was 8.3 °C.

Looking at the summer analysis of the current conditions, the minimum air temperature was 20.7 °C, the maximum was 33.1 °C, and the average air temperature was 26.9 °C. In terms of humidity data, the minimum was 14.4%, the maximum was 38.8%, and the average was 26.6%. Regarding wind speed, the minimum was 0 m/s, the maximum was 1.2 m/s, and the average was 0.6 m/s. For the Mean Radiant Temperature (Tmrt) data, the minimum was 38.3 °C, the maximum was 64.8 °C, and the average was 51.6 °C. In the Physiological Equivalent Temperature (PET) data for summer, the minimum temperature was 36.5 °C, the maximum temperature was 57.4 °C, and the average temperature was 47 °C.

3.2. Thermal Comfort Analysis of the Building Block in the "0° Angle Position"

When analyzing the winter conditions of the building block at the 0° position, the air temperature was found to have a minimum of -12.5 °C and a maximum of 16.2 °C. No variability was observed in air temperature compared to the current conditions. In terms of humidity data, the minimum was 9.7%, the maximum was 144.3%, and the average was 77%. The maximum value increased by 0.3 compared to the current conditions, which also raised the average value by 0.15. Looking at wind speed data, the minimum was 0 m/s, the maximum was 0.18 m/s, and the average was 0.09 m/s. While the minimum remained unchanged for the winter, the maximum increased by 0.3 m/s compared to the current conditions. The Mean Radiant Temperature (Tmrt) data showed a minimum of -14.1 °C, a maximum of 20.3 °C, and an average of 3.1 °C. In the winter analysis compared to the current conditions, the minimum and maximum temperatures decreased by 0.2 °C. For the Physiological Equivalent Temperature (PET), the winter minimum was -2.8 °C, the maximum was 9.4 °C, and the average was 3.3 °C. Compared to the current conditions, the minimum temperature in winter decreased by 5.4 °C, and the maximum decreased by 4.5 °C.

When looking at the summer analysis at the 0° position, the minimum air temperature was 20.7 °C and the maximum was 33.3 °C. While the minimum temperature remained unchanged compared to the current conditions, there was a 0.2 °C increase in the maximum temperature. In terms of humidity data, the minimum was 14.4%, the maximum was 38.8%, and the average was 26.6%. No changes were observed for the summer conditions compared to the current state. For wind speed data, the minimum was 0 m/s, the maximum was 1.44 m/s, and the average was 0.7 m/s. The minimum remained unchanged, while the maximum increased by 0.28 m/s compared to the current conditions. Looking at the Mean Radiant Temperature (Tmrt), the minimum was 38.4 °C, the maximum was 65.1 °C, and the average was 51.8 °C. Compared to the current conditions, the minimum increased by 0.1 °C, and the maximum increased by 0.3 °C. For the Physiological Equivalent Temperature (PET), the minimum was 33.2 °C, the maximum was 52.9 °C, and the average was 43 °C. Compared to the current conditions, the minimum decreased by 3.3 °C, and the maximum decreased by 4.5 °C.

3.3. Thermal Comfort Analysis of the Building Block in the "45° Angle Position"

The study area was positioned at a 45° angle, and this condition was analyzed for both summer and winter months. When looking at the winter analysis at the 45° position, the air temperature had a minimum of -12.4 °C and a maximum of 16.2 °C. Compared to the current conditions, a 0.1 °C increase was observed in the minimum temperature, while no variability was noted in the maximum temperature. In terms of humidity data, the minimum was 9.7%, the maximum was 143.1%, and the average was 76.4%. The minimum value remained unchanged compared to the current conditions, while the maximum value decreased by 0.9. For wind speed data, the minimum was 0 m/s, the maximum was 0.14 m/s, and the average was 0.07 m/s. The minimum remained unchanged for winter conditions, while the maximum decreased by 0.01 m/s compared to the current conditions. The Mean Radiant Temperature (Tmrt) showed a minimum of -8.3 °C, a maximum of 5.9 °C, and an average of -1.2 °C. In the winter analysis compared to the current conditions, the minimum temperature increased by 5.6 °C, while the maximum decreased by 14.6 °C. For the Physiological Equivalent Temperature (PET), the minimum was 3.6 °C, the maximum was 14.3 °C, and the average was 9 °C. Compared to the current conditions, the minimum temperature increased by 1 °C, and the maximum increased by 0.4 °C.

When examining the summer analysis at the 45° position, the minimum air temperature was 20.7 °C, and the maximum was 33.1 °C. No variability was observed in air temperature compared to the current conditions. In terms of humidity data, the minimum was 23.9%, the maximum was 40.5%, and the average was 32.2%. Compared to the current conditions, the minimum increased by 9.5, and the maximum increased by 1.7 for the summer months. For wind speed data, the minimum was 0 m/s, the maximum was 0.94 m/s, and the average was 0.5 m/s. The minimum remained unchanged, while the maximum decreased by 0.22 m/s compared to the current conditions. The Mean Radiant Temperature (Tmrt) had a minimum of 38.3 °C, a maximum of 64.8 °C, and an average of 51.6 °C. No changes were observed compared to the current conditions. For the Physiological Equivalent Temperature (PET), the minimum was 36.4 °C, the maximum was 57.5 °C, and the average was 47 °C. Compared to the current conditions, the minimum decreased by 0.1 °C, while the maximum increased by 0.1 °C.

3.4. Thermal Comfort Analysis of the Building Block in the "90° Angle Position"

For the winter analysis at the 90° angle, the air temperature showed a minimum of -12.6 °C, a maximum of -10.2 °C, and an average of -11.4 °C. Compared to the current conditions, the minimum temperature decreased by 0.1 °C, while the maximum temperature experienced a significant drop of 26.4 °C. In the humidity analysis, the minimum was 70.3%, the maximum was 145%, and the average was 107.7%. Compared to the current conditions, the minimum increased by 60.6, and the maximum increased by 1. Rüzgar hızı data indicated a minimum of 0 m/s, a maximum of 0.15 m/s, and an average of 0.07 m/s. There were no changes compared to the current conditions. For the Mean Radiant Temperature (Tmrt), the minimum was -14 °C, the maximum was 20.5 °C, and the average was 3.25 °C. In comparison with the current conditions, the minimum temperature decreased by 0.1 °C, while no changes were observed in the maximum temperature. For the Physiological Equivalent Temperature (PET), the minimum was 2.6 °C, the maximum was 13.5 °C, and the average was 8.1 °C. Compared to the current conditions, the minimum temperature remained unchanged, while the maximum decreased by 0.4 °C.

In the summer analysis at the 90° angle, the air temperature showed a minimum of 30 °C, a maximum of 33.3 °C, and an average of 31.7 °C. Compared to the current conditions, there was a 9.3 °C increase in the minimum temperature and a 0.2 °C increase in the maximum temperature. For the humidity analysis, the minimum was 14.4%, the maximum was 25.4%, and the average was 19.9%. Compared to the current conditions, there was no change in the minimum value, but the maximum decreased by 13.4. Wind speed data indicated a minimum of 0 m/s, a maximum of 0.93 m/s, and an average of 0.5 m/s. There were no changes in the minimum value, while the maximum decreased by 0.23 m/s. For the Mean Radiant Temperature (Tmrt), the minimum was 38.4 °C, the maximum was 65.2 °C, and the average was 51.8 °C. Compared to the current conditions, the minimum increased by 0.1 °C, and the maximum increased by 0.4 °C. For the Physiological Equivalent Temperature (PET), the minimum was 36.4 °C, the maximum was 57.5 °C, and the average was 47 °C. Compared to the current conditions, the minimum temperature decreased by 0.1 °C, while the maximum increased by 0.1 °C.

3.5. Thermal Comfort Analysis of the Building Block in the "135° Angle Position"

In the winter analysis at the 135° angle, the air temperature recorded a minimum of -12.5 °C, a maximum of -9.9 °C, and an average of -11.2 °C. Compared to the current conditions, there was no change in the minimum temperature, while the maximum temperature experienced a significant decrease of 26.1 °C. For humidity, the minimum was 70.4%, the maximum was 144.6%, and the average was 107.5%. In comparison to the current conditions, the minimum increased by 60.7, and the maximum increased by 0.6. Wind speed data indicated a minimum of 0 m/s, a maximum of 0.15 m/s, and an average of 0.07 m/s, showing no changes compared to the current conditions. The Mean Radiant Temperature (Tmrt) was recorded at a minimum of -8.4 °C, a maximum of 6.3 °C, and an average of -1.1 °C. Compared to the current conditions, the minimum temperature increased by 5.5 °C, while the maximum decreased by 14.2 °C. For the Physiological Equivalent Temperature (PET), the minimum was 3.9 °C, the maximum was 8.9 °C, and the average was 6.4 °C. Compared to the current conditions, the minimum increased by 1.3 °C, while the maximum decreased by 5 °C.

In the summer analysis at the 135° angle, the air temperature showed a minimum of 30 °C, a maximum of 33.6 °C, and an average of 31.8 °C. There was a 0.3 °C increase in the minimum temperature and a 0.5 °C increase in the maximum temperature compared to the current conditions. For humidity, the minimum was 14.4%, the maximum was 25.5%, and the average was 20%. There was no change in the minimum, but the maximum decreased by 13.3 units compared to the current conditions. Wind speed data indicated a minimum of 0 m/s, a maximum of 1.21 m/s, and an average of 0.6 m/s. There were no changes in the minimum, while the maximum increased by 0.05 m/s. For the Mean Radiant Temperature (Tmrt), the minimum was 38.4 °C, the maximum was 64.9 °C, and the average was 51.7 °C, with a 0.1 °C increase in both minimum and maximum temperatures compared to the current conditions. For the Physiological Equivalent Temperature (PET), the minimum was 36.4 °C, the maximum was 57.5 °C, and the average was 47 °C, showing a decrease of 0.1 °C in the minimum and an increase of 0.1 °C in the maximum compared to the current conditions.

For the winter season, the maximum relative humidity at the 45° angle decreased by 0.9 units, indicating a positive outcome for thermal comfort (Figure 5). In the summer, the scenario with the best results for relative humidity was also the 45° angle position, where the minimum humidity was 9.5 units higher and the maximum was 1.7 units higher, positively affecting thermal comfort (Figure 6).

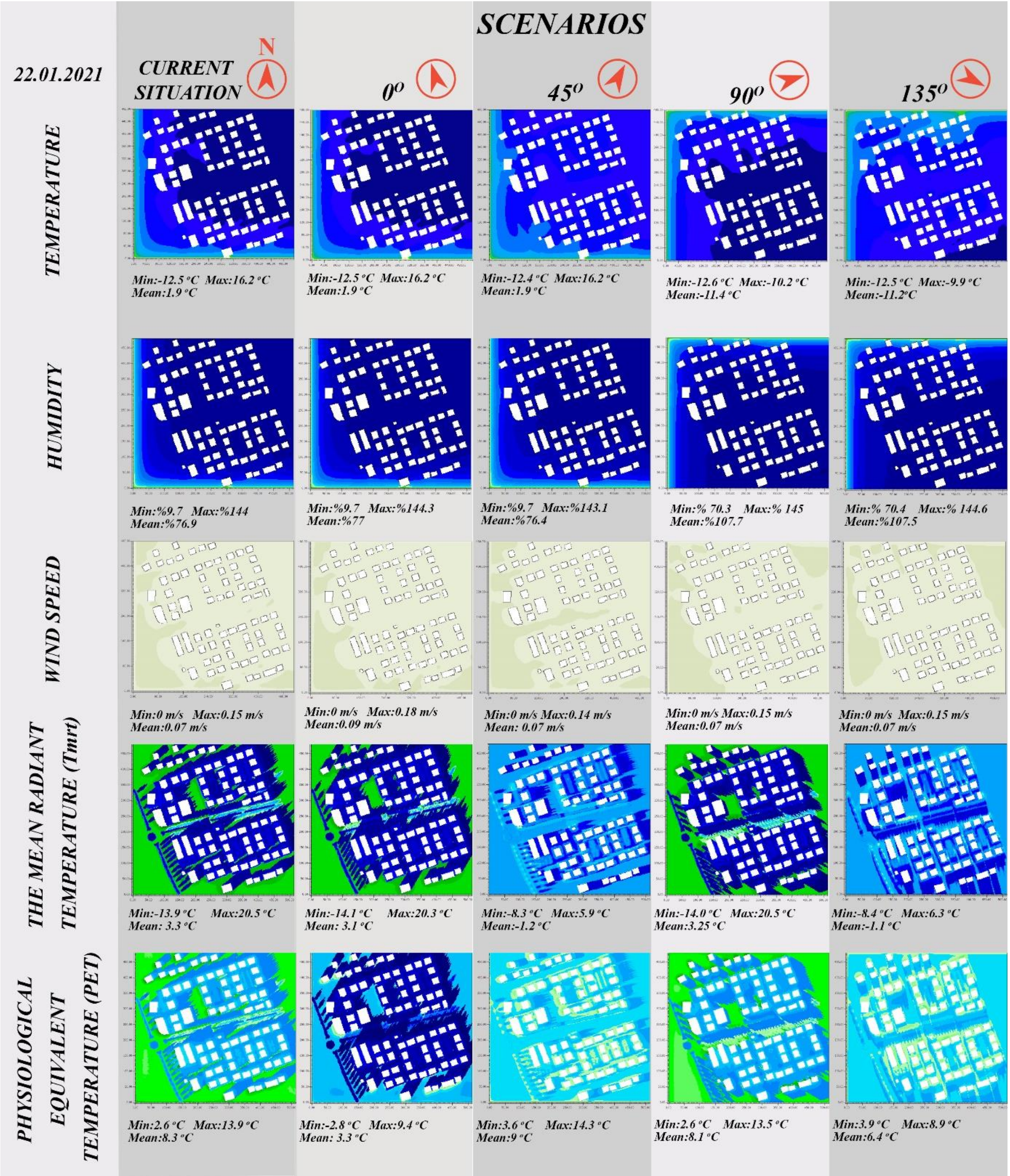

Figure 5. Winter analyses of building blocks at different angles

Figure 6. Summer analyses of building blocks at different angles

Looking at the *wind speed* data, the scenario that provides the best result for the winter months is the 45° angle scenario. While there is no change in the minimum, the maximum wind speed has decreased by 0.1 m/s. The low wind speed in winter makes the effect of cold weather less noticeable (Figure 5). For the summer months, the scenario that yields the best result is the 0° angle scenario. There is no change in the minimum, but the maximum wind speed has increased by 0.2 m/s. The high wind speed in summer creates a more comfortable environment in hot weather in terms of thermal comfort (Figure 6).

When examining the *Tmrt* analyses, no scenario has been identified that yields better results for winter compared to the current situation. On the contrary, Tmrt has decreased significantly at the 45° and 135° angles. This can be seen in Figure 5, where the colors are bluer. In Tmrt analyses for summer, no scenario has been identified that provides better results compared to the current situation (Figure 6).

Looking at the ***PET*** analyses, the scenario that yields the best result for winter is the 45° angle scenario. Compared to the current situation, the temperature has increased by 1 °C at the minimum and by 0.4 °C at the maximum. This has had a positive effect on thermal comfort (Figure 5). In summer PET analyses, the scenario that provides the best result is the 0° angle scenario. Compared to the current situation, the temperature has decreased by 3.3 °C at the minimum and by 4.5 °C at the maximum (Figure 6).

When analyzing the building blocks according to their angles, the scenario that provides the best thermal result for both summer and winter months is the one positioned at a 45° angle. While there are not many changes in angle variations for winter, the best thermal result for summer in terms of PET values has been found at a 0° angle. In other parameters, there have not been significant changes compared to the current situation for both winter and summer months (Table 1). The minimum and maximum values of the identified climate data for building blocks at different angles are presented in Table 2.

Table 2. Air temperature, relative humidity, wind speed, Tmrt, and PET analyses for winter and summer at different building block angles

Air Temperature (°C)				
	WINTER		**SUMMER**	
Scenarious	**Minimum**	**Maximum**	**Minimum**	**Maximum**
Current situation	-12.5	16.2	20.7	33.1
0°	-12.5	16.2	20.7	33.3
45°	-12.4	16.2	20.7	33.1
90°	-12.6	-10.2	30.0	33.3
135°	-12.5	-9.9	30.0	33.6
Air Humidity (%)				
Scenarious	**Minimum**	**Maximum**	**Minimum**	**Maximum**
Current situation	9.7	144	14.4	38.8
0°	9.7	144.3	14.4	38.8
45°	9.7	143.1	23.9	40.5
90°	70.3	145	14.4	25.4
135°	70.4	144.6	14.4	25.5
Wind Speed (m/s)				
Scenarious	**Minimum**	**Maximum**	**Minimum**	**Maximum**
Current situation	0	0.15	0	1.2
0°	0	0.18	0	1.44
45°	0	0.14	0	0.94
90°	0	0.15	0	0.93
135°	0	0.15	0	1.21
The Mean Radiant Temperature (Tmrt) (°C)				
Scenarious	**Minimum**	**Maximum**	**Minimum**	**Maximum**
Current situation	-13.9	20.5	38.3	64.8
0°	-14.1	20.3	38.4	65.1
45°	-8.3	5.9	38.3	64.8
90°	-14.0	20.5	38.4	65.2
135°	-8.4	6.3	38.4	64.9
Physiologically Equivalent Temperature (PET) (°C)				
Scenarious	**Minimum**	**Maximum**	**Minimum**	**Maximum**
Current situation	2.6	13.9	36.5	57.4
0°	-2.8	9.4	33.2	52.9
45°	3.6	14.3	36.4	57.5
90°	2.6	13.5	36.4	57.5
135°	3.9	8.9	36.4	57.5

Based on the results of this study, the most suitable angle for thermal comfort is determined to be 45°. In a study conducted by Mutlu et al. (2018) in a different settlement area in Erzurum, the most suitable angles for air temperature in winter were found to be 45° and 0°. It was noted that the 45° angle is more favorable for thermal comfort in terms of benefiting from sunlight. De & Mukherjee (2016) investigated bioclimatic comfort by applying different angles in residential buildings and found that the best thermal comfort was achieved with a 30° angle. This angle was seen to improve thermal comfort by facilitating wind flow into the area. Additionally, in a study conducted by Yılmaz et al. (2018) in certain streets of Erzurum, the ideal street orientation was determined to be northeast-southwest. It was emphasized that each study area should be evaluated according to its own criteria.

This study has shown that street orientation affects the temperature and PET values of buildings, particularly during the summer months. The highest value obtained for winter was 14.3°C PET from the 45° simulation. In the scenario analysis, the building block with a 45° angle was found to have street orientations in the Northeast-Southwest and Northwest-Southeast directions. Similarly, in a study conducted for a similar area, it was determined that Northeast and Southwest orientations are more suitable for thermal comfort. The East-West orientation was less preferred due to a significant portion of building facades being in shadow during winter (Yavaş & Yılmaz, 2019). This suggests that paying attention to street orientation in new settlement areas will impact thermal comfort. In this research, the PET value for winter increased from 2.6°C in the current situation to 3.6°C in the 45° building block simulation, showing a 1.0°C improvement and positively affecting thermal comfort. A study has also shown that outdoor thermal comfort can be increased up to 2.0°C during winter with microclimate solutions obtained from the area and ENVI-met simulation analyses. Furthermore, it was emphasized that in North-South oriented streets, attention should be paid to the distances between buildings, and if possible, orientations towards the Southeast should be considered (Yavaş & Yılmaz, 2020). However, these studies may yield different results under various microclimate conditions, and numerous parameters influencing thermal comfort are also involved (Acero et al., 2021). A study conducted in a hot and arid city in Iran determined that the most suitable PET range is between 24.5°C and 29.8°C (Narimani et al., 2022). Therefore, simulations should be conducted for each development area to determine the most suitable conditions. It is emphasized that comparing values from different areas is not appropriate in this context (Morakinyo et al., 2019).

The highest wind speed for winter was found to be 0.18 m/s for the 45° angle block. This angle block also showed better PET values compared to other angle orientations. A similar study has determined that urban form and building density affect the thermal environment. Additionally, the thermal environment is influenced by humidity and wind speed (Huang et al., 2020). In terms of wind, in cities with cold climates, street orientations should be designed to align with wind directions to enhance the effect of prevailing northern winds. Especially in cities experiencing significant air pollution during winter, it is important to increase the impact of wind. Indeed, in this study, street orientations in building blocks with 45° and 135° angles correspond to long-term wind data of Erzurum city center (MGM, 2020). The highest PET value for winter was calculated as 3.9°C in the 135° angle block. For Erzurum city, it has been suggested to open air corridors parallel to the prevailing southwest and northwest wind directions on a macro scale.

Regarding humidity, the lowest maximum value of 143.1% for winter and the highest maximum value of 40.5% for summer were calculated for the 45° angle block. High humidity in summer and low humidity in winter have been found to be advantageous for thermal comfort in cold climate cities (Yin et al., 2021). It was determined that humidity and wind speed showed similar results in some scenarios and did not create significant changes. Indeed, a study found that surfaces in scenarios did not significantly affect wind speed up to a certain size (Yücekaya et al., 2022).

ENVI-met Model's Limiting Conditions: In ENVI-met simulation studies, it is possible to encounter restrictive issues. For Erzurum, where winters are typically snowy, the margin of error in simulation data is high (Liu et al., 2018; Ma et al., 2019; Yılmaz et al., 2021a). Additionally, the accuracy of the ENVI-met software decreases when wind speeds are below 1.0 m/s. This error during simulations is also explained within the ENVI-met software (ENVI-met Software, 2024). Some studies using ENVI-met have also noted that if wind speeds are less than 2.0 m/s, the software does not provide the desired results for wind analysis (Song et al., 2014; Acero & Arrizabalaga, 2018). Despite this, it is noted as one of the most widely used software models for outdoor thermal comfort studies (Salata et al., 2017;

Salameh et al., 2024). However, due to its limited options, the software is subject to scrutiny, and development and updates are ongoing (ENVI-met 5.6.1).

4. Conclusion and Suggestions

The study demonstrated that the orientation of building blocks affects outdoor thermal comfort values. ENVI-met scenario analyses were conducted for different orientations based on microclimate data collected throughout the year, including the hottest and coldest days. According to the analyses, the best outdoor thermal comfort was achieved with a 45° orientation for both summer and winter. In winter, an improvement of 1.0°C in thermal comfort was observed. The advantageous orientation was identified as the Northeast-Southwest and Northwest-Southeast directions for optimal thermal comfort.

This study shows that the orientation of building blocks influences air temperature and PET values during summer. This highlights the importance of considering street orientation in new development areas to affect outdoor thermal comfort. It was concluded that design criteria developed for cold climate regions may not be suitable for every settlement area and should be combined with locally specific data.

In winter, the highest wind speed of 0.18 m/s was found in the block with a 45° orientation. During summer, the building blocks with 45° and 90° orientations had the lowest wind speeds. However, the 45° oriented blocks had the highest humidity value at 32.2%. This is due to the dominant wind direction coming at an angle rather than parallel to main avenues and streets, preventing the existing vegetation from removing the moisture from the area. As a result, humidity levels reached their highest point. In contrast, the 90° oriented blocks had low wind speeds but managed to remove moisture from the area due to the dominant wind direction being parallel to the main avenue, resulting in the lowest humidity scenario. The dominant wind direction in building blocks is one of the most significant factors affecting humidity. This indicates that paying attention to the dominant wind direction in designs is crucial for thermal comfort.

The development of climate-sensitive design principles based on simulations and their guidance for future development planning decisions is considered a significant factor. For winter-centric cities like Erzurum, these urban design solutions aim to provide guidance during the implementation process.

For the city of Erzurum, sustainable designs and improvements in thermal comfort environments, which can be used as inputs in transformation areas, are of great importance. The ability of the city's population to live comfortably in winter conditions is directly related to the improvement of the city's thermal comfort values. Analyzing climate values with accurate methods and translating them into physical planning decisions is crucial for enhancing urban livability conditions, even in cities with extreme climate conditions.

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The first author contributed 80% and the second author contributed 20% to the article. The authors declare that there is no conflict of interest.

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Environmental Noise Assessment of Residential Buildings with Ground Floor Commercial Function Specific to the Canyon Effect

Derin Hilal BİLMEZ [1*], Cüneyt DİRİ [2]

ORCID 1: 0000-0002-3318-1982
ORCID 2: 0000-0003-4217-6381
[1] *Mimar Sinan Fine Arts University, Institute of Postgraduate Education, Building Physics and Material, 34427, Istanbul, Türkiye*
[2] *Mimar Sinan Fine Arts University, Faculty of Architecture, 34427, Istanbul, Türkiye*
*** e-mail**: *derinhilalb@gmail.com*

Abstract

Environmental noise is one of the primary important factors that negatively affect human health and quality of life. The canyon effect occurs in the regions between the long structure groups. Canyon effect can cause different conditions in terms of noise, heat, lighting or ventilation. This difference: It depends on the building-road relationship, traffic density, climatic conditions, building dimensions and geometry. Within the scope of this study: The road-structure height relationship of environmental noise specific to street canyons and the trade-housing relationship within the building were examined. Highway was preferred as the sound source. 12 separate operational models were created, and a total of 168 measurement results were obtained from 4 indoor and 10 outdoor measurement points in each model. The results showed the level of the canyon effect specific to different variables.

Keywords: *Canyon effect, environmental noise, trade, housing, operational model.*

Kanyon Etkisi Özelinde Zemin Katı Ticari Fonksiyonlu Konut Binalarının Çevresel Gürültü Değerlendirmesi

Özet

Çevresel gürültü, insan sağlığını ve yaşam kalitesini olumsuz etkileyen önemli faktörlerin başında gelmektedir. Kanyon etkisi, uzun yapı grupları arasında kalan bölgelerde ortaya çıkar. Kanyon etkisi gürültü, ısı, aydınlatma veya havalandırma açısından farklı koşullara neden olabilir. Bu farklılık: Yapı-yol ilişkisine, trafik yoğunluğuna, iklim koşullarına, bina boyutlarına ve geometrisine bağlıdır. Bu çalışma kapsamında: Cadde (sokak) kanyonlarına özgü çevresel gürültünün yol-yapı yüksekliği ilişkisi ve yapı içindeki ticaret-konut ilişkisi incelenmiştir. Ses kaynağı olarak karayolu tercih edilmiştir. 12 ayrı operasyonel model oluşturulmuş ve her bir modelde 4 iç mekan ve 10 dış mekan ölçüm noktasından toplam 168 ölçüm sonucu elde edilmiştir. Sonuçlar farklı değişkenlere özgü kanyon etkisinin seviyesini göstermiştir.

Anahtar Kelimeler: *Kanyon etkisi, çevresel gürültü, ticaret, konut, operasyonel model.*

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1. Introduction

After the industrial revolution, the population in cities increased due to job opportunities (Carlo et al., 2024; Li et al., 2017; Li et al., 2020; Pouya, 2022). City centers have developed and changed rapidly over time (Toy & Esringü, 2021; Yılmaz Bakır, 2020). Due to the increasing urban population, irregular planning and urbanization, the number of vehicles and vehicle roads have shown various developments (Carlo et al., 2024; Li et al., 2020; Thaker & Gokhale, 2016; Yükrük Akdağ, 2003). The increase in the number of vehicles has caused a certain traffic density and the roads to be shaped accordingly (Thaker & Gokhale, 2016; Yükrük Akdağ, 2003). Roads (transportation network) have become one of the main elements of the city. At the International Congress of Modern Architecture (CIAM) held in 1933, the city was divided into 4 functional regions: Housing, recreation, work and transportation (Gold, 1998; Mumford, 1992; Yılmaz Bakır, 2020).

Cities are areas with compact settlements(Kim et al., 2022). In compact settlements, unwanted settlements may occur between vehicle roads and buildings (Arpacıoğlu, 2006, 2012; Sayın, 2022; Šprah, Potočnik & Košir, 2024; Toy & Esringü, 2021; Yuan, Edward & Norford, 2014). Some of these settlements may lead to the formation of microclimate regions (Nasrollahi, Namazi & Taleghani, 2021). Street canyons are the area surrounded by high-rise buildings on both sides of the road (Şimşek & Özçevik Bilen, 2021). Examples of microclimate regions can be given. It has a shape like an open top tunnel (Toy & Esringü, 2021). There are areas exposed to the canyon effect in our country and many cities around the world (Shen et al., 2017; Toy & Esringü, 2021; Ünal Çilek, 2022).

Canyon effect in terms of noise: It is the transmission of sound at a much higher sound level to much longer distances than normal by reflecting many times between high-rise buildings aligned in parallel (Can, Fortin & Picaut 2015; Yılmaz et al., 2023). The canyon effect is the decrease in environmental quality in the region where the noise, emission, and heat from the vehicles cannot be removed due to high buildings (Fatehi & Nilsson, 2022; Gu et al., 2011; Schiff, Hornikx & Forssén, 2010). It consists of more reflected sound than direct sound from the source (Can et al., 2015; Kang, 2000). Standard sound insulation and noise control calculations may be insufficient when designing in areas where the canyon effect is observed (Can et al., 2015; Schiff et al., 2010; Yılmaz et al., 2023). Therefore, at the beginning of the design phase, the land, building-road relationship should be analyzed.

1.1. The Canyon Effect

Canyon: "They are geographical shapes consisting of steep slopes formed by the erosion and cleavage of water permeable rocks under weather conditions or river effect." (Wikipedia, 2024; Zorer & Öztürk, 2021). Due to the similarity between the geometric shapes of the canyons and the locations of the buildings, the settlements where the road is located between the buildings are called "street canyon" in architecture and urbanism (Ünal Çilek, 2022). The concept of "canyon effect" takes its name from here. Canyon effect: "Microclimatic changes in street canyons" (Yılmaz et al., 2023). Sound (Can et al., 2015; et al., 2024; Yılmaz et al., 2023), heat (Battista et al., 2021; Buccolieri et al., 2015), lighting (Šprah et al., 2024), air quality (Du et al., 2023; Li et al., 2020) is effective in multiple comfort parameters. It may cause the formation of heat islands or noisy areas, deteriorate air quality and cause serious effects on human health (Babisch, 2008, 2014; Babisch et al., 2005; Carlo et al., 2024; Farrell et al., 2015; Lugten et al., 2024; Nosek et al., 2022; Schiff et al., 2010; WHO, 2018). It may cause an increase in environmental pollutants (Li et al., 2017; McMullan & Angelino, 2022).

The reason why street canyons are special areas is that they create different conditions according to their surroundings due to the airflow between the buildings (Di Bernardino et al., 2018). In street canyons, turbulence is lower than in open terrain, while air swirls form at the corners and the air becomes more stagnant. These vortices in the canyons cause wind and sub wind levels to differ in terms of air pollution, heat and sound (Farrell et al., 2015). As the height of the building increases, a deeper canyon is formed (Murena & Mele, 2016), and the difference between the lower and upper elevations of the physical environment components increases. For example, many studies have shown that road-level air pollution (for the same vehicle road and traffic density) is higher in an area under the influence of deep canyon than in an open area (Farrell et al., 2015; Murena & Favale, 2007; Vardoulakis, Gonzalez-Flesca & Fisher, 2002). Another result that supports this is: On roads where traffic flow is free, the air pollution concentration at the road level of the canyon (at the lower level of the building) is much lower than at the upper level (Di Bernardino et al., 2018; Kim et al., 2022; Thaker & Gokhale, 2016).

Many design elements have an impact on the canyon effect. It is affected by elements such as wind direction, building geometry, roof plane, road width, building height (Balogun et al., 2010; Buccolieri et al., 2015; Carpentieri et al., 2012; Eliasson et al., 2006; Karra, Malki-Epshtein & Neophytou, 2017; Kim et al., 2022, 2023; Kluková et al., 2021; Lugten et al., 2024). Situations such as the slope, flat or roundness of the roof design, the degree of slope, and the partial design affect the air vortex on the street (Alwi et al., 2023; Kluková et al., 2021). There are various types of roofs in today's cities. Especially in areas with snow and rainfall, the majority of buildings have sloping roofs (Badas et al., 2017). In the studies conducted for such settlements, it is very important to enter the roof details into the simulation in terms of the realism of the results.

Observation (measurement) or simulation can be performed for physical environmental control in street canyons. Observation ensures that instantaneous and unobservable data are also taken into account. Therefore, it is a more suitable method especially for pollution research (Farrell et al., 2015; Guillaume, Gauvreau & L'Hermite 2015; Yagi et al., 2017). Simulation, on the other hand, allows the evaluation of various geometric and meteorological conditions, and since it can be repeated, it is a suitable method for the design phase (Can et al., 2015; Farrell et al., 2015; Guillaume et al., 2015; Kanda, 2006; Schiff et al., 2010). In the simulation, a "numerical model" or "operational model" (Vardoulakis et al., 2003) can be used. Numerical models work with "computational fluid dynamics". However, it is a high-cost calculation method (Guillaume et al., 2015). Therefore, it cannot be used for every canyon. Operational models are an alternative to numerical models. It can also be created and used by non-experts. Although the sources of information are limited, they provide a lot of data on the subject (Kang, 2005; Lee & Jeon, 2011; Lee & Kang, 2015; Murena & Mele, 2016; Yilmaz et al., 2023). Operational models are generally created in such a way that the buildings are accepted as boxes and calculated by mass equation. Since the boxes are considered homogeneous and stable, it is easier to calculate the average values of the pollutants in the street (Murena et al., 2011).

2. Material and Method

The aim of the study is to investigate the relationship between trade and housing functions and building and vehicle road heights in building groups exposed to the canyon effect. Within the scope of the study, uniform operational canyon models were created and environmental noise calculations were made specific to the measurement points.

SoundPLAN software was used for environmental noise calculation. The scenarios planned to be evaluated within the scope of the study are drawn in AutoCAD 2018. Noise data is entered into the model in SoundPLAN. The results were compared with each other for different scenarios. The images of the study were drawn by hand in the Designer-2 application.

3. Findings and Discussion

Within the scope of the study, ground floor residential buildings with commercial functions were evaluated specific to the canyon effect. For this, a building type and a road section were designed, first the combination of commercial and residential functions of this building, then the combination of height between the road and the building was changed. As seen in Figure 1, the types of street canyons used in this study are common in today's cities. Especially in densely populated areas, even deeper canyons are encountered.

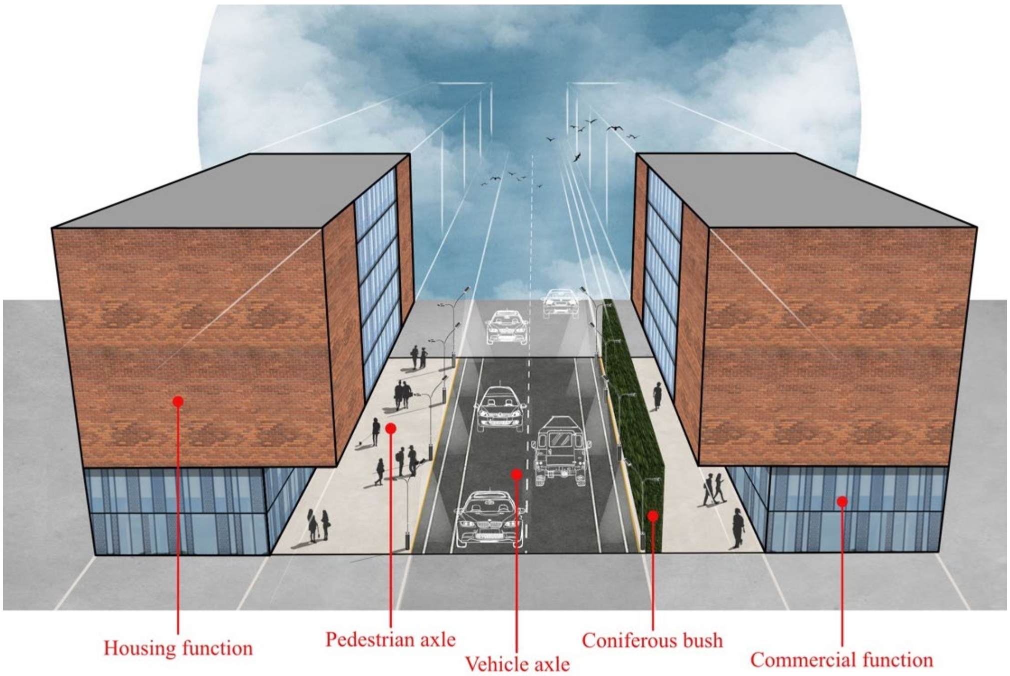


Figure 1. Three-Dimensional Rendering of the Model 7

The road facade of the designed building is 20 meters wide without a flat balcony. The facade consists of glass and brick. Facade size (cm) and material use are shown in Figure 2. Only brick and glass material was used in the residential unit and only glass material was used in the trade.

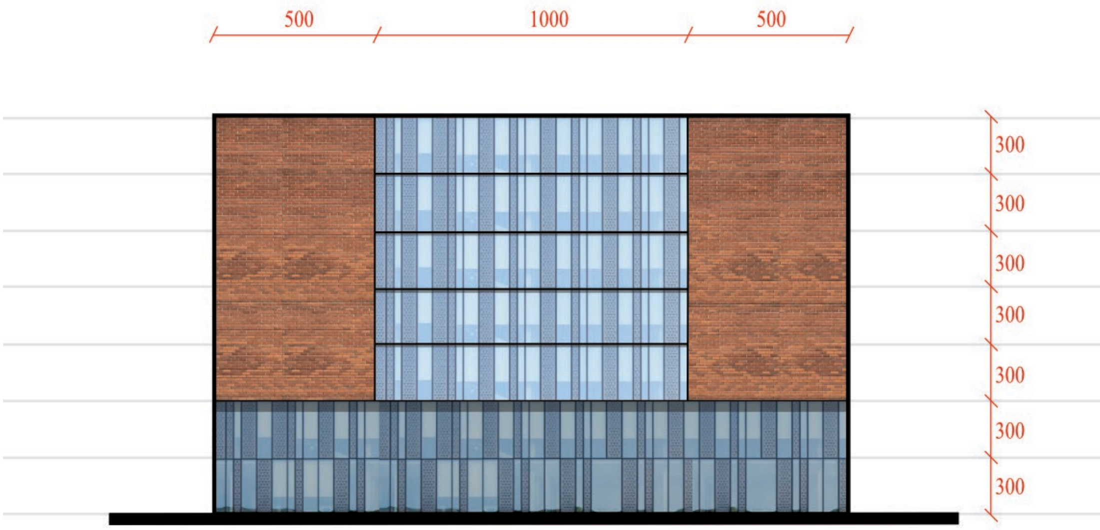


Figure 2. Road Front of the Building (Model 7)

Figure 1 The example of a building model with two commercial five-storey houses is shown in Table 2. The combinations of the building in Figure 2 in 12 scenarios are given in Table 1. The sound absorption values of the materials used in building and road design are given. It is "Rw: 24" for glass material.

Table 1. Sound absorption (α) values of materials used in design

	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz
Glass (Large Panel) *	0,18	0,06	0,04	0,03	0,02
Brick (Machined Brick Mesh) **	0,01	0,02	0,02	0,03	0,04
Asphalt (9,5 mm size aggregate, 4,3 cm thickness) ***	0,01	0,01	0,05	0,8	0,15
Stone (Marble) **	0,01	0,01	0,01	0,02	0,02
Needle Leaf Shrub ****	0,02	0,04	0,03	0,04	0,1

* (Egan 2007), * * (Colorlib & Jekyll 2021), * * * (Knabben et al. 2016), * * * * (M. Li et al. 2020)

3.1. Scenario Design

In the literature, heterogeneous, semi-idealized models have generally been used in studies on the canyon effect (Allegrini, 2018; Coceal et al., 2006; Du et al., 2023; Goulart et al., 2019; Lo & Ngan, 2015; Michioka, Takimoto & Sato, 2014; Nosek et al., 2018; Shen et al., 2017). Uniform street canyons usually consist only of high-rise buildings. However, mixed street canyons are formed in various urban areas with canyon effect today. There is variability in factors such as traffic density, building height, road width (Gu et al., 2011). The models used in the study were aimed to be similar to today's street canyons. Figure 2 shows a three-dimensional rendering of a model.

Scenario design stages are as follows:

- For the examination of the commercial-housing combination: The floor layout of the building is planned as "Ground floor + 6 floor", seven floors in total. The facade was retracted 2,5 meters from the road on the commercial floors of the building. In the scenario editing, three different combinations are included: one layer commercial, two layers commercial and three layers commercial.

- In order to examine the canyon effect, the road section (vehicle and pedestrian) was kept constant, and different elevation heights specific to the road and building were evaluated. Road: The pedestrian axle on both sides (a pedestrian axle 2,5 meters) is planned with a total width of 12 meters in the middle, open to bi-directional traffic and unable to park (double lane, 7 meters). The vehicle path data is taken from the SoundPLAN library. "Road day histogram library + OGT + 24%" was selected and variable and bidirectional traffic was determined. "Main Road" was selected as the road type, and for light vehicles, day speed was entered as 60 km/h (variable), 50 km/h (variable) in the evening, and 40 km/h (constant) at night. For heavy vehicles, 50 km/h (variable) was entered during the day, 40 km/h (variable) in the evening, 30 km/h (constant) at night. Within the scope of these entered and selected values, SoundPLAN calculated the following values for the road: Lday 76,45 dB (A), Levenning 70,62 dB(A), Lnight 66,90 dB(A). This path calculation was used for all models. Asphalt was preferred as vehicle road material and stone (marble) was preferred as pedestrian road (pavement) material. Four different combinations are included: the road is lower than the ground level of the building, the ground floor of the building is at the same height as the first floor and the second floor.

A total of 12 different scenarios were created by crossing commercial-housing combinations with road-building combinations. In the models, the building and road are formed in a length of 20 meters, and the measurement points are at the midpoint of the model (at 10 meters). A total of 14 measurement points were determined in each scenario model, 4 in the building (2 in commerce, 2 in housing) and 10 outside the building. The measurement points are co-located on the right and left sides of the model. In each model, it was decided to place identical buildings on both sides of the road.

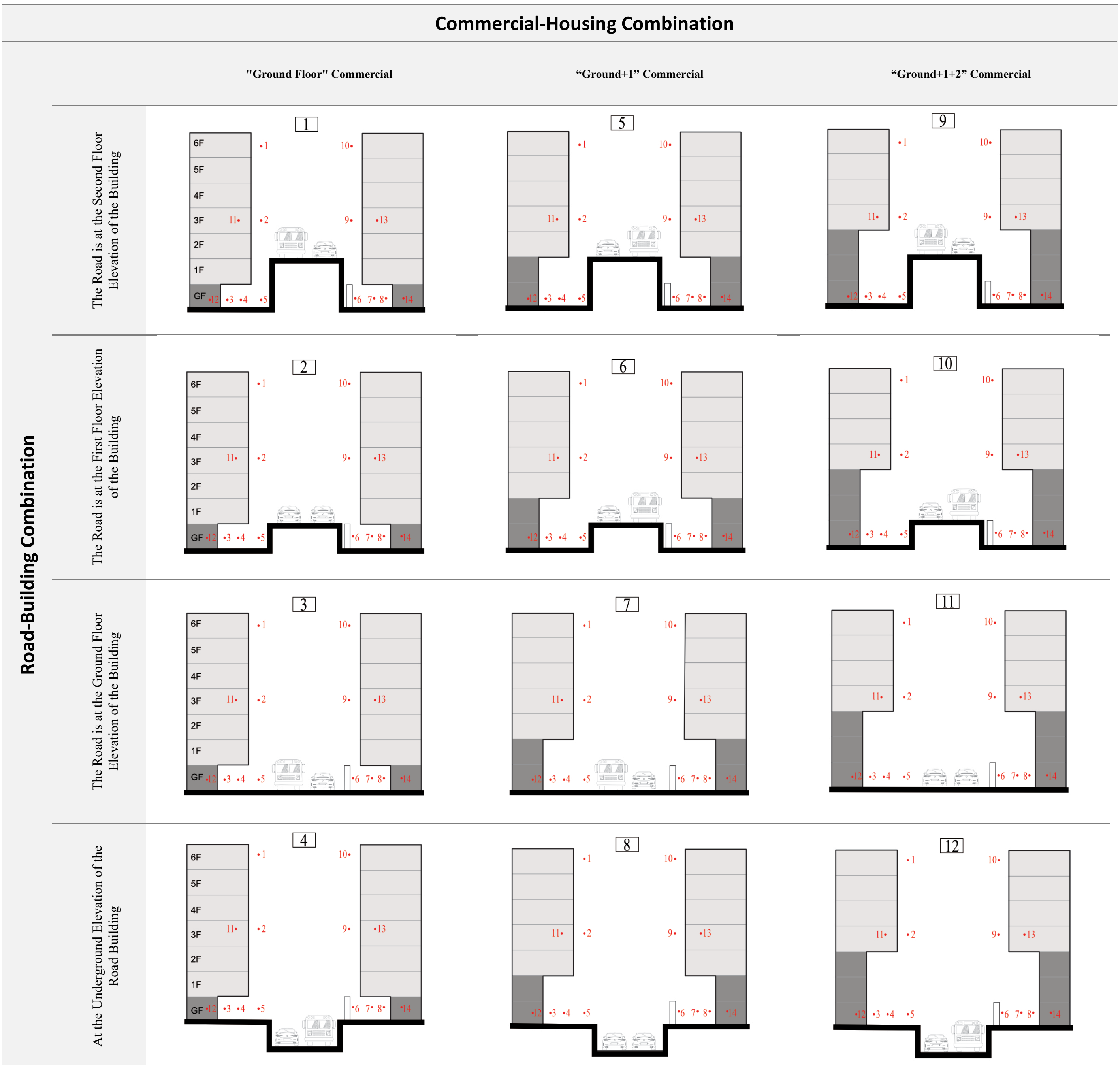
In each model, a coniferous bush with a height of 3 meters and a width of 90 cm is placed parallel to the road (continuing throughout the entire model) on the pedestrian axis on the right side of the road. This bush is planned to act as a natural noise barrier. In addition, bushes have the feature of supporting ventilation and social life under the influence of canyon and preventing the formation of wind corridors (Can et al., 2015; Carlo et al., 2024; Fellini et al., 2022; Van Renterghem & Botteldooren, 2008, 2010). The bush is placed at the pavement elevation and is positioned independently of the road elevation. The shrub height is chosen in accordance with the height of the garden protection wall used in any sheltered site.

It was preferred to leave the cantilever distance in the buildings (between the commercial and residential floors) 2,5 meters and to prefer the materials whose sound absorption values are given in Table 1 to ensure that the models comply with the values allowed by the structural and regulations. In models 1, 2, 4, 5, 6, 8, 9, 10 and 12, when the road elevation is changed, the road edges are assumed to be the same as the road material.

For the meteorological data (wind, temperature and humidity) of the study, Cmet(daytime): 2, Cmet(evening): 1 and Cmet(night): 0,5 values were entered.

Table 2 cross-sections and measurement points of 12 scenarios (14 in each scenario) are shown in. Spaces coloured dark gray represent commerce, and light greys represent housing. In the table, each row shows the same elevation height between the road and the building, and each column shows the same commercial housing combination. The models are designed in three dimensions, shown in their cross-sections in Table 2.

Table 2. Scenarios (Red: Measurement point)



The locations of the measurement points were selected at similar horizontal and vertical coordinates for convenience in calculation and comparison. Measurement points 1, 2, 9 and 10 are located 1 meter away from the building facade. Measurement points 3 and 8 are located 0,5 meters away from the building facade. The X-axis coordinates of measurement points 1,2 and 5 are the same. The X-axis coordinates of measurement points 6, 9 and 10 are the same. The Y-axis coordinates of measurement points 3, 4, 5, 6, 7, 8, 12 and 14 are the same. Measurement points 11 and 13 refer to residential indoor noise, while measurement points 12 and 14 refer to commercial indoor noise. The locations of the measurement points are given in Figure 3. Figure 3 shows the measurement points on Model 3.

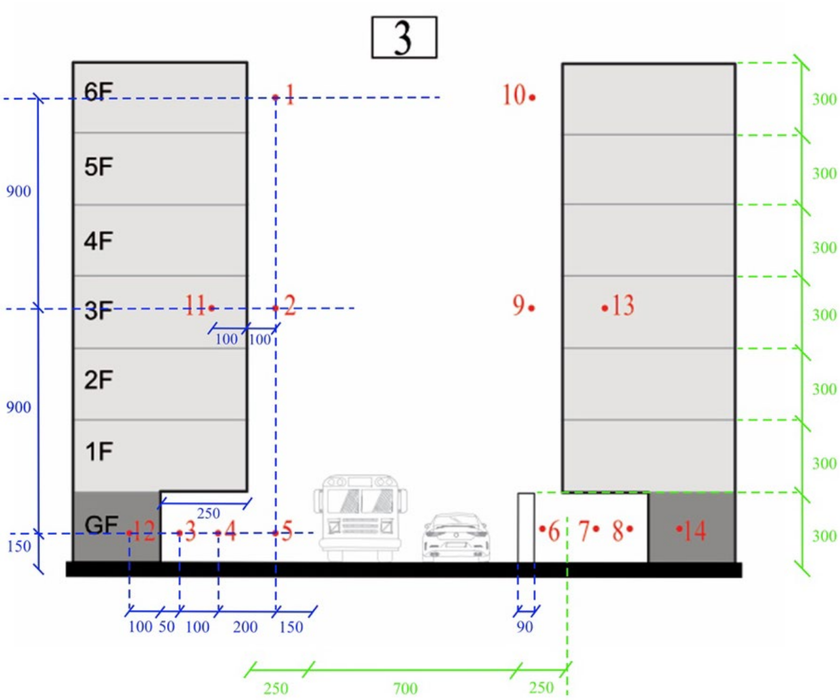


Figure 3. Location of Measurement Points (Model 3)

In the continuation of the study, the measurement points were named according to the name of each scenario. For example, the measurement points of the first scenario are named as 1.1, 1.2, 1.3, 1.4, etc.

4. Conclusion and Suggestions

For the 12 models calculated within the scope of the study, 168 different result data were obtained, 48 of which were indoors (24 in commerce, 24 in housing) and 120 outdoors. Simulation results are given in Table 3. Daily average value (Lden) was used to compare the measurement results. The painted columns in the same color show the measurement point name and the result value.

Table 3 the measurement results given in are examined with the following graphs. Table 5 in, it is shown that the sound reaches long distances without decreasing due to the canyon effect. For this, the 1st, 2nd and 5th measurement points (aligned in the vertical plane) were used from each model. The 5th point is at the pavement level and is the closest to the road, while the 1st point is at the upper level of the building and is the farthest from the road.

- The noise level difference between the 1st and 2nd points is between a minimum of 0,5% (0.3 dB(A), model 12) - a maximum of 2,7% (1,6 dB(A), model 10).
- The noise level difference between the 1st and 5th points is between a minimum of 0,7% (0.4 dB(A), model 2) and a maximum of 8,2% (4,8 dB(A), model 8).
- The noise level difference between the 2nd and 5th points is between a minimum of 0,3% (0,2 dB(A), model 8) - a maximum of 1,5% (0,9 dB(A), models 3, 6 and 10).

Table 3. SoundPLAN simulation results (Lden results dB(A))

Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
measurement point	*result*	*measurement point*	*result*	*measurement point*	*result*	*measurement point*	*result*	*measurement point*	*result*	*measurement point*	*result*
1.1	56,2	***2.1***	56,3	***3.1***	54,7	***4.1***	53,6	***5.1***	56,9	***6.1***	57,2
1.2	57,4	***2.2***	57,3	***3.2***	55,7	***4.2***	54,1	***5.2***	58,6	***6.2***	58,9
1.3	24,3	***2.3***	24,3	***3.3***	23,4	***4.3***	23,3	***5.3***	24,3	***6.3***	24,4
1.4	28,3	***2.4***	28,3	***3.4***	27,0	***4.4***	28,8	***5.4***	28,5	***6.4***	28,2
1.5	56,9	***2.5***	56,7	***3.5***	56,6	***4.5***	54,5	***5.5***	57,8	***6.5***	58,0
1.6	50,4	***2.6***	50,4	***3.6***	48,8	***4.6***	48,5	***5.6***	50,5	***6.6***	50,5
1.7	45,5	***2.7***	45,8	***3.7***	39,9	***4.7***	40,3	***5.7***	46,4	***6.7***	45,6
1.8	22,3	***2.8***	22,4	***3.8***	18,4	***4.8***	18,3	***5.8***	22,5	***6.8***	22,5
1.9	55,4	***2.9***	56,4	***3.9***	56,7	***4.9***	56,0	***5.9***	55,3	***6.9***	55,5
1.10	54,3	***2.10***	54,5	***3.10***	55,2	***4.10***	55,3	***5.10***	54,5	***6.10***	54,5
1.11	29,9	***2.11***	29,3	***3.11***	28,2	***4.11***	26,6	***5.11***	31,1	***6.11***	31,4
1.12	7,3	***2.12***	7,3	***3.12***	6,3	***4.12***	6,3	***5.12***	7,3	***6.12***	7,4
1.13	27,9	***2.13***	28,9	***3.13***	29,2	***4.13***	28,5	***5.13***	27,8	***6.13***	28
1.14	4,9	***2.14***	5	***3.14***	1	***4.14***	1,1	***5.14***	5,1	***6.14***	5,1

Model 7		Model 8		Model 9		Model 10		Model 11		Model 12	
measurement point	*result*	*measurement point*	*result*	*measurement point*	*result*	*measurement point*	*result*	*measurement point*	*result*	*measurement point*	*result*
7.1	53,3	***8.1***	53,2	***9.1***	56,7	***10.1***	57,0	***11.1***	54,1	***12.1***	53,2
7.2	54,0	***8.2***	54,3	***9.2***	58,1	***10.2***	58,6	***11.2***	54,7	***12.2***	53,5
7.3	23,4	***8.3***	23,3	***9.3***	24,4	***10.3***	24,3	***11.3***	23,3	***12.3***	23,4
7.4	26,9	***8.4***	26,4	***9.4***	28,0	***10.4***	28,5	***11.4***	26,9	***12.4***	27,0
7.5	54,2	***8.5***	58,0	***9.5***	57,4	***10.5***	57,7	***11.5***	55,2	***12.5***	53,9
7.6	49,0	***8.6***	48,8	***9.6***	50,4	***10.6***	50,5	***11.6***	48,8	***12.6***	48,7
7.7	40,3	***8.7***	40,0	***9.7***	45,2	***10.7***	45,2	***11.7***	40,0	***12.7***	22,5
7.8	18,4	***8.8***	18,4	***9.8***	22,4	***10.8***	22,3	***11.8***	18,4	***12.8***	18,4
7.9	57,3	***8.9***	56,8	***9.9***	55,8	***10.9***	55,8	***11.9***	56,6	***12.9***	55,9
7.10	56,0	***8.10***	56,0	***9.10***	54,6	***10.10***	54,6	***11.10***	55,6	***12.10***	55,6
7.11	26,5	***8.11***	26,8	***9.11***	30,6	***10.11***	31,1	***11.11***	27,2	***12.11***	26
7.12	6,4	***8.12***	6,3	***9.12***	7,4	***10.12***	7,3	***11.12***	6,3	***12.12***	6,4
7.13	29,8	***8.13***	29,3	***9.13***	28,3	***10.13***	28,3	***11.13***	29,1	***12.13***	28,4
7.14	1	***8.14***	1	***9.14***	5	***10.14***	4,9	***11.14***	1	***12.14***	1

Continuous traffic flowing highways are line sources. When environmental factors are neglected (such as wind, temperature, weather), the sound level at the line source is calculated with the formula:

"$L2 = L1 - 10\log(r2/r1)$" dB

(L: sound level, r: distance) (Yüğrük Akdağ, 2024). Since the sound line source (road) height changes in the models, it is necessary to calculate with different r values. Table 4 in which model, which r values are entered is written. (While calculating the r value, the geometric midpoint of the vehicle road at 1,5 meters above the ground is accepted as the center of the sound source.)

Table 4. R (distance) values in models for line source sound level reduction formula (m)

	Models 1, 5, 9			Models 2, 6, 10			Models 3, 7, 11			Models 4, 8, 12		
	r_1	r_2	$r_2 = r_1$	r_1	r_2	$r_2 = r_1$	r_1	r_2	$r_2 = r_1$	r_1	r_2	$r_2 = r_1$
Point 1 (r_2) and Point 2 (r_1)	**6**	**13,7**	2,2	**8,3**	**16,6**	2	**10,9**	**19,5**	1,7	**13,7**	**22,4**	1,6
Point 1 (r_2) and 5 (r_1)	**7,5**	**13,7**	1,8	**5,4**	**16,6**	3	**1**	**19,5**	19,5	**5,4**	**22,4**	4,1
Point 2 (r_2) and 5 (r_1)	**6**	**7,5**	1,2	**8,3**	**5,4**	0,6	**10,9**	**1**	0,1	**13,7**	**5,4**	0,3

The sound level in the line source was calculated with the data in Table 4. The results are given in Table 5.

Table 5. SoundPLAN simulation and theoretical account levels differences of the 1st, 2nd and 5th measurement points in the models in Table 2 (dB(A))

	Point 1 (r_2) and Point 2 (r_1)		Point 1 (r_2) and 5 (r_1)		Point 2 (r_2) and 5 (r_1)	
	SoundPLAN	Account	SoundPLAN	Account	SoundPLAN	Account
Model 1	1,2	3,4	0,7	2,5	0,5	0,8
Model 2	1	3	0,4	4,7	0,6	-2,2
Model 3	1	2,3	1,9	12	0,9	-10
Model 4	0,5	2	0,9	6	0,4	-5
Model 5	1,7	3,4	0,9	2,5	0,8	0,8
Model 6	1,7	3	0,8	4,7	0,9	-2,2
Model 7	0,7	2,3	0,9	12	0,2	-10
Model 8	1,1	2	4,8	6	3,7	-5
Model 9	1,4	3,4	0,7	2,5	0,7	0,8
Model 10	1,6	3	0,7	4,7	0,9	-2,2
Model 11	0,6	2,3	1,1	12	0,5	-10
Model 12	0,3	2	0,7	6	0,4	-5

According to the data we obtained,

- Table 5 In, the differences between the simulation values and the calculation values are high (the sound does not decrease in direct proportion to the distance)
- The 5th point, which is the closest measurement point to Table 3 the vehicle road, should be minimum 53,9 dB(A), maximum 57,8 dB(A) (difference 3,9 dB(A)), the road noise calculated by SoundPLAN should be lower than the difference value (9,55 dB(A) in the range of minimum 66,9 dB (A), maximum 76,45 dB(A)
- Table 6 Although the second measurement point is moderately close to the road, it can reach higher values than the measurement point closest to the road (5th point).

It is caused by the fact that the sound reflects many times between the mutually parallel surfaces, that is, the canyon effect. Based on this information, the measurement results Table 3in show that these models are suitable for examining a group of buildings exposed to the canyon effect.

According to Table 2 and Table 3 indoor noises, sidewalk noises and building outdoor noises were examined. Color legend is used in the tables. Pink-Purple: Indoor noise level, Blue: Residential outdoor noise level, Yellow-Orange: Sidewalk elevation (commercial) outdoor noise level.

Table 6. Building outdoor noise level dB(A), (Dark gray: 1st, Medium Gray: 2nd, Light gray: 3rd measurement point)

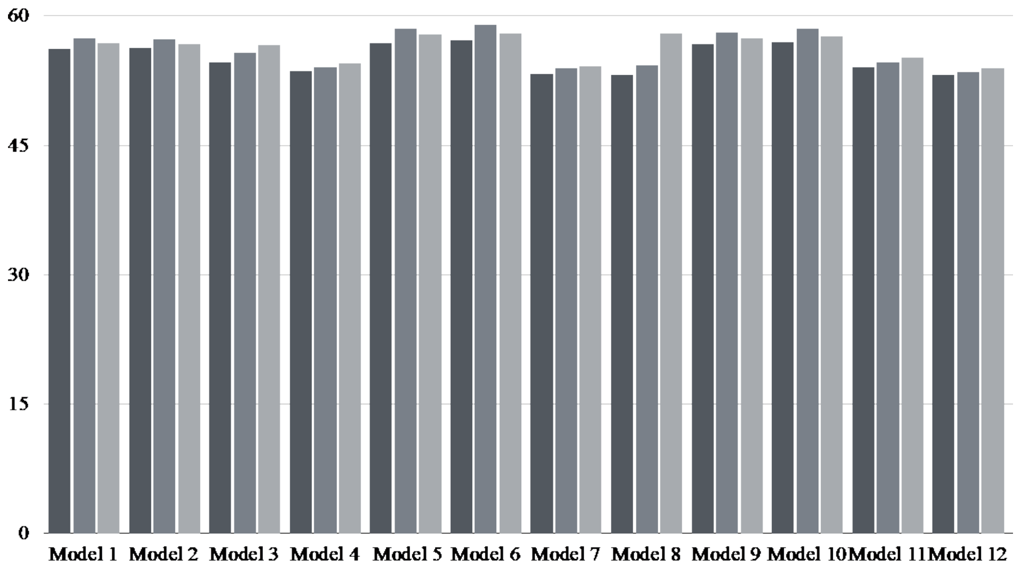


Table 7 and Table 8 the indoor noises of the building were examined in Table 7. It was observed that the commercial indoor noise was lower on the sidewalk side where the natural noise barrier (coniferous bush) was used. The most obvious difference between barrier and non-barrier (right and left) was observed in model 3, model 4, model 7, model 8, model 11 and model 12. The noise level difference between commercial interiors is between 82, 5% (model 4) and 87,3% (Model 7). The difference in these models is more pronounced because the road elevation is lower than or flush with the bush. The difference is clearly read in Table 7. As the road elevation increases from low to high, the noise level in the commercial interior also increases. In other models, no similar effect was observed as the road was positioned at a higher elevation than the bush. The models with the least difference are 1, 5 and 9. In these models, the road is at the same height as the upper level of the bush or 3 meters higher than the road bush. However, a decrease was observed in almost every model due to the presence of the bush.

Table 7. Commercial indoor noise level dB(A), (pink: 12th and purple:14th measurement points)

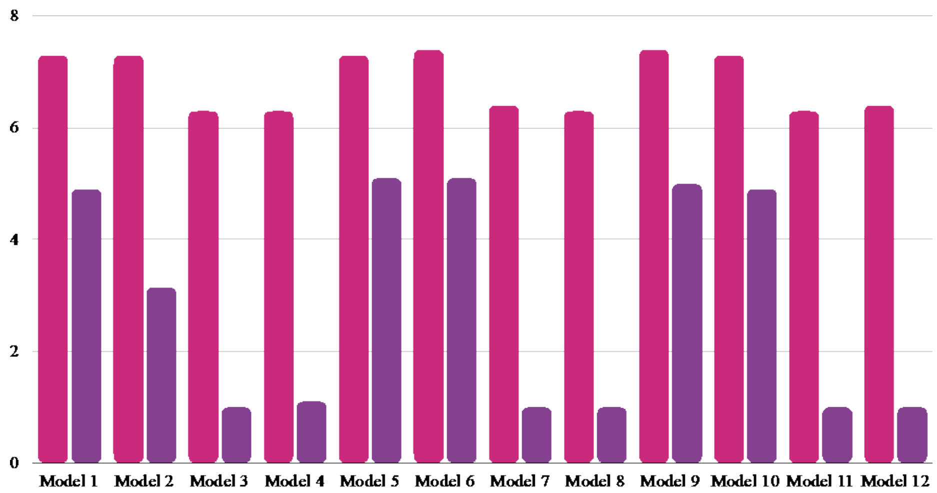


Table 8 The noise difference between the residential interiors in was taken from the 11th and 13th measurement points on the 4th floor. These two measurement points are positioned exactly symmetrically to each other, since the buildings are completely identical to each other, the measurement difference between them is due to the effect of the bush at the pavement level on the sound reflection. The difference is 10,1%, that is, 3,3 dB(A), at most in model 5. However, in some of the models, the sound level was lower in the houses on the opposite side of the bush in some of the building on the bush side. This is due to the fact that the play affects the mutual parallel inter-surface reflections of the sound wave.

Table 1. Residential indoor noise level dB(A), (Pink: 11th and purple:13th measurement points)

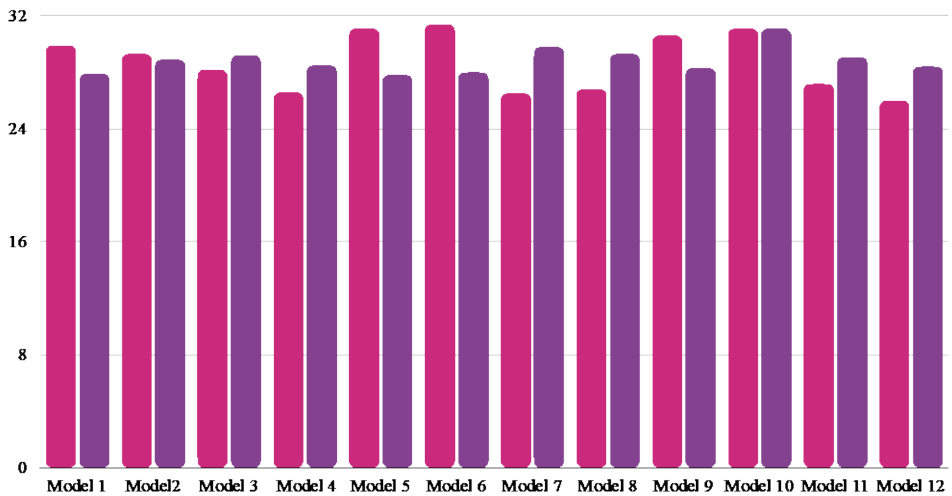


Table 9 The outdoor noise level of the house at the level of the 3rd floor was evaluated in. Measurement points 2 and 9 were used. Both are located one meter away from the facade. The biggest difference between the measurement points is in model 6. 3,4 dB(A) is 5,7%.

Table 2. Residential outdoor noise level at floor level dB(A), (Light Blue: 2nd and dark blue:9th measurement points)

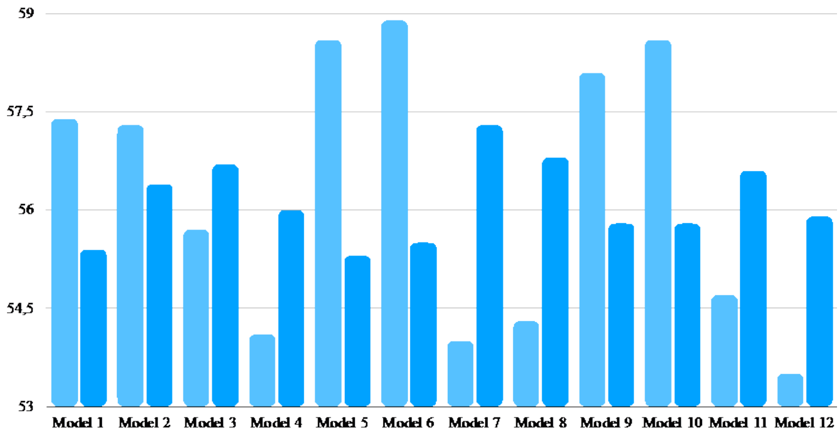


Table 10 The outdoor noise level on the top floor of the building (6th floor, residence) was compared in. The 1st and 10th measurement points were used. The measurement points are located 1 meter away from the facade of the building where they are located. The largest difference is 5% in model 8, with a value of 2,8 dB(A).

Table 3. Residential outdoor noise level at floor level dB(A), (Light Blue: 1st and dark blue:10th measurement points)

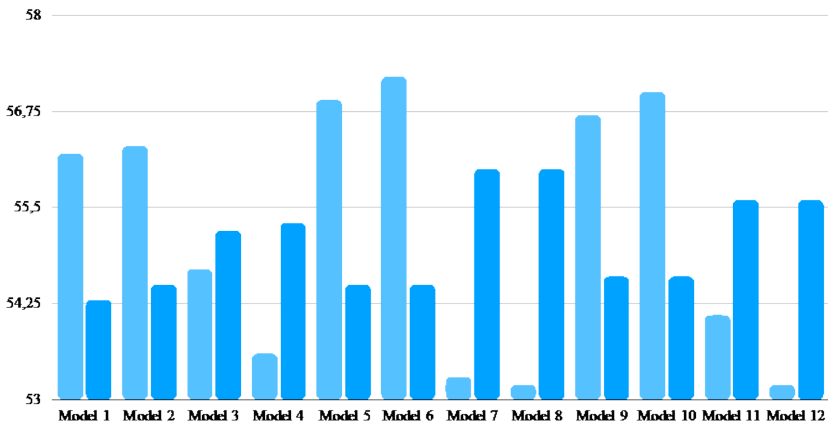
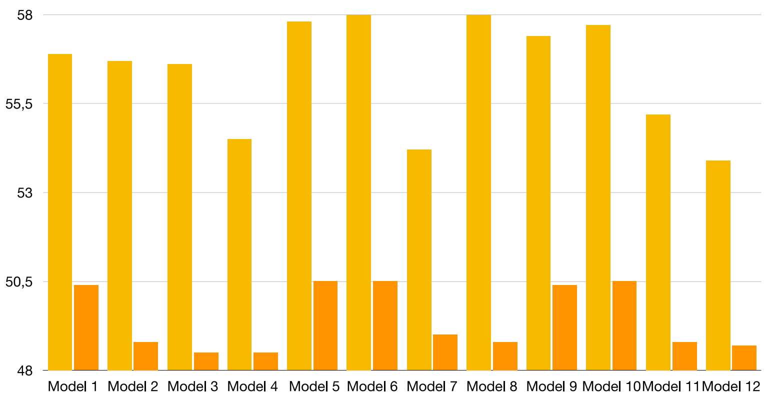


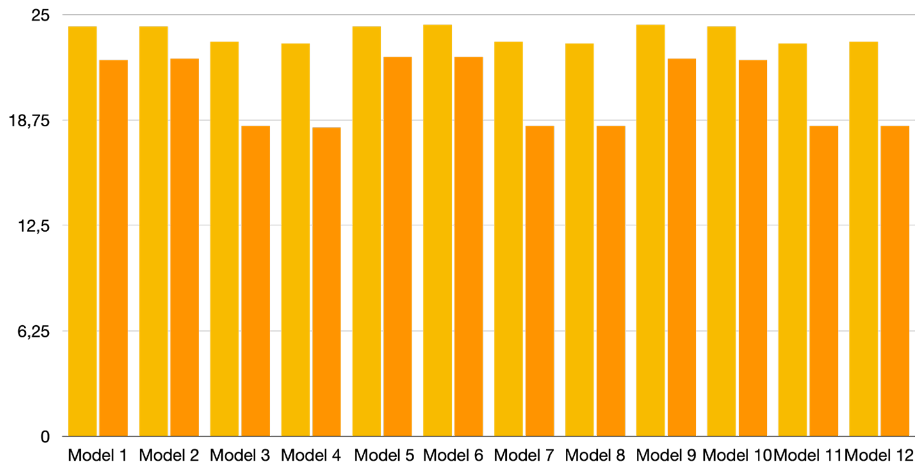
Table 11 In, the outdoor noise level of the pavement elevation was taken from the 5th and 6th measurement points. These points are closest to the vehicle road. While the 6th point is located just behind the bush, there is no obstacle between the 5th point and the road. The difference between them is at most 9,2 dB(A), 15,8% in model 8.

Table 4. Sidewalk outdoor noise level dB(A), (Yellow: 5th and orange: 6th measurement point)



In Table 12, the outdoor noise level of the pavement elevation was taken from the 3rd and 8th measurement points closest to the building (commercial). These measurement points were created in order to evaluate the sounds reflected from the building facade. These points are located 1 meter away from the facade. The maximum difference between them was found to be equal in models 3, 4, 7, 11 and 12, and 5 dB(A) was 21,4%.

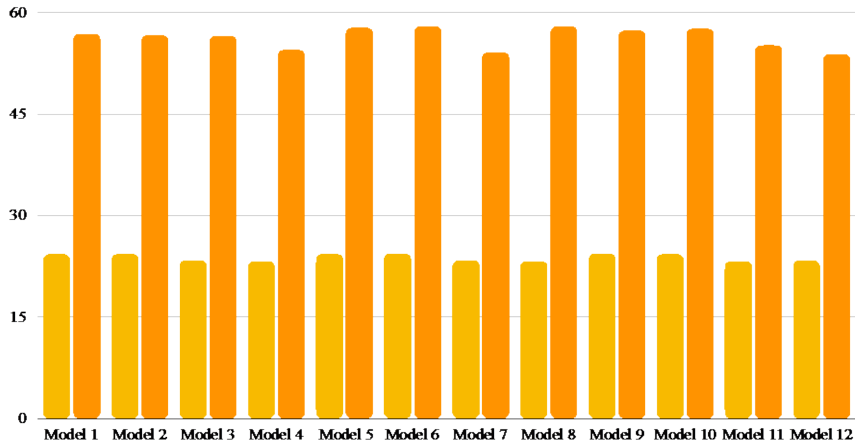
Table 5. Sidewalk outdoor noise level dB(A), (Yellow: 3rd and orange: 8th measurement point)



Unlike other graphs, Table 13 is prepared to compare the measurement points on the same side of the building, not the measurement points in Table 14 reciprocal buildings. The selected measurement points were on the same side of the building and were used to examine the level change of the sound due to the echo. The selected points are the closest points to the road and the closest points to the building at the pavement elevation.

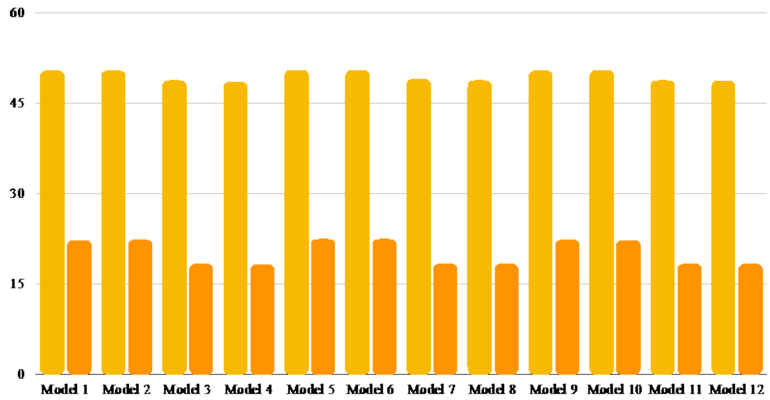
Table 13 In the models, a comparison was made in the building on the left (without bushes). The 3rd point is closest to the building and the 5th point is closest to the vehicle road. The difference between them is at least 30.5 dB(A), 56,5% in model 12. The maximum difference is 33,6 dB(A), 57,9% in model 6.

Table 6. Sidewalk outdoor noise level dB(A), (Yellow: 3rd and orange: 5th measurement point)



In Table 14, a comparison was made in the building on the right (with a bush) in the models. The 6th point is closest to the vehicle road and the 8th point is closest to the building. Point 6 is on the side of the bush close to the building. The difference between them is at least 30,5 dB(A), 56,5% in model 12. The maximum difference is 34,7 dB(A), 59,8% in model 8.

Table 7. Sidewalk outdoor noise level dB(A), (Yellow: 6th and orange: 8th measurement point)



Conclusion

The canyon effect does not work according to the principle that the sound decreases as it moves away from the source. The results of the study summarize this situation:

- Table 6 and Table 7 in the sound levels in models 1, 2, 5, 6, 9, and 10 are higher than the sound levels in other models. This situation is directly proportional to the increase in the sound level as the road height increases. On the other hand, the reason for the relatively lower noise levels in models 4, 8 and 12 can be attributed to the fact that the edges of the vehicle road are closed up to the pavement level.
- Reflections caused by the canyon effect caused the results in Table 9 and Table 10 to be different from Table 6, Table 7 and Table 8. The results in Table 9 and Table 10 show both the effect of the canyon effect on sound reflections and how the environmental noise level creates a change, and that the bush creates an impact not only for the building group in front of it, but also for the entire canyon region.
- Table 12 showed the effect of the bush on the noise level at the road level. The bush served as a natural noise barrier as intended.
- Table 6 and Table 13 consider the 3rd, 4th, 5th measurement results in all models according to the values in and, the effect of reflections from the building protrusions was not observed sufficiently.

Accordingly: Physical environmental conditions should be examined well when designing in a built environment under the influence of a canyon. If necessary, various measures should be taken at the pavement level. It should be noted that road height is a dominant factor.

The latest updated regulations in our country do not allow building overhangs. However, there are buildings with slab overhangs (vertical discontinuities) in the existing building stock. The results of this study provide information about the environmental noise that will be generated and affected by roads or structures that will be built near such structures. It also shows how noise at ground floor height affects the upper floors of buildings. It has caused high levels of noise in both commercial and residential functions. In conclusion: This study revealed with quantitative data that there was a change in the environmental noise level for all areas where there was a canyon effect. It was observed and calculated that the noise decreased less than it should in all combinations at the road building height. It explained one of the factors that architects, urban district designers and engineers should pay attention to in terms of environmental noise. Therefore, the current situation and future scenarios should be considered and well-planned when planning the settlement. If necessary, support from experts should be sought.

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Author Contribution and Conflict of Interest Declaration Information

All authors contributed equally to the article. There is no conflict of interest.

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Diagramming the Topology of Technology and Architecture in the 21st Century

Asude YOKUŞ [1]*, Tolga SAYIN [2]

ORCID 1: 0009-0006-4017-6387
ORCID 2: 0000-0002-8128-7255
[1] *Mimar Sinan Fine Arts University, Graduate School of Architecture, Institute of Science, 34421, Istanbul, Türkiye.*
[2] *Mimar Sinan Fine Arts University, Faculty of Architecture, Department of Architecture, 34421, İstanbul, Türkiye.*
*** e-mail**: *asudeyokus@gmail.com*

Abstract

The research aims to address the existence of neoliberal policies in contemporary architectural production from an onto-political perspective. In Deleuze's ontology, the movement between the self and the other is established between the architect-subject and the ideological other. This relation is explored through the technique's being the object or subject of thought. In this context, the choices made by the architect-subject within the ethical framework are evaluated as active and passive and read through the symbolic plane it externalizes. The active and passive positionings of architectural thought reconstruct the professional boundaries of architecture. The surface formed by the movement of the relationship between the architect-subject and the ideological other on the temporal axis establishes the topology of technology-architecture thought.

Keywords: *Diagram, topology, technology, architecture, neoliberalism.*

21. Yüzyılda Teknoloji ve Mimarlık Topolojisini Diyagramlaştırmak

Öz

Araştırmanın amacı, güncel mimarlık üretiminde neoliberal politikaların varoluşunu onto-politik bir bakış açısıyla ele almaktır. Deleuze'ün ontolojisinde Kendi ve Öteki arasındaki devinim, mimar-özne ve ideolojik Öteki arasında kurulur. İçselleştirme ve dışsallaştırma döngüsü üzerinden okunan bu hareket teseraktta diyagramlaştırılır. İçselleştirme; mimar-öznenin alışkanlıklarını bozulduğu, anlamı ürettiği ve pasif kendilikte düşünceyi sentezlediği süreçtir. Dışsallaştırma ise mimar-öznenin ideolojik Öteki ile kurduğu onto-politik ilişkiyi edimselleştirmesidir. Bu ilişkilenme, tekniğin düşüncenin nesnesi veya öznesi oluşu üzerinden araştırılır. Bu bağlamda mimar-öznenin etik çerçevede yaptığı seçimler aktif ve pasif olarak değerlendirilerek dışsallaştırdığı sembolik düzlem üzerinden okunur. Pasiflik, sistemi olumlayarak sistemin sınırları dahilinde reaksiyon göstermektir. Mimarın bu anti-entelektüel tavrı neoliberalizm mimarlığı olarak karşılık bulur. Aktiflik ise sistemin karşısında bir aktör olarak, Ötekinin belirlediği sınırları ihlal edip kendi içkinliğinde aksiyon göstermektir. Mimarlık düşüncesinin aktif ve pasif konumlanışları mimarlığın mesleki sınırlarını yeniden inşa eder. Mimar-özne ve ideolojik Öteki arasındaki ilişkinin zamansal eksendeki hareketi ile oluşturduğu yüzey, teknoloji-mimarlık düşüncesinin topolojisini kurar.

Anahtar kelimeler: *Diyagram, topoloji, teknoloji, mimarlık, neoliberalizm.*

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1. Introduction

The objective of this study is to reveal the impact of neoliberal policies on current architectural production. Recent turns in political theory provide the theoretical basis for the neoliberal era, viewed through the lens of complexity. Deleuze's political ontology, as a philosophy, has the potential to deconstruct neoliberal chaos politics. It can make compelling assertions without relying on metaphysical or transcendent foundations and generate uncertainty without resorting to clear-cut discourse. The philosophy eliminates boundaries and is based on affirming both meaning and meaninglessness, as well as determination and indeterminacy (Direk, 2021).

Gilles Deleuze's metaphysical framework prioritizes 'becoming' over 'being', 'difference' over 'identity', and 'event' over 'substance'. He describes nature as a plane of immanence where forces, flows, movements, parts, intensities, becomings, machines, and desires are articulated. This metaphysical perspective challenges the prevalent capitalist economy and reshapes Western philosophical understanding. It has evolved into a form of resistance that champions the unrestrained affirmation of life (Direk, 2021). However, neoliberalism adopts Deleuze's philosophy of affirmation and twists it into a justification for violence of positivity (Spencer, 2018). Critiques of neoliberalism have often focused on its surface-level features, rather than delving into the underlying manipulative dynamics. To gain a deeper understanding of neoliberal strategies, it is necessary to examine their intricate interplay with Deleuzian philosophy. This will reveal the true nature of these strategies and their manipulative effects.

Deleuze's conceptual framework assigns significant importance to the concepts of 'Identity' and 'otherness'. In the realm of architecture, the concept of 'otherness' is intricately intertwined with the prevailing ideology of the era. The meaning of architecture's otherness cannot be understood through terms or concepts related to identification or opposition with ideology. Deleuze argues that otherness carries a unique significance or sense. Therefore, architecture's existence or meaning is determined by its relationship with the other. Identity and representation can only capture architecture's superficial dimensions of meaning, failing to fully express its essence (Widder, 2012, pp. 28-35).

In architecture, the relationship with the ideological otherness serves as the foundation for an ontological-political or onto-political interplay, shaping the societal context within which architects operate. Architecture's immanence is characterized by a tendency towards fragmentation and division, stemming from the 'violence' that emerges as a consequence of architecture's external function This immanence is characterized by a tendency towards fragmentation and division, which arises as a result of architecture's external function. However, in architecture, the term 'exteriority' does not refer to an unknowable transcendence or a thing-in-itself in the Kantian sense (Widder, 2012, pp. 38-40). According to Deleuze's ontology of meaning, the other of architecture is not an absolute fullness or an absolute lack in an ideological context. Instead, it emerges as an 'immanent one', a 'fold' in which the relations of distance and proximity change. These relations structure differences in ways that transcend the terms identity-opposition and interiority-exteriority.

2. Method

The research diagrams a tesseract, which is a four-dimensional hypercube, to represent the folded movement of the strong ontology of uncertainty. This movement establishes the immanence of architecture through internalization-externalization. The word 'tesseract' is derived from the Greek words téssara (τέσσερα 'four') and aktís (ἀκτίς 'ray'). The fourth dimension (ray) allows movement in time. When two parallel cubes are connected along this time axis, they form eight cubes (Figure 1). Because the human mind cannot conceive of four-dimensional space, the perception of a tesseract is challenging. However, we can illustrate the relationships between the cubes by representing their perspectives on a two-dimensional surface. One way of imagining a tesseract is to imagine a folding movement, similar to a three-dimensional network of eight cubes (similar to a two-dimensional network of the six faces of a cube).

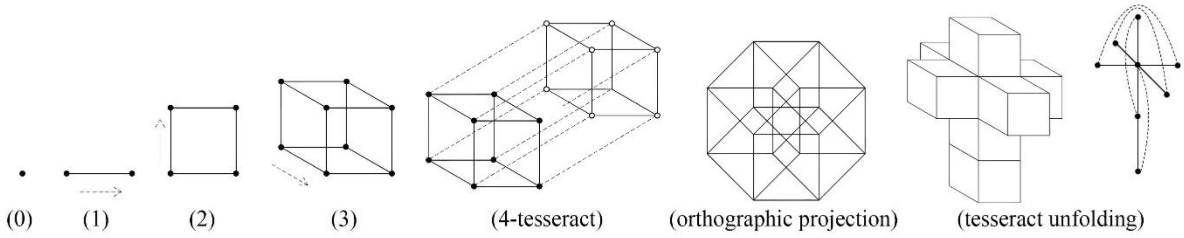

Figure 1. Formation diagram and expansion of tesseract.

The relationship between the self and the other, delineated by the concept of the tesseract, provides a legitimate framework. Embodied along the x, y and z axes, the self relates to the other along the temporal axis (w) and moves intertwined in the spatio-temporal dimension (Figure 2). Temporal space refers to the influence of the passive and the influence of the active. Only the present exists in time; it unites past and future, dissolves them in itself and divides every present infinitely (Deleuze, 2015).

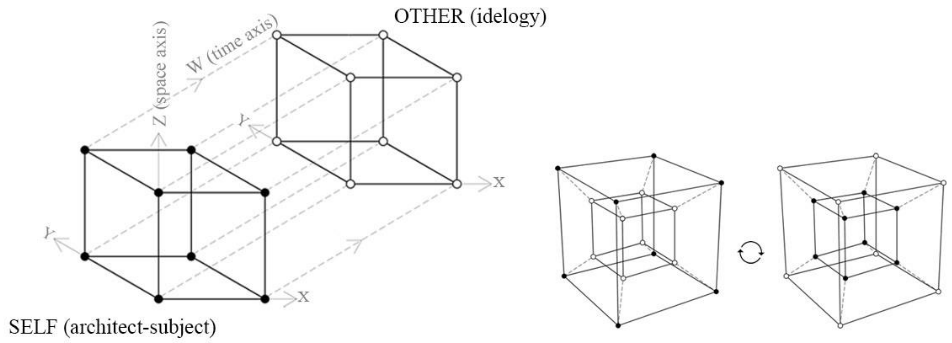

Figure 2. Diagram of onto-political relationship: unfolding of tesseract.

In the context of research, the relationship of temporal difference between the self and the other is established between architecture and ideology; the architect moves forward in time to externalize, or goes back in time to internalize, the previously established structure. The otherness of architecture is differentiated by distancing in both 'reactive' and 'non-reactive' architectural actions, defined as 'exteriorized interiority' or 'interiorized exteriority'. This critical stance, with the intention of metamorphosis, is a product of immanence that suspends identification, rather than a split or fragmentation that indicates transcendence. Identification arises from the need for transcendence as a temporary condition. Thus, architecture remains unsplit or unfragmented. The architect has the power to actively update her/his struggle with her/his awareness of the liberation of the social. The potential flexibility of this possessed plasticity constitutes the immanence of architecture within the architect's agency. The architect-subject, under his profession, internalizes and externalizes himself, in the context of this research in the neoliberal system, as an actor, actant, agent, and sometimes as an assemblage of things that come together in any process. On the one hand, she/he moves in the context of academic intellectualism, in the context of the architecture of her/his being active and the architecture of her/his being reactive.

3. Findings and Discussion

The temporary establishment of the passive self through the synthesis and storage of the architect's emotions in memory and their apprehension in the present within an abstract conceptual framework of relationships does not pose a problem at this stage. The problematization arises in the movement between passivity and activity in the process of internalization-externalization. In the process of externalization, extensity and Intensity find their structural counterparts as twins. At the molar level, each experience of subjectivity is mediated by different architectural subjects. Architects move from chaos to order within a complex and dynamic interrelationship, generating the neoliberal system. The internalization of this order-generating structure emancipates the architect from passive affections. The importance of the architect's name diminishes as she/he becomes an actor. The stage changes, the actors remain the same, but in the eyes of those who assign roles (authority), the agents change. Within each actor, an external agent is involved/coordinated. Therefore, within the neoliberal order, the architect, while remaining within the system, seeks emancipation in terms of both knowing/learning (praxis) and knowing/how to do (techne) while doing.

The liberation of 'praxis' and 'techne' ignites creativity. In this context, architects not only function as agents, but also operate and interpret actively. The ontology of meaning, situating itself within the robust aesthetic dimension of Deleuze's philosophy as identified by Hughes (2012), establishes connections in various allegories (which can be seen as extensions of the tesseract or staged surfaces within the scope of the research), opens a dynamic space of perception and disrupts habits. The movement of thought is represented in the context of this study as a conventional 'tesseract', at the level of representation where concepts are invented. In addition to the architect's obligation to submit to the system, this tesseract also represents the dilemma of the architectural agenda as to how architecture can be managed in a professional and intellectual context.

3.1 The Problematics of Active and Passive Synthesis in the Strong Ontology of Uncertainty

In Deleuze's ontology, the power of the passive self lies in the problematization style of synthesis. The inability to comprehend activities is passivity in the sense that perception cannot reach the intellectual level. Within the linguistic framework, it means a passivity aimed at establishing rules of synthesis for concepts and formulating a new principle of synthesis without recourse to pre-determined concepts. In this scenario, experience emerges from an intuitive understanding that refuses to focus on the sources of real experience through pre-existing concepts, free of a priori and categorical notions. In this context, the experimental facet of experience discovers a new principle of synthesis independent of the existing conceptual framework, based on an intuitive understanding called a posteriori, and ascends to a conceptual level. In the process, the impersonal flow of matter is observed within a non-conceptual 'assemblage'. Thus, instead of adhering to the given verbal limits of legislative concepts and the constraining and debilitating nature of categorical logic on thought, it is situated within the foundational finitude of 'producer-product' that moves with life. The genetic turn, dramatized (in the Kantian sense, schematized) as a tesseract in the flow of life, continues as a dynamic and static genesis between sensibility and understanding, as an experience of subjectivity in the process of self-transcendence (Figure 3).

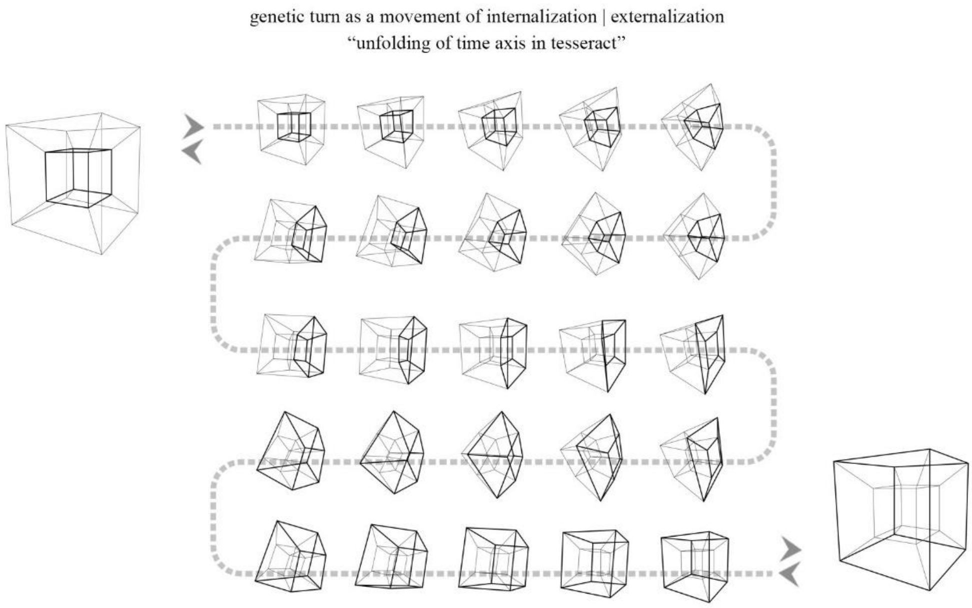

Figure 3. Topological structure of the genetic turn in the tesseract.

Deleuze defines unformed matter, or the 'plane of immanence', as a presupposition of the movement of thought, characterized by dynamic and static genesis. This material plane is complex and in constant flux, devoid of subjectivity and objectivity; life within it is impersonal, undefined, and singular. The dynamic genesis occurring within the plane of immanence generates a progressive series of syntheses from sensibility to understanding. This synthesis establishes the living present by compressing successive and independent moments; time is unfolded here, with the dimensions of future and past belonging to the living present. Deleuze refers to this synthesis as a passive synthesis because it is not carried out by the mind but takes place within the mind prior to all memory and thought. It is constitutive but not effective (Deleuze, 2017, pp. 105-106). Passive syntheses establish the habitus of movement as imagination, perceptual gaze, and automatic repetition so that it is no longer intelligible. It is the synthesis that compresses moments and retains them only in memory, guided by the unconscious (Hughes, 2012, p. 58).

The first passive synthesis is the 'synthesis of apprehension', which unites multiplicity by compressing moments in flux and bringing them into the living present, creating a stationary center within the chaotic plane. It is both primordial and immanent. Time cannot escape the present, but it constantly leaps within the present. The paradox of the present is that while it constructs time, it also exists within the time it constructs. Therefore, another synthesis is necessary that operates within the framework of the first synthesis (Deleuze, 2017, p. 117). The second passive synthesis is the 'synthesis of reproduction', which records and reproduces multiplicity. It takes elements from the first synthesis and records them on its level, in memory. Moments/elements compressed and reproduced in memory are combined/stored in a kind of 'grid of disjunctions' for future use (Hughes, 2012). Memory constitutes the existence of the past as the fundamental synthesis of time. Every past exists together with the now, which is more past than itself. The totality of life is a different manifestation of what preceded it; all degrees coexist and present themselves to the subject's choice (Deleuze, 2017). The third passive synthesis is the 'synthesis of recognition', which brings multiplicity to a concept. As the final synthesis of time, it establishes the present and the past as dimensions of the future. It moves towards a new element, produces meaning, describes a new dimension that is not identical to the immanent plane where the passive self arises. It transitions outwards. All three syntheses reveal the now, the past and the future in different modes of repetition; the now is repetition itself, the past is the repetition of itself, and the future is repetition (Deleuze, 2017, p.139-140). Here, habits are disrupted to allow for the production of meaning, and the creative essence to be used to give meaning, namely 'thought' (idea), is discovered (Hughes, 2012, p.55-74).

According to Deleuze, the body consists of extended parts. The composition of these parts is determined by the violence of the outside, and the body can act to the extent of its capacity to be affected. The body is therefore not static but subject to affectivity. It is influenced by affects, it internalizes them, it is shaped by them, and it either adapts to them or diverges from them. If the body cannot control these affects, it is passive. In contrast, Deleuze describes the process of active becoming as a temporal return. It has the power to intervene in affects and encounters by returning to the level of encounters and passive affects (perception) (Hughes, 2012, pp. 82-86).

The encounter with something that forces one to think is necessary to awaken the absolute necessity of the act of thinking. The contingent nature of the encounter deconstructs an assumed thought and produces thinking in the act of thinking itself. The primary element in thinking is violence; it captures and educates what is perceptible in perception (Deleuze, 2017, p.191). Deleuze labels this movement with the concept of 'eternal return', which he borrows from Friedrich Nietzsche. The concept of eternal return marks the transition from dynamic genesis to static genesis. At this moment, when the boundaries of perception collapse, the combined moments (subjected to external violence) and habits, trapped and stored in memory, are revealed; the personal-non-personal, pre-individual, metaphysical singularities emancipate themselves through dissolution.

Static genesis, defined as the process of activation, is described as a formative synthesis; it consists of two active syntheses, namely good sense and common sense. Good sense is a movement of territorialization towards subjects and objects, setting limits. It individualizes an uncertain object, connects it to the outside and transforms it. But it is not enough to establish the object. This is where common sense intervenes, associating diversity and multiplicity with an individualized subject and an object that serves as the purpose of our actions. This objectacle relationship defines an active synthesis. Unlike passive syntheses, which cannot work together, active syntheses (good sense and common sense) concretize ideas and function integratively. The harmonious relationship between common sense and good sense assigns 'roles' that allow them to express the processes of enactment and individualization by associating thought-related stimuli with object forms during the dramatization process (Hughes, 2012, p.78).

At the genetic turn stage, individuals are faced with a choice. They can either be active and respond or remain passive. Responses are based on already-established patterns of behaviour. However, during a crisis, when the appropriate response is unclear and cannot be resolved using pre-established patterns, individuals turn to ethics. Ethical principles help individuals decide which principles to prioritize or reevaluate during crises.

The study considers the recent turn in political theory as a crisis and examines the ethical decisions made by architect-subjects in response to this change. It uses these crises as opportunities to explore new ways of organizing the body, embracing the crisis as a catalyst for change (Hughes, 2012, pp. 98-104). Actualizations that occur intentionally and consciously in this stage of experience of self do not indicate a transcendent or metaphysical dimension. The metaphysical dimension is represented on the topological surface, known as the plane of immanence, through projection, specifically diagrammatic folding. This representation occurs at the point where the relation established with the other/outside in Deleuze's ontology of meaning confirms the event's inherent self. Acting involves balancing the external and representational aspects of the mask/persona with its social and ethical aspects. Each act of thought staging/dramatization involves depersonalizing ideas that are inherent to events in life and actualizing them in life and the body.

Bernard Stiegler (2012) critiques Deleuze's process of actualization (the third passive synthesis), as interpreted through the lens of 'thought', in parallel with his reading of Edmund Husserl (1859-1938). Stiegler expands on Husserl's primary and secondary retentions by introducing the idea of 'tertiary retentions', which involve the externalization of memories stored during the second passive synthesis. However, any externalized element at this stage continues to exist in a world (the other) previously described by tertiary retentions and contributes to the ongoing construction of this world. This cyclical process, which occurs within the stage of eternal return, constructs the other through technique (Stiegler, 2012). Architecture actualizes through 'technique', shaping its existence and becoming integrated into the other as the pre-existing ideological framework into which it is born.

The direction of the relationship established with the ideological framework is determined through the ethical choices made by the architect-subject. The architect-subject can either affirm the system by developing an alternative that is still bound by its limitations or act creatively within its immanence without being restricted by external boundaries. In both options, actualization refers to the static genesis itself, which involves a movement from understanding to sensibility. In this process, Kantian synthesis is replaced by Kantian schematism (Deleuzian dramatization) as the passive self is reorganized to meet the requirements of the Idea. This results in a return to the body and a redirection of the syntheses of the body (Hughes, 2012, p.76). Schemata concretize conceptual relationships or territorialize them in spatio-temporal coordinates through technique. The genesis of thought culminates in representation that corresponds to both the material or perceptible and the purpose of actions (Hughes, 2012, pp. 50-73).

Deleuze's approach to the ontology of uncertainty through the genetic turn explores rich ontological depths by defining the limits of political and ethical formulations as a strong ontology. The relationship between architecture and the ideological other is unconditionally interconnected through the process of internalization and externalization, without reference to an external plane (Figure 4). In this context, the other is not in a transcendent position but is on the same plane as architecture. The ethical choices of the architect-subject are determined by the interplay between sensibility and understanding. These choices can affect or be affected by the thers. Deleuze's 'strong ontology of uncertainty' highlights the architect-subject's power to define the ethical boundaries of their relationship with the ideological other.

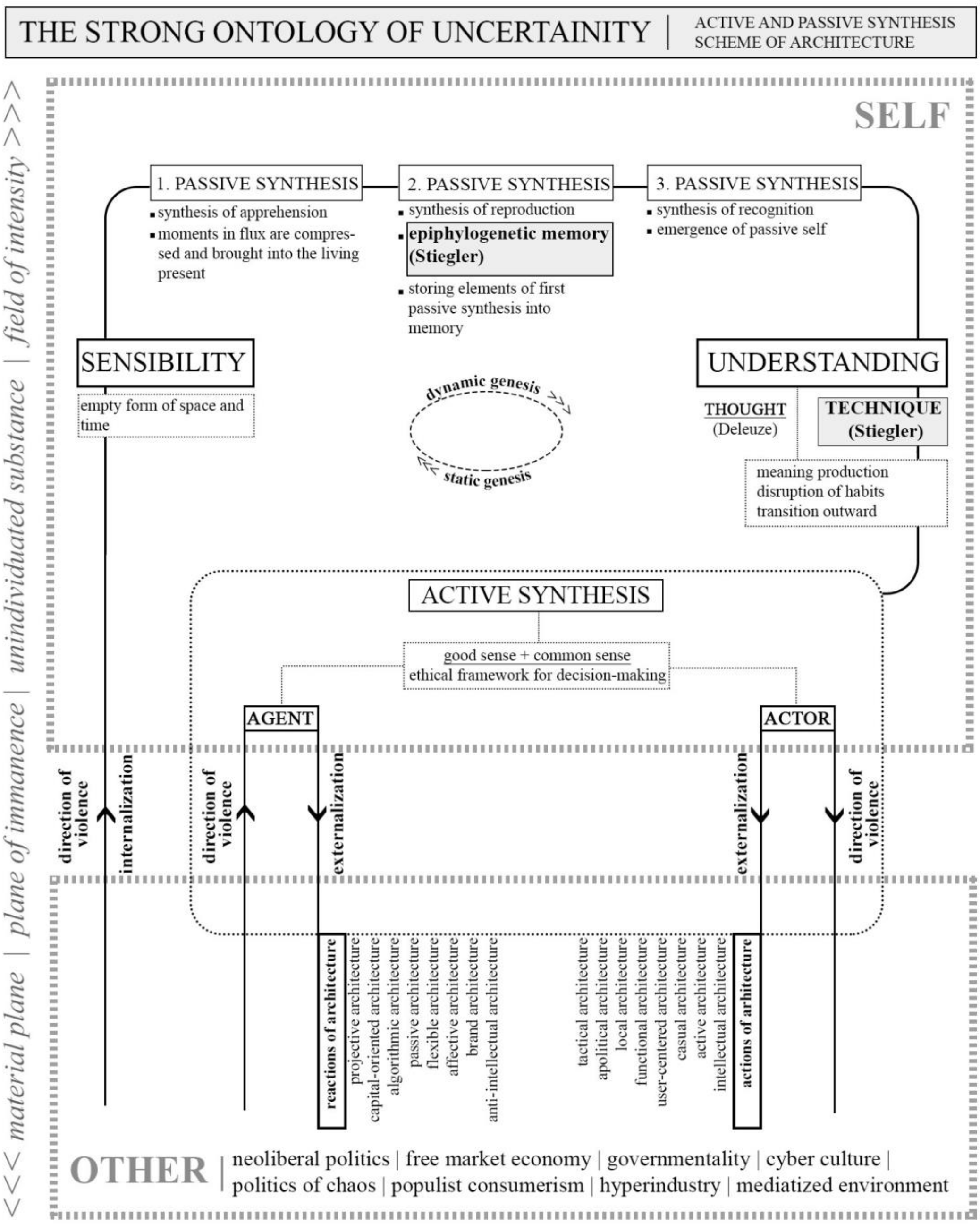

Figure 4. The active and passive synthesis diagram of architecture in the strong ontology of uncertainty.

Architectural thought aims to establish architecture's relationship with the external by intervening from within. It also takes an external position to understand the interdisciplinary network of architecture. This paradoxical positioning continuously reconfigures the disciplinary boundaries of architecture. This line of genetic thought leads to a material and perceptible representation that corresponds to a purpose of actions. The representation that emerges here is the object of both sensibility and understanding, which can be territorialized qualitatively and spatially (Hughes, 2012, 79).

The meaning and existence of architecture are established in relation to the other. Deleuze (2015) does not associate meaning with an essence or depth, unlike classical forms of thought. In Plato's philosophy, everything suppressed and buried emerges to the surface through a Stoic intervention. However, Deleuze considers meaning within an unstable and constantly changing flow, rather than seeking a fixed and stable meaning. According to Deleuze (2015, p.147), meaning lies in the multi-layered surface and is constantly changing. It is not fixed but rather a limitless becoming that occurs and spreads on the surface. Deleuze's thought is topological and cannot be explored with Euclidean

(Platonic) forms, as it is a non-Euclidean formation. The research explores the meaning of architecture in the topology created by the event/violence between architecture and the other.

Han (2016) refers to the different forms (isotopes) of violence, apart from its immutable aspect, as the 'topology of violence'. Violence involves activating neutral power by different forces, serving a purpose by drawing its power from external sources and applying it to alter and reshape the target entity. The spatial domain affected by violence transforms the violence itself. While exploring this transformation through political, ethical, and anthropological complexities between the self and the other, there is a risk of failing to address a problem with clearly defined boundaries. Han (2016) effectively conveys notions of continuity, flexibility, and transition through this approach.

Han (2016) explains the anonymization of brute force and its transformation into a force inherent to the system in our age, which he defines as late modernity, as the violence of positivity, and describes the transformation of violence as 'the shifting of the center from outside to inside'. A new dimension of violence is directed against the self; it simultaneously generates a force from inside to outside, alongside the movement from outside to inside. Thus, all forms of force make inside and outside simultaneously visible on a surface (like a Möbius strip). Topology can therefore serve as a mediator to contemplate the different dimensions of force; while the form changes, the essence remains the same. Force, the essence of violence, delineates the topology produced by the visible and invisible relations between the self and the other (Öner, 2019).

The research depicts the movement of dynamic and static genesis through a diagram that is both qualitative and spatial. The diagram gains elasticity as a 'composition of finite modes' and is embodied by defining a moving surface and topology. This process explains conceptual relationships and the spatio-temporal dimension using a four-axis structure. According to Kuratowski's theorem, binary force sets with more than two elements cannot be represented on a sphere without intersecting edges (Hammack & Kainen, 2021). However, a torus surface can accommodate binary graphs without intersecting edges (Figure 5).

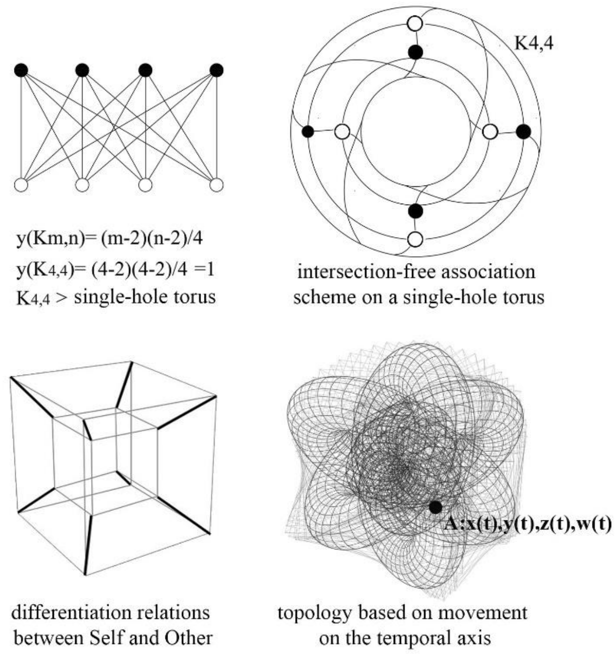

Figure 5 Formation of tesseract topology through the association scheme of binary graphs.

In this dynamic formation, the architect-subject actualizes on topological surfaces and is subject to affects beyond their control. The capacity to experience affections gives way to the faculty of thought, transitioning from sensibility to understanding. This results in a new dimension defined by the plane of immanence, where the passive self finds release. The individuation process occurs as the architect-subject acquires spatio-temporal coordinates (A:x(t), y(t), z(t), w(t)). Thus, by revisiting the realm of sensibility (moving from understanding to sensibility), it generates schemas. These schemas, which reflect the architect-subject's interactions with the ideological other, encompass the decisions made within ethical frameworks, activities undertaken, and intensities experienced, extending beyond personal emotions and perceptions (Deleuze & Guattari, 2001, pp. 140-149). These active and reactive architectures embody externalized affects, perceptions, and onto-political reactions. Within the scope of the research, these architectures describe the topology of the genesis of the thought-body-technology relationship in the mind in the uncertainty of technology-architecture onto-politics in the context of 21st-century neoliberalism. The study aims to reveal the genetic characteristics of non-reactive, strong, liberated, and genuine architecture, as well as the individuals who create it.

3.2 Outside / Other of Architecture

Han (2016) argues that violence was a common occurrence in pre-modern times but became less prevalent in modernity. However, spaces of violence such as gas chambers, prisons, and concentration camps were still in operation, albeit removed from urban areas and kept out of sight. Han explains that post-modern violence has undergone a topological shift and now permeates every aspect of life. Pre-modern physical violence has been replaced by internalization techniques. This is demonstrated by Foucault analysis of governmentality and Rouvroy and Berns analysis of algorithmic governmentality. Power enables society to internalize authority by automating habits. Foucault's discourse on power argues that since the 17th century, power has been established not through execution but through biopower and discipline. The objective is to expose and regulate power. With the rise of industrialization, technologies of discipline that once dominated every aspect of life have become a pervasive social practice. In the 21st century, the subject is no longer that of a disciplinary society, but rather that of a society focused on success and performance, under the violence of positivity (Han, 2016, pp. 88-94).

In contemporary society, the negative perception of those who are different is gradually being discarded over time, with a focus on promoting positivity and eliminating boundaries. While this decrease in negativity does not completely eradicate violence, it can actually strengthen it. This is because the power of positivity operates independently of power. According to Han (2016, pp. 54-56), violence can be internalized/spiritualized and made invisible through an individual's narcissistic self-reference, which severs direct contact with power and self-inflicts violence. Neoliberal power constructs strategies of governmentality through the individual because it can be effortlessly implemented through the indirect manipulation of internal violence. The topological transformation enables the subject of late modernity to become a project that is performance and success-oriented, without any coercion. The process of liberation from external violence is presented as a form of freedom. This process is directly related to neoliberal policies. It is easier for individuals to exploit themselves than for others to exploit them (Han, 2016, p. 20). Han (2016) argues that violence can arise not only from negativity but also from positivity. The demands and expectations placed on individuals from external sources can lead to internal violence, as individuals strive to prove themselves and achieve success. This internal violence is normalized by the labor exploitation imposed by external violence.

The impact of positivity's violence on society foregrounds individualization, while the era's ideologies remain in the background. The absolute focus on oneself is interpreted as the death of the other. According to Han (2022), ideology is not dead; today's ideology is the 'dataizm ideology.' Information determines everything. The most important aspect of dataizm is its paradoxical presentation of the death of the other. Algorithms determine and present only the most superficial and simplistic aspects. By reducing society to mere affect, they obscure the marginal other. This reinforces the dominant neoliberal ideology.

The architect-subject adapts to the violence/power of the other by internalizing it to sustain their professional existence. Power mechanisms operate as an external force of violence, developing totalitarian, directive, and manipulative strategies in decision-making processes. These strategies externalize as spatial policies in the field of architecture.

The study considers the development of neoliberalism up to the present day as significant from an onto-political perspective. This helps to define the outside/other with which architecture constantly interacts. The marginalization of the other is explained through the analysis of governmentality as a critique of capitalism by Foucault, followed by Rouvroy and Berns’ explanation of algorithmic governmentality based on the ideology of dataizm (derived from Foucault's reading).

3.2.1 Governmentality and architectural space / opportunity

Foucault (2015) explains the concept of constructed subjects by referring to them as a disciplinary society, drawing on Bentham's theory of the panopticon. According to the disciplinary model manifested in the panopticon, power controls society directly through the material body, rather than through ideology (Akay, 2013). The space serves as the formative envelope of social relations. According to Tanyeli (2016), practices of othering necessitate spatial practices that enable the subject's surveillance and isolation from society.

Foucault argues that human behavior is shaped by space, and therefore spatial configurations emerging with liberating aims will be effective. However, for subjectivity to have a significant impact, it must compete within the free market. Spencer (2018) objects to this policy's inclusion in the market, as the market economy governs by managing the individual, whereas democratic systems establish social order. The distinction between capitalism and democracy is blurred by the neoliberal system, which makes the concept of freedom dependent on the market.

Alongside globalization, technological advancements have become essential as technical tools of neoliberal governmentality. Venugopal (2015) notes that optimization technologies concentrate on adapting architecture to the market and creating market-sensitive subjectivities. This situation indicates a significant development in the interaction between technology and the market within architectural practice. The impact of technology on architectural processes is now encompassed by governmentality. The use of digital modelling tools and computer-aided design allows architects to efficiently design complex structures and organize construction processes. Sustainability is also improved through project performance monitoring, energy efficiency, and resource management via big data analysis. Smart building technologies aim to optimize building functionality and improve user comfort. This interaction between technology and architecture involves architectural processes becoming part of algorithms. Therefore, the relationship between architecture and governmentality is viewed similarly to the relationship between algorithms and governmentality.

3.2.2 Algorithmic governmentality

The term 'information regime' refers to the dominance established by the decisive influence of information on economic, political, and societal processes through the use of artificial intelligence and algorithms. This differs from the disciplinary regimes analyzed by Foucault, which exploit the body and energy, as it focuses on information. The main distinction between disciplinary and information societies is the management of behavior. The acquisition of power involves access to information for psycho-political monitoring, prediction, and behavior control. The transformation of disciplinary regimes into information regimes creates open networks based on topological principles. Discontinuities are eliminated, transparency replaces closure, and communication networks replace isolation. Individuals voluntarily expose themselves with a demand for transparency. Thus, individuals create both conscious and unconscious maps. Surveillance becomes easier as more data is generated, and communication is established. The intersection of freedom and surveillance can lead to flawless domination (Han, 2022).

In the 21st century, the integration of digital technologies into every aspect of daily life is bringing about profound changes in the social, cultural, economic, and political spheres. The physical infrastructure of society is being transformed under control based on mobile devices such as smartphones, home appliances such as internet-connected smart TVs, residential areas designed according to smart home and smart city concepts, and transport systems based on internet-connected vehicles (Stiegler, 2016). The hyper-synchronization brought about by digital technologies means living in harmony with multiple machines (Şan, 2022a). Everyday life is, in a sense, becoming industrialized. With the recent rise of digital networks, a new sociality is emerging based on personal data, metadata, tags, and other tracking technologies. The technological transformation of social structures and economic systems, and the resulting understanding of governmentality, is referred to as 'algorithmic governmentality' (Berns & Rouvroy, 2013). By analyzing the functioning of algorithmic governmentality, Berns and Rouvroy concretize a new digital reality regime that focuses on outcomes and potentials without the need for material reality within automated systems that rely on big data (Rouvroy, 2011).

Anderson (2008) highlights a shift towards a science based on correlation rather than hypothesis testing and model-based understanding in the era of algorithmic governmentality. Rather than developing cause-and-effect relationships within the framework of theoretical knowledge, it is considered sufficient to analyze the relationship between two variables and convert them into data, i.e. to be in correlation. This process is object-oriented because it is independent of reasoning. The simplest example is the way Google Translate works. None of the languages defined in the system are analyzed in terms of semantics and grammar. The data collection method is based on the statistical properties of the language. Therefore, causal relationships are not taken into account (Şan, 2022a).

The main strategy of algorithmic governmentality is to treat the masses merely as a resource through algorithmic machines, initially without the aim of deceiving or neutralizing them (Stiegler, 2016). It then takes, transcribes, and manipulates the physical world, its inhabitants, their tragedies, behaviors, actions, choices, preferences, and attitudes. However, algorithm-based management appears fundamentally benign and objective. It relies on the existing digital reality without any subjective, individual, or social will. It observes it from the outside by distancing itself from subjects and events. This characteristic of algorithm-based governmentality gives rise to the notion of flawless governance (Berns & Rouvroy, 2013). Delegating decision-making power to machines renders the oppressive dimension invisible (Şan, 2022a). The processes of classifying and managing the subject no longer depend on the will of power. The subject itself becomes less distinct or less effective within these automated processes. This situation represents a transformation towards a kind of 'machinic objectivity' (Rouvroy & Stiegler, 2016).

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3.3. Internalization

The process of transitioning from sensibility, which is defined as the dynamic genesis in the movement of thought in Deleuze's philosophy, to understanding involves internalizing the other (that which is in flux) (refer to Sections 1.1 and 1.2). In summary, the synthesis of thought, along with the production of meaning, describes the external passage. The process leading up to the emergence of thought in understanding consists of a series of passive syntheses. The first passive synthesis consolidates the material plane within its complex and continuous flux. The second passive synthesis records this multiplicity in memory, consolidating it for future use. The third passive synthesis is the recognition synthesis, which produces a passive self. In this stage, meaning is synthesized, and 'thought' is discovered, reaching a new dimension distinct from the material flux in which it resides (Hughes, 2012). Stiegler (2012) argues that the subject of thought that arises through internalization is 'technique', which is also subject to internalization. The multiplicity stored in memory by the second passive synthesis is shaped by the tertiary retentions, which existed much earlier and form the technical world. In addition to externalizing what is recorded in memory by the first and second passive syntheses as thought, these tertiary retentions (technical world) also externalize in technical memory. Therefore, Stiegler argues that technique is the subject of thought, not its object. It is a founding element (prosthesis) that creates humans as humans (Stiegler, 1998).

The concept of 'techne' encompasses all activities related to making, producing, and creating, in the sense of craftsmanship and skill. It derives from the old Grek term 'tekhne' and includes both the science and craft aspects. Architectural creation is considered a technical matter that requires the integration of thought and action, similar to the fields of mathematics, mechanics, electricity, and geology, which require both knowledge and construction skills to bring a building to life (Haşlakoğlu, 2020). The transformation of technique reflects a crisis in economic, social, and political contexts, forming the foundation of contemporary philosophical discourse. The distinction between 'techne' and 'episteme' poses a problem. In Western philosophy, technique is often treated as an object of thought that is separate from thought itself. Knowledge is believed to come from within and is therefore not influenced by external factors such as technique. However, contemporary philosophy views technique as a constitutive element of thought, language, and episteme. According to Stiegler (1998), it is uncertain who or what constitutes the subject or object, and humans cannot be viewed as solely producing technology, nor can technology be viewed as solely produced objects.

Leroi-Gourhan argues that technique is the primary prosthesis of humans, shaping intergenerational material culture and determining learning activities (Leroi-Gourhan, 1964). Stiegler builds upon Gourhan's arguments and conceptualizes technique as a prosthesis of the mind. In this context, the term 'prosthesis' does not imply something replacing an organ's function, but rather a foundational support integral to the human body. Stiegler's approach differs from that of other philosophers (Şan, 2022b). According to Stiegler, technique plays a constitutive role in human existence, and human temporality is aligned with technique. Technique serves as the foundation of the mind through its relationship with memory (Stiegler, 1998).

Stiegler (2012) develops the argument of 'tertiary retentions' based on Husserl's theory of retention and protention discussed in 'The Phenomenology of Internal Time-Consciousness'. According to Husserl, the consciousness of time can be determined by retention and protention. The primary retention is the flow of time itself and the passing present moment. The secondary retention involves the reacquisition of the past present as a memory stored in the mind. Described as a technique of remembrance, tertiary retention, as expressed by Stiegler, signifies the materialization of experience as technique and the spatialization of conscious time beyond consciousness. Tertiary retentions involve the externalization of secondary retentions through remembrance. It transforms individual time into collective time by spatialization. Stiegler (2012) argues that tertiary retentions have a significant impact on primary and secondary retentions. It is important to maintain a clear and logical structure when discussing complex concepts such as these. Technical individuation is the process of internalizing tertiary retentions, which are established in a pre-existing technical world.

Technical production involves externalizing memory, while technical individuation involves internalizing memory. With technique, mental life is externalized, and individuals then internalize the externalized knowledge. This cycle of internalization and externalization brings together both the entity creating the world and the entity coming into the world (Stiegler, 2012). The relationship established by humans with technique reveals 'epiphylogenetic memory.' Epiphylogenetic memory does not refer to genetic or somatic memory. Stiegler (1998) defines it as the memory of all externalized technical objects resulting from the internalization of tertiary retentions. Therefore, humans begin to think with technical memory, surpassing genetic limitations and inheriting an unexperienced past.

3.4. Externalization

Individuals externalize their experience of the world, socialize, and establish their symbolic plane through their relationship with technology. Stiegler (2012) examines the processes of grammatization, arguing that humans and technology co-constitute each other. Grammes serve as the particles of tertiary retentions, externalizing memory. This externalization of memory results in the separation of knowledge from the mind. The externalization of knowledge through memory has taken on a new dimension with digital networks. As a result, individuals may feel powerless and proletarianized due to the overwhelming power and potential of digital networks. This is because memory is now dependent on machines and industrial mnemonic devices. The issue of externalizing memory can be traced back to the invention of alphabetic writing, which facilitated the transferability of information. The act of transforming thoughts into spoken or written language is an instance of grammatization as it disrupts the flow of time with a break in space.

Technology has brought about hyper-synchronization, which occurs when society is simultaneously attracted to and focused on industrial objects. Memory techniques are synchronized through tertiary retentions, which integrate perception with memory through recollection. Algorithmic governance manipulates collective orientations by controlling automated expectations, feeding on this synchronization (Şan, 2022b). The cultural issue has become increasingly central to the economy, industry, and politics. This is due to the production of the sensory society by technologies, which Deleuze refers to as 'societies of control'. The primary international economic struggle now takes place in this domain. Stiegler (2014) argues that society's interaction with symbols through technology and media can lead to symbolic misery. In societies of control, the functional circulation of energies produces consumers by controlling bodies and their effects, continually producing the new. This leads to the loss of symbolic participation. Symbols are both products of intellectual life, such as concepts, ideas, theorems, and knowledge, and emotional life, such as arts, skills, customs, and traditions. Stiegler argues that the current widespread loss of individualization could lead to a symbolic collapse or a collapse of desire.

3.4.1. Reactions of architecture

The architect's reactions are considered responses resulting from cognitive proletarianization. This is where the architect-subject recognizes their inability to alter the other or the external realm, which they engage with continually while maintaining their professional practices. This recognition arises from the externalization of their knowledge of construction into technical objects. Because she/he has externalized his knowledge about practicing in the technical object. According to the architect-subject, as they affirm and develop the external world, particularly the technical world formed by tertiary retentions, they simultaneously begin to fall under the control of the technical framework they have established. Neoliberal policies commodify architectural products and processes, drawing architects into the cycle of capital and requiring them to monitor contemporary technical changes. On the other hand, technological advancements may alleviate certain practical challenges, but they also continuously drive towards the creation of the new and different.

The computer has evolved beyond its traditional role as a tool for statistical analyses, mathematical modeling, and quantitative measurements in pre-designed buildings. With the advancement of digital technologies, it has become a technical object that translates the language of design into algorithms, thereby extending architecture beyond its conventional boundaries. While this transformation expedites and streamlines architectural processes, it also shifts the creative agency from the architect-subject to the technical object, resulting in a cognitive dependence on it. Additionally, this evolving relationship with the technical object broadens the architect-subject's perspective by fostering increased engagement with the other as a critical and cultural 'agent/actor'. Alongside the development of knowledge areas outside of architecture through digital technologies, interdisciplinary approaches are beginning to integrate into architecture. This integration necessitates the formation of collective intelligence through the design process, which accelerates the process (Hight & Perry, 2013). All design is the product of connection techniques, specifically interdisciplinary relationships. To ensure comprehensibility across knowledge domains in architecture, data must be presented in a way that does not require separate expertise. This is where representational methods become crucial in finding common ground. The representational domain of architecture, instead of being a mere representation of architectural thought and practice, evolves into a model of interdisciplinary knowledge (Ponzo, Stoppani & Themistokleous, 2017).

The study considers the architect's externalizations as reactions within the architectural context. These reactions are undertaken as an anti-intellectual affirmation of the other and externalized as **'anti-**

intellectual architecture'. The tesseract diagram depicts the unfolding cycle between reactions and the other (Figure 6). The cube positioned inside (internalized) is characterized by concepts related to the other, while the cube outside is defined by the reactions of the proletarianized architect. The diagram identifies the concepts within the study's framework and elaborates on them through architectural practices.

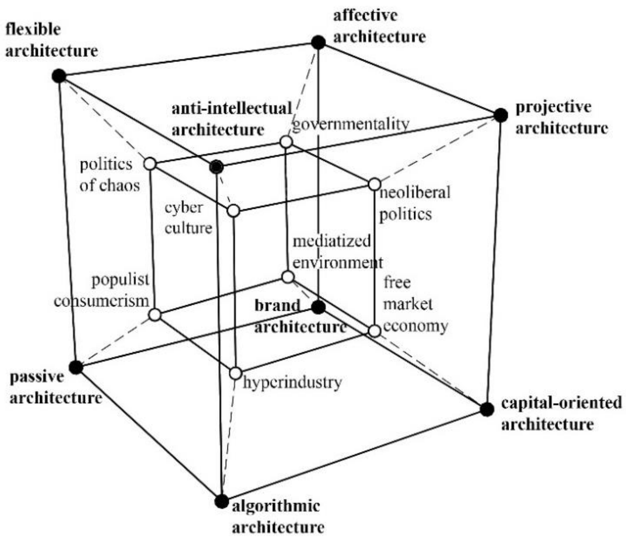

Figure 6. Expansion of the cycle between architectural reactions and the ideological other.

The tesseract diagram illustrates the surfaces that define the interactions between architectural reactions and the ideological other. The tension on each surface represents the violence/power dynamic between the associated concepts. The architect-subject is positioned on these surfaces and is influenced by the tensions on the surface through their reactions. They react to the force of the external and prefer affirmation, leaving responsibility to the other.

Commodification and brand value in architecture: According to Harvey (2015), commodification is the process by which processes, objects, and social relationships are transformed into commodities that can be bought and sold. Capitalist production relations are driven to constantly increase production quantity, potential, technique, and economic gain, making it imperative to increase consumption to maintain production continuity. To sustain demand for purchases, it is necessary to introduce variations in product quality and innovate by generating new products, techniques, fashions, and inventions. Therefore, practices such as innovation, diversification, and plurality are crucial for ensuring the sustainability of the capitalist system (Tanyeli, 2016).

When examining architecture, the process of commodification is associated with the emergence of the concept of the use value of spaces and objects. Neoliberal policies alter society's sentiments, habits, and preferences in their favor and commodify the service sector by incorporating them into the consumption chain. In the field of architecture, a component of the service sector, services are commodified, including their quality, meaning, value, and social identity. The concept of **'brand architecture'** objectifies architectural processes and products within capitalist economic relations. This includes the commodification of buildings, land, spaces, technical equipment, housing, labor, and the architect's name (Tanyeli, 2016).

The advent of digital technologies in the 1990s led to the establishment of universal communication networks and the ascendancy of multinational companies. The market created by the neoliberal economy is streamlined through branding policies. Emancipation is achieved through the subject's ability to adapt to every alternative. Therefore, the subject's preferences should be flexible. This legitimizes multiple alternatives in the new consumption market. The transformation of all aspects of life into consumer objects through branding has led to a shift in the understanding of innovation and difference in the world of architecture. This has resulted in a prioritization of popularity for the benefit of the market. In the context of the neoliberal idea of freedom, **'capital-oriented architecture'** increases the dialogue between the architect and the client by guaranteeing capital continuity. However, this also creates recognition and power competition in order to maintain popularity. This situation gives rise to the phenomenon of branding in the context of architecture (Cestel, 2021).

In modern times, architectural processes involve concealing the constructional production. The architect's role is to express structures and concepts related to neoliberal capitalism, generate flexible formal and conceptual metaphors, and conceal capitalist production processes (Spencer, 2018). The concealment of labour in construction processes, the foregrounding of the structure's brand and aesthetic value, and the masking of difficulties and setbacks in construction and design processes are directly related to the concealment of the capitalist construction process and the commodification of labour.

Projective Architecture: Somol and Whiting refer to the strategies developed by architects to organize multiple systems as **'projective architecture'**. This strategy produces utilitarian practices through the analysis of reality, rather than positioning itself in resistance to the new world order. The term 'projective' is chosen because it refers not to a novel product, but to an approach and methodology (Somol & Whiting, 2017). While critique reflects on past arguments, projecting forward involves planning to actualize an idea. Therefore, critical architectural practice, which is both conceptual and narrative, gives way to projective practice. Projective practice is not derived from or opposed to criticism; it simply diverges from it. Therefore, it should not be considered as a critique of criticism.

Projective design acknowledges modern life and affirms it with a visionary approach. It predicts, develops aesthetic sensitivity, and transforms programs. Instead of supporting or opposing a political discourse, it exhibits a hyper-realistic attitude by remaining unresponsive to the political and theoretical. It is consciously indifferent to its system. Projective practices are therefore necessarily inspired by the ever-changing mutations of neoliberalism.

Spatial Organizations: Flexibility and Affect: The interactivity of new media allows for the simultaneous communication of multiple messages across different times and places. The rapid access to information has led to the emergence of new learning methods, innovative marketing strategies, increased political activism, changes in individual and social communication norms, diverse cultural activities, and changes in work culture due to the blurring of home-office boundaries (Oruç, 2021). In this evolving cultural milieu, neoliberalism directs individuals' focus toward capital. The physical environment must adapt to sustain various production methods. Architectural spatial arrangements serve as mediators of this reality, influencing individuals through their surroundings. Therefore, it is essential to prioritize a plurality of forms and self-organizing qualities. Contemporary architectural practice emphasizes complexity and affect to accommodate diverse relational dynamics and elicit varied effects in users. This is in line with neoliberalism's strategy to stimulate innovation in products, production methods, and needs, which finds expression in spatial flexibility within architectural spaces. These spaces are structured to facilitate uninterrupted production, aligning with neoliberal agendas. Internal contradictions are avoided, and flows are curved and organically contoured. To enhance comfort, efficiency, and overall performance, architectural forms aim to exhibit characteristics such as flexibility, fluidity, adaptability, and dynamism. This creates a **'flexible and affective architecture'** as a tool for shaping neoliberal organisational frameworks by minimising conflict, removing barriers and accepting spontaneous arrangements (Spencer, 2018).

Algorithmic Architecture: Architecture requires creativity, which is often associated with intuition and talent. In contrast, algorithmic logic involves a specific deterministic approach that prioritizes rationality, consistency, compatibility, order, and systematization. Its mechanical nature can lead to it being perceived as an anonymous and automatic procedure. Terzidis (2003) suggests that architects face challenges in algorithmic logic due to the need to balance artistic sensitivity and intuition in their practices. The designer enters the process that he or she has already formalized in his or her mind into the computer's system. The problem that this situation poses is that the designer does not benefit from the computational power of the computer. In this context, **'algorithmic architecture'** creates an alternative option that can avoid this problem (Terzidis, 2006).

Traditionally, designers own their ideas and retain full intellectual property rights to their designs on the assumption that they control them. This is not always the case with algorithmic forms. The hints or suggestions of an algorithm may be the intellectual property of the designer-programmer, but the results of these ideas, tangible or virtual representations, are not necessarily under the control of the designer. The use of multiple spatial criteria as input in architecture and the introduction of algorithm-based systems in order to rationalise decision-making processes, transfers many design stages from conceptual idea generation to structure organisation to the control of the machine. The generation of intermediate values that can represent the uncertainties between 1 and 0, especially with the 'Fuzzy Logic Systems' method that emerged in the last century, makes it possible to use artificial intelligence algorithms that can give the closest result to human intelligence (Baran Ergül, et al., 2022). In this context, the designer consciously relinquishes control to the machine, passivising and proletarianising himself. Because the dependence on the knowledge of the new technique transforms design and implementation process. Computerized processes replace hand, brain and eye coordination, the process is no longer dominated by the architect and is reduced to forms of **'passive architecture'**.

3.4.2. Actions of architecture

Tanyeli (2021) explores how architects can influence society by taking an intellectual stance. Rather than legislating or establishing laws, architects interpret the world to society. The intellectual has an interpretive and explanatory role, regulating the traffic between different fields of knowledge. This socializes and normalizes the architect's role, directing decision-making ability as an escape point. This process normalizes architecture, making it more integrated into society and less exclusive. The architect's interpretive power comes from their ability to perceive reality in a unique way. The term **'intellectual architecture'** refers to the actions and discourses of architects who transcend professional boundaries and interpret the external world without being limited by them. The primary direction of the 21st century is to move away from considering architecture solely within the field of architecture. Objectivity is key to expanding the known boundaries of architecture by responding to it both within and outside of the language of architecture.

Chavez, Walker, and Iturbe discuss the role of the intellectual architect in addressing societal issues, climate crises, political instabilities, and injustices (Chavez, et al., 2021). They argue for a new approach to an **'apolitical architecture'** that is independent of the capitalist order. Catling (2014) discusses the condemnation faced by architects when they fail to exhibit a moral stance in the context of professional ethics yet are deemed unrealistic when they do. This dilemma arises from the inability of activist discourses to find resonance in the realm of architectural action. To enhance their visibility within urban settings, architects should effectively integrate these activist ideas into their responsibilities and take initiative as actors, mediating between discourse and action.

Rouvroy (2016) highlights the use of critique and emancipation as a strategic position against oppressive and hierarchical structures. While adapting the critical tradition of the 1960s to the complexity of today is possible, finding direct solutions through this type of critique can be challenging. The intellectual/active architect can incorporate architectural techniques developed through action with the concept of freedom into their agenda (Chavez, et al., 2021). This power is attained by externalizing thoughts and putting them into action through practical implementation and constructive discourse.

This study examines how architecture engages with the other. The tesseract diagram (Figure 7) illustrates the cyclical relationship between architectural actions and the ideological other. The inner cube represents internalized concepts related to the other, while the outer cube is defined by the architect's actions as an actor. The diagram outlines the concepts identified through the analysis framework and clarified through architectural practices during the study's progression.

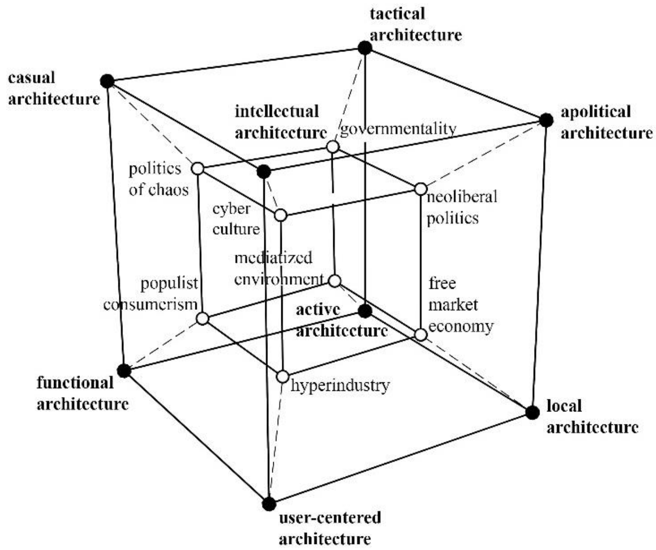

Figure 7. Expansion of the cycle between architectural actions and the ideological other.

In the tesseract diagram, surfaces are delineated that depict the interactions between reactions of architecture and the ideological other. The tension on each surface represents the violence/force between the concepts it is associated with. The architect-subject is situated on these surfaces and alters the tensions on the surface through their actions. They direct the flow and respond to the forces from the outside.

Architecture as Producer-Product: The concept of 'producer-product', introduced by Deleuze and Guattari in their 'Capitalism and Schizophrenia' series (1993), views life as a thinking process. According to Deleuze and Guattari, human actions originate from living labor within the plane of immanence rather than a plane of transcendence. Within this framework, nature and industry are not perceived as opposing forces but as interconnected entities. Contrary to common belief, nature and industry are not opposing forces, but rather synonymous. When humans and nature collaborate, they merge, and industry is no longer just a utilitarian external factor, but rather an integral part of nature. Therefore, the relationship between humans, nature, and industry is not one of conflict but rather reflects the same underlying principle of producer-product. Production is a cycle created by an internal principle (Deleuze & Guattari, 1977, pp. 1-8).

According to Tanju (2008), human makings are defined as 'production' due to their nature as cognitive actions that involve qualitative differences created by these actions. Tanju sheds light on the cognitive process and the resulting qualitative distinctions that emerge from practices within architectural contexts that eschew the notion of transcendence. The development of an idea involves creating subjectivity, where qualitative differences resulting from the production process are formed. The purpose of externalizing production is to make sense of the external world. The producer-product continually reorganizes the narrative and redefines time and space within the given construct of time-space, rather than being confined to its professional boundaries. If it adheres to the given construct of time and space, it remains within the boundaries defined by its professional limits (Tanju, 2008).

The essence of production lies in the possibility of an assemblage formed by the producer architect, the producer user, and the producer space. Production evolves without direct opposition to external forces, adapting to changing agendas and influencing them in turn. Although the architect-subject, acting as the producer-product, offers an alternative approach to creation, it remains constrained by economic factors. In response to the dynamics between architects, employers, and users enforced by neoliberalism and spatial practices, producer-product engages in critical analysis by exploiting small opportunities and employing micro-strategies in its practice. These micro-level actions serve as spatial agency, representing the active involvement of contemporary architecture. The productive architect shatters, alters and transforms the notion of fixity imposed on architecture by the outside world, assigns a function to the space and the user experiences the function. **'User-centered and function-oriented architectures'** keep space in a state of constant construction and adapt it in such a way that it can be constantly experienced by the user.

Spatial agency as an alternative mode of making (agenda): Globalization is the fundamental driver for architecture to reinvent itself in the social, economic, and political context. It is considered a natural phenomenon that requires a shift in architectural paradigms rather than resistance. Architects find themselves constrained within the culture of acceleration fostered by neoliberalism, swept up in the rapid flow of change and exploring newfound formal possibilities. In this constantly changing landscape, architects must maintain a clear political or ethical intention. They should seize opportunities to uncover new societal potentials (Schneider & Till, 2011).

As posited by Schneider and Till, architects demonstrate 'spatial agency' as an alternative mode of making within the critical practice environment. This concept refers to architects' ability to create a space of freedom within architecture by dismantling the restrictive structures imposed by external forces (Schneider & Till, 2009). Therefore, spatial agencies go beyond the concept of space defined by modernism. The idea of 'white spaces between black lines' is too abstracted and stripped of its social context. It is therefore necessary to draw attention to the concept of **'casual and local architecture'**, which can be realised on a vital and social level and which can respond to everyday problems and enable everyday relations (Schneider & Till, 2012). Architects must make micro-interventions across human, social, political, and cultural domains, fostering **'tactical architecture'** by exploring new avenues for action.

Agency refers to the ability to act tactically, free from societal constraints. However, societal structures can also restrict individual agency, despite the potential influence of individual actions on these structures. In the inherent tension between structure and agency, spatial agencies do not align exclusively with one side. The theory of actor-network posits the coexistence and equality of human and non-human entities, serving as the foundation for spatial agency. Therefore, structure and action coexist within the same framework (Schneider & Till, 2011). Spatial agency does not have an ideal solution, but there is a persistent desire to continue questioning. Spatial agency demonstrates that architects have a choice to produce **'active architecture'** and addresses an ethical gap seen in many professions (Schneider & Till, 2012).

4. Conclusion

The prevalence of neoliberalism in the current economic landscape contrasts with capitalism's rationalization process, which excludes unpredictable and incalculable factors from everyday practices. Neoliberalism, on the other hand, aims to increase market freedom by promoting national and international competition through strategies of uncertainty, flexibility, complexity, and privatization. Concurrently, the digital revolution has initiated a shift towards a post-industrial economy centered on information manipulation. In this transition, the production, dissemination, utilization, integration, and manipulation of information assume paramount importance as economic, political, and cultural activities. Consequently, information manipulation fosters a managerial paradigm aimed at controlling the productive and creative masses. According to Stiegler (2012), the unpredictable and incomplete nature of production inherent in creative activities makes it difficult to monetize or incorporate into the system.

The decreasing effectiveness of daily life due to capital's valuation process adversely affects both the urban context and the continuity of the architectural world. The integration of technologies into social life has transformed collective space into a realm of surveillance, reducing architecture's capacity for influence and decision-making. However, the digitization of the discourse of collective intelligence also raises ethical issues. Consequently, contemporary architecture is often overshadowed by technology and culture. This can cause architectural practice to become dominated by techno-science and techno-culture.

The study conducts an onto-political analysis of the changes occurring within the architectural environment alongside neoliberalism. It is observed that neoliberal policies often take an individual-centered, libertarian approach that embraces uncertainty. The study problematizes the need to interpret neoliberalism differently from capitalism. Deleuze's ontology provides an inherent/internal formulation that can affirm the uncertainty and complexity created by neoliberal policies by eliminating boundaries. The structure and trajectory of the study progress through Deleuze's ontology.

Deleuze presents the 'strong ontology of uncertainty' as a path capable of generating ethical and political discourses without relying on transcendent foundations. He does not define the movement of his thinking between self and other as a strong or weak ontology. This text explores how the architect's thinking, and actions are influenced by the ideological other associated with architecture. It also discusses how architects can either assimilate or transform the ideological other by producing counterstrategies. Deleuze's ontology explains this process through active and passive syntheses, which establish a genetic turn between sensibility and understanding. Passive syntheses provide a framework that integrates the past, present, and future simultaneously. The text articulates inherent thoughts by defining the limits of political and ethical concepts. Active syntheses are formative and territorializing syntheses that embody this notion. They represent processes of realization and individualization, establish links to the external world, and assign roles.

The process of active synthesis involves making a choice. Ethics are invoked in moments of crisis that cannot be resolved with already-established patterns of behavior and where the appropriate response is unknown. This study examines the turn in contemporary politics, specifically the emergence of neoliberal policies based on the affirmation of uncertainty, as a crisis. It explores the potential choices that the architect-subject faces in response to this ideological turn. This text examines the interplay between choices and the other, which are mutually influential. The violence between architecture and the ideological other is schematized within a topology, and a topological reading makes the underlying thought visible.

Defining the twentieth and twenty-first centuries requires an examination of the concept of technology. The transformation of technique alongside the machine, and the societal relations imposed by this transformation, are also influenced by governmentality strategies. With neoliberalism, thinking practices extend beyond the sociality created by the production mechanisms of the machine. Presenting political strategies as technology, rather than mediated through technology, is seen as more legitimate (Figure 8). This approach avoids the perception of manipulating individuals' freedoms as solely a political matter, instead framing it as purely technical. The use of technique is often presented as apolitical, even when it is political. Therefore, this study examines neoliberalism, defined as the ideological other, through the lens of technology.

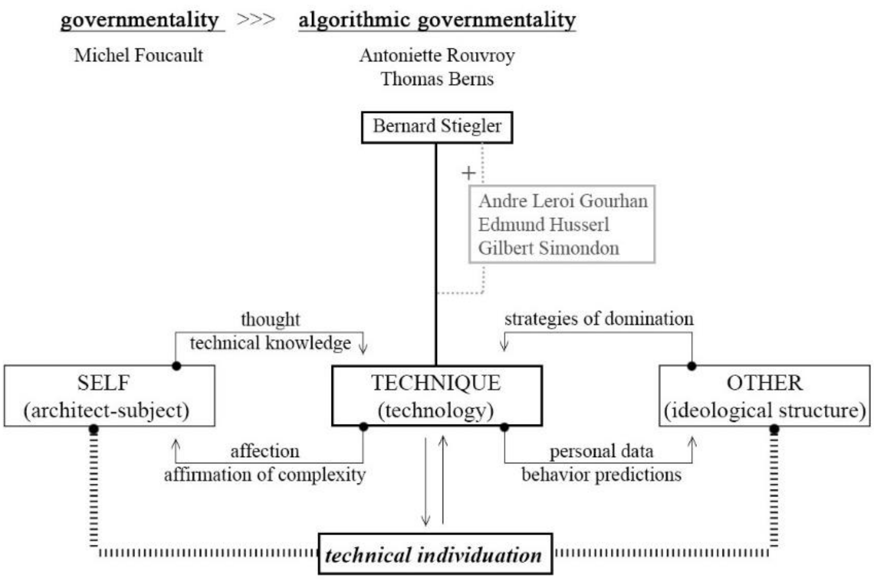

Figure 8. The relation of self, technique and other.

Stiegler (1998) argues that technique is crucial in the ontological turn. The ideological other employs technology to implement domination strategies, making itself invisible and inducing affect. Essentially, technology both internalizes and externalizes the ideological other. The tesseract diagram illustrates this process of internalization and externalization, clarifying the interactions between the architect-subject and the ideological other. The movement along the temporal axis determines the choices that the architect-subject will make within an ethical framework, influenced by the ideological other's power. The surfaces connecting self and other represent the tension between the concepts assigned to the corner points within the tesseract, which consists of two parallel cubes. This study interprets the architect-subject's choices regarding the role of technique as either the subject or object of thought as architectural actions and reactions. Furthermore, the diagram illustrates the surface expansions of the drawn topology.

The first option involves the architect accepting proletarianization by affirming the ideological structure they are in. They externalize their knowledge in the technical object by remaining within the system and surrendering it to the flow of the other. This anti-intellectual attitude results in externalizations that are considered architectural reactions within the scope of this study. The initial response involves accepting the commodification of spaces and objects, which leads to the commodification of architecture. Architectural processes ensure the continuity of capital while manipulating user emotions and preferences in favor of the system. In this context, the media can be an effective tool, integrated into the architectural environment to make user preferences visible and incorporate architectural processes into popular consumer culture. Consequently, architects strive to gain visibility in the media, reshaping their professional practice and identity through the narrative of being likable. The second reaction involves accepting the rapid flow of the new world order as inevitable. As an architect, it is necessary to respond to the demands of capital within the neoliberal order. This requires drawing inspiration from the variables of neoliberalism, developing a formal strategy while remaining loyal to the field of action, and offering a forward-looking, project-oriented architecture. Additionally, spatial organization must adapt to the complexity and plurality of the age. It is important to maintain objectivity and avoid biased language. Space is designed with strategies that allow for multiple functions, facilitating various relationships. User perception is diversified, and space undergoes continuous reproduction. The fourth reaction analyses algorithmic architectures that transfer traditional craftsmanship knowledge to algorithms, enabling the creation of an infinite number of functions. The architect limits their creativity to the machine's standards and aligns the representational language with that of the machine, resulting in a decrease in their competence in design processes and rendering themselves passive.

In the second choice, the architect transitions into a technical individual, reclaiming the knowledge they had previously externalized in technical objects. The intellectual/active and active approaches of the architect are interpreted as actions of architecture within the scope of the study. According to Deleuze, activity is linked to creativity, violating the boundaries of the other by operating within its inherentness. The architect, as a producer-product, transcends professional boundaries by interpreting the other beyond proletarianization and actively integrating it into their practice. The crucial point is for intellectual discourse to find its practical counterpart. In this context, the alternative modes of production they generate are interpreted as spatial agencies through the exploration of new possibilities for action.

When comparing intellectual and anti-intellectual architecture, many architects view architecture as a service for monetary gain, reducing it to a form of economic realism. In the twenty-first century, architectural practices are deeply intertwined with the economy, and architects must contend with economic constraints. When faced with this situation, it is unrealistic to expect the architect to not prioritize earning money. However, the architect should still consider ways to resist this prevailing condition. Historically, the intellectual profile was characterized by individuals who articulated principles and laws aimed at improving the world and possessed comprehensive knowledge. However, in modern times, this form of intellectualism seems to have shifted towards an intellectual architect profile that is capable of interpreting, normalizing, and socializing the world, albeit with limited opportunities for large-scale intervention. In this scenario, architects must undergo socialization, perceive realities in new ways, and establish direct connections with the ideological other.

However, in today's technologically-driven environment, the architect-subject primarily engages with themselves, and as a result, the other becomes increasingly obscured. The violence of positivity as a neoliberal strategy is precisely this; it blinds the architect-subject to the other, redirecting them back to themselves. Even within this schizophrenic cycle, the intellectual/active architect, while sustaining their professional existence, is always in pursuit of the other. What will ultimately rescue them from being constantly engulfed in themselves (self-collapse) is this desire for the other. Responding to the other is the only way they can break free from their habits and reinvent themselves by reconnecting with their true essence.

Upon revisiting the tesseract diagram, each surface expansion represents the tactical transformation of tension between related concepts. The architect-subject acquires spatio-temporal coordinates on the surface of the cubic complex, which constantly folds over itself in the movement of temporal motion. At this point, the tesseract performs the lowest-dimensional motion possible for a Möbius strip. According to Deleuze (2015, pp. 27-28), the folds of the topology are formed by the continuous transformation of reverse and straight forms. The hyper-architect, diagrammatized within these coordinates, delineates the surface of the Möbius strip. They concurrently perceive the interior and exterior, the reverse and the obverse, the past and the future, the self and the other, from their perspective during the tesseract's movement (Figure 9). The agency of the architect involves executing actions while under the influence of external ideologies and disrupting this cycle to devise strategies, make the external influences visible, and acquire the ability to act by mitigating their aggression.

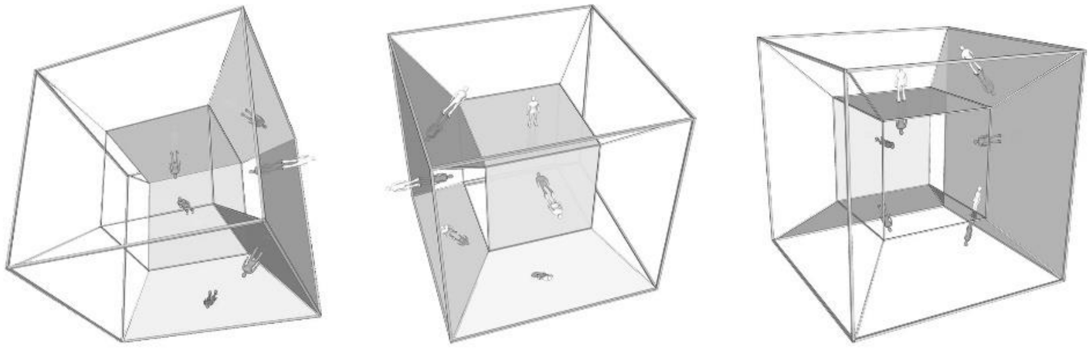

Figure 9: Möbius surface where the architect-subject (hyper-architect) simultaneously sees self and other at point A: x(t), y(t), z(t), w(t).

The study acknowledges the limitations of the tesseract's hypercube series as a basic manifestation and focuses on the architect's position regarding topology and surface. The relationship between self and other in the topology cannot be determined by the architect's active and reactive architectures, which are created through dynamic and static genesis (the strong ontology of uncertainty). The violence/power of continuous 'formlessness' in motion only becomes apparent upon actualization at any given moment (state). The topology, which is constantly experiencing disruption, change, and transformation due to the potency and dynamism of violence/power, embodies the form of (non-existent) relationality between self and other, shaping itself as unformed, unstratified, unorganized, and continuously self-recreating (Figure 10).

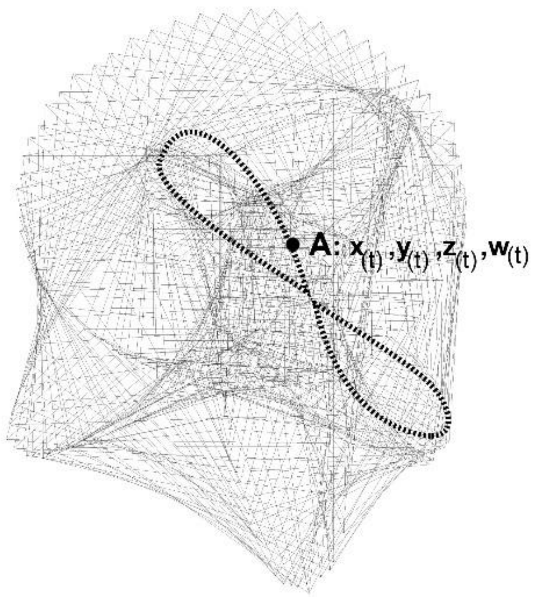

Figure 10. The coincidental position of the hyper-architect individuating by acquiring spatio- temporal coordinates (A:x(t), y(t), z(t), w(t)) at a coincidental moment.

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All authors contributed equally to the article. There is no conflict of interest.

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Examination of Material Selection's Effect on Lighweightness on Structures

Elif Esra BOYLU [1*], Savaş EKİNCİ [2]

ORCID 1: 0000-0002-1899-1995
ORCID 2: 0000-0002-0884-836X
[1-2] *Mimar Sinan Fine Arts University, Institute of Science Architecture, Istanbul, Türkiye.*
**** e-mail**: elifesraboylu@gmail.com*

Abstract

This article encompasses an investigation through the scanning of existing research and structures in the literature, focusing on the influence of material selection on the lightweight nature of the structure. Materials such as paper-cardboard, carbon fiber, wood, ETFE-PTFE, and FRP, along with 53 structures made from these materials, were examined in the context of structural lightness as studied in the literature. In structures produced using these materials and robotic fabrication methods, the effects of the fabrication method on structural lightness were investigated. As a result of the selected materials and systems, various advantages are provided, including structural lightness, reduced damage and deterioration from lateral forces such as earthquakes due to mass reduction, portability, reconfigurability, cost-effectiveness, structural efficiency, and the benefit of rapid installation. While examining structures produced from materials that enhance lightness, the potential negative effects of lightness on the structure were also considered. The findings from this analysis reveal that the lightweight nature of certain material choices affects structural configuration, connections, and subsystems.This study aims to contribute to the literature in the context of the structure-lightweight relationship and aims to serve as a compilation for subsequent research endeavors.

Keywords: *Lightweight structure, structural efficiency, paper and cardboard material, carbonfiber material, robotic fabrication.*

Malzeme Seçiminin Yapıların Hafifliğine Etkisinin İncelenmesi

Öz

Bu makale, literatürdeki mevcut araştırma ve yapıların taranması yoluyla, malzeme seçiminin yapının hafif doğası üzerindeki etkisine odaklanan bir incelemeyi kapsamaktadır. Yapının hafiflemesi üzerine literatürde çalışma yapılan malzemeler olarak kağıt-karton, karbonfiber, ahşap, ETFE-PTFE, FRP malzemeleri ve bu malzemelerden üretilen 53 yapı incelenmiştir. Bu malzemeler ile üretilen ve yöntemsel olarak robotik fabrikasyon kullanılan yapılardaysa bu yöntemin yapıya hafiflik kapsamında etkileri araştırılmıştır.Seçilen malzeme ve sistem neticesinde yapının hafif olması, kütle azalmasına bağlı olarak deprem gibi yanal kuvvetlerden kaynaklanan hasar ve bozulmaların azalması, taşınabilirlik, yeniden yapılandırılabilirlik, maliyet etkinliği, strüktürel etkinlik ve hızlı kurulum faydası gibi çeşitli avantajlar sağlanmaktadır. Hafifliğe katkı sağlayan malzemeler ile üretilen yapılar incelenirken, avantajlarına ek olarak hafifliğin yapıya olumsuz etki yapıp yapmadığı da incelenmiştir. Çeşitli malzeme seçimlerinin hafiflik yönünün, yapısal konfigürasyona, yapısal bağlantılara ve yapısal alt sistemlere etkisi olduğu yapıların incelemesi sonucunda elde edilen bulgulardandır.Bu çalışma, hafif strüktür, yapı-hafiflik ilişkisi bağlamında literatüre katkı sağlamayı ve daha sonraki araştırmalara derleme niteliği taşımayı amaçlamaktadır.

Anahtar kelimeler: *Hafif strüktür, strüktürel etkinlik, kağıt ve karton malzeme, karbonfiber malzeme, robotik fabrikasyon.*

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1. Introduction

Resource management and sustainability are considered important when dealing with limited resources in today's world where the construction industry occupies a large share.The effective use of the material is directly related to its quantity. Designing the existing effect with fewer materials ensures an effective design, reduces the total load, and as a result provides economy in construction. Creating the same strength with a hollow section rather than creating a fully filled section is one of the methods of providing lightness (Figure 1).

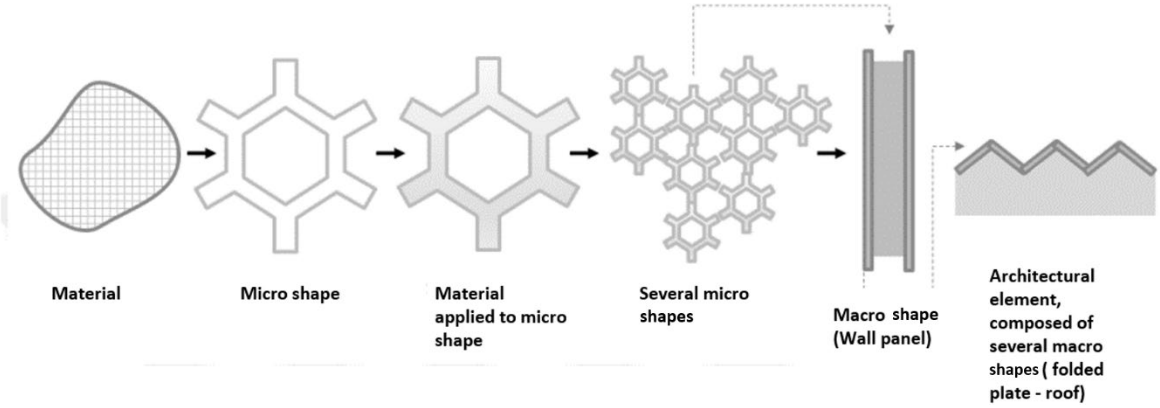


Figure 1. The fact that the material forms the general structure with a hollow form instead of a solid section ensures the lightening of the unit (Adapted from Ashby, 1999).

The lightening with the decrease of the transferred loads also affects the dimensions of the other parts related to the structure and can contribute to the lightening of the system as a whole. In the studies, it is seen that the fact that the facade element is made of light material affects the structure, especially the dimensions of the profiles that carry it, up to the dimensions of the foundation that will serve the load transmission principle. Lightness also provides portability to the structure. The structure's composition of unit elements, its disassembly and reassembly/assembly features support transportability. The lightness of the materials and units also provides the ability to be carried by people. The lightness of the units affords an advantage such as ease of operation and reduction of necessary equipment for operation (Menges, Dörstelmann, Knippers & Auer, 2016).

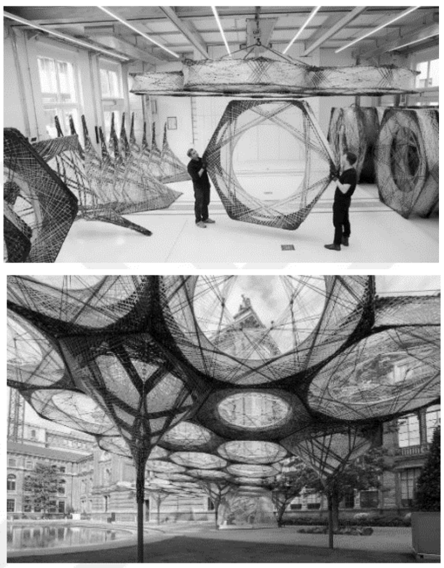


Figure 2. ICD/ITKE Elytra filament pavilion, one unit light enough to be carried by 2 people, (Institute for Computational Design. (n.d.). *Elytra filament pavilion)*

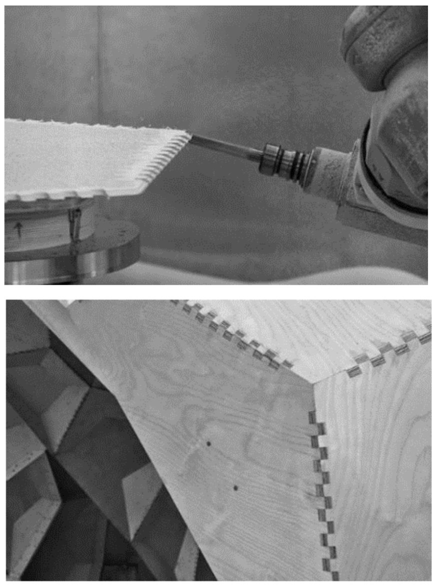


Figure 3. The shell structure, which is combined with the formation of finger joints, does not require any additional material in the joint, providing a lightness brought by the shape, (Krieg, 2011)

In this study, the effects of lightness in the structure were investigated by following the current state of material technology and the studies carried out (ETH Zurich UHPC), experimental university pavilion studies (Figure 2), field studies and researches on a certain lightweight material, such as paper Form and the way the pieces come together are another two of the important supporting factors in making the most impact achievable with the least. It is seen from the examples that robotic fabrication systems are used to create complex forms and ways of coming together with informatics with current technology (Figure 3). It is seen that the entire structure becomes lighter in such structures that do not require new elements in the connections and are built with light materials. With such methods, it is seen that for a certain size scale in the process, it simplifies, economizes and reduces the number of required personnel from the unit element to its installation (Latka, 2017). This study is shaped around the question of how to achieve the maximum effect with the least material. It aims to contribute to the literature by explaining how this problem is done with current materials and to investigate its effects by establishing a relationship with lightness through building examples. The lightness, which can be achieved in many ways, such as thinning the section with geometry, designing the section filled with geometry as hollow, designing the additional joint so that no other material is required, choosing the material with high strength but low density, will be examined through structures using different material groups and the results will be discussed.

2. Material and Method

In this study, sample structures built with 5 selected lightweight building materials in which total of 53 buildings from these five categories were examined. The evaluation question set shown in the Table 1 includes information about the structure in different categories such as numerical data, physical criterion-lightness, compliance with environmental conditions and adaptation to Growth/Proliferation conditions. At numeritical data section, a unit weight (kg/m^2) value of the building was tried to be reached by collecting/taking into account the stated kg and total m^2 data of the buildings (if given). In addition, a question set was created to investigate the structure. Apart from the numerical data of the building, the physical conditions (for example, being collected again, being able to be moved, being able to be divided into parts) were investigated. This information was evaluated as the effects that contribute to the lightness. The structures with the lightest unit weight in each material category were compiled. The life expectancy of the obtained structures, their resistance to atmospheric conditions, the requirement for the foundation of the building and their form of portability (by person or by transport) were investigated. It was also examined if it could provide the strength/support criterion together with the unit weight criterion and not have a negative effect on its lightness.

3.Findings and Discussion

Six different materials and structures using these materials are included in the study. Years of construction are from the oldest, 1966, and the latest, 2021.

3.1. Lightweight Structures Made of Paper and Cardboard Material

In this study, 19 structures were produced from paper and cardboard materials (Figure 4). Structural strength, the structure's resistance to atmospheric conditions, and the elements used at the junction points are the three main elements that must be taken into consideration in order to ensure lightness of the material.

Figure 4. Structures produced with the analyzed paper-cardboard material (Latka, 2017). 1-WUST Pavillion (Archi-Tektura. (n.d.). Projects. Archi-Tektura), 2-Paper House (Shigeru Ban Architects. (n.d.). Paper house (1995, 3-Paper Log House (Azevedo, 2015), 4-Cardboard Cathedral (Cai, 2013), 5-Library of Poet (Shigeru Ban Architects., n.d.). Library of a poet, 1991), 6-Nemunoki Childrens Arts Museum (Shigeru Ban Architects.,1991), 7-Miao School (Latka, 2017), 8-OctatubeDome(Tensinet, n.d.), 9-Paper Arch Dome (Washington, 2012), 10- Cardboard House (Stutchbury,n.d.), 11-Paper Church (Shigeru Ban Architects. (1995), 12- Westbrough Primary School (Katus. (n.d.), 13-Studio Kyoto (Designboom. (2021), 14-Japanese Pavillion (Arquitectura Viva. 2000),15- Apeldoorn Theater (Latka, 2017),16-Wikkelhouse: Modular modern solution) Cottrell & Vermeulen Architects, n.d.),17-Ring Pass Hockey Club (Octatube, 2012). Ring Pass),18-PLY Dome (Latka, 2017)

The questions asked to the structures/buildings can be viewed in Table 1.

Table 1. Question set prepared for the evaluation of lightness of buildings (Boylu, 2022)

Evaluation with Question Set			
Project Information			
	Architect		
	Year of construction		
	Build life		
	Material category		
	Size scale		
	Construction cost		
	Structure function		
Numerical Data			
	Square meter information		
	Span		
	Structural system		
	Shell or material tickness		
	Total weight		
Physical Criterion-Lightness		**(1) Positive**	**(0) Negative**
	Permanence-impermanence	Temporary	Permanent
	Is it possible to transport?	Transportable	Not Transportable
	Is it possible to disassemble/rejoin?	Able	Not Able
	Is it possible for unskilled labor?	Possible	Not Possible
	Number of people required for installation	<5	>5
	Is the unit heavy enough for 2 people to carry?	Yes	No
	Are their combinations with light material? Does is require a heavy material?	No	Yes
	Does it require heavy foundation/ground attachment?	No	Yes
	Is the unit element of the system light?	Yes	No
	Is the system installation overall lightweight?	Yes	No
	Is the embedded energy rating low?	Low	High
Compliance with Environmental Conditions			
	Thermal comfort		
	Light		
	Noise control		
	Resistance to humididty-		

	Athmospheric conditions
Adaptation to Growth/Proliferation Conditions	
	Does it consist of modules?
	What is the reproductibility- growht state?
	What is its adaptibility to different functions?

Paper and cardboard materials are inherently impervious to water. In the structures examined, it is seen that the material is coated with impregnation-like additives to increase its resistance to water. This causes it to be removed from the recyclable feature class. Another way of protection was to insulate the building, which has a cardboard structure, from the external environment by covering it with a linoleum-like cover.In order to provide the structural strength of the material, it has been used in different forms at the element level. These have been in the form of tube elements, multiple layers of material, or folded plates. In experimental structures made with paper and cardboard materials, which are not resistant to moisture together with water, the structure in which the main building very few materials are used in the joints is. The Apeldoorn Theater, which is entirely made of cardboard, including its combinations, has not been used after functioning for 1 week (Latka, 2017).

Table 2. Paper material structures, unit weight comparison, (shown in Figure 5) (Boylu, 2022)

Figure Ref. No.	*Building/ Project Name*	*Building Function*	*Function of Paper in Structure*	*Kg/ m²*	*Result kg/m²*
01	Cardboard House	Residence	Loadbearing Frame	2000kg/32 m²	62.5 kg/m²
02	Wesbrough Primary School	School	Column, roof panel	15000 kg /90 m²	166.6 kg/m²
03	Wikkel House	Residence	Loadbearing frame	3000 kg /30 m²	100 kg/m²
04	Apeldoorn Theatre	Theater	Shell	1500 kg/240 m²	6.25 kg/m²

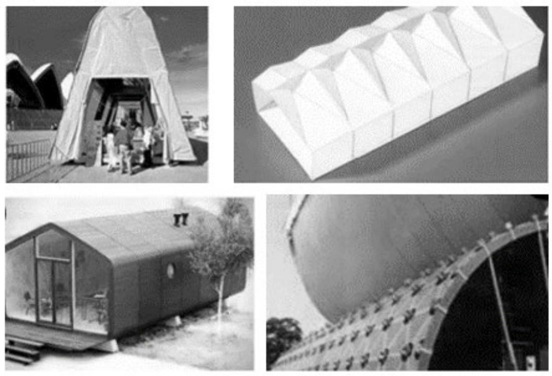


Figure 5. Referance figures for table-1, by order, Cardboard House (Stutchbury, P. (n.d.). Cardboard House) , Westbrough Primary School, (Katus. (n.d.). Wikkelhouse: Modular modern solution) Cottrell & Vermeulen Architects. (n.d.), Apeldoorn Theater (Latka, 2017)

It can be seen in the examples examined that the preferred combination materials for the long-term survival of the building are wood or stainless steel to be more resistant to moisture . The system, which is built from light unit elements such as paper or cardboard, is aimed to be relatively heavier but longer-lasting than the structure made entirely of paper/cardboard. When the structures with unit weight informations are examined, as seen in Table 2, it is seen that the lightest among the structures is the Apeldoorn Theater, which is a temporary, portable structure whose joints are made of paper materials.

3.2. Lightweight Structures with Elements Made of Wood

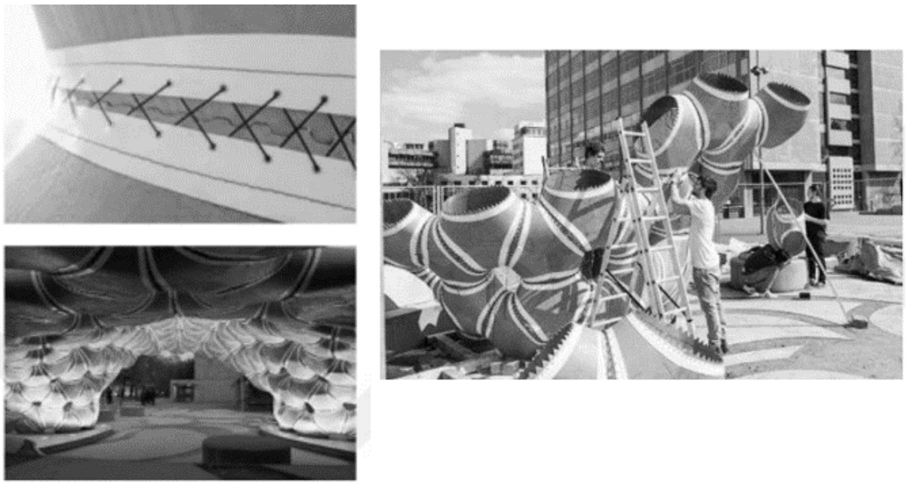


Figure 5. Detailed images of a wooden shell structure (Krieg,n.d.). Elytra Filament Pavilion, Victoria and Albert Museum, Retrieved June 26, 2024)

Within the scope of this study, 11 wooden structures were examined (Figure 5). In the research, examples were examined, especially the experimental pavilion structures made by ICD/ITKE and ETH Zurich. Structures with finger joint that do not require additional material in the joints were found, together with the examples where the wood was sewn very thinly. It can be seen from the examples that arrangements are made regarding the fiber directions in order to increase the strength depending on the thinning of the material, and that the forms that gain strength, such as folded plate are preferred together with the arranged wood materials such as CLT and LVL.

Computer-aided design and robotic fabrication tools were used in the phases of designing the material-effective form, breaking it into pieces, forming and producing the joint details in shell structure formations, which reduced certain items such as required workers and total production time and provided economy (Boylu, 2022).

Table 3. Numbering of structures made of wood and wood types used (Boylu, 2022), 1-Ultralight segmented timber plate Shell(Institute for Computational Design., 2015), 2- Landesgartenschau Exhibition Hall (Parametric Architecture., 2021), 3-SmartShell (MaterialDistrict, 2020), 4-St. Loup Chapel (Birkhäuser., n.d.), 5-Interlocking timber plate Shell (Linden,2017), 6-Vidy Theathre(Yves Weinand Architectes Sàrl + Plus Atelier Cube., 2020), 7-BUGA Pavillion (Institute for Computational Design. (2019)), 8-Sewn Timber Shell (Alvarez, 2017), 9-ITECH, 10-RecyleShell, 11-Portalen Pavillion (Augustynowicz, 2021) and right, material usage by photo referance

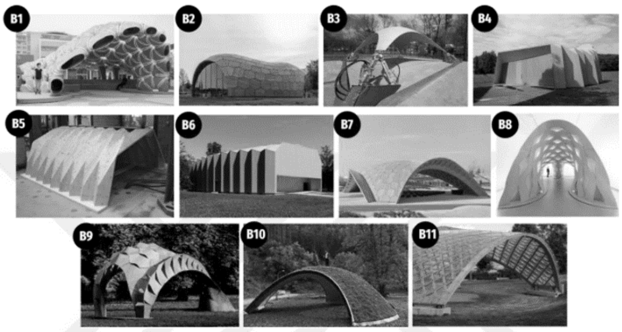


Figure referance number	Wooden Material type
B1	Plywood plate
B2	beech playwood
B3	4mm laminated wood
B4	CLT
B5	LVL-21mm
B6	45mm
B7	-
B8	3.5mm playwood
B9	3mm beech playwood
B10	-
B11	CLT

Stuttgart University's research pavilion structure (Figure 6) is inspired by the sea dollar, with tooth-like recesses in its seams. This plug-in structure of the joints provides a joint area, while additionally the elements are stitched robotically. Thus, a hollow shell structure is formed.While the shape provides strength to the structure, its hollow structure, unit elements, element organizations and combination details provide qualities that reinforce its lightness in many aspects. In the evaluation below (Table 4), it is seen that the structure is the 2nd lightest wooden structure among the structures with weight data.

Table 4. Unit weight values of structures with data produced with wood material (values not given are shown with x), (Boylu, 2022).

Ref. Picture	Building/project name	Kg/m² value	Result value kg/m²
B1	ICD-ITKE 2015-16 pavilion	780kg/85m²	7.85 kg/m²
B2	LAGA pavilion	x/125m²	38.6 kg/m²
B5	Interlocking plate Shell	192kg/25m²	7.68 kg/m²
B7	BUGA pavilion	x/675m²	36 kg/m²

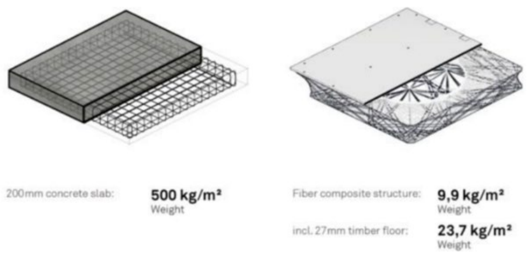
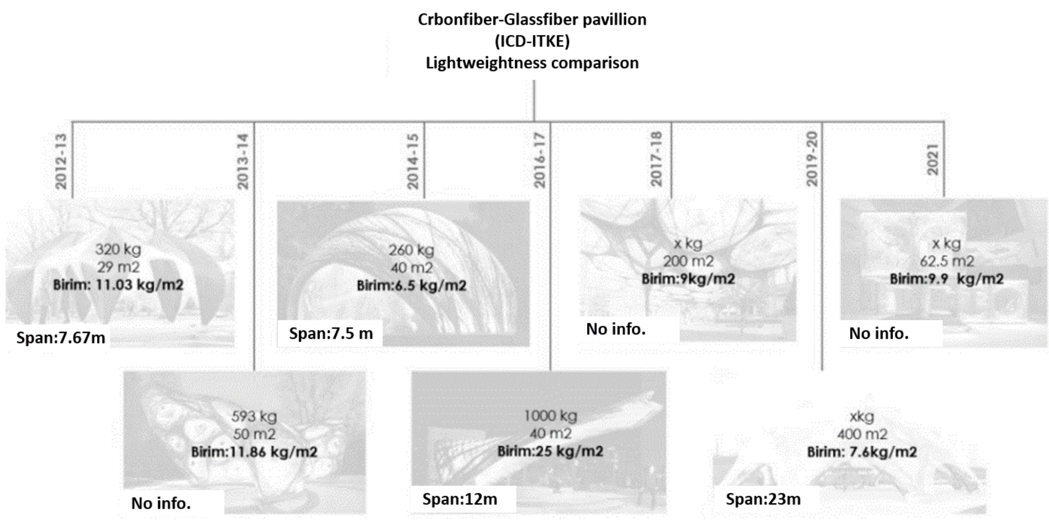


Figure 6. ICD/ITKE 2021 Pavilion, comparison of reinforced concrete slab vs lightweight slab (Menges & Dambrosio, 2021).

3.3. Lightweight Structures with Elements Made of Carbon Fiber, Glass Fiber

In collaboration with ETH Zurich and Stuttgart University, experimentally produced pavilion structures for light structure research, glass fiber and carbon fiber were created using special techniques (such as keeping the fibers in a cold environment - wrapping them in various ways).

Table 5. Weight evaluation of structures made of carbon fiber and glass fiber by years (Boylu, 2022)



These structures were analyzed according to the openings they passed through and according to their weight. It has been observed that there are various forms of cantilevered structures, shell structures or frame structures. According to the unit weight per square meter study, the lightest structure was the 2014-15 pavilion with a unit weight of 6.5 kg/m² (Menges & Knippers, 2015). It is noticed that carbon and glass fiber are used together in the pavilion structures built. The reason why both glass fiber and carbon fiber filaments are used together in structures is the nature of the material as well as the lightness of the material. Carbon fiber is a pure compression material, while glass fiber is a tensile material. The structures were inspired by many natural elements such as lobster shells, the structure of the sea dollar, the behavior of water spiders and the behavior of leafworms, in the name of materials and methods. In the 2012-13 pavilion, which was built by taking the lobster shells as an example, more carbon fiber was wrapped around the parts of the shell that required hardness and strength. In the pavilion structure produced in 2021 with the aim of adaptability and use in interaction with the existing building stock, a floor area of 62.5 m^2 is formed by the fibers wrapped in 2.5m x 2.5m elements. Compared to the reinforced concrete slab structure of the same thickness and area (Figure 6), the unit weight is only 23.7kg/m^2 when the wooden plate to be placed on it is added compared to the 500 kg/m^2 weight (Menges & Dambrosio, 2021). It is 18 times lighter than reinforced concrete flooring.

3.4. Lightweight Structures with Elements Made of Folio material (ETFE, PTFE, PET)

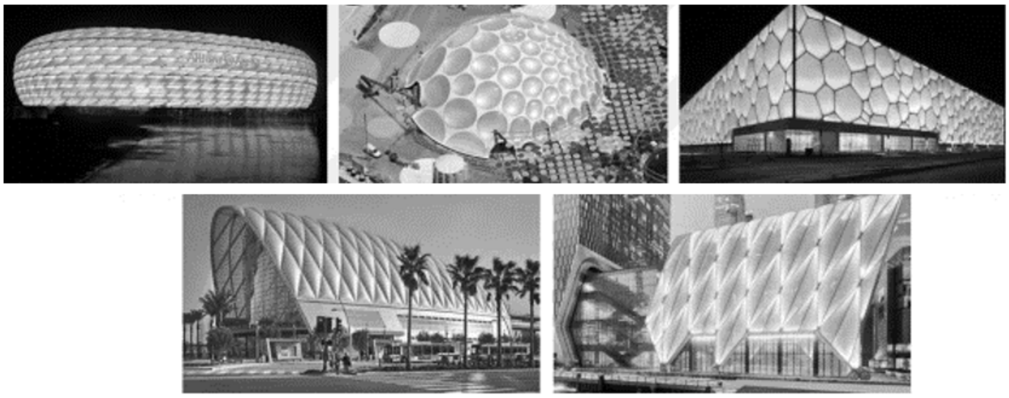


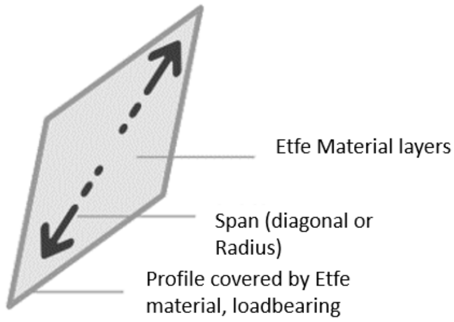
Figure 7. Visuals of the buildings produced with foil material within the scope of the study, 1-Allianz Arena (AGC Chemicals. (n.d.). ETFE film: Allianz Arena. Stylepark.), 2-Thirst Pavilion (Lastra y Zorrilla. (n.d.). Multiple layer covers and facades.), 3-Watercube National Swimming Center (Vector Foiltec. (n.d.). National Aquatics Center), 4-Anaheim Regional Transportation Center (Linden, C. J. ARTICs ETFE pillow assembly), 5-The SHED (World-Architects. (2021). A movable enclosure of air and plastic.)

When the examples in which foil systems are used are examined (Figure 7), it is seen that the general purposes are to provide a closed surface to pass a wide opening, to facilitate the movement mechanism of a large moving area, to give the space a feeling of open space.The material, light in nature, is stretched into a frame. This material, which is chosen to be light when passing wide openings in the construction of the building, comes together by forming unit elements and creates a cover.

These unit elements contain frames.In this study, which is examined for the purpose of lightness, it is seen that the number of layers of the foil material used is increased in order to reduce the number of profiles and thus the load, to increase the opening through which the unit element passes, and to keep the strength of the unit element at the same time. This relationship can be followed in Table 6.

Rather than increasing the profile thickness or number, increasing the number of layers also reduces the transmitted loads of the structure.This affects the associated detail and profile dimensions and the chosen foundation dimensions. The structures examined in the study and the unit element spacing passed depending on the number of layers used are shown in the Table 6.

Table 6. Unit element span chart of structures made of ETFE material (Boylu, 2022)



Year	Building name	ETFE için mesafe (min-max)	Layer number
2005	Allianz Arena	7.3m-17m(diyagonal)	2 layers
2008	Thirst Pavillion	2.8m-9.8m (radius)	2 layers
2008	Beijing National Aquatics Center	0-9m (radius)	3 layers
2014	Anaheim Regional Transportation Center	5m-27m (diyagonal)	3 layers
2019	The Shed	0-21m (diyagonal)	3-4 layers

3.5. Lightweight Structures with Elements Made of FRP Material

Fiber-reinforced material, which is formed by strengthening with various fibers such as glass fiber, carbon fiber and aramid fiber, is preferred in terms of use with its high strength and low weight. It was observed that the facade material and the shell were used as the main material in the structures examined (Figure 8).

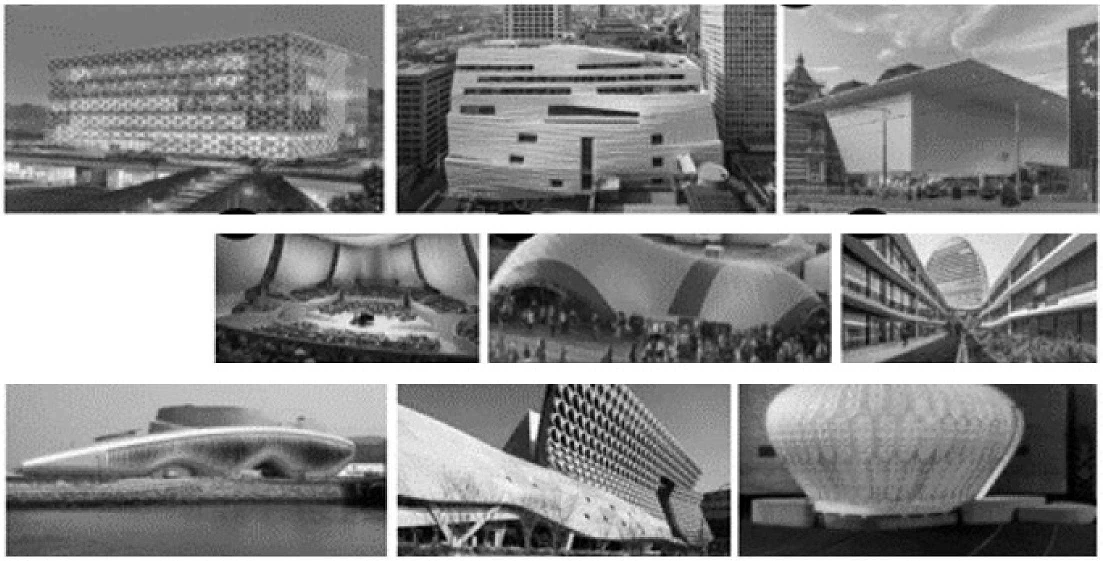


Figure 8. Visuals of the buildings produced with FRP material within the scope of the study, building names given in order on Table 7.By an order 1-Gebouw (Holland Composites., n.d.). Composite façade Windesheim Building X. Holland Composites.), 2-SFMOMA (San Francisco Museum of Modern Art., n.d.). Made in the Bay Area), 3-Stedejik Museum (e-architect., n.d.). Stedelijk Museum Amsterdam.), 4-BING Concert Hall (Bourne, 2023). Concert hall composites), 5-GFRP Gridshell (Linden, 2015), 6-BBVA HQ (Miller, 2013). Update: SFMOMA expansion by Snøhetta. ArchDaily.), 7-Yesou Expo Center(Soma Architecture., n.d.). Thematic Pavilion), 8-Kolon One&Only Center (Sweeney, 2019). Kolon One & Only Tower. Architect Magazine.), 9-Cacoon FS Pavillion (Architizer. (n.d.). Cacoon FS. Architizer.)

It can be molded, shaped by scraping with a robotic arm, and it can be applied by spraying and applying. When the examples are examined, the reasons for using these materials in buildings are shown in Table 7. In the samples examined, GFRP-CFRP and AFRP materials were mostly used as facade materials.

Table 7. Structures examined and the advantage of the material used (Boylu, 2022)

Building name	G/A/CFRP Using Advantage
01-Gebouw Prefabricated Facade	Lightweight facade
02-SFMOMA	Lightweight facade
03-Stedejik Museum	Lightweight facade
04-BING concert hall, acoustic panels	Lightweight panel
05- GFRP Gridshell	Lightweight shell
06-BBVA HQ	Lightweight facade
07-Yeseo Expo Center	Lightweight facade / lower weight through facade mechanism
08-Kolon One & Only Tower	Lightweight facade
09-Cacoon FS Pavillion	Lightweight shell

The lightening of the facade means that less load is placed on the elements carrying the facade and therefore, less material with thinner sections is used. Accordingly, the decrease in the loads transferred to the foundation means that the material required for the foundation automatically decreases.

Among the structures whose unit weights have been reached, the unit weight in the Cocoon FS Pavilion structure is 7.5kg/m^2 (Kromoser, Preinstorfer & Kollegger, 2017). Manufacturers are able to fix the structure to the ground to be able to withstand wind, etc. It is positioned on a concrete platform to protect it from external influences.

It can be said that the lightness in the building affects the other elements and element dimensions with which the lightweight construction material and the lightweight construction element interact.

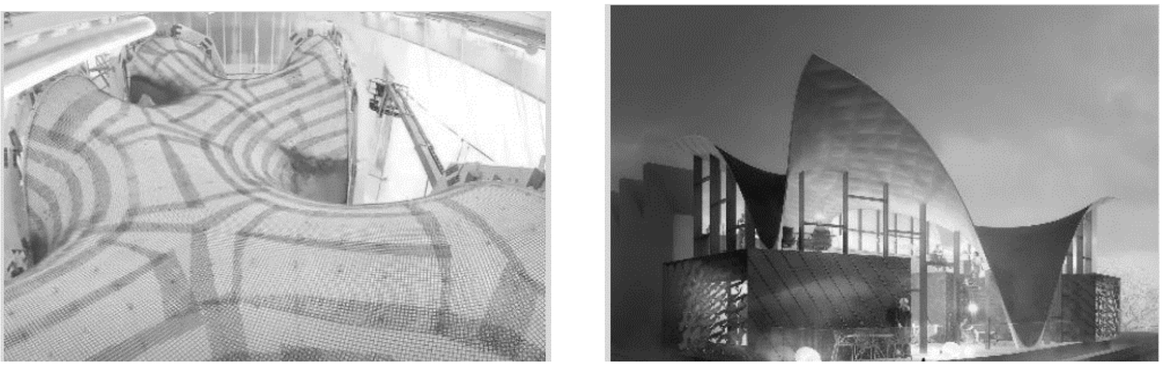


Figure 9. Images of Hilo Shell structure (ETH Zurich., n.d.). Full-scale construction prototype: NEST HiLo shell roof) (Mele et al., 2017).

The building shell system benefits from the knowledge and experience gained in the historical context by supporting it with the mesh elements and fabric used during construction (Figure 9). The shell structure is 4 cm thick and covers an area of 200 m^2 (Mele et al., 2017).

The unit weight of the building, which has a total weight of 800 kg, is only 4 kg/m^2. The benefit of thinning the cross-section provides the advantage of reducing the material used in the final product and covering a similar area with less material.

At this point, the concept of topology optimization becomes crucial in many such structures. In this example Nest Hilo, a common material like concrete has been applied using additive design methods to maximize the effect of topology optimization and achieve complex geometries.

This approach meets four key criteria: complex geometry, three-dimensional concrete printing, robotic fabrication, and material efficiency. As a result, the structure gains lightness, durability, cost and time efficiency, and sustainability. In additive manufacturing technologies, rather than designs lightened by topology optimization, it is predicted that organic forms developed to suit production parameters will shape future design trends (Çalışkan & Arpacioğlu, 2020).

4. Conclusion and Suggestions

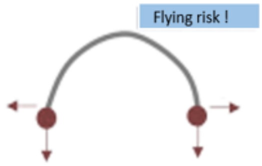
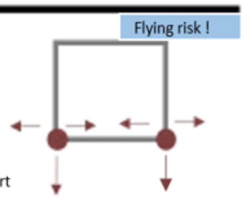
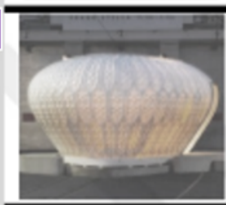
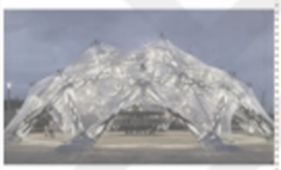
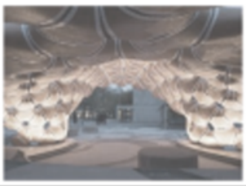
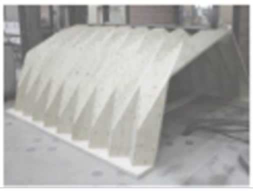
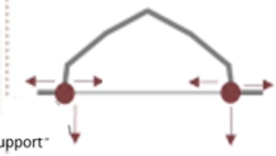
In this study, building samples made of paper, fiber reinforced plastic (CFRP-GFRP-AFRP), carbon and glass fiber, light wood, foil material (ETFE-PTFE) and ultra high performance concrete materials were examined in terms of lightness.

Lightness is divided into two as light portability and light transportability in study. For a structure to be lightly portable, it must be light enough for 2 people to carry, and this must be less than about 50 kg.

Different strategies have been tried with different materials for lightness. The inferences made when looking at the structures with the lightest unit weights are as follows:

- Different lightweight materials have different resistance to atmospheric conditions, water and humidity.
- Although it provides lightness (e.g., pop-up dome), some structures could not provide long-term life conditions. On the other hand, in structures with a durable material nature (Prayor Shelter), both lightness and durability are met. The lightness of the structure requires a connection to the ground in order to withstand impacts such as flying. Making a heavy foundation does not provide the purpose as it will make the whole system heavier. In this regard, Cocoon FS structure can be given as an example with its weighting on the system.
- Although the Apeldoorn structure, which is completely made of paper, shows that the joints can also be produced from paper, only 1 week was given to the structure, whose joints weakened due to the soft nature of the paper. In a different approach, the Cocoon FS structure is made of fiber-reinforced plastic, but incorporates steel elements so that its joints are durable. It is thought that while making the structure durable, it makes it heavier, as it is at the base of this approach.
- As with the UHPC material, although the nature of the material is heavy, its unit weight is reduced to 4kg/ $m^2$with thin sections and advanced structure technology.
- Dismantling and re-installing in structures produced with light materials is an advantage both for transportation and re-deployment, and for sustainability.
- It is deduced that the use of light material thins the profile sections used in parts where strength is important together with atmospheric conditions in the material selection (for example, on facades): therefore, reducing the amount of material used.
- Increasing the number of layers in the structures produced with foil material has ensured the passing of the span and reducion in the number of carrier profiles used.
- Studies have been carried out to increase the structural possibilities of a light material such as paper. The moisture resistance of the material has been improved over time by cutting off its contact with water, which does not aggravate the structure, such as an additional outer layer and isolation from the ground.

Table 8. Compilation and comparison of the lightest structures with data obtained as a result of the study (Boylu, 2022)

cardboard	POP UP DOME		3.125 kg/m2	15m²	<50kg	Folded- dome	+ Able to carry by 2 people ⊘ Water resistance ⊘ Long lifetime + Lightweight foundation-support	
cardboard	2-APELDOORN THEATRE		6.25 kg/m2	240m²	1500kg	shell	⊘ Able to carry by 2 people ⊘ Water resistance ⊘ Long lifetime + Lightweight foundation-support	
polipropilen	3- PRYOR SHELTER		3.97 kg/m2	4m²	15.88kg	Folded	+ Able to carry by 2 people + Water resistance + Long lifetime + Lightweight foundation-support	
FRP	4- COCOON PAVILION		75 kg/m2	10m²	750kg	Shell-segmented	⊘ Able to carry by 2 people + Water resistance + Long lifetime ⊘ Lightweight foundation-support	
Carbonfiber	5-ICD/ITKE 2018-19 PAVILION		7.6 kg/m2	400m²	3040kg	Segmented / geodesic dome	⊘ Able to carry by 2 people + Water resistance + Long lifetime ⊘ Lightweight foundation-support	
Carbonfiber	6-ICD/ITKE 2014-15 PAVILION		6.5 kg/m2	40m²	260kg	shell	⊘ Able to carry by 2 people + Water resistance + Long lifetime ⊘ Lightweight foundation-support	
Wood	7-ICD/ITKE 2015-16 PAVILION		7.85 kg/m2	85m²	780kg	Segmented shell	⊘ Able to carry by 2 people + Water resistance + Long lifetime ⊘ Lightweight foundation-support	
Wood	8-INTERLOCKING TIMBER PLATE SHELL		7.68 kg/m2	25m²	192kg	Folded shell	⊘ Able to carry by 2 people + Water resistance + Long lifetime + Lightweight foundation-support	

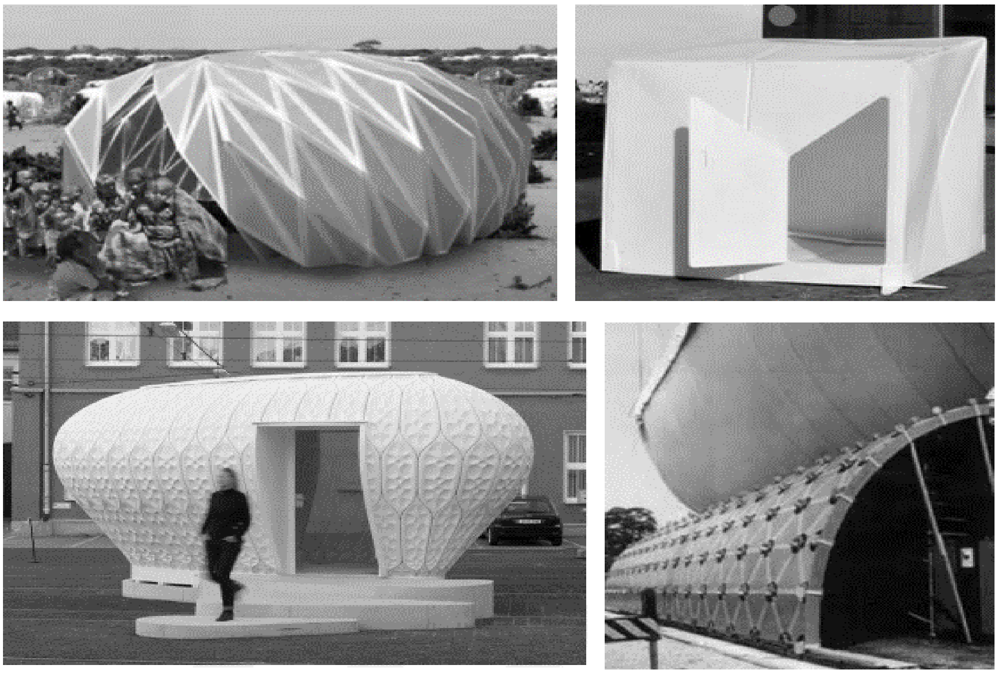


Figure 10 By an order, 1-Pop Up Dome(AIA Chicago., 2018), 2-Prayor Shelter (Pryor, 2018), 3-Cocoon FS Pavilion (Architizer., n.d.), 4-Apeldoorn Theater (Latka, 2017)

It is inferred from this study that the choice of lightweight material in the building directly affects the dimensions of the other building elements with which it interacts. This brings economy to the structure. Due to the lightness (f=m.a) formula, it is a factor that ensures building safety for earthquakes. However, the decrease in mass creates a negative effect due to the danger of flying against factors such as wind (Figure 10). It requires ground fixing. The lightness of the unit element of the system provides lightness in the structure, but for the structure to be light as a whole, the foundation and its joints must also be light.

As a result, in this article the lightest structures of each material were compared, and it was concluded that lightness affects structural configuration, structural connections, and structural subsystems. The direct impact of lightweight materials on structural subsystems provides benefits such as construction economy and ease of assembly throughout the structure. Additionally, instead of evaluating the results solely in terms of lightness, this study developed an approach to examine structural requirements and reconsidered situations where lightness could cause certain disadvantages. As a result of this evaluation, considering the four basic criteria (portability by two people, wind resistance, water resistance, and the ability to be established with a lightweight foundation system), it was found that both the lightness and the nature of the material are important criteria for the reuse or long-term durability of the structure. This study aims to contribute to the literature by covering a broad range, from the use of simple, economical materials like cardboard to complex, advanced materials such as carbon fiber and robotic fabrication processes, while examining applied structures through the lens of lightness. These results suggest that in today's world, where resource management has become increasingly important, lightness will be a fundamental element in creating more sustainable, faster, and more economical buildings.

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The authors contributed equally to the study. No conflict of interest or common interest has been declared by the authors. This study does not require ethics committee permission or any special permission.This article, Mimar Sinan Fine Arts University , Master's Degree, completed in 2024 in the Department of Architecture and Produced from Master thesis completed in 2022.

The article complies with national and international research and publication ethics.Ethics Committee approval was not required for the study.

Author Contribution and Conflict of Interest Declaration Information

All authors contributed equally to the article. There is no conflict of interest.

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Understanding Air Pollution Risk Patterns in Ankara: Influence of Human and Meteorological Factors

Nuriye Ebru YILDIZ [1*], Şükran ŞAHİN [2]

ORCID 1: 0000-0002-3508-4895
ORCID 2: 0000-0002-3730-2534
[1] *Niğde Ömer Halisdemir University, Faculty Architecture, Department of Landscape Architecture, 51000, Niğde, Türkiye*
[2] *Ankara University, Faculty of Agriculture, Department of Landscape Architecture, 06110, Ankara Türkiye*
**** e-mail**: ebruyildiz@ohu.edu.tr*

Abstract

In order to determine the air pollution risk in Ankara city centre, a series of analyses including quantitative measurements of anthropogenic and meteorological parameters were carried out. After the quantitative results were normalised, relevant categorical values were assigned to each parameter. These parameters were overlaid with the overlapping technique by considering their weight scores. According to the research findings, almost all of Çankaya, the south of Yenimahalle and the east of Etimesgut were found to have "Very High (5)" and "High (4)" levels of air pollution, respectively. The results show that 19.78% of the total study area has "very high", 28.92% "high", 30.33% "medium", 16.68% "low" and 4.29% "very low" air pollution risk levels. In future studies, different parameters with different weights can be added to the method based on other environmental factors and requirements in the research area.

Keywords: *Air quality, human effects, urban planning, geographic information systems.*

Ankara'da Hava Kirliliği Risk Deseninin Anlaşılması:Antropojenik ve Meteorolojik Etkiler

Öz

Ankara kent merkezinde hava kirliliği riskinin belirlenmesi amacıyla antropojenik ve meteorolojik parametrelere ilişkin nicel ölçümleri içeren bir dizi analiz süreci yürütülmüştür. Nicel sonuçlar normalize edildikten sonra, her bir parametreye ilgili kategorik değerler atanmıştır. Bu parametreler, ağırlık puanları dikkate alınarak üst üste bindirme tekniği ile çakıştırılmıştır. Araştırma bulgularına göre, Çankaya'nın neredeyse tamamı ile Yenimahalle'nin güneyi ve Etimesgut'un doğusunun sırasıyla "Çok Yüksek (5)" ve "Yüksek (4)" düzeylerinde hava kirliliği tespit edilmiştir. Sonuçlar, toplam çalışma alanının %19,78'inde "çok yüksek", %28,92'sinde "yüksek", %30,33'ünde "orta", %16,68'inde "düşük" ve %4,29'unda "çok düşük" hava kirliliği risk düzeylerinin bulunduğunu göstermektedir. Gelecek çalışmalarda, araştırma alanındaki diğer çevresel faktörlere ve gereksinimlere bağlı olarak yönteme farklı ağırlıklarda farklı parametreler eklenebilir.

Anahtar Kelimeler: *Hava kalitesi, insan etkileri, kent planlama, coğrafi bilgi sistemleri.*

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1. Introduction

The effects of air pollution on human health are one of the major environmental issues caused by industrialization and urban development (WHO, 1992; Hosseiniebalam & Ghaffarpasand, 2015). The population growth over the past century has led to an increase in the number of housing, industrial structures, and vehicles. The increase in building density and traffic density are significant sources that contribute to higher levels of pollutants in the lower layers of the atmosphere. Additionally, due to increased energy demands and the continuous use of non-renewable energy sources, the release of hazardous pollutants into the atmosphere continues (Karimi et al., 2016). The most common pollutants in the atmosphere include carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen oxides (NO and NO_2), particulate matter (PM), smoke, soot, and dust. The sources and effects of air quality variables are shown in Table 1 (CEE, 2018).

Table 1. Air Pollutants and Their Sources (CEE, 2018)

Pollutant	Source
Sulfur Dioxide (SO2)	Fossil Fuel Combustion, Vehicle Emissions
Nitrogen Oxides (NOX)	Vehicle Emissions, High-Temperature Combustion Processes
Particulate Matter (PM)	Industry, Vehicle Emissions, Fossil Fuel Combustion, Agriculture, Secondary Chemical Reactions
Carbon Monoxide (CO)	Incomplete Combustion Products and Vehicle Emissions
Ozone (O3)	The Transformation of Traffic-Generated Nitrogen Oxides and Volatile Organic Compounds (VOC) by Sunlight

In addition to the target limit values for air pollutants in the Turkish Air Quality Control Regulation, limit values reported by the European Union, the World Health Organization (WHO), and the European Environmental Agency are also available (Menteşe, 2017). According to the Clean Air Right Platform (2021), in Turkey, 97.7% of the 175 stations (171 stations) had PM10 averages in 2020 that exceeded the limit values set by the World Health Organization (WHO). When the legal limit values set for Turkey are evaluated, it is observed that the annual PM10 average exceeds national limits in 45 out of 72 provinces where sufficient measurements were taken. Additionally, the WHO's technical guidance states that '24-hour PM10 measurement values should not exceed the limit of 50 µg/m^3 on more than 35 days in a year.' However, it has been found that the specified limit is exceeded in 66.9% (83 stations) of the 124 stations where measurements were taken (Clean Air Right Platform, 2021; Yıldız, 2022). Nevertheless, in the updated WHO (2021), guideline values that should not be exceeded for particulate matter (PM10), particulate matter (PM2.5), nitrogen dioxide (NO_2), ozone (O_3), and carbon monoxide (CO) levels in the air have been lowered (Clean Air Right Platform, 2022). However, in districts such as Istanbul and Ankara, where coal is especially used for heating purposes and where urbanization and traffic are intense, air pollution values are increasing day by day. In Ankara, only a minimum of 90% data acquisition is ensured in 6 out of 18 air pollution measurement stations. When the values of these stations are analyzed, it is seen that the annual average particulate matter concentration in Ankara exceeds the national limit value (Clean Air Right Platform, 2022).

Air pollutants are released into the atmosphere from various sources, and the concentration of pollutants in the atmosphere depends not only on the amount emitted but also on the atmosphere's ability to retain or disperse these pollutants (Karimi et al., 2016). Understanding the behavior of meteorological parameters such as wind speed, wind direction, precipitation, and temperature is crucial for predicting air pollution. This is because the atmosphere is governed by these meteorological parameters and carries pollutants in the air away from their sources (Çelik & Kadı, 2010; Khedairia & Khadir, 2012; Jayamurugan et al., 2013). The combination of emission intensity from different pollutant sources and meteorological parameters determines a condition known as air pollution risk (Bay Area Air Quality Management District, 1998; Mofarrah & Husain Badr, 2011). Therefore, in assessing air pollution risk, both sources of air pollution and meteorological parameters need to be considered together. Pollution sources can vary depending on land use and population density in urban areas.

Especially in densely populated urban areas with high levels of settlement and industrialization, measuring or predicting air pollution using mathematical methods has become an important issue (Ahern et al., 2014). For example, using remote sensing methods and techniques, aerosols in the atmosphere can be measured by the MODIS device placed on the Aqua satellite and air quality modeling can be performed using Aerosol Optical Depth (AOD) data (CEE, 2018). In order to evaluate air quality, interpolation methods can be used for air pollution distribution through geographic information systems software by using daily pollutant measurements obtained from air pollution measurement stations (Toros et al., 2018). In addition, in the international literature, Gassmann & Mazzeo (2000), Pisoni et al. (2009), Achillas et al. (2011), Hosseiniebalam & Ghaffarpasand (2015), Karimi et al. (2016), Habibi et. al. (2017), Zhou et. al. (2020), the distribution of potential air pollution risk was determined using parameters such as traffic and population density, climate parameters, land cover or use. However, in these studies, mostly anthropogenic, meteorological or socioeconomic parameters were evaluated and the effect of microclimatic temperature or heat island effect on air pollution was not analyzed. Unlike the studies in which potential air pollution was determined using multi-criteria decision-making techniques, in this study, in order to determine the potential air pollution risk in the urban core of Ankara, in addition to population density, land use, wind, precipitation data, the urban heat island effect parameter was also included in the method. The parameters specified within the scope of the method were overlaid by taking into account the weight scores in Karimi et al. (2016). In this study, the urban core of Ankara was selected as the study area due to the fact that the annual average particle amount obtained from the air pollution measurement stations is above the national limit values and only 6 of the 18 air pollution measurement stations have a minimum data coverage of 90%.

2. Material & Method

2.1. Study Area

The main material of the study is the core of the city of Ankara, which is located between the northern latitudes of 39°14'46" to 40°13'35" and the eastern longitudes of 32°14'24" to 33°09'49" (Figure 1).

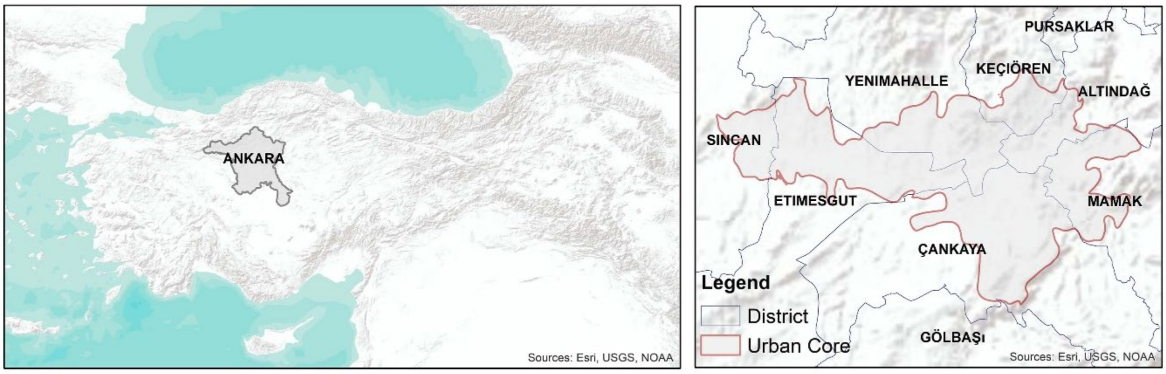

Figure 1. Study area

2.2. Data Sets

The data sets used in the research, their sources, and data details can be found in Table 2. ArcGIS 10.5 software was utilized for Geographic Information Systems and Remote Sensing analyses, and the projection system of the data sets used was set to "WGS_1984_UTM_Zone_36N.

Table 2. Data sets, sources, and data details

Data Sets	Source	Data Details
2012 Urban Atlas (Land Cover) (1/25.000)	Copernicus Land Monitoring Service (CLMS, 2022)	Vector (Polygon)
2018 Population Density Data	(General Directorate of GIS, 2021) Ministry of Environment and Urban Planning, General Directorate of Geographic Information Systems, Directorate General of Geographic Information	Raster (1000x1000m)
Long-term (1959-2018) All Variables Bulletin	(General Directorate of Meteorology, 2022) Republic of Turkey Ministry of Agriculture and Forestry, Directorate General of Meteorology	Vector (Point) Digitization by Station Coordinates
Urban Heat Island	Yıldız (2022) This is one of the ecological indicator analyses conducted in the doctoral thesis by Yıldız (2022) in the Department of Landscape Architecture at Ankara University Faculty of Science, Institute of Science.	Raster (100x100m)
Urban Core	Yıldız (2022) The core of the city boundary was used in the doctoral thesis conducted by Yıldız (2022) in the Department of Landscape Architecture at Ankara University Faculty of Science, Institute of Science.	Vector (Polygon)

2.3. Method

In this study, Geographic Information Systems (GIS) methods and techniques were employed to determine the risk of air pollution. In line with the objectives of the study, anthropogenic factors potentially contributing to air pollution in the core of Ankara city, as well as meteorological parameters, were evaluated. Population density and land cover parameters were utilized to assess the risk of air pollution resulting from human impacts, while meteorological parameters such as wind, precipitation, and urban heat island were included as layers in the methodology. The population density parameter in the study is the 1000 m x 1000 m 2018 population density data obtained from the Ministry of Environment and Urban Planning, General Directorate of Geographic Information Systems, Directorate General of Geographic Information (General Directorate of GIS, 2021). The land use parameter in the study consists of 1/25.000 scale urban atlas data obtained from Copernicus Land Monitoring Service (CLMS, 2022). Long-term (1959-2018) All Variables Bulletin data obtained from the Republic of Turkey Ministry of Agriculture and Forestry, Directorate General of Meteorology were used to obtain wind and precipitation distribution maps. A spatial wind distribution map was obtained by interpolation method using precipitation values converted to point data in ArcGIS. In order to determine the precipitation distribution, the precipitation values in the Long-term (1959-2018) All Variables Bulletin were adjusted for elevation using the Schreiber method in Çiçek & Ataol (2009). The urban heat island effect parameter used in this study was obtained from the work conducted by Yıldız (2022) for Ankara.

In landscape planning studies where different and multiple indicators are used, these parameters cannot be evaluated directly, and all parameters need to be converted into common categorical values (Vihervaara et al., 2017). For this reason, the quantitative results of each sub-layer were normalized and converted into categorical data ranging from "very low (1)" to "very high (5)". In the final stage, each sub-layer was overlaid using the overlay method based on weight values to obtain an integrated result. In this study, parameters and rankings obtained through the multi-criteria decision-making technique, in line with the expert opinions from Karimi et al. (2016), have been adapted to Ankara city (Table 3). Unlike the temperature parameter in Karimi et al. (2016), the urban heat island effect parameter was included for the Ankara city core. Thus, parameters such as building volume, slope, and elevation in the city core were considered (Yıldız, 2022), resulting in a more accurate prediction of air pollution risk for the city core. By overlaying layers and criteria based on weight levels, air pollution densities and spatial distributions were determined (Figure 2).

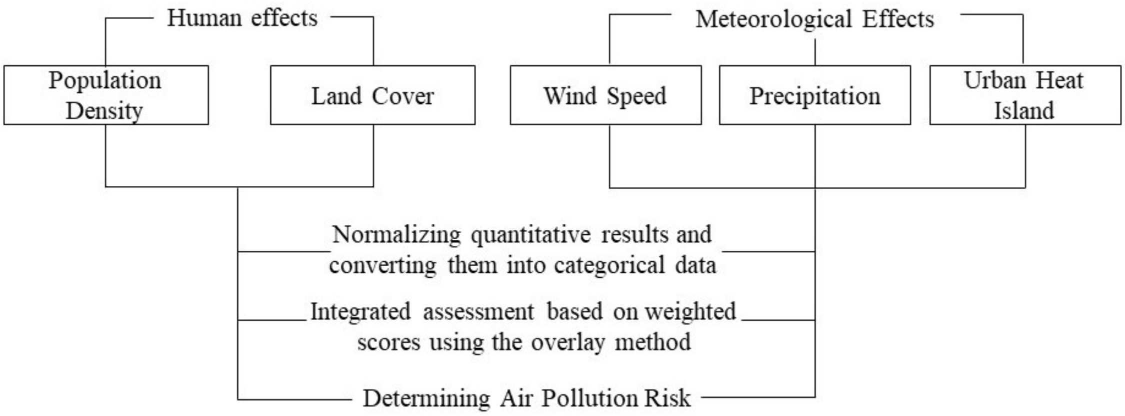

Figure 2. Methodology

Table 3. Weight Degrees of Layers and Sub-Criteria (Adapted from Karimi et al. 2016)

Layers	Weight Score	Sub-Layers	Weight Score
Human Effects	0.3	Population Density	0.75
		Land Cover	0.25
Meteorological Effects	0.7	Wind Speed	0.6
		Precipitation	0.2
		Urban Heat Island	0.2

3. Research Findings

In this section, the human impacts and meteorological effects on air pollution risk have been assessed.

3.1. Human Effects

Population Density: The increase in population density is one of the most significant factors contributing to the increase in CO_2 emissions and other air pollutant parameters in urban areas (Pata & Yurtkuran, 2018). Increasing population density signifies increased fossil fuel consumption, industrialization, and vehicle traffic. Therefore, in studies related to air pollution and carbon storage, when examining the relationships between growth and energy consumption, population density should also be considered as an important variable (Rahman, 2017). The amount of pollutant emissions in the air is higher in regions with high population density, increased vehicle usage, or intensive industrialization. Population density is defined as the number of people per square kilometer (Karimi et al., 2016). This density indicates how much energy is consumed in an area. Therefore, this indicator is crucial for assessing air quality and is particularly important for determining human density, which has a strong impact on emission intensity. In this study, the parameter of population density represents the air pollution risk generated by the number of people per unit area in square kilometers. The obtained population density data were classified into 5 categories: very high (5), high (4), medium (3), low (2), and very low (1). The population density map can be seen in Figure 3. In the core of Ankara city, areas with high and very high population density include the south of Keçiören, the east of Yenimahalle, the southwest of Mamak, and the south and east of Çankaya.

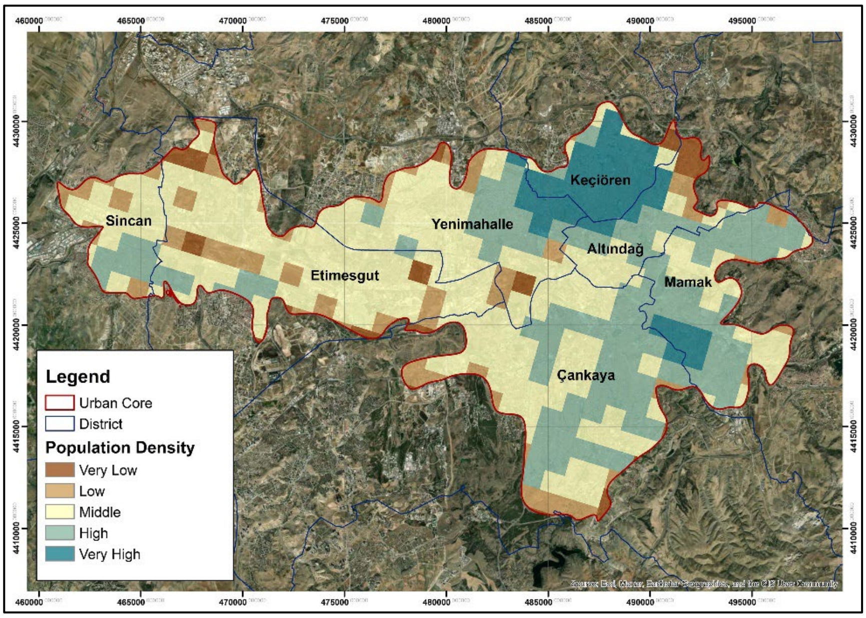

Figure 3. Population Density Map

Land Cover: Increased population density in urban areas, especially in cities, leads to significant changes in land cover (LC) and brings various disadvantages to the city center and its surroundings (Oke, 1973; Voogt & Oke, 2003; Weng et al., 2004). One of the most significant of these adverse effects is the emergence of air pollution. In areas where residential and industrial density is high in cities, traffic density is also high. Along with urbanization, green areas within the city decrease, and the amount of emissions in these areas increases (Karimi et al., 2016). Therefore, it is possible to say that land cover classes have different effects on air pollution. In this context, the land cover of Ankara city was evaluated, and scores ranging from 1 to 5, indicating the levels of air pollution for each land cover class, were assigned. The land cover (Level 1) map can be seen in Figure 4. The land cover classes of the core of Ankara city, along with their areas and air pollution levels, are presented in Table 4. The largest land cover class in the city core is industrial, commercial, public, military, private units (6290 ha), and discontinuous urban settlement (6147 ha).

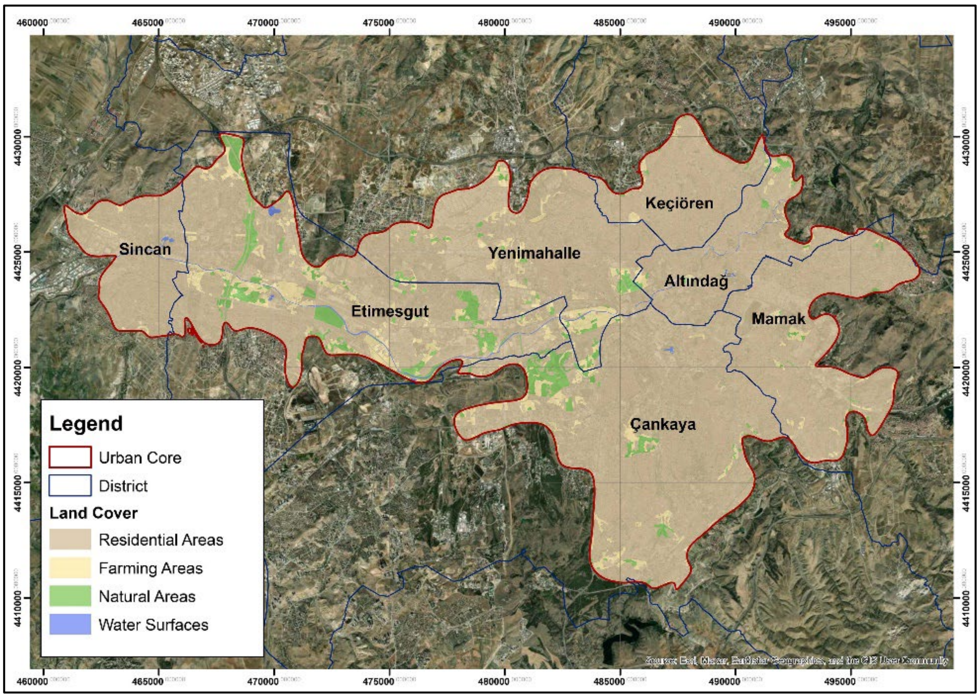

Figure 4. Land cover map

Table 4. Land cover classes and air pollution levels

Land Cover Class	Code	Land Cover/Land Use	Area (ha)	Percentage (%)	Air Pollution Level
Residental Areas	11100	Continuous urban fabric (S.L. > 80%)	3.775	11.40	5
	11210	Discontinuous dense urban fabric (S.L. 50% - 80%)	6.147	18.57	5
	11220	Discontinuous medium density urban fabric (S.L. 30% - 50%)	2.129	6.43	5
	11230	Discontinuous low density urban fabric (S.L. 10% - 30%)	1.064	3.21	5
	11240	Discontinuous very low density urban fabric (S.L. < 10%)	318	0.96	5
	11300	Isolated structures	5	0.02	5
	12100	Industrial, commercial, public, military, and private units	6.290	19.00	5
	12210	Fast transit roads and associated land	84	0.25	5
	12220	Other roads and associated land	4.235	12.79	5
	12230	Railways and associated land	179	0.54	5
	12400	Airports	397	1.20	5
	13100	Mineral extraction and dumpsites	408	1.23	5
	13300	Construction sites	358	1.08	5
	13400	Land without current use	1.538	4.65	5
	14100	Green urban areas	1.952	5.90	4
	14200	Sports and leisure facilities	471	1.42	4
Farming Areas	21000	Arable land (annual crops)	1.572	4.75	3
	22000	Permanent crops	5	0.02	3
	23000	Pastures	591	1.79	2
	31000	Forests	44	0.13	1
	32000	Herbaceous vegetation associations	1.350	4.08	1
	33000	Open spaces with little or no vegetation	49	0.15	1
Water Surface	50000	Water	141	0.43	1

3.2. Meteorolgical Effects

Wind Speed: The fundamental parameter affecting the movement of pollutants in the atmosphere is wind speed and direction. Essentially, the higher the wind speed, the more extensive the distribution of pollutants in the atmosphere (Karimi et al., 2016). Wind speed values obtained from the General Directorate of Meteorology (MGM) of the Ministry of Agriculture and Forestry were input into meteorological stations located in Ankara, and spatial distribution of point data was achieved through interpolation techniques. The obtained wind speed distribution values were classified from very low to very high on a scale from 1 to 5 based on wind speed. Figure 5 shows the spatial distribution map of wind speed. In an area where wind speed is very high, polluted air will be transported through the atmosphere with the wind. Therefore, it is possible to say that air pollution is very low in a location with high wind speed.

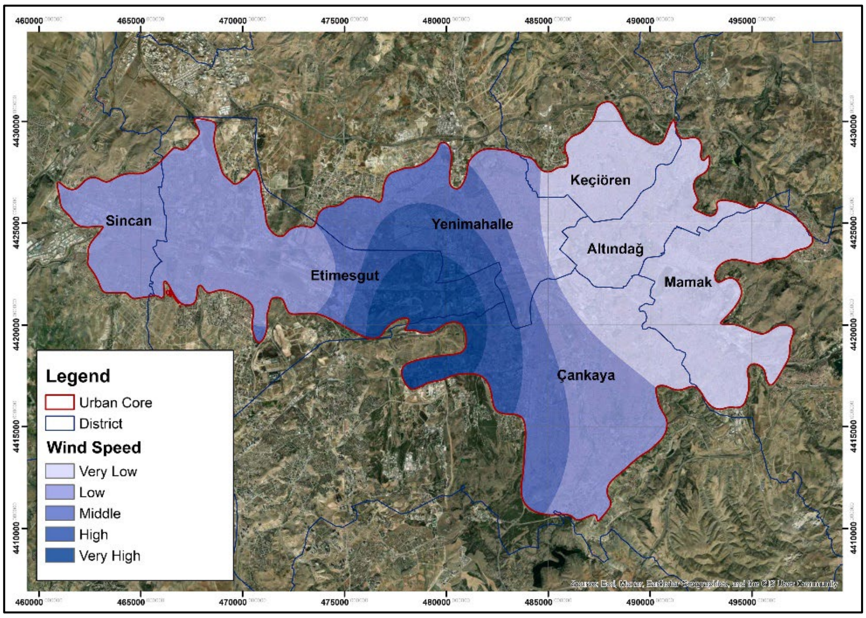

Figure 5. Wind speed map

Precipitation: Another meteorological criterion that needs to be evaluated for the determination of air pollution is precipitation. Precipitation has a cleansing effect on the atmosphere by washing out particles and having the ability to dissolve gaseous pollutants, making it a factor that contributes to cleaning polluted air. Areas with frequent and heavy precipitation generally have better air quality (Karimi et al., 2016). In relation to air pollution, the daily average precipitation required to cleanse the atmosphere of pollutants should be greater than 5 mm (Safavi & Alijani, 2006; Karimi et al., 2016). In this study, precipitation values obtained from the General Directorate of Meteorology (Table 5) were adapted to elevation using the Schreiber method. The obtained data shows that the annual precipitation amount for the Ankara city core ranges from 411.8 to 701.2 mm, and these values are in harmony with the topography. Figure 6 shows the precipitation map of the Ankara city core, and Table 6 lists the air pollution levels for precipitation classes.

Table 5. Annual average precipitation values for Ankara City (General Directorate of Meteorology, 2022)

No	Meteorological Station	Annual Average Precipitation Amount (mm)
1	Akıncı-Mürted	356.6
2	Ankara	409.3
3	Ayaş	427.1
4	Bala	433.2
5	Beypazarı	410.1
6	Esenboğa	411.0
7	Etimesgut	385.8
8	Güvercinlik	359.4
9	Kalecik	411.9
10	Kızılcahamam	575.4
11	Polatlı	363.1

Table 6. Air pollution levels & precipitation classes

Precipitation Amount (mm)	Hava Kirliliği Düzeyi	
411.78 – 459.45	Very Low	5
459.45 – 498.04	Low	4
498.04 – 554.57	Middle	3
554.57 – 595.65	High	2
695.65 – 701.20	Very High	1

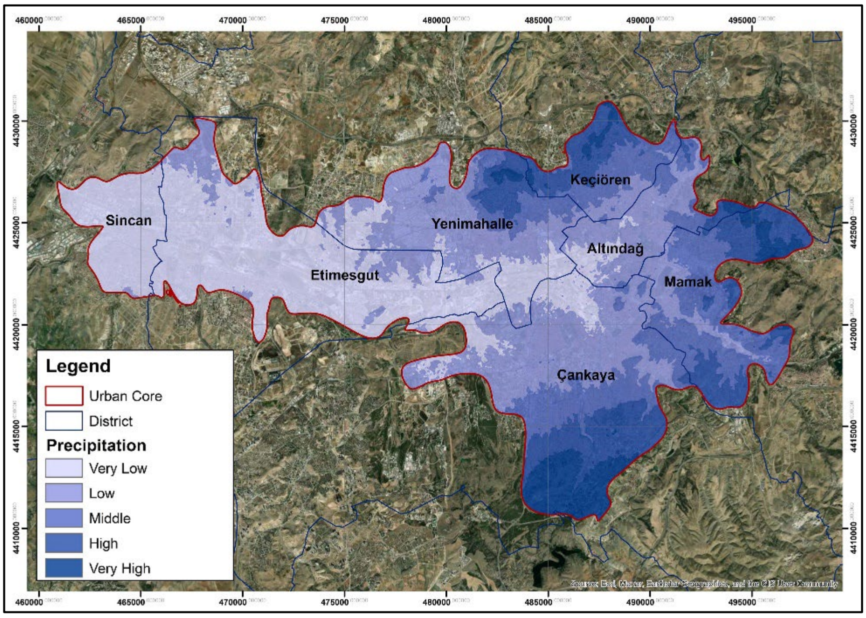

Figure 6. Precipitation map obtained with the Schreiber Method

Urban Heat Island Map: Air masses with high temperatures tend to increase pollutants (Viswanathanand & Krishnamurti, 1989). Urban heat islands also tend to increase pollutants in the atmosphere due to the hot air masses they emit. At the same time, urban heat islands, which occur in areas with intense urbanization, lead to higher energy consumption in these areas. This forces cities to produce more greenhouse gases to meet the demand of power plants. Therefore, increased emissions reduce air quality and increase pollution (EPA, 2022). For this reason, the heat island effect was included in the study. Figure 7 shows the urban heat island effect map obtained from Yıldız (2022) for Ankara. The map reveals that areas with high building volume, such as the northeast of Çankaya, the southeast of Yenimahalle, and the south of Keçiören, also have a high urban heat island effect. However, in areas with high elevation or a large amount of green space, such as the southeast of Çankaya, the urban heat island effect is low.

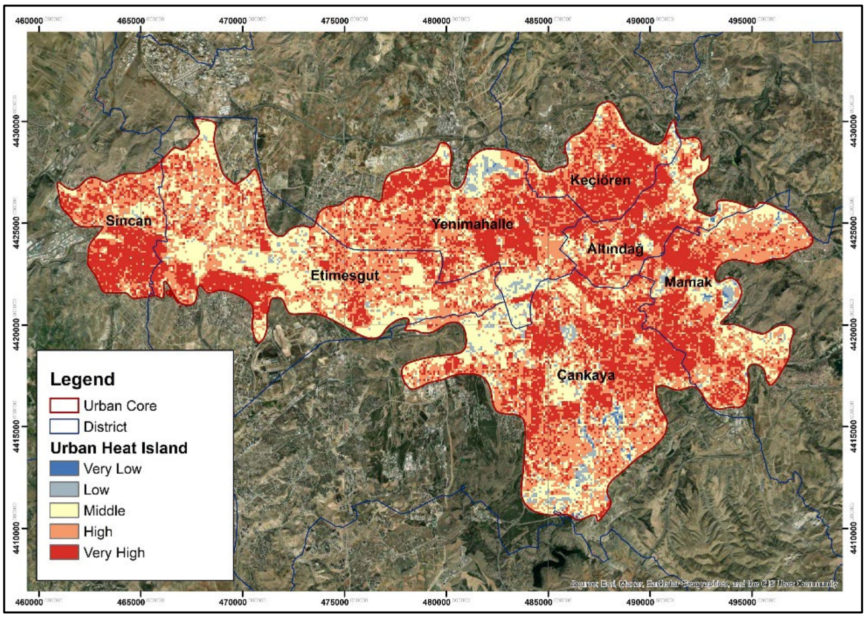

Figure 7. Urban heat ısland map (Yıldız, 2022)

4. Conclusion & Discussion

In this study, the integrated evaluation of anthropogenic effects (land cover and population density) and meteorological parameters (wind, precipitation, urban heat island) was aimed to determine the risk of air pollution in the core of Ankara city. In the methodology of the study, sub-factors related to two main factors, anthropogenic and meteorological, which could cause air pollution, were added to the analysis as layers. The quantitative results obtained for each sub-factor were normalized, and the result values for the parameters were transformed into categorical data, ranging from 1 (very low) to 5 (very high). In the final stage, the weight scores for the sub-parameters were transformed into a single integrated result map using the overlay method. With this method applied in the core of Ankara city, the air pollution risk of the study area has been identified (Figure 8).

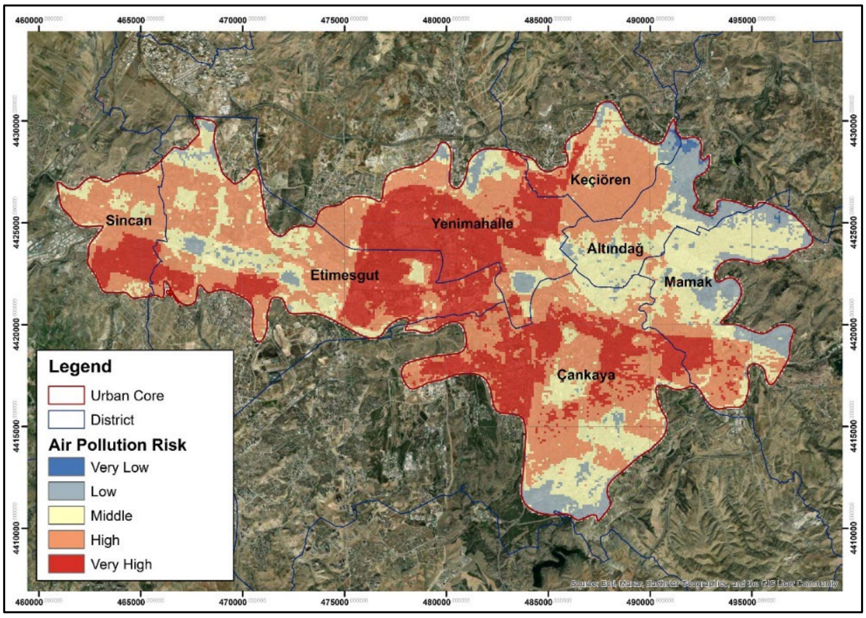

Figure 8. Air pollution risk map

In the resulting map, the risk of air pollution in the east of Etimesgut, southwest of Yenimahalle, southeast of Sincan, south of Mamak and almost all of Çankaya and Keçiören Districts is determined as "high (4)" and "very high (5)". District-specific air pollution levels are in Figure 9. The air quality risk levels and their spatial extents in the district centers are presented in Table 7, while the air quality risk levels and their spatial extents in the total study area are provided in Table 8. The results indicate that "very high" air pollution risk levels are present in 19.78% of the total study area, "high" levels in 28.92%, "moderate" levels in 30.33%, "low" levels in 16.68%, and "very low" levels in 4.29%.

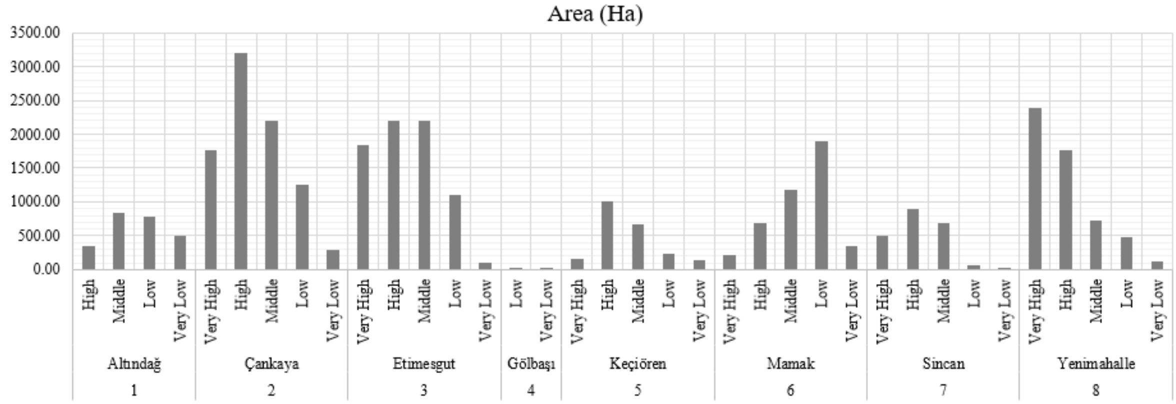

Figure 9. District-specific air pollution levels

Table 7. District-specific air pollution levels and areas (ha)

Number	District	Air Pollution	Area (Ha)
1	Altındağ	High	340.80
		Middle	834.90
		Low	777.43
		Very Low	495.88
2	Çankaya	Very High	1771.79
		High	3190.94
		Middle	2197.07
		Low	1262.31
		Very Low	285.52
3	Etimesgut	Very High	1843.11
		High	2197.91
		Middle	2205.05
		Low	1104.09
		Very Low	95.68
4	Gölbaşı	Low	0.26
		Very Low	2.37
5	Keçiören	Very High	163.95
		High	1000.99
		Middle	659.68
		Low	225.65
		Very Low	130.71
6	Mamak	Very High	218.22
		High	681.72
		Middle	1179.32
		Low	1896.64
		Very Low	341.91
7	Sincan	Very High	503.33
		High	896.76
		Middle	682.76
		Low	64.53
		Very Low	29.00
8	Yenimahalle	Very High	2394.23
		High	1770.54
		Middle	717.72
		Low	483.87
		Very Low	115.56

Table 8. Air quality risk levels and their spatial extents in the total area (ha)

	Very High	High	Middle	Low	Very Low	Total Area
Area (ha)	6894.63	10079.7	10573.8	5814.8	1496.63	34859.46
Area (%)	19.78	28.92	30.33	16.68	4.29	100

The study has identified areas at risk of air pollution. The existing pollution burden can be interpreted below the limit values and alert thresholds for air pollutants under the Turkish Air Quality Assessment and Management Regulation. However, a risk assessment like the one applied in this study provides a proactive action area shedding light on areas where pollutants may intensify in the future. Moreover, this method enables a quick assessment for urban areas where long-term air pollution measurements are scarce or conducted at very few points. Particulate matter (PM10) measurement studies started in 2016, yielding information only for 8 measurement points, including Bahçelievler, Cebeci, Demetevler, Dikmen, Kayaş, Keçiören, Sincan, and Sıhhiye (National Air Quality Bulletin, 2024). In Table 9, the particulate matter (PM10) measurements in the core of Ankara city are presented. Having only 8 measurement points is highly inadequate for the accurate detection of air pollution at the city scale. Therefore, there is no air pollution map available for Ankara city as a whole based on actual measurements. This study is important in guiding urban design and practices, predicting the potential consequences of human interventions on air quality, and mitigating adverse effects.

Table 9. PM10 (µg/m^3) measurements in the core of Ankara City (National Air Quality Bulletin, 2024)

District/Year	2016	2017	2018	2019	2020	2021	2022	WHO's annual PM10 limit values (20 µg/m^3)
Bahçelievler	-	53	47	37.36	53.39	37.66	43.07	The annual average threshold has been exceeded in all years since 2016.
Batıkent	-	-	-	-	-	34.01	-	
Cebeci	65	61	47	81	91.87	-	-	
Demetevler	62	62	65	51	55.63	42.75	38.11	
Dikmen	67	61	60	33	41	-	-	
Etimesgut	-	-	-	-	-	32.74	27.17	
Etlik	-	-	-	-	-	30.22	43.13	
Kayaş	80	100	60	45.32	40	53.98	32.62	
Keçiören	56	68	61	43	41	36.02	24.7	
Ostim	-	-	-	-	-	47.69	47.4	
Sincan	51	61	67	44	56.62	51.08	40.54	
Siteler	-	-	-	-	-	99.64	79.28	
Sıhhiye	72	85	61	50.09	48.17	52.69	50.68	
Törekent	-	-	-	-	-	26.25	34.22	

While determining the parameters used in the study, studies by Gassmann & Mazzeo (2000), Pisoni et al. (2009), Achillas et al. (2011), Hosseiniebalam & Ghaffarpasand (2015), Karimi et al. (2016), Habibi et. al. (2017), Zhou et. al. (2020) were utilised. In these studies, parameters that directly or indirectly affect air quality and air pollution potential such as population density, land use, wind, precipitation, temperature are included. In this study for the city of Ankara, the methods and parameters used by Karimi et al. (2016) were primarily used to estimate the air pollution risk at a higher scale. However, the method does not incorporate some key underlying indicators (e.g., topography, building density, etc.) that could enhance the accuracy of determining pollution risk spatially. In this context, in this study conducted for the Ankara city core, unlike Karimi et al. (2016), the urban heat island parameter was included in the method. Thus, building density and topographic effects in the city were taken into account, and air pollution risk was estimated more accurately based on microclimatic factors in the city core. This is because areas with a high urban heat island effect in the research area have higher air pollution due to the hot air generated by microclimatic factors in the city. Urban heat islands also increase energy demand for cooling, especially in built-up areas during the summer, and this in turn increases hot air masses. Companies supplying electricity typically use fossil fuel power plants to meet most of this demand, leading to an increase in pollutant levels and greenhouse gas emissions (EPA, 2022). However, these power plants are not located in the city core but rather on the outskirts or outside the city, and they contribute to climate change in the atmosphere of their installation area. This situation has an indirect effect on urban areas. In addition, there is a negative relationship between wind speed and topographic height and air pollutants. As air rises from the ground, it expands and cools. Thus, moisture in the air condenses to form clouds. Under these conditions, there are no problems with air pollution in the troposphere, and pollutant parameters do not settle. Similarly, in areas with increased wind speed, air pollutant parameters cannot adhere and are transported to different regions (Kara, 2012). This situation can be significant in the context of open and green spaces in urban areas, but the opposite can occur in the city core with high building density. Structures not only block wind speed but also, by causing inversion in the urban atmosphere, prevent rising hot air, which in turn causes polluted and hot air to settle in the city core (Karimi et al., 2016).

One important point obtained from the research findings is that wind speed is the most significant meteorological factor affecting the distribution of air pollution, especially in polluted areas like the city center of Ankara. Therefore, despite the high wind speeds observed in the city center of Ankara, it is seen that the air pollution risk is very high. The reason for this is that when various criteria such as high building density, relatively low topographic height, and lack of green areas in the city center are evaluated in an integrated manner, wind speed reduces its negative effect on air pollution. In short, in areas with a high amount of green spaces, high topographic height, and high wind speed, the amount of pollutants in the atmosphere decreases, and thus, air pollution decreases. In determining air pollution risk, land cover and population density also play a significant role, in addition to meteorological effects. The amount of pollutants in the air increases depending on industrial areas, industrial zones, and traffic density. In this context, in cities with high air pollution density, considering the dominant wind direction and speed, industrial and industrial areas should be planned in other regions of the city with high wind speed but low air pollution risk in terms of other parameters.

The research conducted within the scope of this study aimed to determine the air pollution risk, taking into account the current state of complex interactions between nature and society, as well as the boundaries of Ankara's city center. However, air movements are not limited to city center boundaries or administrative boundaries. Therefore, conducting air pollution-related studies by considering the values of climate stations in the surrounding districts and cities would contribute to obtaining much more accurate results. This research is considered an important step for future studies aimed at determining air pollution risk. The applied method allows researchers and urban planners to add new layers and assign criteria with appropriate weights to characterize urban air pollution. In future studies, different parameters with different weightings can be added based on the specific problems and requirements of the research area. In existing urban open and green spaces, the use of species with large canopy structures and deciduous species will increase the retention rate of pollutant gases. In this context, plant selection, spatial pattern design, surface roughness, and plant composition and configuration are critical issues in air flow risk. In new settlement areas, integrated consideration of topography, land uses, and the meteorological characteristics of the region in urban planning will contribute to producing healthy and sustainable settlement areas by reducing pollutant emissions to the atmosphere due to urbanization with meteorological effects.

In this study, GIS and Multi-Criteria Decision Making techniques were used to model a potential air pollution risk distribution that can form the basis for landscape planning and urban planning studies. What is important here is to provide a holistic assessment in order to reveal the integrated effect of the factors affecting air pollution, not on the basis of a single parameter. This study presents a methodological approach based on indicators. Strategies developed to reduce air pollution in urban planning can be examined in detail in different studies.

Acknowledgment

In this study, the boundaries of the research were determined based on the urban core boundary presented in the doctoral thesis (Yıldız, 2022). However, the air pollution modeling method used in this study differs from the one used by Yıldız (2022).

Author Contribution and Conflict of Interest Declaration Information

All authors contributed equally to the article. There is no conflict of interest.

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Perception in Human Psychology and Landscape Prioritised Visualisation of Space with Artificial Intelligence

Alper SAĞLIK [1]*, Emine Berfin MİNKARA [2]

ORCID 1: 0000-0003-1156-1201
ORCID 2: 0009-0001-0003-5065

[1] Çanakkale Onsekiz Mart University, Faculty of Architecture and Design, Landscape Architecture Department, 17000, Çanakkale,Türkiye.
[2] Çanakkale Onsekiz Mart University, Graduate Education Institute Landscape Architecture Department, 17000, Çanakkale,Türkiye.
*** e-mail**: *alpersaglik@gmail.com*

Abstract

Psychology examines individuals' behaviors, investigating the underlying motivations and their individual and social orientations. Individuals exhibit specific behaviors to adapt to social life. Landscape spaces, integral components of society, provide social environments. Individuals in these spaces perceive and interact with both others and objects. This study explores perceptual errors and processes, which are key topics in psychology. Concepts were translated into concrete space designs. These concepts were classified and integrated with spatial elements to create cohesive designs. During classification, combinations were identified to visualize the concepts. Space designs were generated using descriptive sentences with AI support. These designs were evaluated for psychological errors and processes. Suitable designs were illustrated with reference lines. The study also assessed the effectiveness of AI on visuals, achieving innovative designs through precise concept definitions with AI assistance.

Keywords: *Artificial intelligence, psychology, space design, perception, landscape design.*

İnsan Psikolojisinde Algı ve Mekânın Yapay Zekâ ile Peyzaj Öncelikli Görselleştirilmesi

Öz

Psikoloji, bireylerin davranışlarını, bunların altında yatan motivasyonları ve bireysel ve sosyal yönelimlerini incelemektedir. Bireyler, sosyal hayata uyum sağlamak için belirli davranışlar sergilerler. Toplumun ayrılmaz bir parçası olan peyzaj alanları, sosyal ortamlar sağlar. Bu alanlardaki bireyler, hem diğer insanları hem de nesneleri algılar ve onlarla etkileşime girerler. Bu çalışma, psikolojinin ana konularından olan algısal yanılmaları ve süreçleri araştırmaktadır. Kavramlar, somut mekân tasarımlarına dönüştürülmüştür. Bu kavramlar, uyumlu tasarımlar oluşturmak için mekân unsurlarıyla sınıflandırılmış ve birleştirilmiştir. Sınıflandırma sırasında, kavramları görselleştirmek için kombinasyonlar belirlenmiştir. Mekân tasarımları, yapay zeka desteğiyle tanımlayıcı cümleler kullanılarak oluşturulmuştur. Bu tasarımlar, psikolojik yanılmalar ve süreçler açısından değerlendirilmiştir. Uygun tasarımlar, referans çizgileriyle gösterilmiştir. Çalışma ayrıca, yapay zekanın görseller üzerindeki etkinliğini değerlendirmiş ve doğru kavram tanımlamalarıyla yenilikçi tasarımlar elde edilmiştir.

Anahtar kelimeler: *Yapay zeka, psikoloji, mekan tasarımı, algı, peyzaj tasarımı.*

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1. Introduction

In recent years, the success of artificial intelligence has increased significantly. The correct and effective use of artificial intelligence supports and accelerates scientific research. Thanks to its different usage areas, various disciplines benefit from artificial intelligence efficiently. In this context, the potential of using artificial intelligence in landscape architecture discipline is attracting more and more attention.

Although there are studies on the use of artificial intelligence in landscape architecture alone, this research focuses on the intersection of artificial intelligence with landscape architecture and psychology. This research aims to explore how interdisciplinary work can be produced through artificial intelligence.

Psychology is a science that studies behaviour. Human behaviour is complex, multifaceted and determined by various processes. For this reason, psychologists examine the processes that determine behaviour separately. Among the basic processes that determine human behaviour, motives and senses are emphasised.

Behaviours are performed by individuals during the day in line with a certain goal. In the psychological discipline, the initiation and progress of behaviour in line with the goals are examined through the concept of motive. Motive is considered a personal power necessary for the initiation and continuation of behaviours. In order for motivational behaviours to be revealed, goals must also be present (Aydın, 2009; p.207). Orientations that emerge as a result of behaviours may differ from socially and individually.

People need to socialise in order to continue their lives in society. Thanks to their role in society, they are affected in various ways. It changes over time with environmental factors. Individuals act by paying attention to the rules of society in order to maintain an appropriate life in society. It is more necessary to adapt in urban areas with high intensive use (Demirkaya, 2012).

Human behaviours also reveal different orientation movements in the physical environment where the individual has to live. Orientations and motivational behaviours in the space, supported by senses and perceptions, maximise the presence of individuals in the space. Sociologically, individuals who want to maintain their social and individual existence in space move by perceiving the surrounding objects with their senses.

The perception level of individuals is affected by the positioning of the elements in the space and features such as distance, colour and form. The space consists of various components and elements, each assuming distinct roles. These elements perform different tasks within the space. These tasks may involve determining, limiting, unifying, emphasising, and focusing (Gür, 1996; Açıcı, 2006).

Perception is a process in which events in the environment are analyzed by interpreting sensory data. The receptive organs that interpret perception incorporate events and elements in data production based on their types. Their properties are classified in line with coldness, temperature, speed, weight, colour. In the later stages of perception, the receptive organs provide the sensory sense to be converted into neurophysiological energy and initiate the perception process (Cüceloğlu, 2002, p. 98).

The theories formed by the individual socially and individually in the external world are shaped according to the individual's perception of objects and the current characteristics of events. The spatial theory also varies depending on the perception forms. The synthesis of perception and space is included in the process and plays a guiding role in the design of the space. Thus, appropriate spaces are created in urban area designs as a result of individuals' perception styles and sensory gains.

Within the scope of the study, considering the perceptions and sensory data of individuals, certain definitions are made with the concepts revealed by the perception styles in artificial intelligence environment. As a result of the definitions, the suitability of the spaces created with the support of artificial intelligence is evaluated.

With the help of intelligent behaviour, the products created by the sensory perception forms defined in the study content in an integrated manner are examined. As a result of the evaluation of the products, while examining how landscape priority designs might be created in artificial intelligence environment in urban spaces depending on the perception levels of individuals, the competence of artificial intelligence in creating space is also examined.

This study addresses how artificial intelligence can be widely used in visualization stages. It aims to create an example that will contribute to the effective expression of designs with artificial intelligence in the discipline of landscape architecture. At the same time, it pioneers making landscape architecture more efficient with AI-supported visualizations. Thus, it brings innovation to existing practices in the discipline of landscape architecture.

Artificial intelligence offers a significant potential to increase the visual creativity of the designer (Liu, 2023). In this study, increasing the design potential of landscape architecture is a priority. Thus, it becomes possible to create sustainable and user-oriented landscape designs that comply with design criteria.

2. Material and Method

Perception errors and perception processes that determine individual orientations in space formation in urban landscape areas were evaluated. The subjects obtained under the titles of perception errors and processes were accepted as necessary tools for space formation. Literature researches were carried out within the scope of the materials for the concepts accepted as the main factor of space formation.

2.1. Perception Errors

Perception errors demonstrate that perceptual patterns may be distorted, leading to an imperfect representation of the perceived object. Perception errors may examine the functions in the perception process. Perception processes are based on perception errors. Thus, in order to distinguish perceptual processes, perception errors are first analysed (Cüceloğlu, 2002, p.119).

2.1.1. Ponzo Illusion

When distance variations are considered, intersecting lines in space are utilized as reference points for comparison (Cüceloğlu, 2002, p.119). Two lines approaching each other represent two walls of a corridor in real observation (Yıldız et al., 2021). In other words, it is the illusion created by the convergence of the two-sided lines at the horizon point (Figure 1), which is reminiscent of single-point perspective drawings.

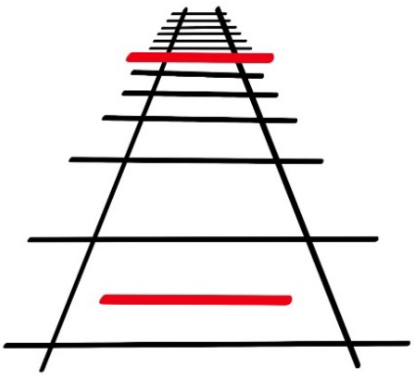

Figure 1. Linear representation of the Ponzo illusion (original)

2.1.2. Müller-Lyler Illusion

The space appears smaller due to its invisible, roughly defined boundaries. Squares with open boundaries are perceived larger than a square area with closed boundaries. A circular area with outwardly open borders is perceived larger than one with inward borders (Yılmaz, 2008) (Figure2).

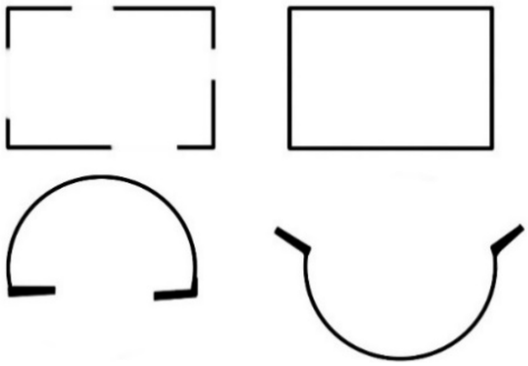

Figure 2. Linear representation of Müller-Lyler illusion (original).

2.1.3. Wundt Illusion

Vertically positioned elements in space are perceived as larger than horizontally positioned elements (Figure 3). Greater effort is required to equalize vertical distances at eye level compared to horizontal distances. Consequently, spaces with a higher density of vertical elements are perceived as larger (Yılmaz, 2008).

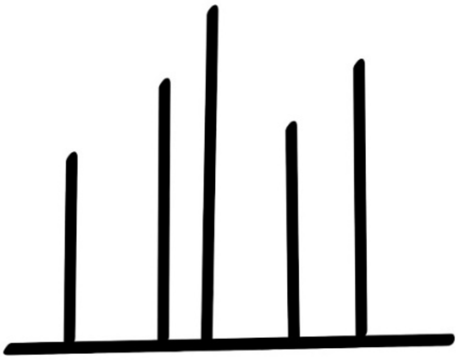

Figure 3. Linear representation of the Wundt illusion (original)

2.1.4. Lipps Illusion

In circular spaces located at the center, the perception towards the center is more intense, while perception in the peripheral areas diminishes. Increasing attention towards the centre reduces the visible size (Yılmaz, 2008) (Figure 4).

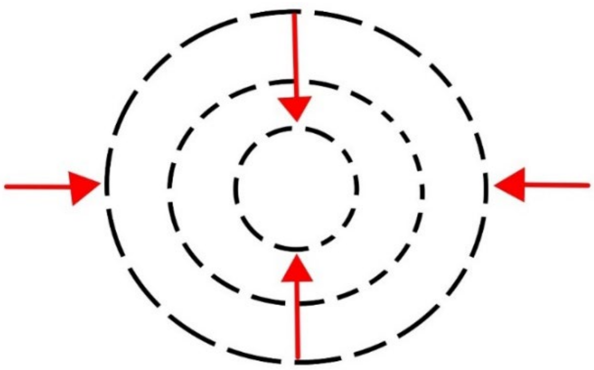

Figure 4. Linear representation of Lipps illusion (original)

2.2. Detection Processes

Titles with dominant visual effect in perception processes were accepted. In this direction, the concepts of selective attention and organisation are explained.

2.2.1. Selective attention

Individuals perceive their environment selectively. Our sense organs always selectively perceive only a part of the stimuli they capture (Cüceloğlu, 2002, p.121). The users' perception of space in landscape areas and their ability to perceive focal points faster than other areas serve as an example.

2.2.2. Organisation

Organization refers to the compositions formed by the objects within the environment. In the process of perceiving spatial components, it facilitates coherent, integrated, and meaningful visual representations.

The 'Gestalt Perception Theory,' which enhances visual impact and supports visual perception, comprises principles that affect the organization stage.

The Gestalt theory is based on the principle that the whole is more meaningful than the parts that make up the whole (Senemoğlu, 2009). The principles are divided into five classes as completion, figure-ground, continuity, similarity and proximity.

Figure-ground Principle: In all forms of perception, there is the existence of figure and ground (Cüceloğlu, 2002, p.123). For the purpose of the figure to be perceived, the ground forming the background is needed.

Completion: It supports the perception of an event formed by parts assembled in a regular and meaningful way that is unable to be perceived as a single visual.

Continuity: It is stated that the coexistence of points, stimuli and lines with the same directions supports perception (Cüceloğlu, 2002, p.123).

Proximity: Objects that are close to each other are perceived by grouping (Cüceloğlu, 2002, p.123). Thus, it becomes easier to perceive the items outside the group.

Similarity: Concepts with less distinctiveness preserve integrity. All visuals strengthen perception.

The intersections of the materials on the space design were determined and the space design was created in artificial intelligence environment. A work flow was created for the creation of the space design. The flow is shown below:

1. Firstly, material classification was carried out. The concepts to be used in the descriptions directing the formation of space in artificial intelligence environment were separated.

2. The concepts were turned into descriptions with certain combinations to support the visualisation of urban landscape spaces. Concept combinations are shown (Table 1).

3. Depending on the descriptions, the suitability of the designs created by artificial intelligence was evaluated.

4. The visuals or designs considered appropriate within the scope of perception errors and perception processes were accepted as the product of the study.

Tablo 1. Demonstration of concept combinations (original)

Concepts	*Figure-ground*	*Completion*	*Continuity*	*Proximity*	*Similarity*
Ponzo Illusion	✓				
Müller-Lyler Illusion					✓
Wundt Illusion			✓		
Lipps Illusion		✓		✓	

2.3. Creating Space Designs with Artificial Intelligence

Descriptive sentences for artificial intelligence with concept combinations were used. The definitions were tested in different artificial intelligence programmes and landscape spaces were created in the appropriate artificial intelligence programme.

'It is desired to create landscape spaces in urban areas based on the “ponzo illusion”, which is a psychological perception illusion, and also the “figure-ground principle”, which is the principle of Gestalt Perception Theory.” By accepting two concepts as the main factors with the definition, artificial intelligence was asked to create urban landscape spaces. The generated visual is given below (Figure 5).

Figure 5. Ponzo illusion and insufficient visualisation of the figure-ground principle (Microsoft Bing Copilot, 2024)

The visual encompassed landscape areas centred around structural elements. Perceptual concepts could not be easily read in the space. A different artificial intelligence programme was requested to reduce the structural elements. The resulting visuals (Figure 6) are shown.

Figure 6. Ponzo illusion and figure-ground principle landscape visualisations (Leonardo Ai, 2024)

The images created based on the ponzo illusion and the figure-ground principle are appropriate in terms of perception values. In the second image, the depth provided by the ponzo illusion created reference lines for distance perceptions. The figure-ground principle was emphasised in all images.

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‘It is desired to create landscape spaces in urban areas depending on the “Müller-Lyler Illusion”, which is a psychological perception illusion, and also the “similarity principle”, which is the principle of Gestalt Perception Theory.’ With this definition, artificial intelligence was asked to create urban landscape spaces by accepting two concepts as the main factors. The generated visual (Figure 7) is shown below.

Figure 7. Müller-Lyler Illusion and similarity principle landscape visualisations (Leonardo Ai, 2024)

'It is desired to create landscape spaces in urban areas depending on the "Wundt Illusion", which is a psychological perception illusion, and also the "continuity principle", which is the principle of Gestalt Perception Theory.' With this definition, artificial intelligence was asked to create urban landscape spaces by accepting two concepts as the main factors. The resulting visuals (Figure 8) evaluated the illusion of vertical distances only through vegetative design. In other space components, a descriptive sentence was added to reinforce the vertical perception. Structural elements were also included to reinforce the illusion that the vegetative design is in focus again (Figure 9).

Figure 8. Wundt Illusion and continuity principle landscape visualisations (Leonardo Ai, 2024)

Figure 9. Wundt's Illusion and Continuity Principle Adding structural elements to Landscape Visualisations (Leonardo Ai, 2024)

'It is desired to create landscape spaces in urban areas based on the "Lipps illusion", which is a psychological perception illusion, and also the "completion principle", which is the principle of Gestalt Perception Theory.' With this definition, artificial intelligence is asked to create urban landscape spaces by accepting two concepts as the main factors (Figure 10).

Figure 10. Lipps illusion and completion principle landscape visualisations (Leonardo Ai, 2024)

‘It is desired to create landscape spaces in urban areas depending on the “Lipps illusion”, which is a psychological perception error, and also the “proximity principle”, which is the principle of Gestalt Perception Theory.’ With this definition, it is requested to create urban landscape spaces from artificial intelligence by accepting two concepts as the main factors (Figure 11).

Figure 11 Lipps illusion and proximity principle landscape visualisations (Leonardo Ai, 2024)

3. Findings and Discussion

In the content of the study, artificial intelligence created space designs in line with descriptive sentences. The designs obtained were evaluated in line with the perception processes and perception illusions and the most appropriate visuals were separated from the combination. The images (Figure 12,13,14,15,16), which are considered more appropriate within the framework of the definitions, are indicated. The explanation of the concepts in the resulting landscape spaces is presented using linear expressions.

3.1. Space Designs

In the visual created with Ponzo Illusion and figure-ground concepts, the appropriate visual was determined by creating reference lines. From the starting line depending on the perspective, the point of visual distancing was determined. In the continuation of the reference lines, the most appropriate visual for the Ponzo illusion (Figure 12) is indicated. The vegetal elements designed on a white background represent the concept of shape ground.

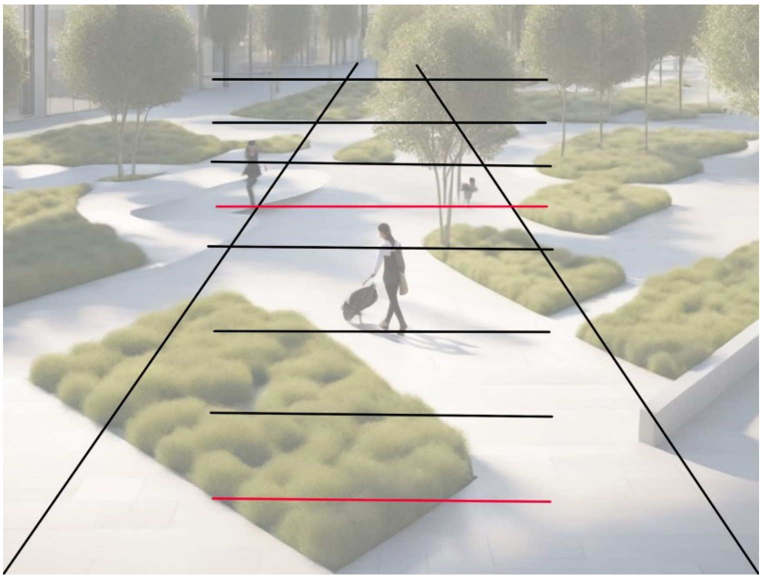

Figure 12. Demonstration of the figure-ground principle with the Ponzo illusion on space (original)

The limiting effect of the Müller-Lyler illusion appears with sharp lines separating the water elements from the hard ground and vegetal design. Plant groups, which have a softening effect on the hard floor, have created a short wall effect by standing as a whole. Plant selection and formal lines used on the ground expressed the principle of similarity. The designed landscape space (Figure 13) is considered appropriate in the focus of both concepts.

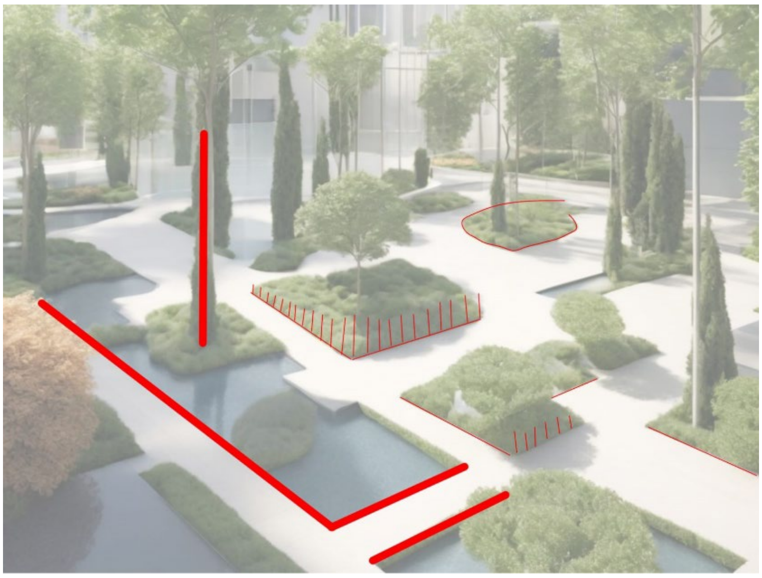

Figure 13. Illustration of the Müller-Lyler illusion and the similarity principle on space design (original)

The vertically positioned plants supporting the Wundt illusion were perceived larger, although they were positioned away from the horizontal components on the ground. When focussed on the whole, they are perceived differently from their real distance. The principle of continuity is dominant throughout the space. The informal progressing lines continued their continuity by merging with each other at any point. Although it is difficult to visually express the continuity principle in the designed landscape space (Figure 14), artificial intelligence has provided us with the desired space.

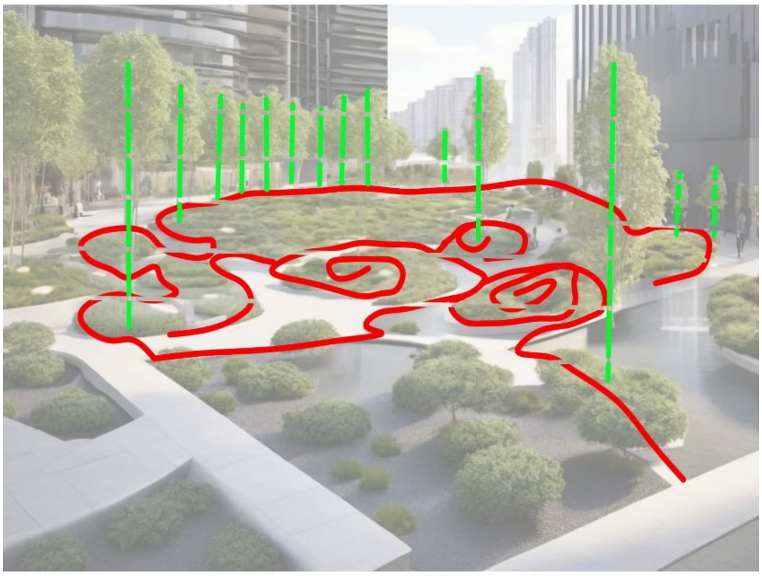

Figure 14. Illustration of the principle of continuity with Wundt's illusion on space design (original)

The feeling of withdrawal to the centre is at the forefront in the landscape area. The design includes all the elements represented by Lipps illusion. Although the circles shrinking towards the centre have different parts with different materials between them, the parts could be read as a whole when looking at the space. Artificial intelligence was especially successful in creating the image (Figure 15) where we clearly see the Lipps illusion.

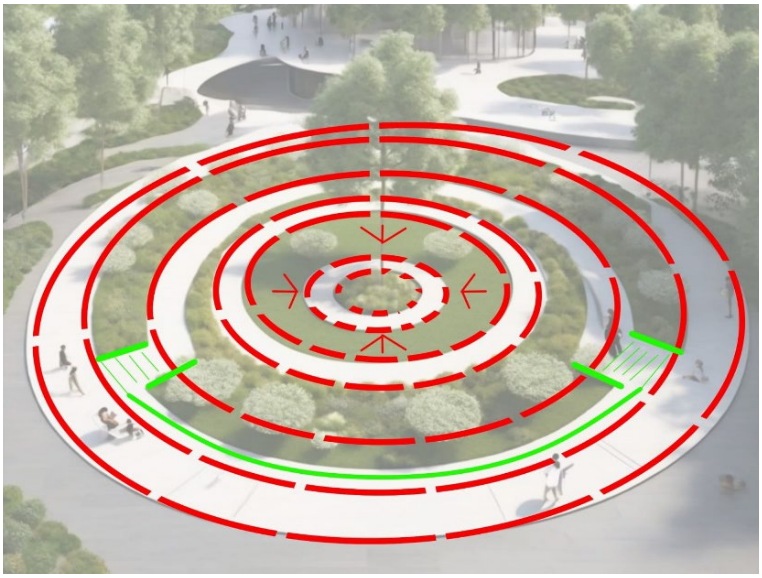

Figure 15. Demonstration of Lipps illusion and completion principle on space design (original)

The positioning of the parts in the space around the circle strengthens the perception. The effect of Lipps illusion is seen less than in Figure 15. The sense of centre is also preserved in this design. In the plant design, the trees close to the centre support the formation of a different layer in a circular manner. The spatial design (Figure 16) presents the concept definitions in a balance in general.

Figure 16. Demonstration of Lipps illusion and proximity principle on space design (original)

As a result of the evaluations for the visuals, the appropriateness of the directions given to the artificial intelligence programme was evaluated in line with the determined criteria.

3.2. Effectiveness of Artificial Intelligence on Visuals

In order to distinguish the undesirable in definitions and to present antonyms together: Although it progressed in line with the definitions, the visual in Figure 5 was far from representing the subject. After the definition of undesired elements, the visual created after the definition of undesired elements became suitable for the content and definitions of the study. Artificial intelligence was able to distinguish unwanted negative definitions within the scope of the study.

To be able to distinguish definitions from others: By analysing the perception processes and perception illusions within itself, it provided different visual formation by separating them from other concepts.

Perceiving concepts: By making the definitions of the materials, they created visuals in the same colour, line and space scale in the next definition.

4. Conclusion and Suggestions

The study 'Perception in Human Psychology and Landscape Priority Visualisation of Space with Artificial Intelligence' it has been demonstrated that user criteria may be effectively translated into practical designs by incorporating principles from human psychology into spatial configurations. With the appropriate use of artificial intelligence, a study supporting the continuity of innovative studies has been put forward. Thanks to the spaces obtained with artificial intelligence, it is ensured that the user may read the space better and perceive the elements in the space easily.

Analyzing the principles of human psychology has facilitated the diversification of orientations and targets within the space. By integrating human characteristics with all design elements, it has been demonstrated that more sustainable outcomes may be achieved.

Advancements in technology have enabled the achievement of detailed design outcomes (Sağlık & Temiz, 2019). In addition to traditional computer-aided designs, the integration of artificial intelligence-supported designs has resulted in more efficient and higher quality designs.

The success of artificial intelligence is closely related to the appropriate interpretation and transfer of values associated with work discipline. The designs obtained have been directed by appropriate descriptive sentences and the clarity of the concepts. Modifying undesired values and presenting the material to artificial intelligence within the subject has strengthened the design. It has been demonstrated that obtaining accurate data with detailed definition is possible to maintain the applicability of studies conducted with artificial intelligence.

Within the framework of architectural disciplines, artificial intelligence has helped to produce various designs in perceiving and defining abstract concepts. Artificial intelligence has facilitated the creation of different design ideas based on variables (Hegazy and Saleh, 2023).

In addition to providing design ideas, intelligent behavior has enabled the creation of alternative designs with the feedback of integrated tasks of visual designs. These alternative designs contributed to an efficient and effective design process (Xu, 2023).

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The article complies with national and international research and publication ethics. Ethics Committee approval was not required for the study.

Author Contribution and Conflict of Interest Declaration Information

All authors contributed equally to the article. There is no conflict of interest.

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The Influence of Daylight Availability on Thermal Comfort in Classroom Environments

Büşranur MERCAN [1*], Gizem İZMİR TUNAHAN [2]

ORCID 1: 0009-0003-0776-6535
ORCID 2: 0000-0003-1473-9351
[1-2] *Dokuz Eylül University, Faculty of Architecture, Department of Architecture, 35390, İzmir, Türkiye*
**** e-mail**: mercan1643@outlook.com*

Abstract

Daylight, a critical environmental factor influencing the visual quality of indoor spaces, significantly impacts human health and well-being. Despite extensive research focusing separately on daylight and thermal comfort, their relationship and their effects on human behaviour remain insufficiently understood. This study aims to investigate how daylight conditions affect students' thermal comfort in a classroom setting, using student observations along with thermal and daylight measurements. This study concludes that while daylight affects participants' thermal comfort and behaviour, its impact is influenced more by individual perceptions and adjustments, and other factors, such as activity levels, also play a significant role. The limitations of the study include a small sample size and the reliance on mobile phones for measuring indoor air quality and comfort levels. Future studies should improve the reliability and validity of the results by using larger sample sizes and more specialized measurement instruments.

Keywords: *Daylight, thermal comfort, thermal behaviour, indoor environment quality, sustainability.*

Sınıf Ortamlarında Gün Işığı Mevcudiyetinin Termal Konfora Etkisi

Öz

Gün ışığı, iç mekanların görsel kalitesini etkileyen önemli bir çevresel faktör olmasının yanı sıra insan sağlığı ve refahı üzerinde de önemli bir etkiye sahiptir. Gün ışığı ve ısıl konfor üzerine ayrı ayrı yapılan kapsamlı araştırmalara rağmen, bu iki faktörün ilişkisi ve insan davranışları üzerindeki etkisi yeterince anlaşılamamıştır. Bu çalışma, gün ışığı koşullarının sınıf ortamında öğrencilerin ısıl konforunu nasıl etkilediğini, öğrencilerin gözlemlenmesi ile termal ve gün ışığı ölçümlerinden faydalanılarak araştırmayı amaçlamaktadır. Bu çalışma, gün ışığının katılımcıların ısıl konforu ve davranışlarını etkilediğini, ancak bu etkinin daha çok bireysel algılar ve ayarlamalarla şekillendiğini, ayrıca etkinlik seviyeleri gibi diğer faktörlerin de önemli bir rol oynadığını ortaya koymaktadır. Çalışmanın kısıtlamaları arasında küçük bir örneklem büyüklüğü ve iç mekan hava kalitesi ile konfor seviyelerini ölçmek için mobil telefonların kullanılması yer almaktadır. Gelecek çalışmalar, bulguların güvenilirliğini ve geçerliliğini artırmak için daha büyük örneklem büyüklükleri ve daha özel ölçüm araçları kullanmalıdır.

Anahtar kelimeler: *Gün ışığı, ısıl konfor, ısıl davranış, iç ortam kalitesi, sürdürülebilirlik.*

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1. Introduction

In reality, light serves the purpose of aiding human vision, and variations in light output and colour temperature have been shown to alter operator perception, cognition, and mood (İzmir Tunahan et al., 2022). Daylight is important for optimizing natural light in buildings. Due to the awareness of its effects on human health, it influences many design parameters such as the orientation of the building, the position and even the colour of the windows, wall colour, interior space dimensions, and ceiling height (Bellia et al., 2021). The presence of daylight also makes it important to create environmentally friendly structures as it contributes to the building's energy production. Daylight plays a crucial role in providing visual comfort conditions to ensure user satisfaction indoors. It is also a factor that stimulates metabolism, controls bodily functions and affects individuals' health and performance in their daily lives (Kutlu, 2019). Additionally, the effect of daylight on thermal comfort should not be overlooked. Thermal comfort is the comfort individuals feel depending on parameters such as environmental temperature, humidity level, and airflow. Controlling the thermal comfort of an indoor environment and developing design strategies are essential for ensuring the comfort of building occupants, enhancing their performance in daily life, and limiting the building's energy consumption (Chinazzo et al., 2019a).

Daylight utilization in architectural designs has been extensively studied mostly regarding its impact on health and well-being, and energy efficiency (İzmir Tunahan et al., 2022). However, studies focusing specifically on its effect on thermal comfort are fewer in comparison. In particular, there is a notable lack of research investigating these effects within the context of daily activity environments in specific settings. The literature review indicates that while experimental setups have been created for this purpose, the impact of daylight on thermal comfort under existing normal conditions, along with environmental influences, has not been measured. Furthermore, most of the studies conducted involve outdoor measurements, whereas the number of studies focusing on indoor environments is significantly lower.

Examining the relationship between daylight and the concept of thermal comfort is important to understand how a well-designed structure contributes to individuals feeling comfortable within indoor spaces. Researchers have claimed that thermal comfort and behaviour are the initial objective responses to the physical environment and strongly correlate with physiological reactions. The balance created in the indoor environment to achieve thermal preference or thermal comfort is seen as a reflection of the level of acceptability and emotions; this, in turn, makes it possible to form a thermal assessment (Chinazzo et al., 2019a). It has been found that exposure to intense light at the start of the day induces a quick increase in body temperature (te Kulve et al., 2016).

Indoor Environmental Quality (IEQ) and Indoor Air Quality (IAQ) encompass many factors such as lighting, acoustics, and thermal comfort (Ganesh et al., 2021). In recent years, it has been recognized that Indoor Environmental Quality (IEQ) is important for enhancing comfort and health in all aspects, and this awareness has led to various studies being conducted (Geng et al., 2017). The connection between building occupants and the natural landscape around them is primarily established visually through windows. Studies have shown that the position of windows has positive effects on the comfort and behaviour of building occupants (Jiang et al., 2022).

There are also PMV values created to measure thermal comfort, similar to IEQ. The Predicted Mean Vote (PMV) index is designed to determine the average thermal comfort of a group of people using physical and individual data. PMV values are calculated for each participant, based on environmental measures, such as air temperature and mean radiant temperature derived from measured globe temperature, air velocity, and relative humidity. Additionally, factors like clothing insulation and metabolic rate are taken into account as physical attributes (Chinazzo et al., 2019a). PMV is commonly utilized in evaluating thermal comfort and building design. The PMV value can serve as a guide to assess how comfortable or uncomfortable the thermal environment is for individuals. Improving the accuracy of the PMV index, as proposed in Zhang, Yao and Li's (2024) research, can enhance predictive advantages and lead to better performance in evaluating thermal conditions in building design (Zhang et al., 2024).

It has been found that research has been primarily focused on health and a few basic user satisfactions. Therefore, investigating the impact of daylight indoors and understanding its relationship with thermal comfort necessitates exploring behavioural dynamics. In this context, a study focusing on a classroom environment aims to address this knowledge gap in the literature. The fundamental purpose of the study is to monitor the behaviour of individuals in a selected classroom at Dokuz Eylül University Faculty of Architecture and to measure thermal comfort by observing daylight in the classroom environment.

2. The Role of Daylight in Thermal Comfort

For centuries, the sun, the most important renewable energy source for life on Earth, has been a natural source of energy. Before the discovery of various sources of energy production, people focused on the sun, developing designs to maximize its potential. Architects also consider harnessing daylight in their designs as an important criterion to ensure users can benefit from daylight optimally. The sun has been considered a natural lighting source and viewed as the ideal light source until the advent of artificial lighting sources. In indoor environments, especially enclosed spaces, daylight serves to reduce the building's energy consumption and aims to create visual quality in terms of lighting (Çiftçi & Arpacıoğlu, 2021). Especially in private residences, skylights are also utilized in addition to windows to maximize the use of natural light. Ensuring visual comfort, reducing the need for artificial lighting, and lowering energy consumption and costs are directly linked to the efficient use of daylight (Erdem et al., 2023). This situation often results in user dissatisfaction and may imply a deficiency in architectural design. The proper use of daylight can not only serve as an energy source but also enhance the quality of the indoor environment, thereby providing the comfort needed for an active lifestyle. This study aims to investigate how the impact of daylight on thermal comfort is reflected in users' behaviours. Particularly in work environments, exposure to direct daylight in areas near windows is not conducive to a healthy working environment (Figure 1). Therefore, it would be preferable to use areas near windows for circulation or relaxation purposes (Tatar, 2014).

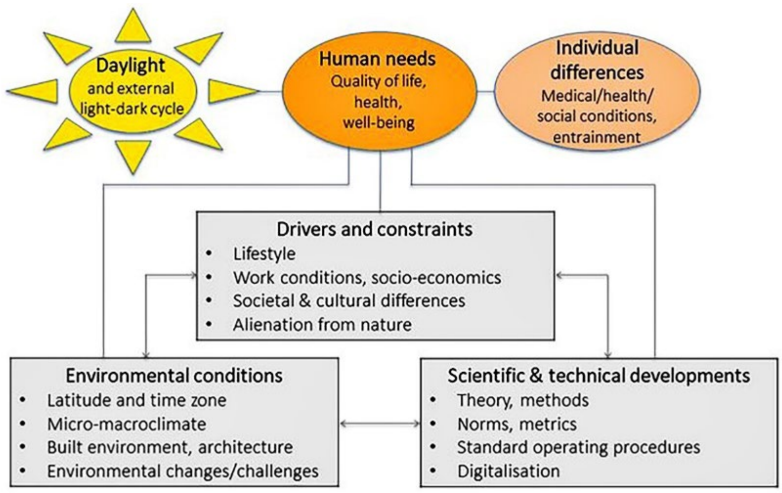

Figure 1. Daylight and other factors as determinants of human health (Münch et al., 2020)

The effects of natural light on spatial utilization can be examined in two primary categories: functional and symbolic. From a functional perspective, natural light should enhance visual comfort for the users of a space, improve the efficiency of activities carried out within the space, and meet the physical and psychological needs of users. In this way, the functional effects of natural light support users' daily activities, providing a healthier and more productive environment.

The Average Daylight Factor expresses the ratio of the total daylight flux incident on a plane to the area of the plane, relative to the outdoor daylight level under unobstructed overcast sky conditions. An Average Daylight Factor of 5% or higher indicates sufficient daylight presence within the space, while an Average Daylight Factor between 2% and 5% signifies situations that may require additional artificial lighting (Kılıç & Yener, 2017). In general, illuminance levels between 100 lux and 2000 lux are considered beneficial for users within a space. Research conducted on office buildings has determined the following illuminance ranges to be beneficial for workspaces (Mardaljevic & Nabil, 2005).

- Insufficient daylight illumination (<100 lux),
- Insufficient on its own, additional artificial lighting required daylight illumination (100<x<500 lux),
- Desired daylight illumination (500<x<2000 lux),
- Daylight illumination exceeding desired limits, causing thermal and visual discomfort (>2000 lux).

Architectural space can be perceived by users along with its boundaries and gains meaning by integrating with the life within it. Spatial elements provide limitations, guidance, and defining features in the perception of space (Bahar & Yalçınkaya, 2021). Outdoor climate comfort is influenced by microclimate conditions, along with various physical personal factors such as activity level, clothing, age, and psychological state, which affect the usability and perceptibility of outdoor spaces. Among these factors, air temperature, humidity, wind speed, and radiation fluxes (especially solar radiation) play crucial roles (Figure 2) (Menteşe & Koca, 2023).

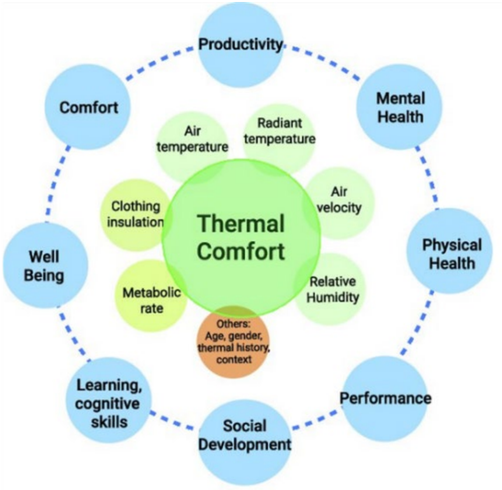

Figure 2. Thermal comfort factors and their effects (Lala & Hagishima, 2022)

Thermal comfort and the behaviours exhibited according to thermal comfort are of great importance in observing the satisfaction of users throughout their time in a place. Users achieve comfort when they achieve thermal balance in the space with the air temperature, globe temperature, and the temperature they emit to their surroundings. The PMV value, which helps to understand this value, provides information about how users feel according to specific conditions in which they are located. Understanding the PMV concept can provide insights into how researchers assess and measure thermal comfort experiences in indoor environments; this could be valuable for designing spaces that enhance users' well-being and productivity (Laouadi, 2022). If the PMV value is negative, people are generally expected to feel cold, while if it is positive, they are typically expected to feel warm. A PMV value close to 0 indicates an environment where people generally feel comfortable. It has been understood that besides the criteria necessary to calculate the PMV value, the selection of an external location is also important, and therefore observation parameters have been established (Toussakoe et al., 2023).

While daylight has been investigated in the context of energy efficiency and visual comfort, its effect on thermal comfort remains less understood (Table 1). Previous research has mostly focused on the effect of artificial lighting or temperature control systems on occupants' thermal comfort. However, little attention has been given to how daylight influences occupants' thermal perception and behaviour. This study seeks to address this gap by investigating how variations in daylight availability influence occupants' thermal comfort. Understanding this link has important consequences for building design, energy efficiency, and occupant well-being in the indoor environment.

Table 1. Literature survey on related topics in the last 10 years

Author/Year	Purpose	Method	Sample/ Location	Findings	Recommendations/Conclusions
Tatar, E. (2014)	Creating a new design that increases daylight usage, positively impacts work motivation, and incorporates sustainable solutions.	Case study	Studios	The use of daylight in architectural design is important for human health, psychology, spatial quality, and visual comfort.	Intentional daylight design increases comfort in workspaces and reduces glare and overheating. This helps people feel comfortable and happy, positively affecting their work motivation.
te Kulve, M., Schellen, L., Schlangen, L. J. & van Marken Lichtenbelt, W. D. (2016)	The article aims to highlight how light affects non-visual responses such as alertness, mood, and circadian rhythms beyond vision.	Literature Survey	48 articles	Light can trigger physiological responses not directly related to visual perception; for example, temperature regulation.	Light can evoke thermos-physiological responses, while visual input can alter the perception of the thermal environment.
Geng, Y., Ji, W., Lin, B. & Zhu, Y. (2017)	To examine the effects of indoor air quality (IAQ), lighting, acoustics, and overall environment, as well as the relationship between the thermal environment and occupant satisfaction and productivity.	Experimental Study	7 groups in the office environment	The thermal environment has a comparative effect on indoor air quality (IAQ), lighting, and acoustic perception.	Thermal discomfort is more pronounced in cool or cold conditions compared to warm or hot conditions.
Kılıç, Z., A. & Yener, A. (2017)	The purpose of this article is to emphasize the effective use of daylight in buildings and to propose metrics to enhance daylight performance in office structures.	Case Study	Office environment	The sensitivity of various daylight performance metrics has been determined.	Although no metric provides a complete assessment for successful daylight design, each offers evaluation services for different designs and rooms.
Chinazzo, G. Wienold, J. & Andersen, M. (2019a)	To investigate how daylight influences human thermal responses in indoor environments.	Experimental Study	84 participants	It shows that the amount of daylight affects people's thermal perception, particularly leading to a cross-modal effect.	Daylight should be considered a factor in thermal comfort models and research. Building operation and design strategies must be adjusted and modified to ensure the thermal comfort of occupants.
Münch, M., Wirz-Justice, A., Brown, S. A., Kantermann, T., Martiny, K., Stefani, O., Skene, D. J. (2020)	The effects of decreasing daylight and increasing electric lighting in urban areas on human health and quality of life, and to categorize the knowledge gaps into three groups.	Workshop	Members of Daylight Academy	The need to develop new tools, methods, and approaches is significant, and some possibilities are highlighted here.	New techniques are needed to monitor and assess exposure to daylight in the field.

Author/Year	Purpose	Method	Sample/ Location	Findings	Recommendations/Conclusions
Bahar, Z. & Yalçınkaya, Ş. (2021)	To explore the approaches for utilizing natural light in design, enabled by advancing technologies and construction techniques	Case Study	Buildings of Jean Nouvel	With metallic brise-soleils, reflective glass, light-sensitive motorized systems, sun-shading technologies, and brie-soleil glass, it has controlled the light entering the space and ensured the buildings' energy efficiency.	The view of natural light as one of the simplest and most effective ways to shift spaces from static to dynamic highlights the importance of daylight in spatial design.
İzmir Tunahan, G., Altamirano, H. & Teji, J., U. (2021)	To understand the relationship between seating occupancy and the availability of daylight.	Case Study	UCL Bartlett Library	Although daylight significantly influences seat selection, students' seating preferences cannot be explained by daylight alone.	Studies should continue to include individual perception alongside occupancy data, considering factors such as privacy, outdoor views, quietness, and daylight conditions.
Bellia, L., d' Ambrosio Alfano, F. R., Fragliasso, F., Palella, B. I. &	To investigate how warm and cool light affects thermal perception at different temperatures through an experiment using white adjustable LED sources.	Experimental Study	163 participants	Warm light appears to reinforce a warmer thermal sensation.	Due to thermohygrometric conditions close to comfort, there was no effect on thermal evaluation and preference in either microclimate scenario.
İzmir Tunahan G., Altamirano H., Teji, J., U. & Ticleanu C. (2022)	To develop a methodology for evaluating daylight perception within the context of cultural background.	Experimental Study	50 participants	It was found that the subjective rating and seat preference methods were consistent with actual daylight levels. However, the participants' boundary lines did not reflect the actual presence of daylight in the area.	In the context of cultural background, individual daylight perception can be evaluated using subjective rating and seat preference methods.
Kutlu, R. (2019)	To examine the effects of sunlight on climatic comfort and the performance of transparent surfaces, demonstrating how natural light can be utilized in lighting design.	Literature Survey	--	Using daylight in design is not difficult, but it requires the integration and optimization of many factors concerning user comfort and energy management.	The necessity of addressing design with a holistic approach is emphasized through the impact of design decisions on energy costs, drawing attention to the topic.
Çiftçi, M. E. & Arpacıoğlu, Ü. (2021)	To examine the contributions of daylight redirecting systems developed in the 19th century to indoor lighting and comfort, as well as their benefits in contemporary architecture.	Evaluation and rating method	Based on 6 criteria, systems are divided into two groups according to direct and diffuse light types.	The impact of artificial lighting on energy consumption can be reduced by using daylight lighting systems, which provide benefits for both people and the environment.	Daylight transport systems are important for both using sustainable energy sources and ensuring visual and thermal comfort in spaces.

Author/Year	Purpose	Method	Sample/ Location	Findings	Recommendations/Conclusions
Ganesh, G. A., Sinha, S. L., Verma, T. N. & Dewangan, S. K. (2021)	To examine the effects of Indoor Environment Quality (IEQ) on human comfort and health.	Literature Survey	Published articles in the last 10 years	Various indoor environmental quality (IEQ) issues, such as sick building syndrome, cold air drafts, and hot-cold radiation, are being discussed.	It is no longer sufficient to design a static building; the building design must also be tested for the health, performance, and well-being of its occupants.
Lala, B. & Hagishima A. (2022)	To investigate the thermal comfort of primary school students and discuss the challenges specific to children in machine learning-based predictions	Articles published since 1962/ Primary school students	Literature Survey /Case Study	A case study on AI/ML shows that model performance is significantly different for children and adults.	Further research is necessary to elucidate the impact of temporal factors, such as circadian rhythm and time of day, on thermal comfort predictions.
Jiang, Y., Li, N., Yongga, A. & Yan, W. (2022)	To investigate the effects of visual windows that provide natural views and daylight on thermal perception, health, and energy savings	19 participants	Experimental Study	It was found that participants with visual windows felt more comfortable in cool conditions.	This research provides evidence that biophilic design elements affect thermal comfort, stress levels, and fatigue.
Erdem, Y. D., Yılmaz Erten, Ş., & Umaroğulları, F. (2023)	To highlight the effects of daylight on energy savings and indoor comfort, and to address efforts related to energy efficiency and sustainable architecture.	2 builder models	Case study	Daylight levels are efficient in single-story buildings, but in multi-story structures, the efficiency decreases as one moves from the upper floors to the lower floors.	Daylight must be efficiently delivered to lower floors by coating the skylights with reflective surfaces and considering the size of the windows opening to the skylights.
Menteşe, S. & Koca, S. (2023)	To examine the thermal comfort conditions of the outdoor environment.	Bilecik, Turkey	Case study	The PET index analysis revealed that thermal comfort varies throughout the year and is only at an optimal level in May.	No season directly falls into the 'comfortable' category in the work area. The season’ s closest to the comfortable
Zhang S., Yao, R. & Li, B. (2024).	To propose a new algorithm to enhance the performance of the PMV index.	14 climate zones	Data Analysis	The new algorithm-based PMV index can effectively avoid the 'zero crossing' issues in the original solution process, match data with low errors under various thermal conditions, and improve average performance by 34.5-37.7% compared to previous optimization methods.	The new PMV curves demonstrate a better fit with actual TSV and can significantly reduce predicted deviations across various temperature ranges.
Cılasun Kunduracı A. & Kızılörenli E. (2024)	To evaluate the efficiency of TDGS and movable shading elements in enhancing daylight performance in a deep-plan layout that receives daylight.	Classroom/ Studio	Measurement and simulation	Compared to the existing condition scenario, the design proposal increased daylight usage for each area and met the latest LEED daylight criteria, requiring at least 55% sDA and a maximum of 10% ASE in the workspace.	The proposed design strategy has demonstrated that a large portion of the area meets LEED criteria and that the systems work effectively together.

3. Material and Methods

The study's primary goal is to evaluate daylight's effect on individual thermal comfort in a classroom setting. To achieve this goal, days with intense classes were initially selected. It was decided to assess a total of six different days during the last week of March, which has the highest average student attendance, continuing into April 2024. Additionally, the classroom location was determined by considering the times when maximum classroom usage was ensured. It was also taken into account that the selected classroom should be easily accessible. After identifying the classroom, observations were conducted during afternoon classes between 1:00 PM and 4:00 PM on Mondays, Tuesdays, and Fridays, when the classroom was most frequently used. The specific observation days were March 25, 26, 29, and April 1, 2, 5. The focus of the study was on behaviours. Therefore, the main approach was to observe participants during the class sessions to determine whether they were affected by daylight and to make notes of those moments.

3.1 Development of the Evaluation Process

The methodology of the research was developed through a systematic approach consisting of specific stages. At the beginning of the study, appropriate environments and users were selected to understand the impact of daylight on thermal comfort and behaviours. However, sufficient devices that could be used within the methodology of the study could not be accessed. Instead, a more accessible systematic method was developed, considering the purpose and progress of the study, allowing for easier adaptation. For this purpose, improvements were made based on the results of the pilot study, facilitating further development (Figure 3).

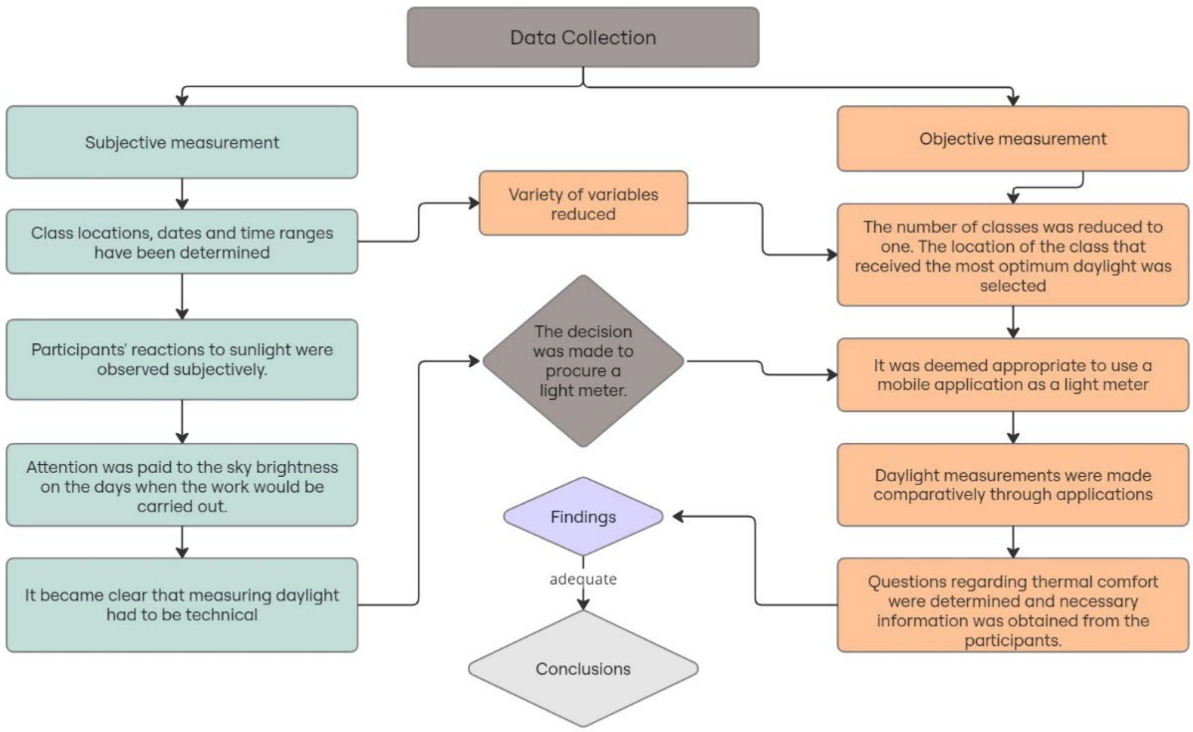

Figure 3. Flowchart of the methodology stages

Stage 1

In the initial stage of the study, two classes were identified, and these two classes were examined on the same days of the week (Figure 4). Photographs were taken from the classes, and the brightness levels of the photographs were compared. On days determined to have bright daylight, students were observed, and at this stage, only the answer to the question "How do you feel in terms of thermal comfort?" was expected. Additionally, no information was collected from the observed individuals, and only the colours of the clothing they chose were noted. As a result of the first stage, parameters were developed. The thickness of the clothing and any extra jackets they brought with them were questioned, and age, height, and weight information were requested.

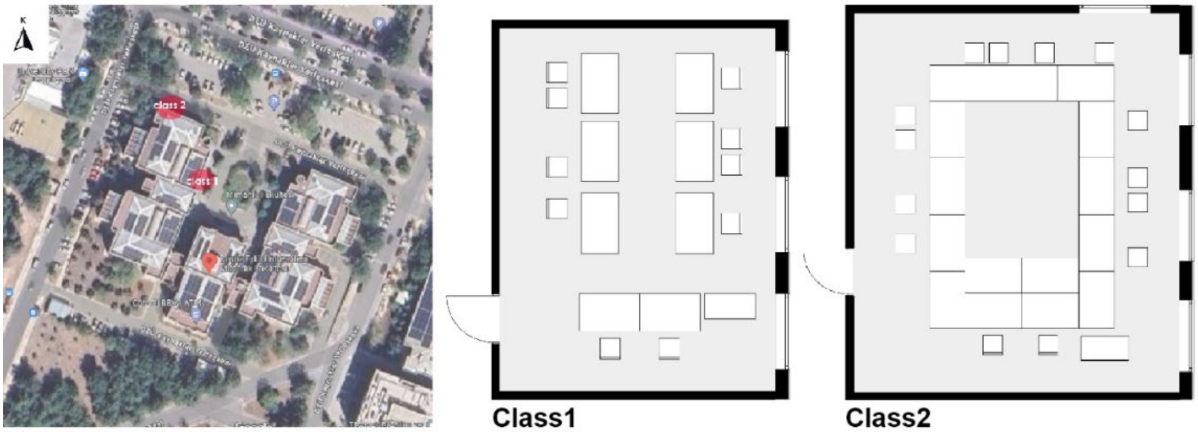

Figure 4. Stage 1- Selected classroom locations and plans

Stage 2

At this stage, thanks to improvements made in observations and parameters compared to the pilot study, more detailed feedback was obtained from the individuals observed. However, the various locations of the assigned classrooms made it difficult to achieve precise results when measuring and comparing daylight values (Figure 5). Thus, it was determined that there would be only one class. Additionally, the number of days was increased, and the number of students was also increased.

Figure 5. Comparison of the daylight availability in different classrooms

Stage 3

In the final stage, efforts were made to find a device for accurately measuring daylight values. However, due to the institution's limited resources, a measurement device could not be found. Instead, additional research was conducted to explore daylight measurement methods, and it was concluded that mobile devices could be used (Figure 6). This enabled the measurement of daylight values, resulting in a more accurate measurement of the Predicted Mean Vote (PMV) value.

3.2. Measurements

Since this study takes place in a school environment and involves observing behaviours, daylight measurements were conducted using a mobile application. During the literature review, it was found that mobile applications provide measurements of daylight at least as accurately as conventional daylight measurement tools, with a negligible margin of error (Gutierrez-Martinez et al., 2017). The conclusion of this study indicates that smartphones can be used in methodological studies where highly precise measurements are not necessary (Figure 6). Additionally, there is no objection to using smartphones due to advancements in technology and the improved sensor features of smartphone cameras during the time frame in which this study was conducted. This is because the PMV (Predicted Mean Vote) value to be measured in the determined thermal behaviour observational process does not require high precision.

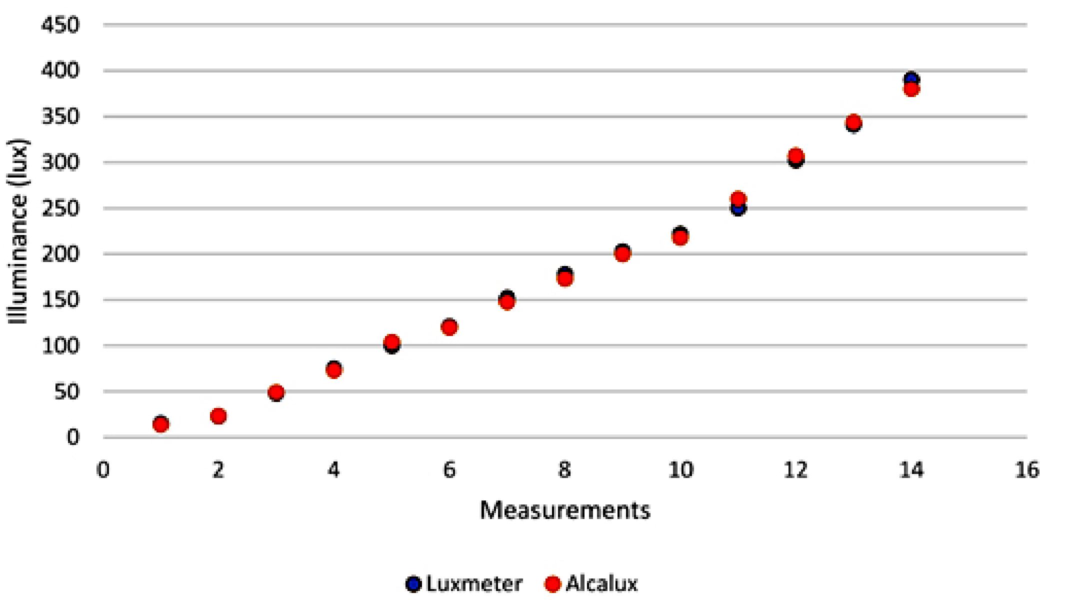

Figure 6. External sensor device (Alcalux) vs. luxmeter accuracy (Gutierrez-Martinez et al., 2017)

During daylight measurements, a 2021 model Samsung Galaxy Note 20 Ultra was used. The values at the measurement points were measured using the three highest-rated applications within smartphone applications, and then their averages were calculated. Thus, the aim was to obtain the most accurate data possible and minimize the margin of error. The window that received the most daylight from the windows in the classroom was selected, and a location marking was made. Each day, the smartphone was placed in the same location for measurements, and daylight measurement was first taken from the outdoor environment. Then, the midpoint of the student desks was calculated and determined to mark the positions of these measurement points inside the classroom. While one of the students faces the daylight (window), the other students turn their faces away from it. Observations were made regarding where the students sat in the classroom, and it was taken into consideration because it was determined to be essential by studies examining the effect of daylight on seat preferences (İzmir Tunahan et al., 2021).

3.3. Details of the Selected Classroom

The selected classroom for measurements is located in the southwest corner of the faculty building. After the initial stage of the study, the number of classes was reduced to one, and the number of days was increased. When selecting the chosen classroom, attention was paid not only to the intensity of light but also to the higher student usage. The other classroom, located northwest of the faculty building, was not selected by the institution for graduate-level courses (it was understood to be an additional classroom in case of need), and it was also understood that students did not prefer it for studying or waiting during breaks. This constitutes an important output of the pilot study. Additionally, it receives maximum daylight, especially during midday hours. The classroom is located on the ground floor of the faculty building, which makes it easily accessible (Figure 7).

Figure 7. The selected classroom's location and plan

Being close to the entrance of the architectural department building, which consists of three floors including a basement, students entering the classroom can reach it without much fatigue. Its three large windows allow direct daylight into the interior. The walls of the classroom are painted in light colours, providing a generally airy environment. The curtains of the classroom are dark red and are thick enough to almost completely block out daylight when used, especially during presentations. When these curtains are drawn during presentations, students create a dark environment, resulting in nearly 80% of the two-hour class being conducted in darkness (Figure 8).

Figure 8. The selected classroom

3.4. Participants

After the literature review of “thermal comfort”, “daylight” and “mental health”, a classroom was determined in the Faculty of Architecture of Dokuz Eylül University Campus. The majority of graduate students in the class are female, typically characterized by those who are accepted into the graduate program for that semester. Among the instructors teaching the selected courses, only two are male. Apart from them, there is only one male student enrolled in the class. Since the ages of the observed individuals were close to each other, it was understood that there were no noticeable differences in metabolic rate. The participants were selected from individuals admitted to postgraduate studies during the period when the educational program was conducted, including both postgraduate students and the teaching staff. Parameters for understanding thermal comfort were established through behaviour-oriented studies, and a mixed method was employed. For the final stage of the study, participants were asked to provide their age, weight, and height to generate the Predicted Mean Vote (PMV). This method aimed to achieve a more subjective outcome for the study. Moreover, as the study progressed from the beginning, the development of the methodology was also taken into consideration.

The parameter ranges for which the PMV index can be evaluated are as follows (Li-Xin, 2002);

- Metabolic Rate: 0.8 – 4 met
- Clothing Insulation: 0 – 2 clo
- Dry Air Temperature: 10 – 30°C
- Radiant Temperature: 10 – 40°C
- Air Velocity: 0 – 1 m/s

Collecting factors such as age, height, and weight, which are necessary for metabolic rate, is important for generating the PMV value in the study. The fact that the students in the classroom environment were young and energetic, and their weights were close to their ideal weights, is also important for the basal metabolism of a sedentary individual and for the temperature and comfort they felt at that moment (Table 2).

Table 2. Participant characteristics

Gender	Sample size	Age (y)	Height (m)	Weight (kg)
Female	14	32,1	166,5	58,2
Male	3	44	180	70,3

3.5. Methods for Collecting Thermal Responses

On the days when observations were conducted, the classroom environment was pre-ventilated and curtains were opened to achieve an optimal condition before usage commenced. In this scenario, any changes made by the individuals in the classroom were noted. After spending a certain amount of time in the space to establish thermal comfort (typically requiring a short duration like ten minutes), participants were asked, "How do you feel?" to record their initial impressions (Table 3). Following the responses from the participants, they were asked about the reasons for their choice of clothing on that day to understand the diversity of clothing preferences. This question aimed to gauge the thickness of the clothing worn. Since clothing thickness typically falls between 0 and 2, a value was assigned to represent the thickness of the clothing.

Table 3. Questions to ask during observation

Questions to Ask During Observation					
How do you feel in terms of thermal comfort? (score)	1	2	3	4	5
What should the preferred outfit be like today?	Thick (2)			Thin (0)	

The basic parameters for observing participants' behaviours were primarily established by drawing upon findings from other studies. Firstly, the parameter of clothing choice was calculated to generate a PMV (Predicted Mean Vote) value. Body movements directly related to thermal values were also deemed significant. For instance, behaviours such as waving hands to create airflow when feeling hot, swinging legs, or shifting chairs were noted. Additionally, interventions related to lighting were included as parameters. The opening and closing of curtains determined natural lighting while turning the classroom lamp on or off indicated behaviours related to artificial lighting. Changes made to door and window openings for airflow or repositioning were also recorded. At the end of the entire class session, participants were asked, "How do you feel in terms of thermal comfort today?" to understand their clothing choices or behavioural correlations.

4. Findings and Discussion

In daylighting, external environmental factors such as climate, weather conditions, and the latitude of the location are important. Additionally, the orientation and geometry of the building, daylighting strategies, the form and material properties of solar control elements, as well as the shape, position, and light transmittance properties of light-transmitting surfaces are key parameters in determining the penetration and distribution of daylight within the interior space (Çiftçi & Arpacıoğlu, 2021). After measurements and observations in the initial stage of the study, it was decided that there were deficiencies, and it was accepted as a preliminary study as a result. Subsequently, the methodology was revised to evolve into a more systematic study based on daylight measurements. As a result of this preliminary study; in this study, the thermal comfort effects of daylight on users were investigated on 5 different days in the same locations, ensuring that many variables remained constant. Throughout the observation period, the temperature balance remained consistent. The temperature fluctuated approximately 9°C, ranging between 18°C and 27°C. These temperature changes observed at the end of March and the first week of April resulted in significant fluctuations in outdoor conditions and daylight balance. It appears that students first check the weather conditions when setting out for school in the morning, and then decide on their clothing based on whether the sky is cloudy or clear. The initial data reveals that daylight can alter human subjective thermal perception from a psychological standpoint, with the effects being linked to the thermal environment in which users are exposed.

On the days when observations were conducted, the daylight values in the outdoor environment were as follows:

- The lowest daylight illuminance: 2600 ± 50 lx
- Medium daylight illuminance: 27350 ± 50 lx
- The highest daylight illuminance: 116500 ± 50 lx

The average values of daylight measured in the indoor environment are as follows:

- The lowest daylight illuminance: 33 ± 5 lx
- Medium daylight illuminance: 100 ± 5 lx
- The highest daylight illuminance: 140 ± 5 lx

When these values were measured, average values were taken as they were measured from three different applications. The presence of plus and minus indicates the quantitative difference between the applications (Mardaljevic, 2023).

On days when observations were conducted, there were instances of both cloudy skies and clear skies, as the daylight conditions varied. Although a clear sky is not directly correlated with the brightness of daylight, it significantly influences it (Dolnikova et al., 2022). Therefore, these days were chosen to minimize the effects as much as possible. However, it was understood that the presence of clouds did not necessarily correlate with lower levels of daylight. Additionally, before the observation process in the classroom began, ventilated curtains were opened, lights were turned off, and the environment was optimized. Nevertheless, it was observed that users could change these factors in the space according to their preferences.

4.1. Observations and Analysis of Thermal Comfort and Daylight Interaction

Shortly after exposure to daylight, participants were asked two general comfort questions. Firstly, similar to the thermal comfort question, participants were asked why they chose their clothing and for general judgements in terms of thickness, simply asking them to identify it as thick or thin (Table 3). The participants were then asked to rate their present thermal comfort on a scale of 1 to 5, with 5 meaning "very comfortable" and 1 meaning "very uncomfortable."

Understanding the impact of buildings on users alone is not sufficient; it is essential to adopt an approach that aims to improve user health. Therefore, in the design, construction, and evaluation processes of buildings, structural and spatial characteristics must be considered alongside user health as a crucial criterion (Şentürk Sipahi & Yamaçlı, 2021). When observing participants' behaviours, it was noted that their clothing choices tended to be of moderate thickness relative to the ambient temperature. However, on some days (for instance, the third day), unexpected rainfall led to rapid changes in temperature. The interaction between clothing and daylight can influence the overall aesthetic experience of spaces. Glossy surfaces have the ability to reflect and direct daylight rays in a specific direction because they maintain a consistent angle of incidence and reflection. These surfaces exhibit both a shiny and shimmering appearance, and the intensity of the illumination varies depending on our viewpoint. This indicates that the surfaces in our environment have a significant impact on our perception of daylight and contribute to shaping our luminous environment (Grønlund et al., 2024). Nevertheless, this did not significantly impact participants' thermal comfort levels, as indicated by their responses to the thermal comfort rating question, where they reported feeling comfortable. Participants indicated feeling thermally uncomfortable on days when they believed they had chosen their clothing incorrectly. Furthermore, on days when clothing thicker than level 1,5 was chosen, temperatures ranged between 25 and 26 °C. On these days, daylight values varied considerably, indicating a direct relationship between participants' clothing choices and environmental conditions (Table 4).

Table 4. Behaviour parameters

Parameters	Day 1	Day 2	Day 3	Day 4	Day5	Day 6
Outdoor Daylight (Lx)	10770	20446	4741	2667	116570	9018
Indoor Daylight (Avg. Lx)	56,6	110	50	32	129	40
Clothing Choice (Avg.)	1,8	1,5	1,5	1	1,2	1
Body Movements	+	+	+	-	-	-
Behaviour Associated with Natural Light	+	-	-	+	-	+
Behaviour Associated with Artificial Light	-	+	+	-	+	-
Behaviour Related to Airflow	+	+	-	-	-	+
Displacement Process Behaviour	+	+	-	-	+	+
Participants' Thermal Comfort Score (Avg.)	3	2	1	3	4	4

In another study by Chinazzo (2019b), the focus is on investigating the thermal and visual comfort evaluations of daylight transmitted through spectrally selective glass, as well as its overall impact on indoor comfort. However, the study primarily discusses the effects of daylight colour and temperature on comfort perceptions, without specifically addressing the influence of clothing on comfort assessments. The type of clothing individuals wear can significantly influence how they perceive and experience thermal conditions in a given environment. Therefore, there is a recognized need to develop methodologies with a tendency towards observing this aspect, as it is crucial for enhancing understanding in this area (Chinazzo et al., 2019b). Participants' clothing choices were not only measured to assess the PMV value but also to observe whether they changed their clothing based on daylight when exhibiting behaviour to leave the environment. This formed a sub-question of the study. The importance of participants bringing a jacket with them is significant in this regard.

Participants' hand and foot movements during class were also observed. Some conscious or unconscious movements, such as swinging legs when feeling warm, moving hands to feel air, or tying up hair, were noted. Particularly on the first, second, and third days, intense body movements were observed, correlating with lower thermal comfort ratings.

- First day, on 25th March, the daylight value of 10770 is considered acceptable as an average value for outdoor conditions, but its reflection in the indoor environment is considerably low. In a classroom setting, an average of 56.6 lux falls below the daylight value that an individual should ideally receive.
- Second day, on 26th March, compared to the first day, a higher value of 20446 lux was measured in the outdoor environment on the second day, resulting in an effect indoors that was twice as much as the outdoor value. However, despite the expected minimum daylight value of 100 lux on the second day, it was observed that artificial lighting was turned on and the perceived level of comfort decreased to 2 in terms of thermal comfort compared to the first day. One of the main reasons for this was that participants wore lighter clothing, mistakenly assuming the thermal comfort from the previous day.
- Third day, on 29th March, the daylight value outdoors was measured quite low at 4741 lux compared to previous days. However, due to lighter clothing choices compared to previous days, the thermal comfort decreased to 1 point. Additionally, since the daylight value indoors was less than the expected 50 lux, a change in artificial lighting was observed.
- Fourth day, on 1st April, which recorded the minimum daylight value of 2667 lux, the value measured indoors naturally was the lowest at 32 lux. Therefore, artificial lighting was turned on. However, thermal comfort was mostly considered as 3.
- Fifth day, on 2nd April, which had the highest daylight value of 116570 lux, the indoor value was also the highest on average at 129 lux. It was observed that participants exhibited leaving the classroom behaviour, with thermal comfort being considered as 4. This behaviour could be considered as an attempt to balance the outdoor daylight with the indoor environment.
- Sixth day, on 5th April, the daylight value was measured at 9018 lux, similar to the first day. It was observed that participants exhibited leaving the classroom behaviour, despite the indoor value being 40 lux.

When evaluating daylight quality and glare sensation indoors, it indirectly emphasizes the importance of artificial lighting measurements and standards (Garretón et al., 2016). The relationship established by participants between natural and artificial light was also examined. This was because presentations are sometimes given in the classroom environment, leading to the closure of curtains. However, on days when natural light was not bright, it was observed that the curtains remained open during presentations. Additionally, it was noteworthy that on the fourth day, for example, when natural light was at its lowest, curtains were open and artificial lighting was used despite no presentations taking place. According to IESNA standards, the recommended brightness ratio for optimal lighting conditions indoors is 1:20. The 1:20 brightness ratio guide serves as a practical criterion for lighting designers and architects to enhance artificial lighting quality in various indoor spaces, ultimately improving the overall visual environment for occupants. A direct relationship between the use of natural and artificial light was identified (Samiou et al., 2022). Additionally, the importance of curtains inside the classroom is significant due to the shading that will be implemented. The installation of shading devices can provide solutions to glare issues; however, glare reduction measures may further restrict daylight penetration into the deeper areas of the room (Cılasun Kunduracı & Kızılörenli, 2024). Furthermore, it was noticed that participants generally only fully closed one of the two curtains in the classroom while leaving the other partially open.

Similarly to the direct relationship established with light, some changes related to airflow are among the parameters affecting the classroom environment. Yang & Shekar (2014) conducted several experiments in their studies on airflow, investigating both turbulent and stagnant airflow conditions. According to their study, the behaviour of opening windows provides significant information about users' thermal comfort (Yang & Sekhar, 2014). On days with intense daylight, compared to other days when it was measured lower, the preference for opening windows was not observed. However, airflow was considered important on days with average brightness measured between 9000 and 21000 lux. One reason for this might be associated with users' tendency to move away from windows on days with intense daylight. Additionally, it is understood that participants' desire to go outside decreases on days with low daylight brightness, leading to a reduced need to move away from windows and towards artificial light, thereby exhibiting such behaviours.

After observing these parameters, the PMV value was calculated. Firstly, the metabolic rate (M) of the participants was calculated. For this purpose, participants were asked for their age, height, and weight values. Upon examining the participants' characteristics, it was found that their physical attributes were similar, with no extreme differences. However, after calculating the metabolic rates of individual participants, an average value was obtained. Metabolic rate is a value used to calculate the calories burned by a person at rest. Taking into account light levels, activity, and food intake, it can be hypothesized that the higher metabolic rate observed in individuals exposed to light levels above 500 lux during the day may contribute to this result (te Kulve et al., 2016)

Taking into account that participants were exposed to a maximum of 140 lux in the classroom environment, it is understood that the variability of a metabolic value is not of significant importance for this study. However, it is still important to gather information about an individual's physical characteristics to understand changes in their behaviour (Haddad et al., 2013). Therefore, this value has been considered, but it has not been accepted as a parameter with intense sensitivity. One reason for the thermal comfort responses given by individuals in the classroom environment being so close to each other is also that the importance of this variable is less influential compared to other variables.

The clothing insulation value was measured by considering the material of the fabric used in the garment. If the participant wears a t-shirt without any garment on their arms, it is given a value of 0, while if they wear a wool sweater providing the highest insulation, it is given a value of 2. The values found are determined according to these clothing layers. The metabolic rate was measured electronically using a website (https://www.calculator.net/bmr-calculator.html) that calculates basal metabolism. PMV (Predicted Mean Vote) measures comfort on a 7-point scale from +3 ("Very Hot") to -3 ("Very Cold"), with 0 indicating "Neutral."

Table 5. Average predicted mean vote value (Quadco Engineering BV, 2024)

Days	Air Temperature (ta)	Mean Radiant Temperature (tr)	Air Velocity (VA)	Relative Humidity (RH)	Clothing (clo)	Metabolic Rate (M)	PMV
Day 1	25	28	0,1	30	1,8	1,3	0,7
Day 2	26	27	0,5	50	1,5	1,3	0,9
Day 3	26	28	0,8	50	1,5	1,3	1,1
Day 4	27	25	0,5	30	1	1,3	0,6
Day 5	24	26	0,5	30	1,2	1,3	0,3
Day 6	24	25	0,5	30	1	1,3	0,2

Considering the temperatures and the value of daylight over the six days, it was observed that the weather was not excessively hot, which directly influenced thermal comfort (Table 5). The PMV value did not exceed 2 or fall below 0, indicating that the environment was neither too hot nor too cold. The proximity of the PMV value to zero corresponds closely with the ratings given by users for each day (Figure 9).

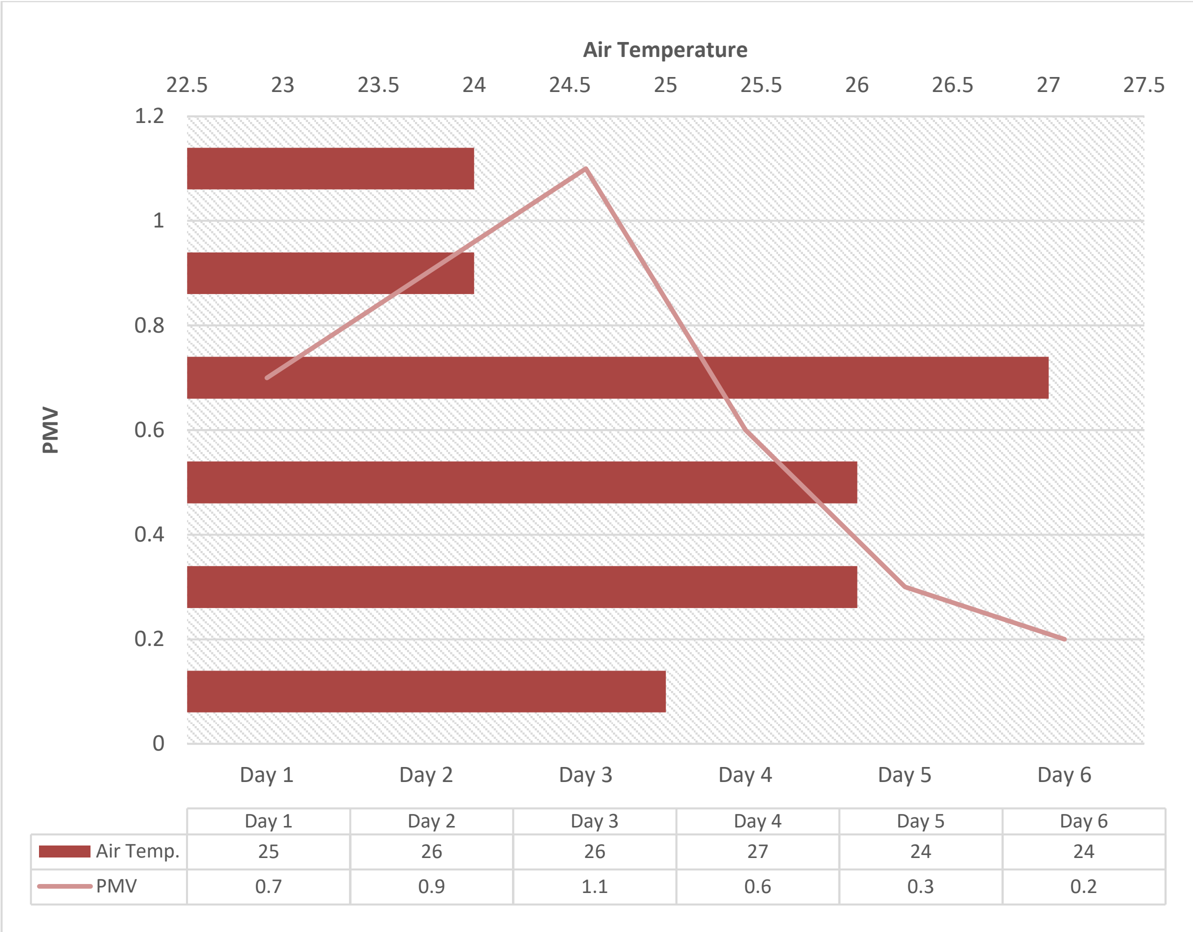

Figure 9. Comparing the calculated PMV values across days

Understanding the effects of thermal comfort perception can lead to improved building and environmental design strategies that enhance occupants' well-being and productivity. (Laouadi, 2022). In this context, the sixth day, with a daylight level above 9000 lux, was closest to optimum thermal comfort, with the majority of participants giving a rating of 4 (comfortable) (Figure 10). According to the results of many studies, it has been determined that the lighting level should not be below 550 lux and the highest satisfaction level is achieved between 600 and 650 lux (Fakhari et al., 2021). However, in this study, the light falling on the classroom being below these lux values implies that it could negatively affect the individuals in the classroom. This indicates that even on days when daylight is not excessively bright, participants can feel comfortable. In this regard, it was observed that on days when daylight was not too bright, participants balanced the temperature between the outdoor and indoor environments. Participants formed a perception of temperature based on the brightness level of daylight, and they began to feel comfortable as a result of expectations that fell below this perception.

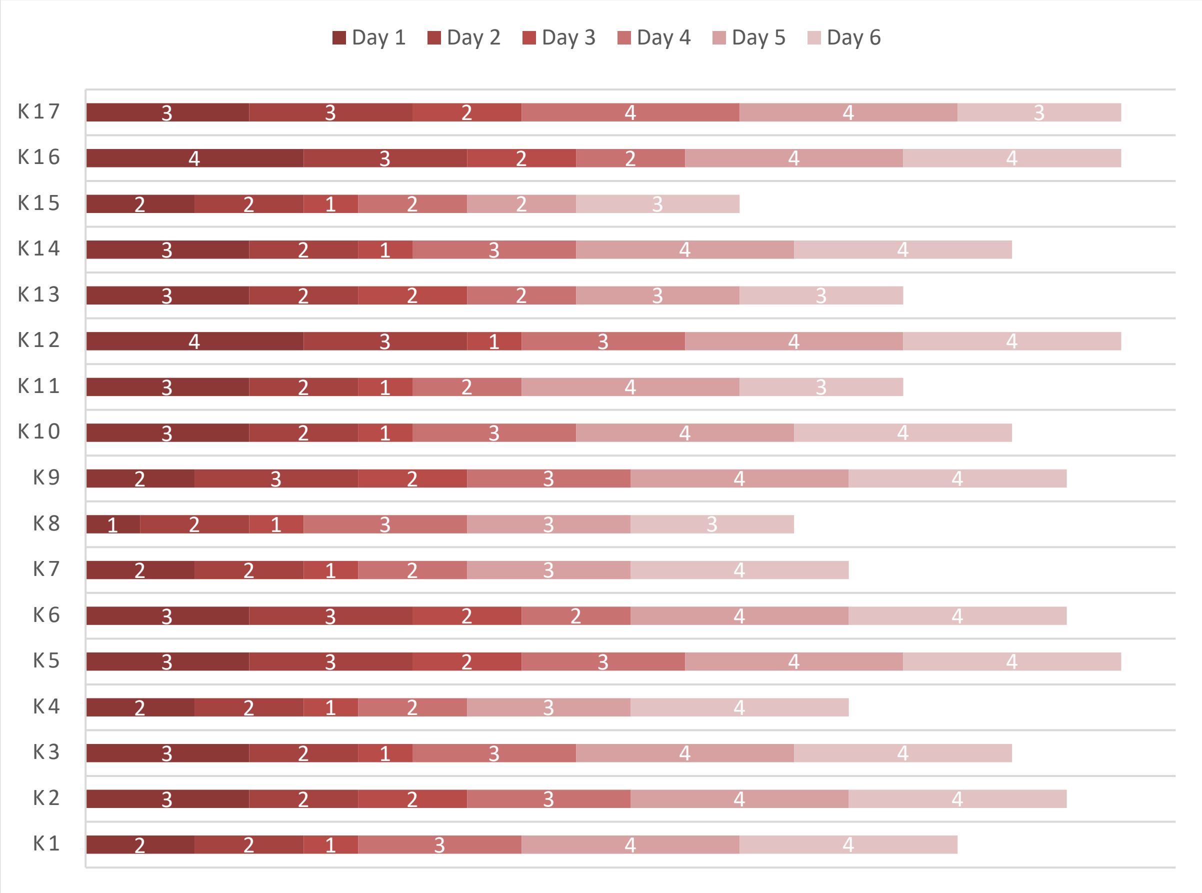

Figure 10. Participants' thermal comfort score

4.2. Limitations and Future Research

This study has several limitations regarding occupants' daylight perception and thermal comfort. First, the measurement of illuminance levels was conducted using a mobile phone's light sensor due to the lack of access to a lux meter. While mobile phone sensors can generally indicate light levels, they are not as precise or calibrated as dedicated lux meters, potentially affecting the accuracy and reliability of the illuminance data collected. This limitation may introduce some degree of variability or error in the assessment of occupants' daylight perception.

Furthermore, the sample size and diversity of the participants influenced the generalizability of the findings. Since the study was conducted in a specific type of building or with a particular group of occupants, the results may not be representative of other settings or populations. Future research should consider using standardized and calibrated equipment for measuring illuminance, expanding the participant pool to include a more diverse population, and controlling for external environmental variables. Despite these limitations, the study provides valuable insights into the interplay between daylight perception and thermal comfort in building environments.

5. Conclusion

User satisfaction is the most crucial outcome to consider in design. During the design process, an architect must consider both energy efficiency and the creation of the most functional and comfortable environment for users. Therefore, attention should be paid to daylight, and careful consideration should be given to the orientation of the building and the choice of materials. In this study, daylight was observed to impact user satisfaction regarding thermal comfort, and users' thermal behaviours were examined according to daylight brightness levels. No experimental environment was created; instead, a classroom environment was naturally selected, and an experimental methodology was developed beforehand. During the observation period, while the temperature balance remained unchanged, daylight values varied between 2000 and 116,000 lux on different days of the study. Maintaining a similar number of students in the classroom throughout the observation process helped achieve more accurate results. Observations revealed that participants checked the weather before coming to school and made clothing choices based on whether the sky was cloudy or clear.

Initial findings suggest that daylight may alter people's subjective thermal perception from a psychological standpoint, and these effects are related to the thermal environment they are exposed to. This behaviour-focused study primarily considers participants' responses, with the diversity of behaviours observed alongside their responses allowing for an assessment of thermal comfort in terms of daylight. It was observed that on days with lower daylight values, participants tended to balance their thermal comfort by adjusting their clothing choices, effectively changing their comfort levels and almost deactivating the impact of daylight. Consequently, the influence of daylight on thermal comfort and thermal behaviour varies with participants' perceptions. On bright daylight days, participants seemed to associate this with warmth, influencing their clothing choices and even classroom movement levels. Ultimately, it was found that participants' behaviours were shaped by daylight, though it's important to note that behaviour is not solely related to daylight. When participants' thermal comfort was observed objectively and subjectively, daylight alone was not found to be the determining factor.

Various factors, such as participants' preparation for presentations and class, as well as their level of engagement, also contributed to changes in body temperature. Additionally, while daylight does not have a physiological effect on participants, it appears that there is a psychological desire for warmth when exposed to bright daylight levels. Among factors affecting thermal comfort, the importance of daylight is relatively low; however, it should still be taken into consideration. This is mainly due to the relationship between thermal comfort and behavioural responses based on environmental perception. Future studies that increase the number of days observed and conduct comparative measurements across different seasons will allow for a more detailed examination of the effect of daylight on thermal comfort.

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Author Contribution and Conflict of Interest Declaration Information

All authors contributed equally to the article. There is no conflict of interest.

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Determination of Visitor Satisfaction in The Tourism and Recreational Use of Kovada Lake National Park

Emine DEMİRCİ [1*], Murat AKTEN [2]

ORCID 1: 0000-0003-2607-4975
ORCID 2: 0000-0003-4255-926X
[1] *Independent Researcher*
[2] *Süleyman Demirel University, Faculty of Architecture, Department of Landscape Architecture, 3250, Isparta, Türkiye*
*** *e-mail***: *eminedemirci01@gmail.com*

Abstract

This study includes the data obtained by face-to-face survey technique interviews with 250 visitors in the national park area between 01.05.2021 and 01.05.2022, in order to determine the recreational satisfaction of Kovada Lake National Park visitors. With the survey questions, the determination of the visitors' thoughts about the functions in the national park and the differences of opinion about the educational status of the users with the factors related to this situation were examined. In conclusion; It has been determined that factors such as "natural resource values of the national park, visual quality", "outdoor recreational activities", "accessibility, use of space", "discovering natural resources and finding peace", "desires to benefit from the area" are effective in visitor satisfaction. As a result of the findings, it is seen that Kovada Lake National Park has not been able to effectively evaluate the recreational potential it has and it is seen that carrying out recreational activities in limited areas has a negative impact on natural resources.

Keywords: *Kovada Lake National Park, visitor satisfaction, recreation, protected areas.*

Kovada Gölü Milli Parkı'nın Turizm ve Rekreasyonel Amaçlı Kullanımında Ziyaretçi Memnuniyetinin Tespiti

Öz

Bu çalışma, Kovada Gölü Milli Parkı ziyaretçilerinin rekreasyonel memnuniyetinin belirlenmesi amacıyla, 01.05.2021- 01.05.2022 tarihleri arasında milli park alanında 250 ziyaretçiye anket tekniği ile yüz yüze görüşülerek elde edilen verileri kapsamaktadır. Anket soruları ile ziyaretçilerin milli parkta yer alan fonksiyonlara ait düşüncelerinin tespiti ve bu duruma ait faktörlerle kullanıcıların eğitim durumuna ait görüş farklılıkları irdelenmiştir. Sonuç olarak; "milli parkın sahip olduğu doğal kaynak değerleri, görsel kalite", "açık hava rekreatif faaliyetler", "ulaşılabilirlik, alan kullanımı", "doğal kaynakları keşfetme ve huzur bulma", "alandan yararlanma istekleri" gibi faktörlerin ziyaretçi memnuniyetinde etkili olduğu tespit edilmiştir. Elde edilen bulgular sonucunda Kovada Gölü Milli Parkı sahip olduğu rekreasyonel potansiyeli etkili bir biçimde değerlendiremediği ve rekreasyonel faaliyetlerin kısıtlı alanlarda gerçekleştirilmesi, doğal kaynaklar üzerinde olumsuz etki yarattığı görülmektedir.

Anahtar kelimeler: *Kovada Gölü Milli Parkı, ziyaretçi memnuniyeti, rekreasyon, korunan alanlar.*

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1. Introduction

In the use of protected areas for tourism and recreation purposes, it is necessary to ensure the sustainability of the area and provide the highest level of satisfaction to the visitors, to determination of the factors affecting tourism/recreational activities, to reveal the relationship of these factors with other factors.

As a result of technological developments and environmental factors, people's holiday perceptions have changed. Interest in protected areas (national parks, nature conservation areas, etc.) has increased considerably in order to get away from city life and experience the peace of natural beauty. The unconscious and excessive use of natural resources, the decrease in species diversity due to global warming and climate change have revealed the pressures and destruction on these ecosystems. Planning and management are needed to identify and eliminate the negative effects that arise as a result of pressure.

The demand for tourism and recreation, along with threats and degradation to natural and cultural resources in protected areas, causes to decreases in the post-recreation experience and satisfaction of visitors. For this reason, in addition to protecting natural and cultural resources, visitor management should also be designed within the scope of sustainability (Candrea & Ispas, 2009).

Visitor management is the minimization of the environmental, cultural, economic and social pressures created by tourism. With the increase in visitor usage in protected areas, negative effects may be observed on resource values and visitor experience quality. In the scientific researches conducted in the last 20 years, visitor management is a tool used to minimize the negative effects on the result of tourism/recreation activities (Mason, 2005).

The primary purpose of visitor management plans is to increase the quality of satisfaction of visitors by offering tourism/recreation activities while ensuring the protection of natural and cultural resources within the framework of sustainability.

Research has been conducted on visitor impacts and management, user expectations and satisfaction qualities, and the importance of the subject in terms of sustainable management has been revealed. Hof & Lime (1997), Leung & Marion (2000), Eagles et al. (2002), Cole (2004), Mason (2005), Müderrisoğlu et al. (2005) and (2009), Candrea & Ispas (2009), Memişoğlu (2009), Akten (2009), Uzun & Müderrisoğlu (2010), Akten et al. (2012), Sıvalıoğlu (2012), Cheung (2013), Kılıç (2020) in their studies they have attracted attention to the expectations and requests of visitors from the area, recreational activities, visitor behavior, points where there is a high density of visitors on the area, the negative effects of recreational activities, acceptable exchange limits, resource protection, and the place and importance of approaches such as visitor experience and quality in planning and management.

The scope of the study is to determine the visitor satisfaction status, requests and demands for area use, to identify problems related to visitor use and methods to be followed for their solution. Protected areas; these can be affected directly and indirectly by natural and human-related sources. These impacts on the use of protected areas usually appear as negative results. In line with the findings obtained as a result of the study, the demands for visitor preferences in Kovada Lake National Park were determined and management suggestions for the use of the national park were developed.

2. Material and Method

Kovada Lake National Park (KLNP) is located within the borders of Eğirdir and Sütçüler districts of Isparta province in the west of the Mediterranean region. The national park, located in the south of Eğirdir district, is between 37° 34' 47" - 37° 42' 24" northern latitudes and 30° 50' 45” - 30° 55' 53" eastern longitudes (UDGP, 2008).

Kovada Lake and its surroundings were declared a National Park on 03.11.1970, and the total area of the national park is 6,534 hectares. 790 hectares of this area is covered by the lake surface. Kovada Lake is the extension of Eğirdir Lake towards the south and took its current form as a result of the narrow valley in between being filled with alluvium. The natural ecosystem and geomorphological structure of the National Park make the area important both regionally and nationally. In 1992, the

1626 hectare area of Kovada Lake and its surroundings was declared a 1st Degree Natural Protected Area. Kovada Lake National Park is used as an outdoor recreation area. The natural resource values of the park contribute to outdoor recreation and use, which is the main resource value of the national park (UDGP, 2008). The KLNP is suitable for recreational activities such as camping, caravanning, picnics, horse farm and horse riding, water sports, hiking and photo safari and others (Aydemir et al., 2020).

The aim of the research is to reveal the satisfaction level of Kovada Lake National Park visitors. Requests and demands of visitors from the national park, reasons for coming to the national park, area usage preferences, recreational activities they do in the park, services and facilities that are considered deficient, situations that prevent them from spending time in the area for a long time, institutions and organizations that should play a role in increasing visitor satisfaction, whether information activities in the area are sufficient and materials that should be available, the determination of their opinions about the functions in the national park, and the factors related to this situation and the differences in opinions regarding the educational status of the users were examined.

In this context, plans and reports prepared by relevant institutions and organizations in Kovada Lake National Park, photographs taken in the research area, observations and investigations made in the national park, and surveys made to visitors were used to obtain current data about the research area and to guide the method of the study.

The stages of the method applied within the scope of the study; a) “Sustainable management and planning of protected areas, factors affecting user satisfaction, protecting the visitor experience and resource, scanning of domestic and foreign literature on the concepts of visitor activities management process”, b) “Field studies carried out for the purpose of obtaining the inventory”, c) “Survey study conducted to determine visitors' opinions about the area”, d) “Field studies carried out for the purpose of obtaining the inventory” and e) “Conclusion of the study with suggestions for problem identification” it consists shaped of 5 successive stages.

When examined in terms of the purpose of the study, the research method suitable for the process of collecting and evaluating data is a case study. Case study is preferred in research because it provides the opportunity to analyze and adopt social realities in detail and to identify differences of opinion among participants and make assumptions (Cohen & Manion, 1994).

The universe of the study creates visitors visiting Kovada Lake National Park. In order to have detailed information about the subject and for the reliability of the study, attention was paid to the fact that the educational status, age group and professions of the visitors were different and that the test subjects were randomly selected. While determining the number of test subjects, the number of visitors included in Table 1 was taken into consideration.

The data on the number of people who have visited the national park in the last 5 years have been obtained from the Isparta Provincial Nature Conservation National Parks Directorate and is given in Table 1 below. In Table 1, the average number of people who visited the national park in the last 5 years is seen as 13,453.

Table 1. Number of visitors to visiting Kovada Lake National Park

NUMBER OF VISITORS		YEARS				
		2018	2019	2020	2021	2022
MONTHS	January	100	400	700	13	0
	February	100	300	200	9	150
	March	400	300	200	3000	300
	April	400	800	-	2000	1000
	May	2400	2495	-	1100	1050
	June	900	3525	1095	1100	400
	July	700	3192	2200	2200	1700
	August	1700	3765	2700	0	1000
	September	700	1860	2700	300	700
	October	700	1600	2400	700	800
	November	1300	2830	1200	700	800
	December	700	880	1700	700	400
TOTAL		**10100**	**21947**	**15095**	**11822**	**8300**

In the calculation of the sample size to be used in the survey research, the following formula was used.

$n= [N * t^2 * p * q] / [d^2 * (N-1) + t^2 * p * q]$

In this place it is expressed as follows;

n= Number of samples
N= The size of the population
t= Confidence coefficient (This coefficient is taken as 1.96 for 95% confidence)
p= The possibility of the feature you want to measure being found in the population (p=0.5)
q= The possibility that the feature you want to measure is not found in the population (q=0.5)
d= Accepted sampling error (d=% 10)
When the values are replaced in the formula, the sample size is;
$n= [13.453 * 1.96^2 * 0.5 * 0.5] / [0.10^2 * (13.453-1) + 1.96^2 * 0.5 * 0.5] =$ ***95.36***

Although it was found that it would be sufficient to apply a survey to 95 people as a result of the calculation, the reliability of the study was increased with a face-to-face survey conducted on 250 people who visited the study area on 01.05.2021-01.05.2022. A visitor interview (survey) form was used as a data collection tool in the study. A field study was conducted to determine whether the survey questions to be created within the scope of the study were suitable for data collection tools in the national park area before starting the research. The information obtained as a result of literature searches was adapted to the survey and a scale was created. In the preparation of the interview (survey) form; the studies of Kılıç (2020), Yıldız (2019), Karakaya (2019), Düzgüneş (2015), Albayrak (2010), Alkan & Korkmaz (2009), Akten (2009) were used. The opinions of experts were taken at the stage of deciding the suitability of the prepared visitor interview (survey) form, correcting errors and determining the reliability of the scales. After the necessary arrangements have been made, the visitor interview (survey) form has become applicable.

There are a total of **21** questions in the visitor interview (survey) form applied in the study and it consists of **three parts**:

In the first section, 6 questions regarding the personal information and demographic characteristics of the visitors are included.

In the second section, there are 5 questions where the visitor's area usage preferences are evaluated. Of these questions are: 3 of them are multiple-choice, 2 of them are non-multiple choice.

In the third section, there are 10 questions to determine the perceptions and attitudes of visitors towards the national park. Of these questions; 6 of them are multiple-choice, 3 are non-multiple choice, and the other question is a five-point Likert scale consisting of 10 statements/judgments. This question can be answered by visitors as follows and they were asked to evaluate the questions as: ***"1. I Strongly Agree, 2. Agree, 3. Undecided, 4. Disagree, 5. I Strongly Disagree"***. They were asked to evaluate the statements in the indicator list by giving a value of 1 to the statement they considered the most important and a value of 5 to the statement they considered the most insignificant. The evaluation of each of the responses of the participants to the factors related to the measures to be taken in the national park included in the indicator below the average of 2.5 shows that they participate in the factors and the level of importance is high.

SPSS 25.0 (Statistical Package for Social Sciences) program was used in the analysis of the surveys. In the analysis of the data; In order to determine which of the tests (parametric or non-parametric tests) to be used in the evaluation of the data is appropriate, Kolmogorov-Smirnov and Shapiro-Wilk tests and normality test, analysis of frequency and percentage values for multiple-choice and non-multiple-choice questions, descriptive statistics for Likert-scale questions (means standard deviation, variance) and reliability test, Mann-Whitney U test and Kruskal-Wallis test were used to determine whether the demographic characteristics of the visitors and their opinions and attitudes about the national park differed. In statistical analyses, the confidence interval of 95% and the margin of error significance level were taken as criteria in calculating the representativeness of the sample group to the universe. Cronbach's Alpha coefficient was used to analyze the reliability of the data. Cronbach's Alpha value was determined as 0.810 and the scale is highly reliable.

3. Findings and Discussion

3.1. Demographic Information

%56.4 of the participants in the survey are male and %43.6 are female. 33.6% of the participants are between the ages of 18-30, 31.6% are between the ages of 30-40, 16.8% are between the ages of 40-50, 14.8% are between the ages of 50-60, % 3.2 of them are aged 60 and over. Participants aged 18 and over were included in the study so that they could participate in the survey independently. When the educational status of the participants was examined; 1.6% of them had literate, 10.8% had primary education, 24% had high school education, 11.2% had associate degree, 34% had undergraduate education and 18.4% had postgraduate education. When we look at the their income status; 14.8% have low income, 74% have medium income, 10.8% have high income and 0.4% have very high income. When we look at the professions of the participants; 20% are workers, 17.6% are students, 16% are civil servants, 12% are forest engineers, 8.4% are housewives, 7.6% are other professional groups (architects, doctors, teachers, managers, etc.), 6.4% are academic personnel, 5.2% are farmers, 4% are self-employed and 2.8% are retired people. The places where they permanently reside are; 75.6% of it is Isparta, 14.4% is other cities (Aydın, Niğde, Denizli, etc.), 7.2% is Antalya and 2.8% is Burdur.

3.2. Area Use Preferences

3.2.1. Frequency of visits to national park

When the frequency of participants visiting the national park was examined, the option "a few times a year" (69.2%) was most preferred (Table 2).

Table 2. Frequency of visits to Kovada Lake National Park

Frequency of visits to National Park		Gender		Total
		Female	Male	
Every day	Frequency	1	7	8
	Percent	0,4%	2,8%	3,2%
Once in a few days	Frequency	4	6	10
	Percent	1,6%	2,4%	4,0%
Once a week	Frequency	2	3	5
	Percent	0,8%	1,2%	2,0%
Once in a month	Frequency	9	16	25
	Percent	3,6%	6,4%	10,0%
Once in a few months	Frequency	0	2	2
	Percent	0,0%	0,8%	0,8%
Once in a year	Frequency	6	0	6
	Percent	2,4%	0,0%	2,4%
Several times a year	Frequency	77	96	173
	Percent	30,8%	38,4%	69,2%
Once in a few years	Frequency	4	8	12
	Percent	1,6%	3,2%	4,8%
Several times	Frequency	1	0	1
	Percent	0,4%	0,0%	0,4%
When I came to Isparta	Frequency	2	0	2
	Percent	0,8%	0,0%	0,8%
Just once	Frequency	3	3	6
	Percent	1,2%	1,2%	2,4%
Total	Frequency	109	141	250
	Percent	43,6%	56,4%	100,0%

3.2.2. Preferred days, seasons and time interval to go to the national park

The most preferred options of the participants were weekend (47.5%) and no difference (34.9%) options (Table 3).

Table 3. Preferred days to visit the national park

Preferred days to visit the Kovada Lake National Park		Gender		Total
		Female	Male	
Weekend	Frequency	53	68	121
	Percent	20,8%	26,7%	47,5%
Weekdays	Frequency	10	10	20
	Percent	3,9%	3,9%	7,8%
Public holiday	Frequency	8	17	25
	Percent	3,1%	6,7%	9,8%
No difference	Frequency	41	48	89
	Percent	16,1%	18,8%	34,9%
Total	Frequency	112	143	255
	Percent	43,9%	56,1%	100,0%

The most preferred seasons of the participants are autumn (35.5%) and summer (33.9%) (Table 4).

Table 4. Preferred seasons to go to the national park

Preferred seasons to go to the Kovada Lake National Park		Gender		Total
		Female	Male	
Spring	Frequency	33	51	84
	Percent	10,9%	16,8%	27,6%
Summer	Frequency	40	63	103
	Percent	13,2%	20,7%	33,9%
Autumn	Frequency	54	54	108
	Percent	17,8%	17,8%	35,5%
Winter	Frequency	5	4	9
	Percent	1,6%	1,3%	3,0%
Total	Frequency	132	172	304
	Percent	43,4%	56,6%	100,0%

The most preferred time period for participants to go to the national park is the afternoon (54.8%) (Table 5).

Table 5. Preferred time interval to go to the national park

Preferred time interval to g oto Kovada Lake National Park		Gender		Total
		Female	Male	
Before midday	Frequency	34	34	68
	Percent	13,1%	13,1%	26,3%
Afternoon	Frequency	61	81	142
	Percent	23,6%	31,3%	54,8%
Towards evening	Frequency	19	30	49
	Percent	7,3%	11,6%	18,9%
Total	Frequency	114	145	259
	Percent	44,0%	56,0%	100,0%

3.2.3. Duration of stay in the national park

The maximum duration of stay of the participants in the national park is 1-3 hours (50.4%) and 4-6 hours (39.2%) Table 6).

Table 6. Duration of stay in national park

Duration of stay in national park		Gender		Total
		Female	Male	
1-3 hours	Frequency	51	75	126
	Percent	20,4%	30,0%	50,4%
4-6 hours	Frequency	47	51	98
	Percent	18,8%	20,4%	39,2%
7-9 hours	Frequency	9	8	17
	Percent	3,6%	3,2%	6,8%
9 hours and more	Frequency	2	7	9
	Percent	0,8%	2,8%	3,6%
Total	Frequency	109	141	250
	Percent	43,6%	56,4%	100,0%

3.3. Perceptions and Attitudes Towards The National Park

3.3.1. Reasons for coming to Kovada Lake National Park

It was determined that the most common reasons why the participants came to the national park were to be in touch with nature (20.3%), to relax (12.4%) and to take a walk (12.2%) (Table 7).

Table 7. Reasons for coming to Kovada Lake National Park

Reasons for coming to Kovada Lake National Park		Gender		Total
		Female	Male	
To relax	Frequency	33	26	59
	Percent	7,0%	5,5%	12,4%
To enjoy	Frequency	19	21	40
	Percent	4,0%	4,4%	8,4%
Have a picnic	Frequency	26	24	50
	Percent	5,5%	5,1%	10,5%
To do sport	Frequency	6	9	15
	Percent	1,3%	1,9%	3,2%
Being in touch with nature	Frequency	40	56	96
	Percent	8,4%	11,8%	20,3%
Getting to know the region	Frequency	16	30	46
	Percent	3,4%	6,3%	9,7%
Take a walk	Frequency	27	31	58
	Percent	5,7%	6,5%	12,2%
To take photos	Frequency	23	24	47
	Percent	4,9%	5,1%	9,9%
Educational purposes	Frequency	18	18	36
	Percent	3,8%	3,8%	7,6%
Viewing the landscape	Frequency	11	15	26
	Percent	2,3%	3,2%	5,5%
Other (Observation of bird etc.)	Frequency	0	1	1
	Percent	0,0%	0,2%	0,2%
Total	Frequency	219	255	474
	Percent	46,2%	53,8%	100,0%

When looking at the reasons why visitors come to national parks in previous studies, it was determined that Tolunay et al. (2004) they came for the most picnic (85%); Karakaya (2019) have a picnic (68.2%); Kılıç (2020) landscape/landscape viewing (21.9%); Akten (2009) have a picnic (30%) and to relax (24%) purposes.

While the visitors coming for picnic purposes were ranked first in previous studies, it seems to be less preferred in this study. There were differences in the preferences of the participants. The biggest reason for this is that in recent years, desiring to experience natural beauties and find peace has increased in recent years, depending on the public's level of awareness. In addition, the idea of picnic activities in national parks causing forest fires and environmental pollution has become widespread among the public.

3.3.2. The preferred characteristics of Kovada Lake National Park

Among the most preferred features of the national park, the most popular ones are its calm and peaceful environment (27.9%), lake (26.0%) and landscape beauty (23.1%) (Table 8).

Table 8. Preferred characteristics of the national park

Preferred Characteristics of Kovada Lake National Park		Gender		Total
		Female	Male	
Landscape (Beauty of the landscape)	Frequency	61	61	122
	Percent	11,6%	11,6%	23,1%
Calm and peaceful environment	Frequency	67	80	147
	Percent	12,7%	15,2%	27,9%
Flora	Frequency	34	43	77
	Percent	6,5%	8,2%	14,6%
Its specific climate	Frequency	22	22	44
	Percent	4,2%	4,2%	8,3%
Lake	Frequency	63	74	137
	Percent	12,0%	14,0%	26,0%
Total	Frequency	247	280	527
	Percent	46,9%	53,1%	100,0%

3.3.3. Activities in the national park

The most common activities that participants do in the national park are nature and environmental trips (29.1%) and to relax (21.2%) (Table 9).

Table 9. Activities carried out in the national park

Activities in the national park		Gender		Total
		Female	Male	
Nature and environmental trips	Frequency	82	103	185
	Percent	12,9%	16,2%	29,1%
To relax	Frequency	62	73	135
	Percent	9,7%	11,5%	21,2%
Have a picnic	Frequency	47	58	105
	Percent	7,4%	9,1%	16,5%
Have a chat	Frequency	23	22	45
	Percent	3,6%	3,5%	7,1%
To do sport	Frequency	12	26	38
	Percent	1,9%	4,1%	6,0%
To take photos	Frequency	56	49	105
	Percent	8,8%	7,7%	16,5%
Listen to music	Frequency	7	6	13
	Percent	1,1%	0,9%	2,0%
Reading to book etc.	Frequency	6	4	10
	Percent	0,9%	0,6%	1,6%
Total	Frequency	109	141	250
	Percent	43,6%	56,4%	100,0%

In the activities that visitors do during their time in the national park; Karakaya (2019) defined as that visitors mostly come for recreational purposes (picnics, sightseeing) with a rate of 68.2%; Gül et al. (2006) defined as that visitors mostly come to the national park for picnics (39.7%), being in touch with nature (27.4%) and resting (5.1%), According to Kervankıran and Eryılmaz (2016), exploring nature and trekking; Akten (2009) defined that visitors engage in activities such as eating (21%), resting (19%), nature and environmental trips (15%), taking photographs (8%), and doing sports (3%).

In a research conducted in the national parks in our country, the density levels of recreational areas were examined and it was determined that 75.9% of the picnic areas were used intensively (Çoban, 2016).

3.3.4. Services and facilities that visitors see as missing in the national park

Services and facilities that visitors see as missing in the national park the most common are car parking areas (16.1%), picnic areas (12.3%), WC (11.4%) and children's playgrounds (10.8%) (Table 10).

Table 10. Services and facilities that are missing for visitors in the national park

Services and facilities that are missing for visitors in the national park		Gender		Total
		Female	Male	
Picnic areas	Frequency	45	43	88
	Percent	6,3%	6,0%	12,3%
Shopping units	Frequency	28	39	67
	Percent	3,9%	5,5%	9,4%
WC	Frequency	43	38	81
	Percent	6,0%	5,3%	11,4%
Children's playgrounds	Frequency	34	43	77
	Percent	4,8%	6,0%	10,8%
Campsites	Frequency	23	36	59
	Percent	3,2%	5,0%	8,3%
Water fountain	Frequency	21	27	48
	Percent	2,9%	3,8%	6,7%
Sports fields	Frequency	12	38	50
	Percent	1,7%	5,3%	7,0%
Lack of information boards	Frequency	30	34	64

	Percent	4,2%	4,8%	9,0%
Areas of car parking	Frequency	50	65	115
	Percent	7,0%	9,1%	16,1%
Administration building	Frequency	4	4	8
	Percent	0,6%	0,6%	1,1%
Trash bins	Frequency	35	21	56
	Percent	4,9%	2,9%	7,9%
Total	Frequency	325	388	713
	Percent	45,6%	54,4%	100,0%

When the studies are examined; similar results were encountered to the results of our study. Lack of social equipment elements in protected areas (information and direction signs, children's playgrounds and equipment, sports fields, garbage bins, WC, fountains, etc.) inadequate information service/consultation, and security deficiencies have been identified. (Düzgüneş, 2015; Yıldız, 2019; Kılıç, 2020; Akten, 2009; Gül et al., 2006).

3.3.5. Reasons affecting a long stay in a national park

The most common reasons why visitors not stay in the national park for a long time are; they indicated that inadequacy of time (20.4%), difficulty in transportation (15.1%), inadequacy of lighting elements (13.4%), inadequacy of buffets etc. (13.4%) and weather conditions (11.1%) (Table 11).

Table 11. Reasons affecting a long stay in a national park

Reasons affecting a long stay in a national park		**Gender**		**Total**
		Female	**Male**	
Transportation difficulty	Frequency	45	41	86
	Percent	7,9%	7,2%	15,1%
Weather conditions	Frequency	35	28	63
	Percent	6,2%	4,9%	11,1%
The crowd	Frequency	14	21	35
	Percent	2,5%	3,7%	6,2%
Being uncomfortable with those around	Frequency	6	13	19
	Percent	1,1%	2,3%	3,3%
The area is not safe	Frequency	8	11	19
	Percent	1,4%	1,9%	3,3%
Inadequacy of lighting elements	Frequency	30	46	76
	Percent	5,3%	8,1%	13,4%
Inadequacy of buffet etc.	Frequency	29	47	76
	Percent	5,1%	8,3%	13,4%
Inadequacy of time	Frequency	54	62	116
	Percent	9,5%	10,9%	20,4%
Not finding what you expected	Frequency	15	30	45
	Percent	2,6%	5,3%	7,9%
Uninhabited	Frequency	15	18	33
	Percent	2,6%	3,2%	5,8%
Total	Frequency	251	317	568
	Percent	44,2%	55,8%	100,0%

3.3.6. Thoughts regarding the functions in the national park

It was determined that the average of the values given by the participants to most of the expressions was under 2.5. These values under the 2.5 mean show that the participants agree with these expressions and consider them important. "Horseback riding routes should be created" (2,72) expression has the least value by the participants.

Table 12. Thoughts regarding the functions in the national park

Thoughts regarding the functions in the national park	Gender						Total		
	Female			Male					
	Mean	Std. Deviation	Var.	Mean	Std. Deviation	Var.	Mean	Std. Deviation	Var
Social facilities (buffets, restaurants, etc.) are inadequate.	1,9450	1,11251	1,238	1,9716	1,09508	1,199	1,9600	1,10057	1,211
The units in the picnic areas are inadequate.	1,9541	1,01275	1,026	2,1489	1,09503	1,199	2,0640	1,06227	1,128
Children's play areas and equipment are inadequate.	1,9450	1,06140	1,127	2,0780	1,02867	1,058	2,0200	1,04305	1,088
Trekking areas are irregular.	2,3303	1,13900	1,297	2,4043	1,16483	1,357	2,3720	1,15192	1,327
There are no activities related to sports fields.	2,0734	1,10308	1,217	2,0000	1,07571	1,157	2,0320	1,08614	1,180
There should be water sports (angling, pedal boating, etc).	2,3303	1,22516	1,501	2,4255	1,31058	1,718	2,3840	1,27241	1,619
Landscape viewing areas should be created.	1,7890	1,00989	1,020	2,0142	1,08881	1,186	1,9160	1,05898	1,121
Camping areas (with tents and caravans) should be created.	1,8807	1,00669	1,013	2,0780	1,14686	1,315	1,9920	1,09027	1,189
Educational activities related to nature should be organized.	1,5963	,73433	,539	1,8156	,98273	,966	1,7200	,88812	,789
Horseback riding routes should be created.	2,6881	1,38576	1,920	2,7589	1,30877	1,713	2,7280	1,34060	1,797

"Educational activities related to nature should be organized" the expression (1,72) has received the highest value by the participants. This is followed by the following preferences respectively;

- ✓ "Landscape viewing areas should be created." (1,91)
- ✓ "Social facilities (buffets, restaurants, etc.) are inadequate." (1,96)
- ✓ "Camping areas (with tents and caravans) should be created" (1,99)
- ✓ "Children's play areas and equipment are inadequate." (2,02)
- ✓ "There are no activities related to sports fields." (2,03)
- ✓ "The units in the picnic areas are inadequate." (2,06)
- ✓ "Trekking areas are irregular." (2,37)
- ✓ "There should be water sports (angling, pedal boating, etc.)."(2,38) (Table 12).

In the research carried out; It has been determined that children's playgrounds, recreation and excursion areas, sports areas, picnic areas and landscape viewing areas are inadequate in protected natural areas for visitors. (Alkan & Korkmaz, 2009; Düzgüneş, 2015; Gül et al. 2006, Akten, 2009). When compared to our study, similar results were observed. In addition, Alkan & Korkmaz (2009) defined in their study conducted in the same area that the people living in Isparta could not visit protected areas due to limited recreational activities, and that the visitors had to be content with just nature walks. It has been defined that it is possible to do angling in Kovada Lake, but this activity is prohibited. Managers associate the reason for not increasing the variety of recreational activities and not being able to establish facilities with the incompleteness of the area plans.

It has been determined that informative and promotional slide shows, voice-overs and promotional signs carried out by the park management in New York State Park and Rocky Mountains National Park are effective in increasing the awareness of visitors and their attitudes towards natural resources. It has been determined that visitor information activities are effective in reducing ecological and social impacts. (Manfredo, 1992; Cable et al. 1987).

3.3.7. Promotion, information, education, etc. of the national park management adequacy status of activities

"Is the national park management adequate in the promotion, information and education activities of the visitors“? it was determined that the most 38.4% of them gave the answer “not enough” to the question. (Table 13).

Table 13. Promotion, information, education, etc. of the national park management adequacy status of activities

Is the national park management adequate in information, promotion and training activities?		**Gender**		**Total**
		Female	**Male**	
Very Enough	Frequency	2	6	8
	Percent	0,8%	2,4%	3,2%
Enough	Frequency	11	17	28
	Percent	4,4%	6,8%	11,2%
Normal	Frequency	36	44	80
	Percent	14,4%	17,6%	32,0%
Not enough	Frequency	41	55	96
	Percent	16,4%	22,0%	38,4%
Never Enough	Frequency	19	19	38
	Percent	7,6%	7,6%	15,2%
Total	Frequency	109	141	250
	Percent	43,6%	56,4%	100,0%

In previous studies; It has been determined that the promotion and information activities of the national park management are inadequate. (promotion, information signs, services and facilities offered to visitors, parking, etc.) (Öztura, 2010; Düzgüneş, 2015; Yıldız, 2019; Kılıç; 2020; Akten, 2009).

Çoban (2016) asked the national park management whether slide shows were made for informative purposes to visitors. 48.7% of the national park management defined that this application was necessary but they did not implement it, 28.2% defined that they implemented it, and 23.1% defined that there was no need to implement it.

The reason why visitors find the national park management inadequate in promotional and informative activities is that internet promotions are inadequate, there are no activities for young people in the area, and education for national parks is not provided in schools. In order to create awareness about nature, public participation should be ensured by organizing activities such as promotions, exhibitions, brochures, tours and nature schools at visitor centers (Atik, 2005).

3.3.8. Materials that should be included in the national park for informational purposes

Visitors most preferred the materials "Map showing places to visit" (30.4%) and "Introductory signs on travel routes" (29.6%) (Table 14).

Table 14. Materials required in the national park

Which materials should be in the national park for informational purposes?		Gender		Total
		Female	Male	
Brochure / CD introducing the area	Frequency	43	54	97
	Percent	8,9%	11,2%	20,1%
A map showing places to visit	Frequency	65	82	147
	Percent	13,5%	17,0%	30,4%
Introductory signs on travel routes	Frequency	65	78	143
	Percent	13,5%	16,1%	29,6%
Lists of plants and animals	Frequency	34	23	57
	Percent	7,0%	4,8%	11,8%
Lists of birds	Frequency	14	25	39
	Percent	2,9%	5,2%	8,1%
Total	Frequency	221	262	483
	Percent	45,8%	54,2%	100,0%

3.3.9. Institutions and organizations that should take an active role in increasing visitor satisfaction in the national park

55.5% of the visitors think that the most important institution and organization that should take an active role in order to increase visitor satisfaction in the national park is the national park directorate (Table 15).

Table 15. Institutions and organizations that should take an active role in increasing visitor satisfaction in the national park

Institutions and organizations that should take an active role in increasing visitor satisfaction in the national park		Gender		Total
		Female	Male	
National park directorate	Frequency	99	108	207
	Percent	26,5%	29,0%	55,5%
Cooperatives	Frequency	16	18	34
	Percent	4,3%	4,8%	9,1%
Local tourism businesses	Frequency	30	40	70
	Percent	8,0%	10,7%	18,8%
District governorship	Frequency	24	38	62
	Percent	6,4%	10,2%	16,6%
Total	Frequency	169	204	373
	Percent	45,3%	54,7%	100,0%

In the study of Yıldız (2019), similarities were found in the direction that the national park management and district governorships should be more active in increasing visitor satisfaction. Additionally, Yıldız (2019) attracted attention that the media and local governments should also make efforts.

3.3.10. The state of meeting the expectations of the visit

The satisfaction levels of the visitors to the area were determined as; 56.0% “Met my expectations”, 39.6% “Below my expectations” and 4.4% “Above my expectations” (Table 16).

Table 16. The state of meeting the expectations of the visit

The state of meeting the expectations of the visit		Gender		Total
		Female	Male	
It was above my expectations	Frequency	4	7	11
	Percent	1,6%	2,8%	4,4%
It met my expectations	Frequency	64	76	140
	Percent	25,6%	30,4%	56,0%
It was below my expectations	Frequency	41	58	99
	Percent	16,4%	23,2%	39,6%
Total	Frequency	109	141	250
	Percent	43,6%	56,4%	100,0%

3.4. Differences Of Opinion According To The Educational Levels of The Visitors' Thoughts About The Functions İn The National Park

According to the results of the Kruskal-Wallis H test conducted according to the educational level of the participants;

- "The units in picnic areas are inadequate (tables, etc.)." (p =0,023<0,05).
- "Children's playgrounds and equipment are inadequate." (p =0,010<0,05) .
- "Trekking areas are irregular." (p =0,043<0,05) There were differences in terms of educational status at 0.05 significance levels in the expressions (Table 17).

Table 17. Differences of the functions in the national park according to the educational level

	Educational Level	N	Mean Rank	Kruskal-Wallis H	df	Asymp Sig.(P)
Social facilities are inadequate..	Literate	4	116,25	9,118	5	,104
	Primary Degree	27	105,48			
	High School Degree	60	118,17			
	Associate Degree	28	114,84			
	Bachelor's Degree	85	128,72			
	Postgraduate Degree	46	148,15			
	Total	250				
The units in picnic areas are inadequate (tables, etc.)	Literate	4	112,75	13,069	5	**,023***
	Primary Degree	27	96,89			
	High School Degree	60	121,27			
	Associate Degree	28	102,18			
	Bachelor's Degree	85	139,11			
	Postgraduate Degree	46	137,98			
	Total	250				
Children's playgrounds and equipment are inadequate.	Literate	4	94,00	15,168	5	**,010***
	Primary Degree	27	97,26			
	High School Degree	60	129,41			
	Associate Degree	28	95,55			
	Bachelor's Degree	85	133,44			
	Postgraduate Degree	46	143,27			
	Total	250				
Trekking areas are irregular.	Literate	4	122,50	11,480	5	**,043***
	Primary Degree	27	102,09			
	High School Degree	60	127,24			
	Associate Degree	28	96,57			
	Bachelor's Degree	85	139,72			
	Postgraduate Degree	46	128,57			
	Total	250				
There are no activities for sports fields.	Literate	4	116,88	9,182	5	,102
	Primary Degree	27	93,39			
	High School Degree	60	121,29			
	Associate Degree	28	119,93			
	Bachelor's Degree	85	135,95			
	Postgraduate Degree	46	134,67			
	Total	250				
There should be water sports (angling, pedal boating, etc.).	Literate	4	144,50	2,531	5	,772
	Primary Degree	27	114,04			
	High School Degree	60	128,93			
	Associate Degree	28	114,34			
	Bachelor's Degree	85	131,19			
	Postgraduate Degree	46	122,38			
	Total	250				
Landscape viewing areas should be created.	Literate	4	128,50	5,097	5	,404
	Primary Degree	27	116,04			
	High School Degree	60	138,73			
	Associate Degree	28	106,71			
	Bachelor's Degree	85	123,97			

	Postgraduate Degree	46	127,80			
	Total	250				
Camping areas (with tents and caravans) should be created.	Literate	4	153,00	4,005	5	,549
	Primary Degree	27	105,15			
	High School Degree	60	133,82			
	Associate Degree	28	123,64			
	Bachelor's Degree	85	126,12			
	Postgraduate Degree	46	124,20			
	Total	250				
Educational activities related to nature should be organized.	Literate	4	115,50	3,996	5	,550
	Primary Degree	27	128,94			
	High School Degree	60	138,09			
	Associate Degree	28	115,68			
	Bachelor's Degree	85	124,49			
	Postgraduate Degree	46	115,76			
	Total	250				
Horseback riding routes should be created.	Literate	4	130,63	5,320	5	,378
	Primary Degree	27	110,17			
	High School Degree	60	131,50			
	Associate Degree	28	103,86			
	Bachelor's Degree	85	132,98			
	Postgraduate Degree	46	125,58			
	Total	250				

***** $P<0,05$

When the average ranks were examined to determine the differences in opinion, differences were observed in terms of educational status. Located in the indicator;

- “The units in picnic areas are inadequate.” to the expression, It has been seen that individuals of all educational levels agreed with the expression. There were differences between individuals with primary education, associate degree, literate education and individuals with bachelor's degree and postgraduate degree education. Individuals with primary education, associate degree and literate education level are more likely to agree with the opinion that picnic units are inadequate. The reason for this difference is that people other than individuals with bachelor's degree and postgraduate degree education come to the national park for the purpose of having a picnic.
- “Children's playgrounds and equipment are inadequate.” to the expression, It has been seen that individuals with all educational levels agreed with the expression. Differences were observed between individuals who were literate, had an associate degree, primary education, and individuals with bachelor's degree and postgraduate degree education. Individuals who are literate and have an associate degree and primary education level are more likely to agree with the opinion that children's playgrounds and equipment are inadequate. The reason for this is that individuals who are literate, have an associate degree and primary education level, see the national park as a place to spend time with their children.
- “Trekking areas are irregular.” to the expression, It has been seen that individuals with all educational levels agreed with the expression. It is seen that individuals with associate degree education need more trekking areas than individuals with other education levels.

4. Conclusion and Suggestions

These areas, which have been declared national parks for their nature protection purposes and various natural-cultural values, provide opportunities for tourism / recreational activities. While the tourism and recreational activities offered provide economic benefits, the increasing number of visitors and demands are causing pressure on natural resources. After the recreational activities of the visitors;

pollution on the area, damaging the flora, disturbing the fauna, forest fire caused by carelessness after a picnic, compaction of the topsoil, etc. negative effects are observed.

Failure to control recreational uses and being insensitive in this direction negatively affect the values of natural and cultural resources. Although the balance between protection and use is emphasized in theory, it is seen in many examples that this balance is not be achieved in practice.

The management plans of Canada, America, Australia and European countries include *the management of natural resources* supported by scientific research (the status of the resources of the park, the importance of the area, the recreational activities carried out, the requests of the visitors, the orientation of the visitors on the area, visitor satisfaction, determination of priorities in management), *management plan, zoning, strategies, monitoring, reporting and evaluation processes*. In Turkey, there are long-term development plans in response to the management plans of these countries.

In his study examining Long-Term Development Plans, Cırık (2007) emphasized that the national park management described the Long-Term Development Plans as an inventory study, that they were not used actively, and that there were problems in the applicability of the plans.

The management plans included in the Long-Term Development Plan of Kovada Lake National Park, which creates the main material of our study, have been examined by considering the balance of protection and use in visitor management plans.

With the survey carried out in the area; some personal characteristics of visitors (gender, age, educational status, occupation, income status, residence), reasons for coming to the national park, area usage preferences, recreational activities in the park, missing services and facilities , situations that prevent spending time in the area for a long time, institutions and organizations that should play a role in increasing visitor satisfaction, whether information activities in the area are sufficient and the materials that should be available, determining the opinions about the functions in the national park, and identifying differences or similarities of thoughts in this context, solutions and suggestions can be developed.

As a result of the preferences of the participants, it is understood that the national park management is inadequate in information, promotion and educational activities. In the study we have conducted, it has been determined that there are no educational activities related to nature. In order to meet the demands of visitors in this direction the protection of natural and cultural resources, the activities carried out, the feature of being a national park (endemic species, historical aspect, etc.) computer-aided information systems on topics such as, informative visual materials (brochures, audio and visual messages, animated videos, etc.), should be prepared. In terms of the definition of the area, there should be a consultation/information unit and activities should be created here at certain times to raise awareness, especially for children.

Alkan & Korkmaz (2009) defined that the lake is the most important resource value of Kovada Lake National Park in their studies where they evaluated the national parks of Isparta province. They also determined that the most damaged resource in the national park was the lake and that the protection activity for this situation consisted only of a hunting ban. They also emphasized that the wastes coming from the Kovada Canal continues to pollute the lake.

In the studies carried out; It has been determined that visitor activities damage vegetation and wildlife, pollute the environment and cause loss of biodiversity. (Özvan, 2020; Çoban, 2016; Düzgüneş, 2015; Yıldız, 2019; Albayrak, 2010; Akten, 2009; Kılıç, 2020).

As a result of the activities of visitors in camping areas in America's Isle Royale National Park, there has been a decrease in the vegetation on the soil surface. Studies have been carried out to reduce these effects. As a result of this study, it was defend that taking into consideration the size of the area, it is necessary to limit the size of the group in accordance with ecological and social carrying capacities (Marion & Farrell, 2002).

The visitor density in Huangshan National Park, known as Yellow Mountain in China, at certain periods has caused a decrease in visitor satisfaction. Studies have been carried out to reduce the density of visitors in the national park. In order to ensure the equal distribution of visitors to the national park in terms of time and space within the borders of the national park, to carry out information and educational activities, to make differences in price applications, etc. with various methods, it has been tried to reduce the density in the national park. This has also ensured to increased in visitor satisfaction (Yang & Zhuang, 2006).

There is a need to limit the number of visitors in protected areas during periods when the number of visitors is high. Visitor management tools should be used for limitation work. In addition to reducing the density of visitors, limitation provides benefits in protecting and ensuring the sustainability of natural and cultural resources and increasing the quality of visitor experience (Yang & Zhuang, 2006).

Our recommendations regarding the findings obtained as a result of the survey are;

- Ecotourism activities carried out uncontrollably without a specific plan threaten the values of natural and cultural resources, causing irreparable damage and subsequent depletion. In order to ensure sustainability, the requests and demands of visitors should be included in planning and management decisions.
- Long Term Development Plans of the national parks in our country have been made. However, in the Long-Term Development Plans of most national parks, there are no visitor management, strategies, management tools and recreational carrying capacity analyses. There is a visitor management plan in Kure Mountains National Park, Sultan Sazlığı National Park, Ilgaz Mountain National Park. There is no visitor management plan in the Kovada Lake National Park Long-Term Development Plan. Adequate budgets should be allocated by the relevant ministries and directorates, recreational carrying capacity analyses should be carried out by forming teams from different disciplines, and visitor management plans should be created.
- Access to the parking area is difficult for those who do not have a private car. For this reason, public transportation facilities should be provided during certain periods when visits to the park increase (in summer and autumn months).
- Kovada Lake National Park has not been able to effectively evaluate the recreational potential it has. The presence of water and forest landscape in the park area is an opportunity for recreational activities. Visitors to come to the area can mostly make picnic and trekking activities. This situation affects the number of visitors and the quality of visitor experiences. Taking into consideration the potential situation of the area, recreational activities should be diversified (camping activities with tents and caravans, angling, mountaineering, mountain biking, etc.).
- The natural landscape values of the national park are the presence of forests and lakes. By taking advantage of the active topographic structure of the area, new travel routes and observation terraces should be built at the dominant points of the landscape beauty, in addition to the existing trekking and viewing areas.
- The walking path around the lake is made of wooden platforms and is suitable for use. But at a certain point, this platform ended. Other parts of the area are stony and it is difficult to walk. In the planning, designs should be made, especially considering the visits of disabled citizens to the area. The way to the observation terrace should also be arranged.
- There are no sports areas and recreational activities related to sports in the national park. Taking into consideration the requests of visitors, recreational activities should be included in accordance with the potential of the area.
- The caution signs showing the way to the walking path and the observation terrace are broken and not mounted on the ground. It has ensured to stand upright by placing stones around it.

It is in a situation where we can take it with hand and place it in a different point. In such a case, visitors may go to a different destination. Repairs should be made and made functional.

- It has been determined that some information boards in the area are empty. Appropriate visual materials should be prepared and placed on the boards.
- The zoning method should be used to determine the effects of recreational activities and to prevent the spread of these effects. The division of the park into zones in management decisions should be made by experts, taking into consideration ecological and biological factors.
- The lack of regular parking areas in the national park area causes irregular parking. As a result of irregular parking; effects such as reduce in visual quality, visual pollution, degradation of vegetation and soil compaction are observed. Visitors to come to the area expressed the problems they had with parking due to the lack of car parking areas. In order to eliminate these problems, regular car parking areas should be built.
- The lack of social equipment in the park area is among the requests and demands of visitors. Deficiencies in this regard should be eliminated.
- Educational activities related to nature should be organized and promotional activities should be carried out in order to raise the awareness and inform visitors about the use of the park. In the survey results, the requests of the visitors in this regard have in the first. For the promotion of the area; brochures, guidebooks, magazines, promotional publications, information signs, visual and audio messages, animated videos, websites should be prepared and updated at certain period of time. During the planned time periods, various activities and visual short cartoons should be prepared, especially about instilling a love of nature to children and nature protection.
- A consultation/information center should be established to promotion the park and to provide the requests and demands of visitors. In addition, request and complaint boxes should be installed to collect visitor opinions. This center should be responsible for enriching the area with information boards and caution signs, and updating the boards at certain periods. Solution-oriented service should be provided to the problems encountered by visitors. It should serve as a bridge in transferring visitor requests to management plans and studies.
- Intensive use of the lake surroundings, which reflects the characteristic feature of the park, increases pollution. Necessary measures should be taken to eliminate the factors causing pollution or reduce the effects.
- Recreational activities around the lake should be carried out considering the habitats of aquatic creatures and planned so that the living creatures are not affected.
- The picnic units in the wooded areas and around the lake are worn out due to long-term use or other reasons. In the field studies we have carried out, it has been seen that some units are broken and shaking. The use of these units is dangerous. Those that are unusable should be rebuilt, and those that need to be repaired should be repaired in a way that does not harm the natural structure and aesthetics of the park.
- Some of the plants in the park have been tagged in the area for promotional purposes. But there are inaccuracies in the Latin names of these tags. These should be fixed and the necessary repairs should be made to non-functional tags.
- It has been seen that the swings in the children's playground located at the entrance of the park were unbalanced and their chains were rusty. Additionally, only 2 swings are not enough for the area. The children's playground should be maintained and the area usage capacity should be determined and increased in number.

- When the distribution of existing uses is examined, it is seen that usage increases especially in autumn and summer months. In order to reduce the seasonal pressure on the area, the area should be planned in such a way that it can be used in all seasons.

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All authors contributed equally to the article contributed. There is no conflict of interest.

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Stormwater Management and Green Infrastructure Suggestions for Sustainable Campus; Example of Yozgat Bozok University Campus

Melek KAPLAN [1]*, Kübra YAZICI [2]

ORCID 1: 0000-0003-4667-0328, **ORCID 2:** 0000-0002-6046-1648

[1] *Yozgat Bozok University, Graduate Education Ens., Department of Agricultural Sciences/ Directorate of Construction Works, 66100 Merkez, Yozgat, Türkiye.*

[2] *Yozgat Bozok University, Faculty of Agriculture, Department of Landscape Architecture, 66100 Center, Yozgat, Türkiye.*

***e-mail**: k-yazici-karaman@hotmail.com*

Abstract

Due to concrete structures, transportation networks, and impermeable surfaces, the overpopulation of cities makes it difficult for water to filter through the soil. Cities, in particular, disrupt the natural cycle of rainwater, leading to surface runoff. As a result, the soil skips the stages of water filtering, feeding the groundwater, evaporating, and returning to the atmosphere, leading to an increased frequency of floods that are not part of the hydrological cycle. One of the alternative solutions to global warming is the green infrastructure system. Practices such as rainwater collection systems, water recovery technologies, and the development of irrigation systems ensure efficient use of water resources and prevention of water pollutiYozgat Bozok University Campus has planned for a sustainable campus from a green infrastructure perspective, and has presented a master plan that addresses issues like rainwater management, wastewater recovery, solid waste recycling, and the qualities and quantities of campus open-green areas. The study involved landscape planning, the identification of rain harvesting areas for the campus, which is currently facing a water shortage, and the presentation of plant preferences and water-efficient solution suggestions for the region.

Keywords: *Landscaping,stormwater management, planning.*

Sürdürülebilir Kampüs için Yağmursuyu Yönetimi ve Yeşil Altyapı Önerisi; Yozgat Bozok Üniversitesi Kampüsü Örneği

Öz

Kentlerde aşırı nüfus artışyla birlikte beton yapılar, ulaşım ağları ve *geçirimsiz yüzeyler sebebiyle suyun toprak içerisinde süzülmesi zorlaşmaktadır.Özellikle kentlerde yağmur suyunun doğal döngüsü bozulmakta ve yüzey akışı gerçekleşmektedir. Bu nedenle suyun toprak tarafından filtrelenerek yeraltı suyunun beslenmesi ve buharlaşıp atmosfere geri dönmesi aşamaları atlanarak hidrolojik döngüde yeri olmayan sel vb. taşkınlarla artık daha çok karşılaşılmaktadır. Küresel ısınma ile alternatif çözümlerden biri de yeşil altyapı sistemidir. Yağmur suyu toplama sistemleri, suyu geri kazanma teknolojileri ve sulama sistemlerinin geliştirilmesi gibi uygulamalarla, su kaynaklarının verimli bir şekilde kullanılması ve su kirliliğinin önlenmesi sağlanmaktadır. Bazı mevcut uygulamaların yer aldığı Yozgat Bozok Üniversitesi Kampüs'ünde yeşil altyapı perspektifinden sürdürülebilir bir kampüs için planlama yapılmış, yağmur suyu yönetimi, atık suların geri kazanılması, katı atıkların geri dönüştürülmesi, kampüs açık-yeşil alanların nitelikleri ve miktarları gibi konularının ele alan master planı ortaya konulmuştur.Çalışmada peyzaj planlama yapılmış, mevcutta su sıkıntısı yaşan kampüs için yağmur hasadı yapılacak alanlar belirlenmiş, az su isteyen bölgeye uygun bitki tercihi ve çözüm önerlileri sunulmuştur.*

Anahtar kelimeler: *Peyzaj, planlama, yağmur suyu yönetimi.*

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1. Introduction

Since the beginning of time, humans have been focusing on development, change, and consumption, which they have accelerated over time to meet the increasing needs of themselves and their environment. Rapid population growth has led to an imbalance in the scales of development, change, and consumption, resulting in unconscious consumption. Initially, this imbalance did not appear to pose a threat. Then it has become increasingly evident for a more comfortable life, the activities of individuals, and nations due to their selfish desires. For example, various problems such as environmental pollution, global warming and climate change, unconscious consumption of water resources, floods, drought, epidemics, wars, urbanization, migration, and noise pollution have made the world more dangerous (Malkoç True & Kılıçarslan Deniz, 2012; Benison & Payne, 2022; Çon & Polat, 2020). These circumstances have prompted contemplation on the necessary steps to mitigate and avert these issues. These problems could affect human life and the continuity of ecological life. Therefore, the concept of sustainability has gained importance worldwide.

Sustainability is a type of system created against the threats of the decrease and disappearance of the resources used by all living things interacting with each other in the ecosystem in the world today and in the future (Gülgün et al., 2014; Öktem, 2016; Özdal Oktay & Özyılmaz Küçükyağcı, 2015; Aşur et al., 2022; Altuğ & Malkoç True, 2021). Sustainability plays an important role in protecting natural resources, improving the damaged ecosystem by conserving energy, creating social and economic welfare, and social participation (Qadis et al., 2019; Yazici et al., 2018; Gülgün & Yazici, 2016; Gülgün & Akça, 2020; Bertiz et al.,2019; Yazici & Gülgün, 2017). With the roles it has assumed, the importance of sustainability has increased and become a goal of many reports, conferences, agreements, institutions, and organizations aimed at sustainability by real and legal persons. Green infrastructure systems serve the protection, development, and support of urban ecosystems by connecting green areas in the city, reducing flood risk through natural drainage, promoting climate quality, and addressing various other issues. In recent years, green infrastructure has become a widely used strategic approach in sustainable land use, providing alternative solutions to ecological, social, and environmental problems worldwide (Ak & Güneş Gölbey, 2021; Ak, 2022). This approach refers to a holistic system of natural, semi-natural, and artificial functional ecologic factors at all spatial scales in and around urban areas (Tzoulas et al. 2007).

According to Benedict and McMahon (2002), green infrastructure is a system of interconnected natural areas and open spaces that could protect ecosystem values and help maintain clean air and water for people and wildlife. Derse (2023) defined the green infrastructure system as a network that enhances human welfare and quality of life, strategically planning the environmental characteristics of outdoor green spaces to provide ecosystem services. The green infrastructure system supports the ecosystem in many ways. Urban streams are basic green infrastructures that form the ecological backbone within the urban fabric, protect biodiversity and species movements, and create green corridors and connections with natural systems in the urban periphery. Individually, they serve as the green veins of the city, but when combined with an integrated approach, they create ecological corridors that connect the green infrastructure units surrounding them to the natural systems in the city's periphery. Green infrastructure offers many advantages in terms of being ecologically based, practical and applicable, innovative, multidisciplinary, and protecting public health. However, it also presents certain challenges, such as the need for coordinated efforts with all stakeholders and the inability of different professional groups to demonstrate the same level of sensitivity towards the subject from a multidisciplinary standpoint. This study developed a landscape master plan for a campus, taking stormwater management into account. Due to the intense increase in urbanization, cities are facing significant challenges in protecting and effectively using water, a basic natural resource essential for the continuation of vital activities. Compared to rural areas, cities have impervious surfaces that reduce water infiltration. Therefore, groundwater and soil recharge are significantly reduced (Vanwoert et al., 2005; Ekşi et al., 2016).

When the precipitation passes through the surface runoff, it carries various pollutants to the receiving environment. Urban designs based on the current understanding of urbanism either prevent or incompletely disrupt the hydrological cycle of water (Vanwoert et al., 2005). Depending on the type of receiving environment, precipitation, which should move in the hydrological cycle, reaches the gutters from the roofs, from there to the sewage system and concrete channels, and then to the water basins such as rivers, lakes, and seas (Figure 1).

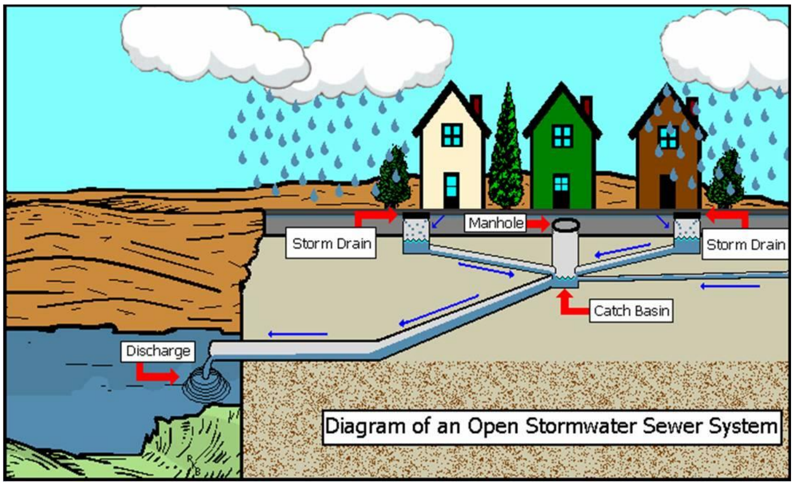

Figure 1. An example of stormwater management (Town of Sweden, 2024)

According to Ekşi et al. (2016), the hydrological cycle no longer accommodates the stages of water filtering by the soil, feeding the groundwater, evaporating, and returning to the atmosphere, leading to an increased frequency of floods. In another study, Saygın & Ulusoy (2011) presented a strategy for the use of low-cost and green infrastructure elements that will contribute to the ecosystem and ensure that rainwater is recycled to serve different purposes (toilet reserves, irrigation, recreation corridors, landscaping elements, etc.) on the land where it falls instead of being classified as a waste and produced recommendations that will guide the implementation of these strategies. Coşkun Hepcan & Hepcan (2018) emphasized that in areas with a large extent of irregularly distributed parts and corridors within the urban development area, the continuity in the landscape between them is low. Hepcan & Hepcan (2018) revealed the importance of a green infrastructure system in cities, highlighting specific green areas that can significantly contribute to the urban ecosystem when used appropriately to establish a green infrastructure system in the future. We conducted this study with the aim of fostering a sustainable environment on campuses. The green infrastructure proposals on the Yozgat Bozok University campus provided similar results and recommendations. The topographical structure and ecology of the land are important determinants in planning. Summarizing the findings from this research reveals the absence of a green infrastructure system on campus, insufficient open and green areas in the campus landscape, and no green areas suitable for inclusion in the green infrastructure system on the city's periphery. We provide stormwater management solutions and recommendations based on our examination of Yozgat Bozok University's Central Campus. The university designed and planned its master plan for a sustainable campus, addressing issues such as reducing carbon footprint and climate change, managing rainwater, recycling wastewater, recycling solid wastes, and increasing the number of open-green areas on campus.

2. Material and Method

The main material of the study consists of Erdoğan Akdağ East Campus and Bilal Şahin West Campus of Yozgat Bozok University (Figure 2), which was founded within the borders of Yozgat province. Yozgat, where the university is located, is in the Bozok plateau and the Central Kızılırmak section of Central Anatolia. It has neighboring provinces such as Kayseri, Sivas, Nevşehir, and Çorum. It is a city with a surface area of 14.074 km2 and a population of 418,442. In 2006, Yozgat Bozok University officially established its infrastructure; Erciyes University followed suit in 1982, and YOBU began as Yozgat Vocational School. Gazi University established a second vocational school in 1989. Currently, there are 14 faculties, 4 schools, and 8 vocational schools. Additionally, YOBU boasts 23,877 students, 964 academic staff, and 1140 administrative staff (Figure 3).

Erdoğan Akdağ East Campus and Bilal Şahin West Campus currently have 14 Faculties, 1 College, 1 Vocational School, 2 Institutes, 1 Research and Application Hospital, 1 Technopark, 1 laboratory building, 1 Science and Technology Application and Research Center, 1 Career Center building, 1 Guest House, 1 Central Dining Hall, 1 Central Library, 1 Mosque and Complex, 1 Practice Mosque, 1 Cannabis Building, 1 Congress and Culture Center, 1 market, 2 restaurants, 1 café that has not yet been opened, 1 gymnasium, 1 Male Student Dormitory, 1 Female Student Dormitory, 1 gymnasium, sports complex (football field, outdoor tribune, indoor astroturf field, basketball court) affiliated to the Credit Dormitories Institution (Yozgat Bozok University Report, 2022). The campus is located on a 4,070,000 m^2 area. Yozgat Bozok University Campüs consists of Erdoğan Akdağ East Campus and Bilal Şahin West Campus because it is divided by highways. The campus is approximately 1300 m above sea level.

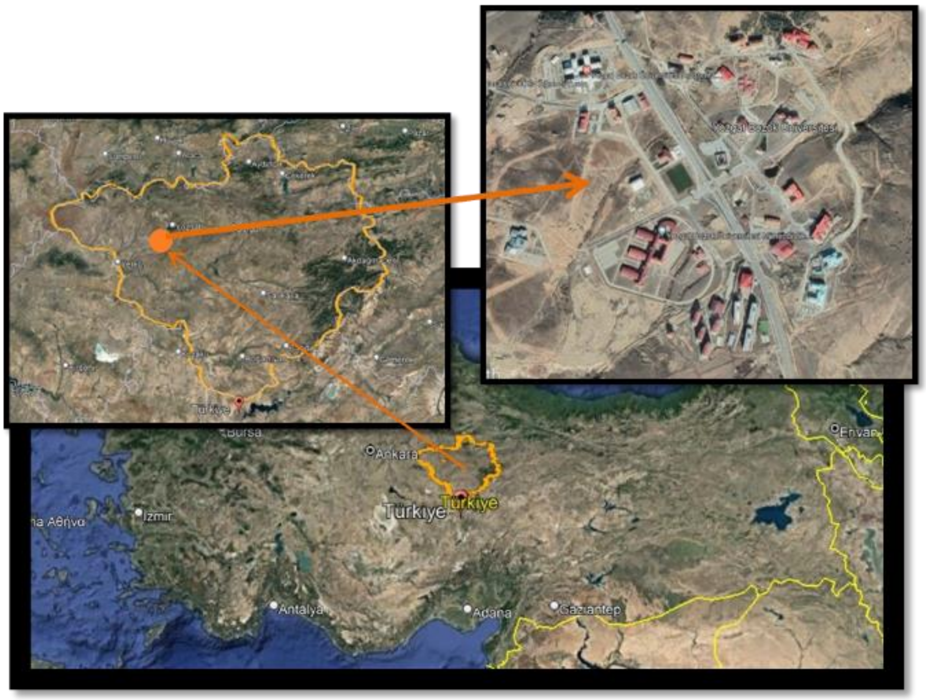

Figure 2. Yozgat Bozok University Satellite image (a) (Yozgat Bozok Üniversitesi Report, 2022)

Figure 3. General view of Yozgat Bozok University (b) (Yozgat Bozok Üniversitesi Report, 2022)

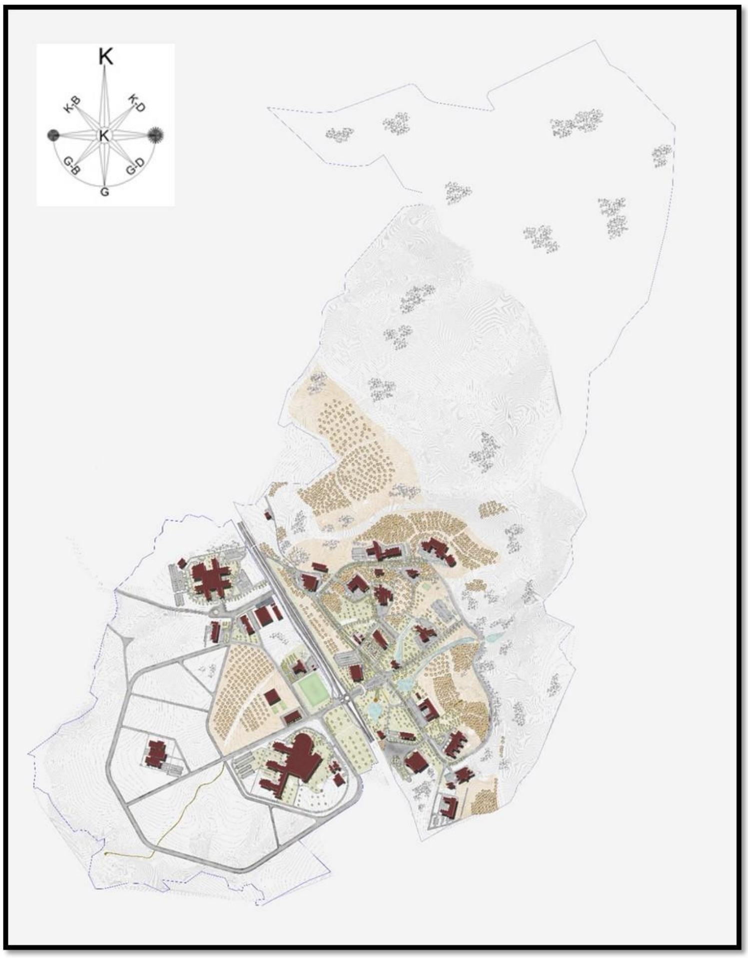

Figure 4. Yozgat Bozok University master plan

The other materials of the study consist of photographs of YOBÜ Erdoğan Akdağ East Campus and Bilal Şahin West Campus (Figure 4), as well as plans, various reports, and digital resources including the study area. We conducted the study between 2022 and 2023. Following the theoretical literature research, data on the study area were collected to prepare the landscape master plans of Yozgat Bozok University Erdoğan Akdağ East Campus and Bilal Şahin West Campus. We obtained the necessary data to understand the geographical and environmental conditions of the area. We conducted on-site observations in the study area and took photographs to depict the current situation.

3. Findings and Discussion

A water collection pond with a depth of approximately 10 m collects the stream inside the campus. There are two pools and ponds suitable for water storage on the campus. Despite this, the campus lacks a green infrastructure system, and the quantity of open and green areas within the urban landscape remains inadequate. Appropriate use of the area to establish a green infrastructure system will enhance its contribution to the urban ecosystem. This study planned green areas, rainwater storage, and rainwater harvesting, and presented recommendations accordingly. One of the most effective tools for addressing existing issues in ecosystem services in countries like Turkey is a rain garden. In this study, like Özdoğan & Akpınar (2023), it was important to choose a university campus as a study area to show that rain gardens are an important part of life by showing that both young people and academicians live in close contact with these systems and to be the most suitable area for a prototype area. Research should explore the potential for establishing rain gardens on a regional scale in our country, similar to studies conducted abroad. Future studies should also investigate the volumes of rainwater infiltration and redistribution by rain gardens. Considering the deficiencies, the proposed master landscaping plan covering the landscape area is shown in Figures 5 and 8. The Yozgat Bozok University campus area, with its large surface area, divides the proposed master project into layouts, as depicted in the figures. Rocky ground is quite common in the campus area. The project places rocks in a representative manner to demonstrate their presence. A nature walking path circulation has been designed for the campus users to take a tour of the forest area to be created. In the forest fires experienced in the past years, thousands of hectares of land could not be prevented from burning due to the lack of strips that cut the connection between the plants in the forest areas to prevent fires. The General Directorate of Forestry plans to build fire safety lanes, as specified in their application principles, to prevent and extinguish forest fires in the future.

Figures 5 and 8 show the forested areas created with the proposed master plan. We have designed natural areas at specific locations, along with active areas that campus users can utilize. The plan places roads and fire safety lanes in forest areas. The plan also incorporates nature walking paths to access all desired areas on the campus. The planning of natural water collection areas, considering the land's slope, aims to create a campus that is both conducive to living and proficient in battling forest fires. The nature walking paths, fire safety, and road lanes shown in Figures 6 and 7 are located throughout the campus.

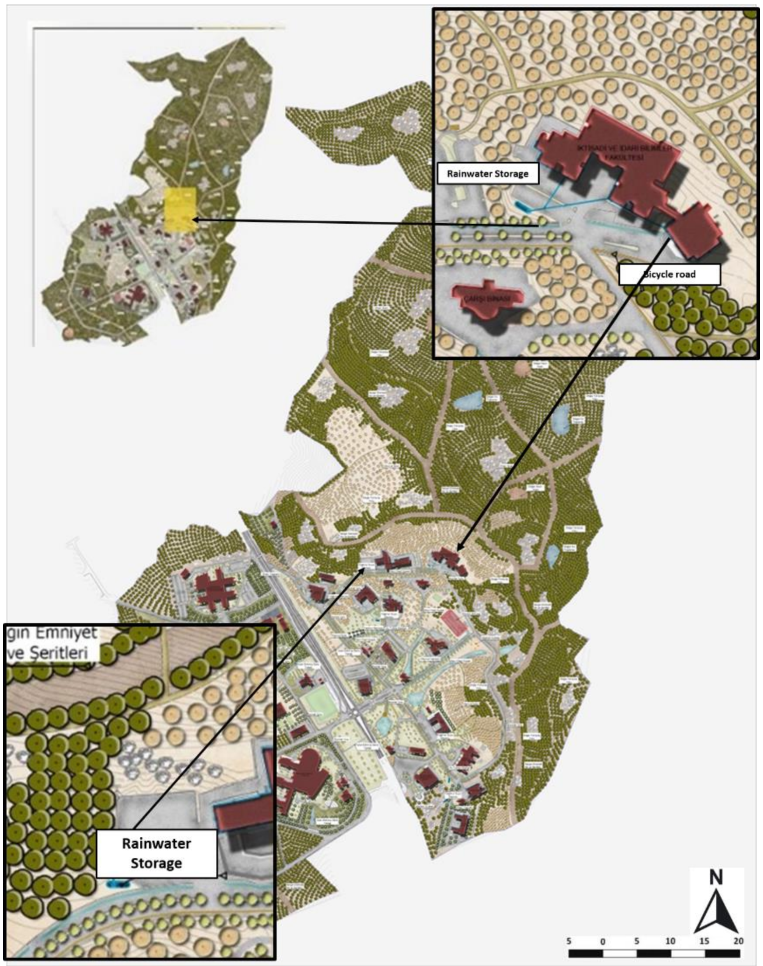

Figure 5. An example of stormwater management for Yozgat Bozok University (Layout 1)

Given the impact of global warming on the world, and the imminent end of this period known as the global boiling age, the university campus has planned rainwater collection tanks with sufficient capacity around the buildings to minimize water loss and adapt to the changing times. Leafy and coniferous trees (*Pinus nigra*, *Robinia pseudoacacia,* which grow naturally and do not require maintenance in the region) are planted in areas around the campus where there is no landscaping study. The goal was to observe the impact of the four seasons and provide benefits to the campus residents. Figure 8 shows the transformation of existing unused parking lots into activity workshops, providing campus residents with indoor social spaces for their use. We design observation towers taking into account the land's elevation difference. Saygın & Ulusoy (2011) stated that the problem should be recognized before planning in the area. We carried out planning in accordance with the problem and needs identified in this study. We planned rain gardens in some areas, considering the land's slopes and on-site observations. The designated areas were determined at the points where the elevation difference of the areas connected to the hard ground where there is a slope affects the surface flow. We used the location of existing coniferous trees, which are suitable for the region. These plants are already present. Due to its low water demand, the project has continued in unplanted areas. We have created water retention areas to collect surface water and enhance the campus's aesthetic appearance. Observations reveal that the existing water in the area has carved out a haphazard path. The master plan aims to rehabilitate these waterways, integrate them into the landscape, and create a habitat for living creatures. Figure 6 depicts the continuation of rainwater harvest, blue-green application, bicycle paths, walking paths, and stream rehabilitation on the university's west campus. Figure 7 shows the planning of a recreational park for hospital users, students, and staff, with careful consideration of its proximity to the research hospital. Another study similar to this study, Artar et al. (2019), emphasized that universities have innovative features and pioneering roles in society. Every year, the Bartun University Kutlubey Campus undergoes development with the addition of new buildings and a changing landscape. Sustainability practices used within the scope of the proposed project will contribute to the spread of a sustainable lifestyle in society. To support this statement, Yozgat Bozok University is also open to development and needs to adapt to climate change. Adaptation of campuses to climate change is easier to plan and implement than in cities. Even though campuses are typically located far from the city center, they still provide the services necessary for the city concept.

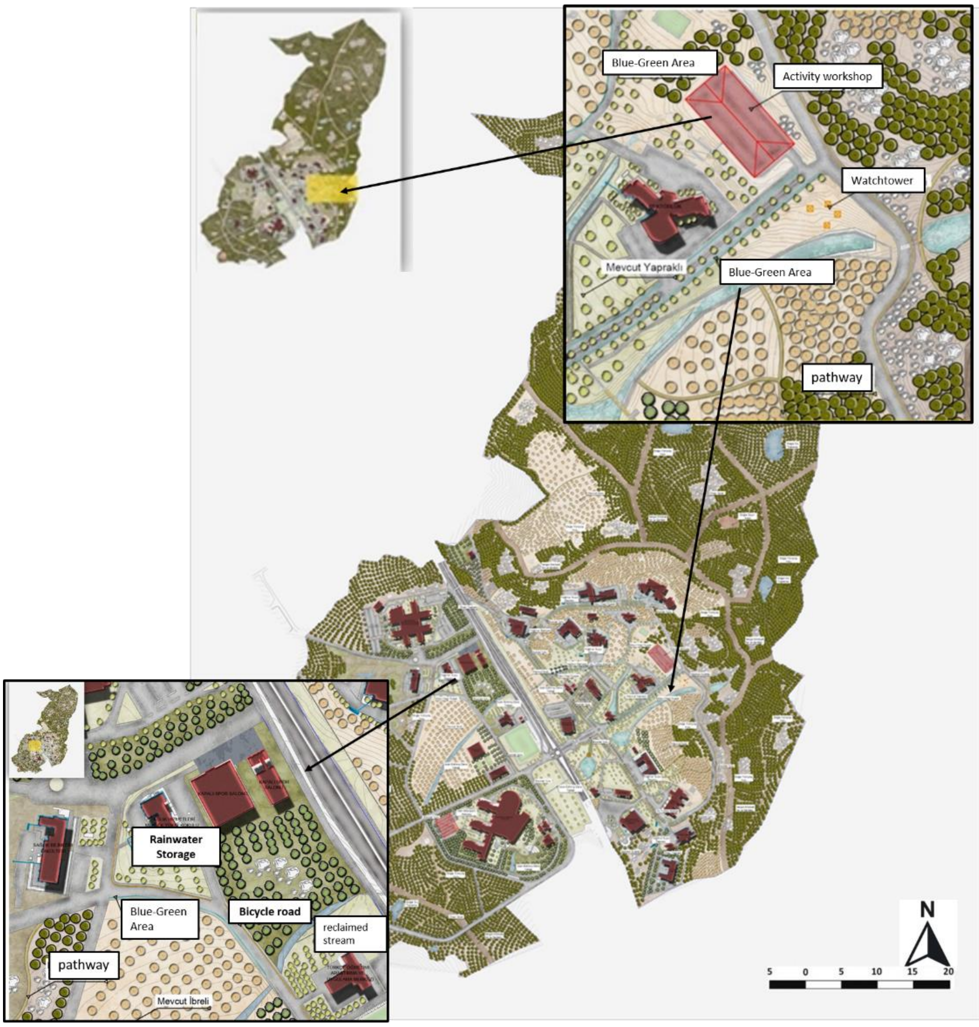

Figure 6. An example of stormwater management for Yozgat Bozok University (Layout 2)

In figures 6 and 8 have been shown the planning of bicycle paths, forest nature walkways, fire safety roads and lanes, rainwater storages, a water collection area, a watching tower, and rehabilitated stream beds throughout the campus. The project incorporates both existing and planned plants. Yozgat Bozok University Campus is unique in incorporating the aesthetic appearance of green rocks into the campus landscape. Figure 6 showed that the placement of the watch tower atop the rocks. Coşkun Hepcan & Hepcan (2018) emphasized the crucial role of planning open and green spaces in implementing environmentalist approaches. Open-green areas produced through planning will be much more functional in terms of many ecosystem services functions, such as wildlife protection and development and rainwater management, and would serve as a backbone in and around the city.

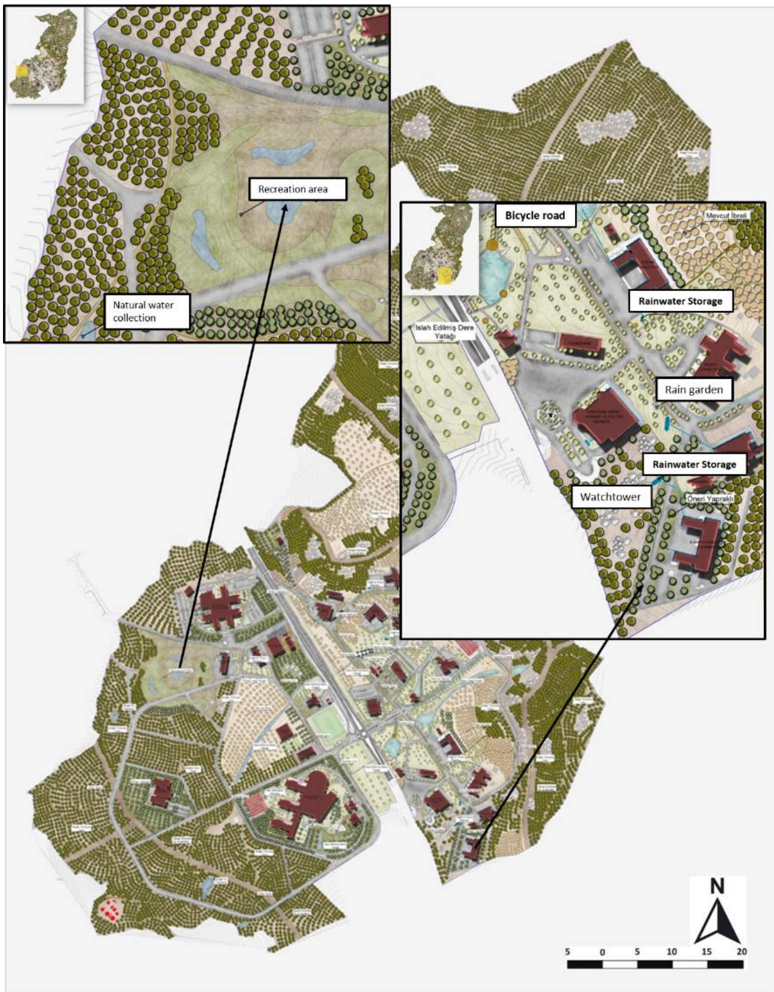

Figure 7. An example of stormwater management for Yozgat Bozok University (Layout 3)

The green infrastructure system, which aims to connect large and small open-green areas in the city within an integrated framework, has proven how successful it is with examples of applications in the world. This study aims to provide an evaluative perspective on the concepts of rain harvesting, green infrastructure, and stream rehabilitation, with a focus on the rehabilitation of urban streams using a green infrastructure approach. Figures 6 and 7 show the study area. Figure 8 shows the green infrastructure applications proposed in rehabilitation and restoration projects. Tülek & Ersoy Mirici (2019) Integrating green infrastructure studies that provide ecosystem services into urban planning levels can lead to a more sustainable urban ecology. In this study, rain harvesting areas were planned in areas with high slopes on the campus where water storage areas were created with connected pools. This planning approach is ecologically appropriate for the region. According to Bastian et al. (2012), ecosystem services offer a crucial viewpoint for ensuring the long-term viability of green infrastructure in providing amenities. The examples given are very weak.

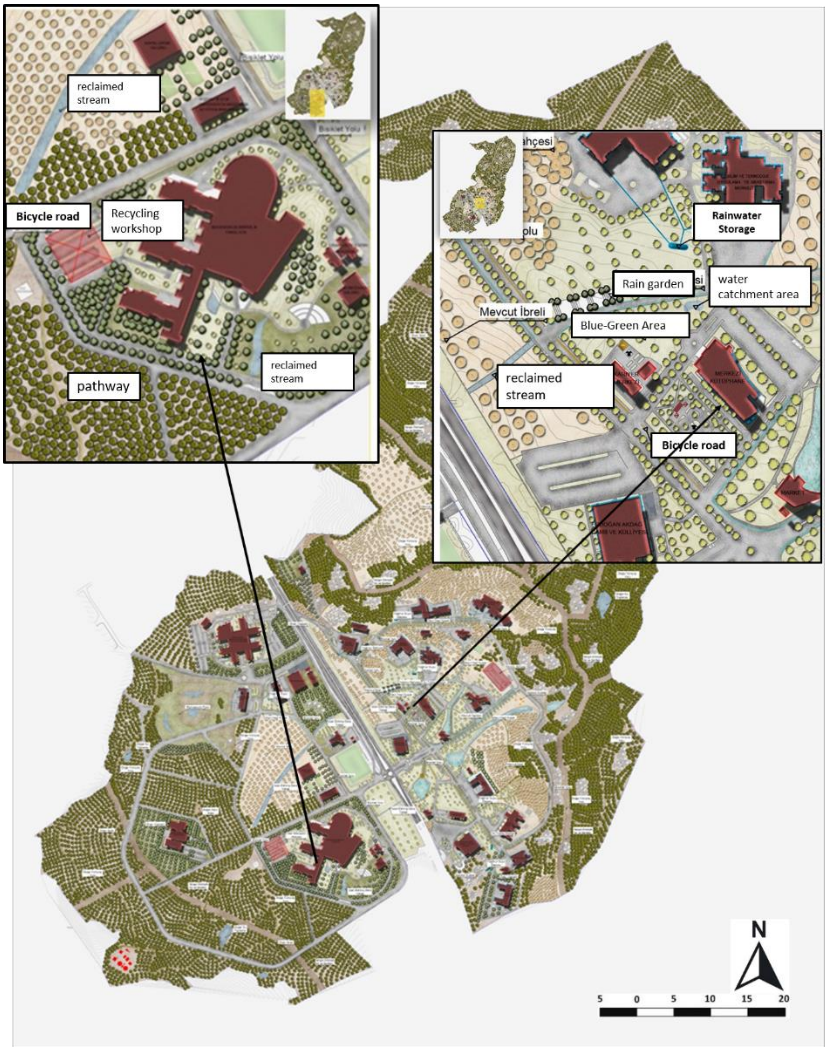

Figure 8. An example of stormwater management for Yozgat Bozok University (Layout 4)

Simultaneously, the Yozgat Bozok University was incorporated rain gardens, rain ditches, water retention areas, and green roof applications into its rehabilitation project, despite not currently using them. Aksu (2022) posited that an ecological approach should guide campus management, allowing for an evaluation of the area's features. This study approached planning holistically. Özdoğan & Akpınar (2023) designed a rain garden parking lot. In addition, we designed a car washing station and a greenhouse facility in the area to generate financial resources from the rain garden designs. We have developed systems that rely on rain gardens to supply their water needs. Therefore, the design of rain gardens plays a crucial role in enhancing the university campus's natural appearance, preventing surface runoff, and effectively storing and utilizing rainwater. This study adhered to the planning recommendations from Figure 5 to Figure 8. In addition, Samancı & Karadağ (2024) emphasized that the location of the green areas to be created in the region, where vegetation is important in green infrastructure works, should be compatible with the region and cut cold winds. This study recommends planting plants in open parking lots, as they serve a natural shading function. They emphasized that afforestation can provide permeable surfaces for rainwater on hard surfaces.

4. Conclusion and Suggestions

One of the most important factors in climate change is the surface characteristics of cities (Toy & Esringü, 2021). Impervious surfaces increase with urbanizationin urban areas . Impervious surfaces negatively affect the functions and benefits of ecosystems in cities (Pataki et al., 2011). The lack of green spaces disrupts ecosystem balance, leading to the loss of habitats for plant and animal species, reduced biodiversity, and decreased air quality by increasing pollution (McKinney, 2008; Wojnowski et al., 2022). When green areas are not taken and new fields are created, it increases the heat island effect and the amount of carbon released into nature (Demirbaş & Aydın, 2020). The density of built-up and paved areas, caused by rapid growth, reduces open green areas. Uncontrolled migrations, stemming from various dynamics such as food crises, global warming, disasters, and international developments, continue to occur worldwide. Therefore, it is crucial for local governments, in particular, to enhance the infrastructure of cities to accommodate these migrations. First and foremost, we must prioritize the sustainability of the projects during the planning stage. Creating a balance between environmental and economic values in the planned designs can lead to the emergence of projects that enhance the city's dynamism. These days, when we feel the effects of global warming more closely, designers should be more sensitive to climatic elements while designing.

Green infrastructure designs within the framework of sustainable urban management stand out as a potential solution to many basic problems. We predict that the active role of Xeriscaping, sustainable agricultural production, stormwater management, and sustainable treatment methods in green infrastructure applications in cities will significantly contribute to the creation of an economic, ecological, healthy, and sustainable environment. As a result, this master plan was prepared for Yozgat Bozok University Erdoğan Akdağ East Campus and Bilal Şahin West Campus. We plan to use this study as a guide to create a sustainable, environmentally friendly, and green university. Reporting and evaluating the sustainable and green university is necessary. We could monitor these processes in the short, medium, and long term, and reprogramme and plan in response to change and development. By leaving a livable and sustainable campus for both current users and future generations, the university would gain preference. We should increase green campus areas with local studies, increase the number of local plants, and reduce the water requirement. Given Yozgat's water management issues and its arid climate, it is imperative to adopt more water-saving practices. Buildings can recycle generated wastewater and use it for landscape irrigation. Again, switching to water-saving devices with sensors will reduce irresponsible use of water in buildings. Rainwater management will also be supportive in terms of campus water needs. Additionally, we should encourage local governments to incorporate the quantifiable advantages of rain gardens for sustainable cities and the upcoming generation of Turkish city dwellers. As a result, adaptation of campuses to climate change is easier to plan and implement than in cities. Despite the fact that campuses are typically located far from the city center, they still provide the services necessary for a city. Rather than categorizing rainwater as waste, we have devised a strategy that employs low-cost, environmentally friendly infrastructure components to support the ecosystem and recycle it for various uses such as toilet reservoirs, irrigation, recreation corridors, and landscaping elements. We have also produced recommendations to guide the implementation of these strategies.

Acknowledgments and Information Note

This article, Yozgat Bozok University, Institute of Graduate School of Postgraduate Education Master's Degree, completed in the Department of Agricultural Sciences. The article complies with national and international research and publication ethics. Ethics Committee approval was not required for the study.

Author Contribution and Conflict of Interest Declaration Information

All authors contributed equally to the article.

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Analysis of Urban Growth and Land Use Changes in Çankaya District Using Urban Atlas Data

Tuğba ÜSTÜN TOPAL [1], Sultan Sevinç KURT KONAKOĞLU [2]*, Meryem Bihter BİNGÜL BULUT [3], Öner DEMİREL [4],

ORCID 1: 0000-0002-9687-927X, **ORCID 2:** 0000-0001-5383-0954
ORCID 3: 0000-0003-4496-8198**, ORCID 4:** 0000-0002-8102-5589
[1] *Tekirdağ Namık Kemal University, Department of Landscape Architecture, Tekirdağ, Türkiye.*
[2] *Amasya University, Department of Urban Design and Landscape Architecture, Amasya, Türkiye.*
[3, 4] *Kırıkkale University, Department of Landscape Architecture, Kırıkkale, Türkiye.*
**** e-mail**: sultansevinc.kurt@amasya.edu.tr*

Abstract

The aim of this study is to monitor the land use/land cover (LULC) changes in Çankaya district. In the study, the LULC changes of Çankaya district between 2012 and 2018 were examined using Urban Atlas data. Continuous urban fabric in Çankaya increased from 632.16 hectares to 644.03 hectares, and discontinuous dense urban fabric increased from 1,735.30 hectares to 1,795.05 hectares. Construction areas saw a significant rise from 122.40 hectares to 666.04 hectares. In contrast, arable lands decreased from 11,844.45 hectares to 11,347.11 hectares, pastures from 2,089.28 hectares to 2,025.83 hectares, and forests from 1,803.52 hectares to 1,793.67 hectares. Additionally, herbaceous vegetation associations reduced from 16,097.70 hectares to 15,666.54 hectares. These changes clearly illustrate the impact of urban expansion on natural and agricultural lands in Çankaya. The results highlight the need to balance urban growth with the conservation of natural and agricultural areas. Future research could benefit from expanding the scope of Urban Atlas data and integrating additional datasets to enable more comprehensive and long-term analyses of urban development. Effective use and management of such high-resolution data are crucial for supporting sustainable urban development.

Keywords: *Urban atlas, land use, landscape planning, urban growth, Çankaya.*

Kent Atlası Verileriyle Çankaya İlçesi'ndeki Kentsel Büyüme ve Arazi Kullanım Değişikliklerinin Analizi

Öz

Bu çalışmanın amacı Çankaya ilçesindeki arazi kullanımı/arazi örtüsü (AKAÖ) değişimlerini izlemektir. Çalışmada, Kent Atlası verileri kullanılarak Çankaya ilçesinin 2012 ve 2018 yılları arasındaki AKAÖ değişiklikleri incelenmiştir. Çankaya'daki sürekli kentsel doku 632.16 hektardan 644.03 hektara, süreksiz yüksek yoğunluklu kentsel doku ise 1,735.30 hektardan 1,795.05 hektara artmıştır. İnşaat alanları 122.40 hektardan 666.04 hektara büyük bir artış göstermiştir. Tarıma elverişli alanlar 11,844.45 hektardan 11,347.11 hektara, mera alanları 2,089.28 hektardan 2,025.83 hektara, ve ormanlar 1,803.52 hektardan 1,793.67 hektara düşmüştür. Ayrıca, otsu bitki toplulukları da 16,097.70 hektardan 15,666.54 hektara gerilemiştir. Bu değişiklikler, Çankaya ilçesindeki kentsel genişlemenin doğal ve tarımsal alanlar üzerindeki etkilerini net bir şekilde ortaya koymaktadır. Sonuçlar, kentsel büyüme ile doğal ve tarımsal alanların korunması arasında denge sağlanması gerekliliğini vurgulamaktadır. Gelecek araştırmalar, Kent Atlası'nın kapsama alanının genişletilmesi ve ek veri setleri ile entegrasyon sağlanması suretiyle, daha kapsamlı ve uzun vadeli kentsel gelişim analizlerinin yapılmasına olanak tanıyabilir. Sürdürülebilir kentsel gelişimi desteklemek için, bu tür yüksek çözünürlüklü verilerin etkili kullanımı ve yönetimi büyük önem arz etmektedir.

Anahtar kelimeler: *Kent atlası, arazi kullanımı, peyzaj planlama, kentsel büyüme, Çankaya.*

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1. Introduction

Land use (LU) refers to how land is used by habitats and people. Land cover (LC) refers to the biophysical extent of the Earth's surface (Petrisor & Petrişor, 2015; Regasa et al., 2021). Changes in land use and land cover are not only changes of natural origin, but are also realised by humans in line with the new needs that arise with the increasing human population (Regasa et al., 2021). The rapid population growth in urban areas, particularly in developing countries, is placing significant pressure on natural resources (Bokaie et al., 2016). Indeed, the rate of human-induced transformations on the Earth's surface today is occurring at an unprecedented pace in human history (Lambin et al., 2001; Mohan et al., 2011). This causes changes on a global scale today (Lambin et al., 2001; Regasa et al., 2021; Topal & Konakoğlu, 2023). These changes include the gradual loss of habitat (Lumia et al., 2023), decrease in biodiversity, negative impact on water yield, water cycle and flow, increase in environmental pollution such as water, soil and air pollution (Regasa et al., 2021); increased risk of natural disasters such as drought and floods, greenhouse gas emissions (Arowolo & Deng, 2018); loss of agricultural areas, forest areas, green and natural areas to create new settlements (Pauleit et al., 2005; Mohan et al., 2011); urban temperature increase and urban heat island effects due to increasing impervious surfaces with high urbanisation (Jiang & Tian, 2010; Pal & Ziaul, 2017; Tran et al., 2017; Das et al., 2021); adverse impact on local climate and global climate change (Han et al., 2015; Pal & Ziaul, 2017; Regasa et al., 2021); decrease in quality of life and welfare level (Demir & Demirel, 2018). In this context, studies aimed at understanding the factors affecting LULC in urban areas and studies on the detection and modelling of LULC are very important (Mohan et al., 2011; Han et al., 2015; Arowolo & Deng, 2018; Wang et al., 2022) . Because, there is a need to realise urban sprawl in the most accurate and rational way without putting pressure on natural resources, to monitor effective urban planning and decision-making processes and to develop appropriate management strategies in this direction (Aksoy et al., 2022; Topal, 2023a).

The purpose of the LULC classification is to automatically generate labels that describe land type and use (residential, industrial, etc.) (Helber et al., 2019). Quantitative assessment of LULC is very important for land use planning, natural resource management, environmental assessment and decision-making processes (Mohan et al., 2011; Han et al., 2015; Arowolo & Deng, 2018; Talukdar et al., 2020; Wang et al., 2022). Therefore, it is of great importance to monitor and map the changes in LULC over time (Srivastava et al., 2012).

In the last few decades, with the advent of remote sensing technology and the launch of numerous satellites, satellite imagery and aerial spatial imagery and data have increased exponentially thanks to advances in technology (Wang et al., 2022). Satellite imagery provides both multi-temporal availability and wide spatial coverage for mapping the LULC (Talukdar et al., 2020).

The European Space Agency (ESA) is making a significant effort to improve Earth observation within the framework of the Copernicus programme and operates a series of satellites known as Sentinel (Helber et al., 2019). Urban Atlas (UA) is a GIS database created by the European Space Agency in 2009, which contains spatial and statistical data such as area and population data for different land cover zones, where land use and land cover of Functional Urban Areas (FUAs) with more than 100.000 inhabitants can be monitored. These data can be accessed free of charge from the Copernicus Land Monitoring Service data portal (Prastacos et al., 2012; Petrisor & Petrişor, 2015; Pazúr et al., 2017; Tsagkis & Photis, 2018; Dobesova, 2020; Alomar-Garau, 2023). The first Urban Atlas database contains 319 FUAs with 2006 data. The next database contains 785 FUAs with more than 50.000 inhabitants with 2012 data. The last UA database is from 2018 and includes 788 FUAs. In addition, changes between the relevant years are also among the data provided (Alomar-Garau, 2023).

Urban atlas data has become an important data in recent years (Micek et al., 2020), and is widely used by researchers due to its high resolution (Pazúr et al., 2015; Kolcsár et al., 2021; Aksoy et al., 2022; Duru et al., 2022; Özmekik et al., 2022; Alomar-Garau, 2023; Topal, 2023a, 2023b). Specifically, the spatial resolution of the Urban Atlas is 0.25 hectares, with temporal resolutions available for the years 2006, 2012, and 2018, providing a six-year interval (Alomar-Garau, 2023).

1.1. Aim(s) of Study

The importance of appropriate urban interventions in addressing environmental issues cannot be overstated. Monitoring temporal and spatial changes in land cover is essential for effectively tackling these issues and making informed decisions. This challenge is even more pronounced in developing countries, particularly in rapidly growing cities with expanding urban areas.

Ankara, the capital of Türkiye, is the second most populous city in the country. In this context, this study aims to monitor land use/land cover changes in Çankaya district, the most populous district of Ankara, using Urban Atlas (UA) data.

2. Material and Method

Çankaya district, which constitutes the main material of this study, is located in Ankara, the capital of Türkiye. It is located between 39° 55′ 4″ North latitude and 32° 51′ 45″ East longitude (Anonymous, 2024). The district is situated in the Upper Sakarya Region in the northwestern part of Central Anatolia. Çankaya is bordered by the districts of Mamak and Altındağ to the east and northeast, Gölbaşı to the south, and Etimesgut to the west (Republic of Türkiye Ministry of Environment Urbanization and Climate Change, 2021) (Figure 1).

Ankara is one of the most populous cities in Türkiye, ranking second after Istanbul. The population of many of its districts is higher than many cities in Türkiye. Çankaya district, in particular, has experienced significant population growth in recent years, leading to a rapid increase in new residential areas. According to 2023 population data from TUIK, Ankara's population is 5,803,482. Çankaya district is the most populous in the province, with a population of 937,546. Reviewing the population data for 2012 and 2018, which correspond to the study years for which Urban Atlas data is available, the district's population increased from 832,075 in 2012 to 920,890 in 2018 (TUIK, 2024a; TUIK, 2024b).

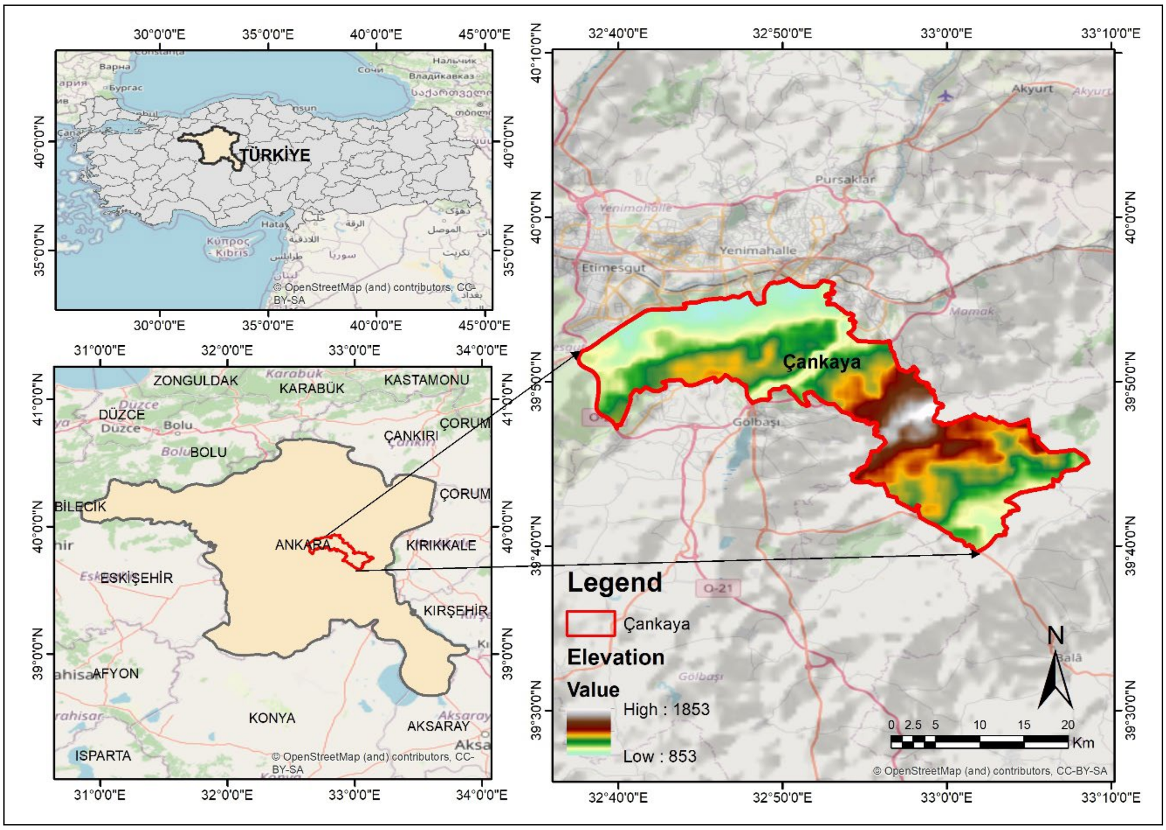

Figure 1. Location map of the study area (Authors, 2024)

The provincial and district boundaries of the study area were obtained from OpenStreetMap (OpenStreetMap, 2024). To determine land use within the study, Urban Atlas data from the years 2012 and 2018 were utilized. These data were downloaded free of charge in vector format from the

Copernicus website. Area calculations of land use classes were made using the downloaded vector formatted data. The Urban Atlas is a project under the EU Copernicus program, managed by the European Space Agency (ESA) and the European Environment Agency (Copernicus Land Monitoring Service, 2024). ArcMap 10.8 software was used for data processing and presentation.

3. Findings and Discussion

According to Urban Atlas data, there are 23 land use classes for the Çankaya district (Table 1, Figure 2). Analyzing changes in the urban fabric of the district between 2012 and 2018 reveals that the area of continuous urban fabric increased from 632.16 hectares to 644.03 hectares. Areas with discontinuous dense urban fabric, with 50%-80% density, increased from 1,735.30 hectares to 1,795.05 hectares. On the other hand, areas with discontinuous medium density urban fabric, with 30%-50% density, decreased from 1,228.16 hectares to 1,215.55 hectares, showing a -1% reduction. Areas with discontinuous low density urban fabric, with 10%-30% density, increased from 1,119.67 hectares to 1,160.60 hectares, reflecting a +4% increase. Additionally, areas with discontinuous very low density urban fabric, with less than 10% density, increased from 646.64 hectares to 743.37 hectares, showing a +15% increase. Overall, the continuous and discontinuous urban fabric areas grew from 5,361.93 hectares in 2012 to 5,558.60 hectares in 2018. These results indicate an increase in the settlement fabric within the district.

When examining the area of isolated structures, it is observed that these areas increased from 25.49 hectares to 39.08 hectares, reflecting a +53% rise. In terms of industrial, commercial, public, military, and private units, the area covered by these uses grew from 2,357.80 hectares in 2012 to 2,589.67 hectares in 2018, indicating a +10% increase. Evaluating the classes related to roads in the district, it is noted that the area designated for fast transit roads and associated lands remained unchanged at 103.72 hectares between 2012 and 2018. Additionally, other roads and associated lands, another transportation-related class, increased from 1,712.36 hectares to 1,728.60 hectares, showing a +1% rise. The area of mineral extraction and dump sites in the district expanded from 419.67 hectares in 2012 to 490.04 hectares in 2018, resulting in a +17% increase.

The most significant change in the district has undeniably occurred in construction areas. Such that, while these areas were 122.40 hectares as of 2012, they increased by +444% as of 2018 and reached 666.04 hectares. It has also been observed that the land without current use areas in the district have also decreased. These areas decreased by -14% from 659.56 hectares to 564.43 hectares. This shows that these areas have been given a function. Looking at the green urban areas class in the district, it is noteworthy that these areas have increased at a lower rate compared to the increase in built-up areas such as roads and urban fabric. In fact, these areas cover an area of 715.25 hectares as of 2018 and have increased by +3%. Looking at the areas of sports and leisure facilities, it is seen that these areas, which were 115.03 hectares as of 2012, reached 116.65 hectares.

Among the land uses in the district, arable land (annual crops) hold the second-largest share within the district's total area. However, it is noteworthy that these areas have decreased from 11,844.45 hectares in 2012 to 11,347.11 hectares in 2018, reflecting a -4% reduction. One of the areas with the largest share in the district is pasture areas. Yet, these areas have also decreased during the same period, showing a -3% reduction from 2,089.28 hectares to 2,025.83 hectares. Similarly, forest areas have decreased by -1%, from 1,803.52 hectares to 1,793.67 hectares.

Another noteworthy finding is the decrease in areas covered by herbaceous vegetation associations, which represent the largest share of land in the district. These areas, which covered 16,097.70 hectares in 2012, decreased by -3% to 15,666.54 hectares by 2018.

In general, it is observed that the main use type covering the largest area is natural areas. While these areas covered 18,484.11 hectares as of 2012, they decreased to 18,043.10 hectares as of 2018. The second main use type for the district was agricultural areas. While these areas covered 13,933.73 hectares as of 2012, it was observed that they covered 13,372.94 hectares in 2018. This is an important finding in terms of showing that natural areas and agricultural areas have been lost in the district. Looking at the total area of artificial areas for Çankaya district, it was observed that the area of 11,575.48 hectares in 2012 increased to 12,576.64 hectares in 2018. For the district, the main use type of other areas with water and wetland use has the lowest area and increased from 150.01 hectares to 150.64 hectares in the relevant years.

Table 1. Urban Atlas Classes and Spatial Distribution of Çankaya District in 2012 and 2018 (Authors, 2024)

	Legend Code	Nomenclature	2012 ha	2012 %	2018 ha	2018 %
Artifical Areas	11100	Continuous Urban fabric (S.L. > 80%)	632.16	1.43	644.03	1.46
	11210	Discontinuous Dense Urban Fabric (S.L.: 50% - 80%)	1,735.30	3.93	1,795.05	4.07
	11220	Discontinuous Medium Density Urban Fabric (S.L.: 30% - 50%)	1,228.16	2.78	1,215.55	2.75
	11230	Discontinuous Low Density Urban Fabric (S.L.: 10% - 30%)	1,119.67	2.54	1,160.60	2.63
	11240	Discontinuous very low density urban fabric (S.L. < 10%)	646.64	1.46	743.37	1.68
	11300	Isolated Structures	25.49	0.06	39.08	0.09
	12100	Industrial, commercial, public, military and private units	2,357.80	5.34	2,589.67	5.87
	12210	Fast transit roads and associated land	103.72	0.23	103.72	0.23
	12220	Other roads and associated land	1,712.36	3.88	1,728.60	3.92
	12230	Railways and associated land	3.92	0.01	3.92	0.01
	12400	Airports	0.64	0.00	0.64	0.00
	13100	Mineral extraction and dump sites	419.67	0.95	490.04	1.11
	13300	Construction sites	122.40	0.28	666.04	1.51
	13400	Land without current use	659.56	1.49	564.43	1.28
	14100	Green urban areas	692.96	1.57	715.25	1.62
	14200	Sports and leisure facilities	115.03	0.26	116.65	0.26
Agricultural areas	21000	Arable land (annual crops)	11,844.45	26.83	11,347.11	25.71
	23000	Pastures	2,089.28	4.73	2,025.83	4.59
Natural areas	31000	Forests	1,803.52	4.09	1,793.67	4.06
	32000	Herbaceous vegetation associations (natural grassland, moors...)	16,097.70	36.47	15,666.54	35.49
	33000	Open spaces with little or no vegetations (beaches, dunes, bare rocks, glaciers)	582.89	1.32	582.89	1.32
Other types	40000	Wetlands	11.94	0.03	11.94	0.03
	50000	Water	138.07	0.31	138.70	0.31

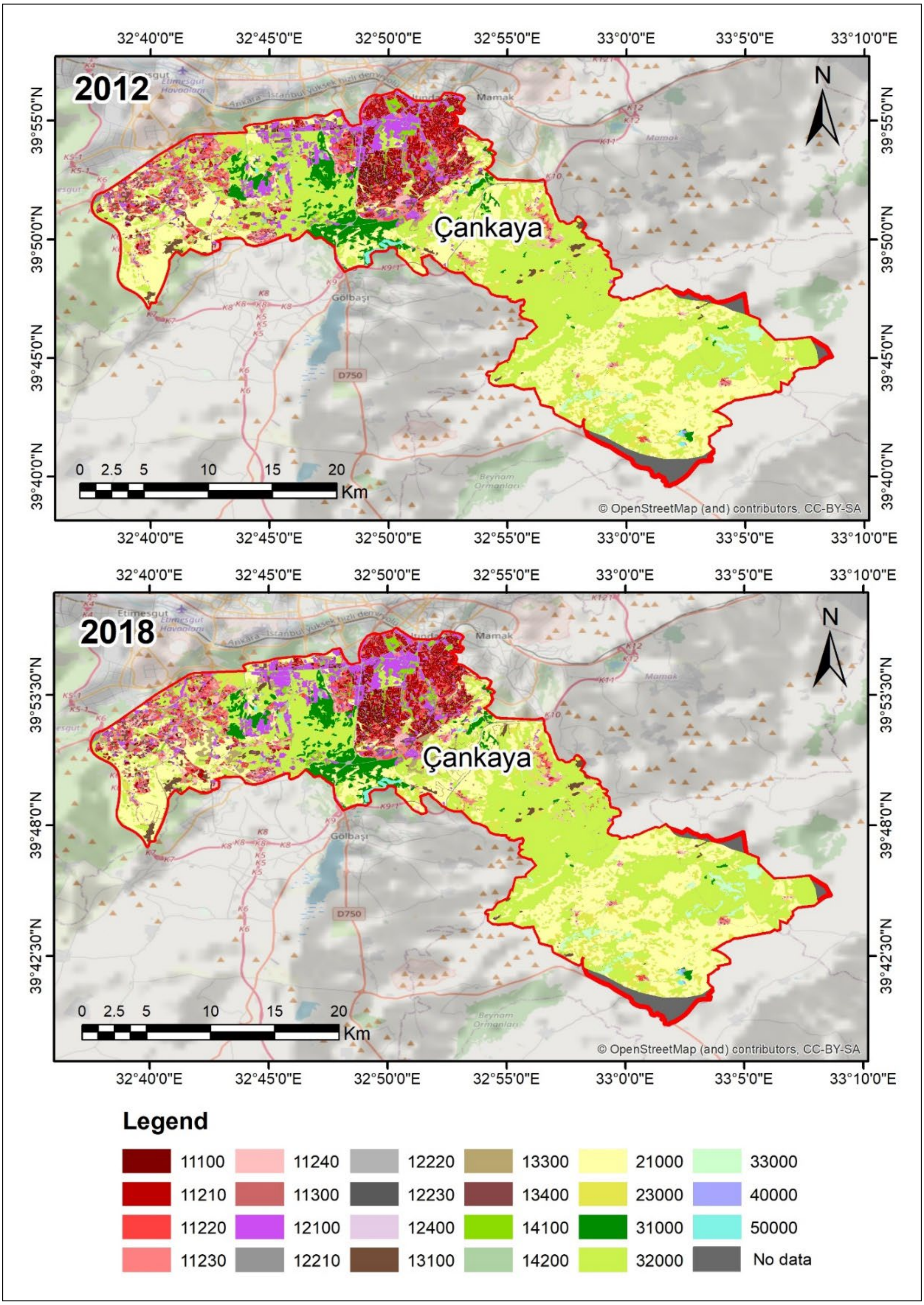

Figure 2. Spatial Distribution of Urban Atlas Classes of Çankaya for 2012 and 2018 (Authors, 2024)

4. Conclusion and Suggestions

In this study, Urban Atlas (UA) data was used to monitor land cover changes in Çankaya district between 2012 and 2018. The numerical data obtained from the study indicate that artificial areas in Çankaya district have increased, while agricultural and natural areas have decreased. The +444% increase in construction areas, along with the expansion of built-up areas, demonstrates significant urban growth. However, the most striking result of this growth is undoubtedly the loss of agricultural and natural lands. Detailed examination reveals that the increase in construction areas is primarily due to the conversion of agricultural areas (338.06 ha), followed by the transformation of herbaceous vegetation associations (192.73 ha) and pastures (39.89 ha). This indicates that land is being used for purposes other than originally intended. In this context, it is crucial to implement smart growth models to prevent the misuse of land and to protect natural resources, ensuring a balance between natural resources and urban uses.

As stated by Poyatos et al. (2003), information obtained from aerial imagery can provide crucial insights into land use and cover changes. According to Roy & Roy (2010), satellite-based remote sensing has revolutionized the study of land use and land cover changes at specific times and locations. In this study, Urban Atlas (UA) data was used as the dataset. These data provide high-accuracy results due to their high resolution. Thus, Urban Atlas data is an effective tool for monitoring changes. However, these data are produced specifically for urban areas and cover European countries and surrounding central regions. The data available are from the years 2006, 2012, and 2018. For Türkiye, data access is limited to 2012 and 2018, which confines the analysis to these periods. Expanding the production area boundaries of Urban Atlas data and developing new high-accuracy databases could broaden research scopes and enable long-term monitoring of changes. As emphasized by Petrisor & Petrişor (2015), frequent acquisition of Urban Atlas data could become a significant tool for identifying urban changes at appropriate temporal and spatial scales.

On the other hand, with the developing imaging technologies and software, simulations of future scenarios to be prepared for the urban growth areas that will emerge according to the future population projection by using such high accuracy data can also be useful in developing the right strategies in the management of cities. However, as stated by Prastacos et al. (2012) Urban Atlas data will provide an important dataset that can be used for the estimation of various indicators within the scope of urban planning studies, especially when combined with other datasets for the analysis of urban areas.

In conclusion, the negative impacts resulting from urbanization increasingly affect our cities and, on a global scale, our world. These issues arise from human activities that often come at the expense of destroying natural resources. Therefore, in urban planning, it is essential to adopt a multidimensional approach that includes ecological, socioeconomic, and environmental considerations within the framework of sustainability. This approach should guide ecological planning and design decisions with a holistic perspective. To achieve this, significant responsibilities fall upon stakeholders, managers, and the scientific community at every level of planning services. Emphasis should particularly be placed on interdisciplinary research in this regard.

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Author Contribution and Conflict of Interest Declaration Information

All authors contributed equally to the article. There is no conflict of interest.

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Determination of the Importance Level of Basic Criteria in Building Construction with AHP and FAHP Methods

Serkan YILDIZ [1], Sinan GÜNEŞ [2*]

ORCID 1: 0000-0002-6020-1993
ORCID 2: 0000-0001-7753-8333
[1, 2] Ankara University, Faculty of Applied Sciences, Department of Real Estate and Development, 06590 Ankara, Türkiye.
**** e-mail**: sinan.gunes@ankara.edu.tr*

Abstract

The primary expectations from buildings include safety, cost-effectiveness, aesthetics, durability, functionality, and sustainability. Addressing these complex criteria and potential trade-offs requires determining their relative importance to guide construction practices. This study evaluates these criteria using the Analytic Hierarchy Process (AHP) and Fuzzy Analytic Hierarchy Process (FAHP). Interviews with seven engineering experts helped define the criteria. Subsequently, 22 architects and engineers performed pairwise comparisons, producing individual matrices. These matrices were aggregated into a single matrix via geometric averaging, with consistency verified. Safety emerged as the highest priority, followed by durability, while the remaining criteria were balanced. FAHP enhanced robustness by integrating fuzzy logic to handle subjective judgments. The findings offer practical insights for designers, contractors, and industry professionals, aiding in informed decision-making and prioritization of building criteria.

Keywords: *Building construction, safety, durability, AHP, FAHP.*

Yapı İnşasında Temel Kriterlerin Önem Seviyesinin AHP ve BAHP Yöntemleri ile Belirlenmesi

Öz

Binalardan öncelikli beklentiler güvenlik, maliyet etkinliği, estetik, dayanıklılık, işlevsellik ve sürdürülebilirliği kapsamaktadır. Bu kriterlerin karmaşıklığı ve potansiyel ödünleşimleri göz önüne alındığında, göreceli önemlerinin belirlenmesi, inşaat uygulamalarını optimize edilmiş sonuçlara doğru yönlendirebilir. Bu çalışma, bina yapımında bu temel kriterlerin önemini Analitik Hiyerarşi Süreci (AHP) ve Bulanık Analitik Hiyerarşi Süreci (FAHP) yöntemleriyle değerlendirmeyi amaçlamaktadır. İlk olarak, her bir kriteri tanımlamak için yedi mühendislik uzmanı ile derinlemesine görüşmeler yapılmıştır. Daha sonra, 22 mimar ve mühendis kriterleri değerlendirmek için ikili karşılaştırmalar yapmış ve sonuçta bireysel karşılaştırma matrisleri elde edilmiştir. Bu matrisler geometrik ortalama yoluyla tek bir matriste toplanmış ve tutarlılık teyit edilmiştir. Analizler, güvenliğin en yüksek öncelik olduğunu, bunu dayanıklılığın izlediğini, diğer kriterlerin ise nispeten dengeli bir öneme sahip olduğunu ortaya koymuştur. FAHP yöntemi, öznel yargıları hesaba katmak için bulanık mantık kullanarak değerlendirmeye sağlamlık katmıştır. Bulgular, tasarımcılar, endüstri profesyonelleri ve yükleniciler için değerli bilgiler sağlayarak bina kriterlerinin önceliklendirilmesinde bilinçli karar vermeyi desteklemektedir.

Anahtar kelimeler: *Yapı inşası, emniyet, dayanıklılık, AHP, BAHP.*

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1. Introduction

Building is the activity initiated by early humans to meet the need for shelter. The first shelters were built to meet the need for a controlled environment to mitigate climate impacts. Shelter construction enabled humans to adapt to different climatic conditions and paved the way for humans to become a global species. Building activities have evolved and exhibited different trends. The principles that determined this development and trend were the materials' durability, the growth in building heights and widths, the degree of control over the internal environment and the energy that can be used for the construction process (Designingbuildings, 2023). The initial substances utilized were perishable materials, including leaves, branches, and animal skins. Subsequently, there was a shift towards more enduring natural elements like clay, stone, and wood. Eventually, synthetic materials, such as bricks, concrete, metals, and plastics, became prevalent. The advancement of robust materials and an enhanced understanding of their behavior have enabled the construction of taller buildings with larger footprints. This progress has been instrumental in refining the control of the indoor environment, with a heightened focus on precise regulation of factors such as air temperature, light intensity, sound levels, humidity, odors, air velocity, and other elements that impact human comfort. Finally, while the first shelters were built entirely based on human muscle power, the energy of powerful and technological machines began to be utilized (Chang & Swenson, 2023). While the first function of building construction, which has developed and changed in close relation and interaction with human civilization, has been to provide shelter and security, over time, this function has started to include reflecting the cultural and social values of different periods, adopting and developing technological developments (Designingbuildings, 2023). In contemporary times, construction endeavors involving diverse stakeholders have emerged as a significant facet of industrial culture. This phenomenon serves as a reflection of the intricate and multifaceted nature of the industry, representing a measure of proficiency in harnessing natural forces to create a diverse spectrum of built environments that cater to the varied needs of society (Chang & Swenson, 2023). All this transformation has caused users' expectations of the constructed buildings to grow in content.

Increasing prosperity and education level have led to the diversification and elaboration of conscious consumption criteria. There needs to be more than one point of view to meet increasing expectations. Besides the criteria such as safety, durability, aesthetics, economy and functionality that affect building construction, sustainability criteria should be considered. However, it is naturally not possible to maximize the expectations in all these criteria. For example, it may be necessary to sacrifice functionality for greater aesthetics or to compromise durability in order to build more economical structures. For an optimum solution, determining the relative importance levels of these criteria is necessary and such a study will guide the sector stakeholders. In this study, the importance levels of the mentioned criteria were determined by AHP and BAHP analyses, and safety and durability were ranked as the first two. In contrast, the other criteria were given approximately equal importance.

2. Basic Expectations of Users from Buildings

Article 5 of the Zoning Law No. 3194 defines a building as follows: "A building is a structure that can be used on its own, is covered and can be entered by people, and is used by people to live, work, have fun, rest or worship, and for the protection of animals and goods" (Zoning Law, 1985). While the definition requires a building to be inherently safe, limited resources require it to be economical and human nature requires it to be aesthetic. Adding durability, functionality, and sustainability, become increasingly indispensable every day, is possible to these three basic expectations.

2.1. Safety

Naturally, the first thing expected from a structure is to be safe. Safety refers to the ability of a structure to resist loads and stresses with a sufficient margin of safety. Errors related to structural design create a severe risk of loss of life and property. In this respect, particular care should be taken during the structural design phase to ensure that structural components can provide safe service under the loads to which they will be subjected. The structures' capacity generally refers to its mechanical resistance to its weight, user loads, furniture and effects such as snow, wind and earthquake loads. The damage or collapse of the structure due to the insufficiency of this resistance is not only a consequence related to the structure. Many negative consequences, such as loss of life, injuries, loss of property, disruption of services and psychological damages, occur. Large-scale damages caused by floods, hurricanes, fires, explosions, and especially earthquakes can even shake the economy of countries (Mittal, 2023). For example, the February 6, 2023 Pazarcık and Elbistan earthquakes in our country caused hundreds of thousands of houses to be unusable. They caused a cost exceeding 100 billion dollars (Presidency of Strategy and Budget, 2023).

Another issue considered in safety is the usefulness of the structure according to its structural purpose. For example, the floor on which a high-precision mechanical equipment is placed should not vibrate in such a way as to disturb the precise settings of the equipment. Similarly, floors should not oscillate in such a way as to create a sense of insecurity when people move around on them.

Understanding the structural capacity of the structure to withstand environmental influences throughout its projected working life is a crucial aspect of safety. Factors that threaten safety, such as exposure of a timber structure to termite attacks due to lack of precautions; damage to concrete and reinforcement due to a lack of good waterproofing; settlement and collapse of foundations over time, should be thoroughly understood and addressed (Housing for Health, 2024).

Errors in design and detailing are among the most critical factors that may cause a structure to be so unsafe that it may collapse completely. However, this is not the only reason and dozens of other reasons can be mentioned. Some of these include poor geological conditions, poor quality materials, defects in construction methodology, poor craft, poor quality control, non-compliance with standards, inadequate maintenance, thoughtless structural additions or alterations, changes in types of use, overloading, keeping in use beyond the planned service life, exposure to all kinds of additional/new loads not taken into account in the design, accidents, negligence during design and construction, unethical behaviors such as corruption, ignorance, incompetence, lack of supervision, lack of interest, regulatory deficiencies, system and procedure deficiencies, inadequacy and indifference in the implementation of laws (Mittal, 2023). It is of utmost importance that users who expect their buildings to serve safely are aware of these issues, the number of which can be increased much more.

2.2. Economy

The second thing expected of a building from an engineering point of view is that it should be economical. Everyone wants to incur the least cost to have a structure that is equally satisfactory in all other respects. The term "economy" pertains to the financial and material resources allocated for the constructing and maintaining buildings and related structures. This encompasses expenses associated with labor, materials, and additional resources essential for the successful completion of a Project (Mamauag, 2023). The main problem with economics is that although human needs and wants are unlimited, their resources are limited. Owners have a limited budget available to them and in reality this limit sets the limits of design (Robinson & Symonds, 2015). So much so that even structural design, although directly related to the safety of life and property, is related to economics and it is essential to use an adequate but not excessive safety factor in the design. For example, regulations on earthquake-resistant building design stipulate that structures should not be damaged in small earthquakes, their structural elements should not be damaged in moderate earthquakes, and they should be severely damaged in large earthquakes. Hovewer, they should not collapse and cause loss of life and property. Otherwise, it would mean designing structures that are not economical.

Similar to structural design, architectural design is intricately tied to economic considerations. The geometric attributes of a building, encompassing aspects such as size, shape, layout, and height, exert a notable influence on capital expenses. Projects marked by intricate designs and challenging geometries incur higher costs than simpler, often repetitive projects that benefit from economies of scale and reduced unit costs. The level of complexity significantly impacts costs, especially in instances where projects involve unconventional, untried, and untested design features, making planning, construction, and management more challenging (Robinson & Symonds, 2015).

The materials and equipment to be used in the building also significantly affect the cost. Contractors try to get the best quality products at the lowest cost. Similarly, customers, whether they are in high or low-income groups, try to obtain the most economical structure that meets their needs according to their budgets. This fact does not change the fact that when the general economic conditions are good, more ostentatious and expensive designs are tried to be acquired, and when the economic situation is poor, more practical and functional designs are tried to be acquired (Mamauag, 2023).

Economy in building design is not just about the initial construction or acquisition cost, but also about the long-term utilization cost. This includes maintenance and repair costs that accrue over time, as well as energy costs for functions such as heating, cooling, lighting and ventilation. In some cases, the savings from utilization costs can offset the high initial construction cost, making the building more advantageous for the users. Ultimately, designing a building with economic factors in mind is crucial to creating buildings that are not only aesthetically pleasing and functional but also financially viable and sustainable in the long term. The goal is to create buildings that are economically viable and cost-effective, without compromising on quality, functionality, and sustainability. Every building should be economically viable and cost-effective without overdoing it in terms of permanence, beauty and fulfillment of function, as well as other necessary qualities that the users seeks.

2.3. Functionality

Functionality encompasses movement areas, ventilation needs, lighting, relationships between spaces, technical requirements, movement and communication in a building and requires consideration of all human needs, psychological, social and cultural (Majeed, Oleiwi & Yaseen, 2019).

It covers many aspects, such as how the spaces are organized, how people move around the area, how accessible the space is and whether it contains the necessary services. For example, a window that is too high and therefore difficult to open and close; a socket that is too far away from the mirror when you connect your electric shaver; a kitchen that is too narrow to accommodate a dining table; a layout where all rooms open onto the living room is inherently non-functional. Each of these is a design mistake that leads to a decrease in quality of life and comfort. In this respect, functionality is an indispensable requirement for the success of architectural design. A functional building is a building with the practical components necessary for its successful and efficient operation. It includes layout, design, and features that guarantee that the infrastructure fulfills its task as effectively as possible (Vrcconstruction, 2023).

An intelligently designed space maximizes efficiency and usability. Whether it is a commercial office, residential complex or retail space, the design must be fit for the intended purpose and ensure that it best serves its occupants.

Several pivotal principles underpinning functionality in architecture and design include program, flexibility, accessibility, energy efficiency, and safety and security (Archisoup, 2023). The program entails the information and documentation distinctly outlining the function and intended use of the building upon which the design will be based. This encompasses details such as the anticipated number of occupants, the nature of activities to be conducted within the space, and the requisite equipment and resources. Flexibility denotes the building's capacity to undergo easy modifications or reconfigurations to adapt to evolving needs or requirements. Accessibility pertains to the building's ability to be easily reached and enjoyed by individuals of diverse ages and abilities, incorporating features like ramps, elevators, and wide doors to accommodate those with disabilities. It is also part of the functionality that the building includes elements that help reduce energy costs, such as insulation, energy-efficient windows and equipment. The fact that the building includes safety and security measures for its users, such as fire prevention systems, security cameras, emergency exits, etc., is also one of the principles of functionality.

As a result, almost intuitive functionality includes aspects that benefit the user, and the utility component is a prerequisite that must be met in all human production. The consistency between functionality and form indicates satisfaction and confidence in the validity of the production. In this respect, it is possible to define architecture as the science of building structures that meet people’s material, spiritual, mental, individual and collective needs, including the conditions of utility, beauty and economy (Majeed et al., 2019).

2.4. Aesthetics

It is impossible to say that any building whose aesthetic features are not pleasing, which does not arouse a sense of beauty in its users and the surrounding residents, meets expectations and is satisfactory. Aesthetics emphasizes the artistic dimension of architectural quality and points out that buildings should be beautiful and attractive (Architects' Council of Europe, 2019). The allure of a building is the cumulative result of various factors, including its shape, size, texture, color, balance, unity, movement, emphasis, contrast, symmetry, proportion, space, alignment, pattern, decoration, cultural considerations, and contextual relevance (Designingbuildings, 2020). Buildings that are aesthetically pleasing and attractive possess the capacity to inspire individuals, instill a positive sense of identity, pride in their activities, and a connection to their living environment. More importantly, such structures have the potential to motivate people to strive for personal and communal achievements, thereby inspiring a sense of motivation and inspiration (McIntyre, 2006).

Like painting and sculpture, architecture can be regarded as a visual art to which aesthetic philosophy can be applied. However, applying aesthetics to buildings and architecture is intricate due to physical constraints such as program, budget, structural system, standards, climate, and weather. This complexity implies that building design is influenced by both form and function, in addition to aesthetics (Designingbuildings, 2020). Amidst these considerations, it is essential to acknowledge that beauty and attractiveness are subjective concepts. Santiana notes, "The sense of beauty is not just a perception but an understanding of the value of the discovery of an aesthetic signifier." Alberte defines architectural beauty as "the harmony of everything and a certain harmony between all the elements of the building in such a way that no part can be added, removed, or changed without damaging the design." Cliff Bill sees it as an impressive photograph of all kinds of relationships between lines, colors and volumes (Mohsen, 2000). Based on these definitions, it will be understood that when it comes to aesthetics, the exterior designs of buildings can be considered, and the aesthetics of each production can be mentioned. Just as a bad exterior design is not aesthetic, plasters that are not on their plumb, cornices that do not come together with the ceiling from every point, ceramics whose joints do not match each other even if they are of high quality and expensive, paint productions where brush strokes are visible, doors and windows that are not fully closed, installation columns that are not fully vertical and parallel to each other, wallpapers whose joints are visible, floor coverings laid at different levels, and similar productions that are often the result of poor craft are not aesthetic, even if they do not prevent use.

2.5. Durability

Another crucial aspect expected from a building is its durability. Durability, by definition, denotes the capability to resist damage, deterioration, and degradation over a specified period (Nireki, 1996). Mora has characterized durability as an indicator of the degree to which a material maintains its original specifications over time. A material, component, or system can be deemed durable when its helpful service life aligns considerably with the time needed for the ecosystem to assimilate the associated impacts on the building (Mora, 2007).

The way materials and buildings deteriorate over time depends on their physical structure, how they are manufactured and the environmental conditions to which they are exposed (NAHB, 2002). Several factors contribute to determining the durability of a material, encompassing molecular structure, resilience against moisture and water, resistance to corrosive substances, protection against pests and insects, resilience to mold and rot, fire resistance, adaptability to movement, ability to withstand atmospheric pollution, resistance to heat and cold, moisture absorption capacity, surface profiles, orientation, texture, and color (Designingbuildings, 2021). The type and frequency of durability problems and overall performance issues can be related to design, materials, construction method, maintenance or a combination of these factors (NAHB, 2002). Buildings are subjected to wear and tear from users, and the constant effects of environmental conditions such as snow, rain, frost, sun and heat. These effects cause deterioration and decrease in the durability of the materials and the structure, often leading to deterioration of the aesthetic appearance. The effects of climate change should be taken into account when selecting materials. As an illustration, materials like concrete, brick, and stone may exhibit greater durability than in specific climates wood or plaster. Similarly, materials like stainless steel or fiberglass may demonstrate increased resistance to corrosion (Archisoup, 2023). The outer cover of the building, including the roof covering, has a protective function. It acts as a barrier to prevent rain, and snow and moisture from seeping into the building. It also provides protection against fire, strong sunlight and frost, while saving heating and cooling energy by preventing heat from entering and leaving the building (Turton, 2012).

In some cases, wrong design or wrong construction method may prevent the material from showing the expected performance by losing its durability. Even if the right material is used for insulation, it is known that design and workmanship errors cause damage to structural elements caused by water or moisture. The greater the durability of buildings, the less time and resources are required to maintain them. Nevertheless, even the most durable materials need to be maintained over time. Lack of maintenance or poor designs that make maintenance difficult negatively affect durability.

The fact that building elements are not durable for various reasons does not only lead to negative consequences such as increased maintenance and repair costs, deterioration of aesthetics, and decreased user comfort. At the same time, it may also cause the structural system elements to lose their bearing capacity, thus jeopardizing building safety. All these problems should be considered together during the design phase and balanced solutions should be produced to increase durability even if the initial cost is high. This includes designing spaces that are easy to clean and maintain, and incorporating materials and systems that are easy to repair or replace (Archisoup, 2023). Choosing the best materials is often the most costly but often results in using the highest quality and most durable materials. Nowadays, the increasing number and duration of extreme weather events due to climate change require putting more emphasis on the durability of buildings (Designingbuildings, 2021).

2.6. Sustainability

The most familiar definition of sustainability is to support the fulfillment of the needs of future generations while meeting the needs of the present (WCED, 1987). Sustainability involves improving the quality of life, thus enabling people to live in a healthy environment with better conditions (Ortiz, Castells & Sonnemann, 2009). Sustainable development encompasses numerous economic, social, and environmental factors that benefit human development and improve the quality of human life (Stead & Stead, 2014). The construction sector is a vital element of any economy, but it has significant negative impacts on the environment. The sector consumes large amounts of natural resources, mainly raw materials and energy, to create the built environment where human life occurs. It, therefore, has a much more significant impact on society, the environment and the economy than any other industrial sector, making it one of the leading sectors on which sustainability is focused (Xia, Rosly, Wu, Bridge & Pienaar, 2016; Aghimien, Aigbavboa & Thwala, 2019). Hence, there is an increasing consensus among organizations dedicated to environmental performance goals that implementing suitable strategies and initiatives is imperative to enhance the sustainability of construction activities (Barrett, Sexton & Green, 1999; Abidin, 2010).

Considering the substantial influence of the construction sector, adopting a sustainable construction approach holds substantial promise for making a meaningful contribution to sustainable development. Sustainable construction ensures that all activities, from the planning phase to completion and eventual demolition, are conducted sustainability. This approach considers construction activities' economic, social, and environmental impacts (Ismail, Halog & Smith, 2017). It has been noted that sustainable construction plays a vital role in protecting the local environment through the use of resources, assets and water and that the industry contributes significantly to improving the quality of human life (Oke, Aigbavboa & Semenya, 2017; Shurrab, Hussain & Khan, 2019). Sustainable construction aims to improve indoor air quality while reducing energy, water and material use and waste generation, both during the construction process and throughout the operational life of buildings (Archisoup, 2023; Ismail et al., 2017; Shurrab et al., 2019). The concept of sustainability within the construction industry has evolved, shifting from a primary focus on addressing challenges related to insufficient resources, particularly energy, to encompass technical considerations. These technical aspects include materials, building components, construction technologies, and designs commonly known as “eco-building”, “green building” and “sustainable building” (Balasubramanian & Shukla, 2017). A sustainable project is one that is designed, constructed, renovated, operated, or repurposed in an ecologically and resource-efficient manner (Ortiz, Pasqualino & Castells, 2010). This entails achieving specific objectives such as resource and energy efficiency, reduction of CO2 and greenhouse gas emissions, pollution prevention, noise reduction, improvement of indoor air quality, and environmental compatibility. An exemplary sustainable construction project is characterized by its cost-effectiveness, long-lasting quality with minimal maintenance requirements, and the ability to return entirely to the earth upon abandonment (Bainbridge, 2004). Advocates argue that sustainable buildings can significantly decrease energy consumption by 24% to 50%, lower CO_2 emissions by 30%, and reduce water usage by 40% (LEED, 2000).

Sustainable buildings are expected to uphold robust and consistent levels of local economic growth and employment to achieve economic sustainability. Simultaneously, they aim to ensure the adequate protection of the environment and the judicious utilization of natural resources, aligning with principles of environmental sustainability. Moreover, these structures aspire to contribute to social progress that acknowledges the needs of all stakeholders, promoting social sustainability (Akadiri, Chinyio & Olomolaiye, 2012).

Safety, economy, functionality, aesthetics, durability, and sustainability criteria are the main factors prioritized in building construction. However, their interactions with each other and determining their order of importance are critical for effective building construction management. This study aims to reveal the relative importance of these criteria by focusing on their conceptual content.

3. Material and Method

In AHP and FAHP methods, the relative importance of the criteria is determined through pairwise comparisons. Each criterion should be explained to the respondents shortly and concisely for pairwise comparisons. For this reason, it was decided to conduct the study using a mixed research method. The mixed research method, which meets the criteria of scientific rigor, combines the strengths of quantitative and qualitative approaches while compensating for the weaknesses of both approaches (Khaldi, 2017). The first part is the qualitative research part, in which the participants are asked to explain what the essential criteria expected from a building mean to them. This part, conducted with a fewer participants, tried to determine how the participants handled the essential criteria and the similarities and differences of their views with the literature. Thus, making short and correct definitions of each criterion was possible. The second part is the Analytic Hierarchy Process (AHP) and Fuzzy Analytic Hierarchy Process (FAHP) analysis study conducted to determine the weights of the main criteria. AHP is a hierarchical and pairwise comparison matrix-based multi-criteria decision analysis technique that helps to solve the multi-criteria decision problem (Belay, Goedert, Woldesenbet & Rokooei, 2022). AHP tools help construction practitioners make quick decisions (Razi, Ramli, Ali & Ramadhansyah, 2020). In this section, the importance level of each criterion was obtained from the matrix obtained as a result of the pairwise comparisons of the participants and the results were compared. In the study, the importance level of the criteria was also determined by the FAHP method, and the results were compared. Fuzzy logic cannot measure the level of consistency in a decisionmaker's judgments. On the other hand, AHP cannot capture the subjectivity of human judgments as verbal assessments are converted into crisp values (Ishizaka, 2014). FAHP, as a method that combines the advantages of Fuzzy logic and AHP, is used widely in construction sector in multi-criteria decision-making problems (Iqbal, Ma, Ahmad, Ullah & Ahmed, 2021; Mathiyazhagan, Gnanavelbabu & Lokesh Prabhuraj, 2019).

3.1. Qualitative Analysis

This part of the study was carried out to provide brief and accurate definitions of the criteria. Therefore, conducting the study with 7 participants, consisting of engineers from different branches, was deemed sufficient. The participants were asked to state what they understood by the essential criteria a building should meet: Safety, Functionality, Aesthetics, Economy, Sustainability and Durability.

As a result of the interviews with the participants, the basic criteria for building construction were evaluated as follows:

The participants defined safety as the need for a building to ensure the safety of people's lives and property. In this context, they associated the concept of safety with the ability to resist risky situations such as earthquakes and fires. Safety's purpose is summarized as ensuring that users are in a safe environment in the face of such emergencies.

The economy was a concept where participants generally focused on the initial investment cost. However, it was stated that the operating cost should also be considered when evaluating affordability. Economy was defined as the ability to produce at low cost without sacrificing quality, as well as the ability to construct the building economically and for the contractor to make a profit. In this context, the economy has a perspective that aims to optimize both the initial costs in the construction process and the costs in the structure's operation process by the set standards and to make a profit.

The participants generally defined functionality as the ability of a building to fulfill its expected tasks. In this context, functionality includes a structure's capacity to meet the expected needs and effectively fulfill predetermined functions. This perspective understands functionality as the ability not only to meet basic needs, but also to fulfill these functions efficiently and user-friendly.

Two participants defined durability as the ability not to deteriorate physically and to serve for a long time, while others emphasized resistance to natural disasters. In this context, a similar understanding of durability and safety is observed. The participants understood durability as both the ability of a building to remain physically intact and its ability to resist natural disasters.

One participant defined aesthetics as having a visually pleasing and balanced appearance and being designed in harmony with the environment in a way people like. In this context, the concept of aesthetics includes a visually attractive design and environmental harmony. On the one hand, aesthetics is associated with the materials' shape, size and appearance. On the other hand, architectural style, color selection and exterior appearance are emphasized.

Participants generally focused on not harming the environment, being environmentally sensitive and protecting natural resources. In this context, the concept of sustainability emphasizes energy efficiency, recycling and building longevity requirements. Sustainability has a perspective that focuses on minimizing environmental impacts, using resources effectively and fulfilling environmental responsibilities for future generations.

3.2. Analytic Hierarchy Process (AHP)

AHP is a decision-making and estimation method used when a decision hierarchy can be defined. It gives the percentage distribution of decision points regarding the factors affecting the decision. The method aims to enable people to make better decisions by allowing them to recognize their decision-making mechanisms instead of forcing them to use a method on how they should decide (Albayrak, 2004). AHP is a frequently used method for analyzing complex decision problems due to its simplicity, flexibility, ease of use and straightforward interpretation (Yılmaz, 2005).

Solving a decision-making problem using the Analytical Hierarchy Process (AHP) involves several key steps. The decision-making problem is initially defined by identifying decision points and factors, emphasizing the importance of a precise and detailed factor description for consistent pairwise comparisons. Subsequently, a comparison matrix is created, capturing the relationships between factors. Percentage importance distributions are assigned to factors, and the consistency of comparisons is measured. The calculations extend to determining percentage importance distributions at decision points and analyzing the distribution of results. Careful adherence to a predefined importance scale is maintained throughout this process, as outlined in Table 1, to ensure accuracy and reliability in the decision-making model. Overall, AHP provides a systematic approach, aiding in informed and comprehensive decision-making. After creating the pairwise comparison matrices, the percentage importance distributions of each factor are determined. According to the AHP method, the eigenvector corresponding to the largest eigenvalue in the comparison matrix determines the importance distributions. AHP requires consistency in thought and judgment, but preference consistency may be violated. At this stage, it is necessary to calculate the consistency ratio for each generated comparison matrix to measure whether the decision maker acts consistently when comparing factors (Dağdeviren, Diyar & Mustafa, 2004). The consistency ratio (CR) obtained from the product of the pairwise comparisons matrix and the importance distribution vector should be less than 0.10. The other two stages of the AHP, which were not used in this study since no decision-making problem was solved within the scope of the study, are the stages of finding the percentage importance distributions at m decision points and the distribution of results at the decision points, for each factor.

Table 1. Importance scale (Saaty, 1980)

Imp.	Definition	Description
1	Equally important	Both options contribute equally to the goal.
3	Moderately more important	Experience and judgment slightly favor one over the other.
5	Strongly more important	Experience and judgment strongly favor one over the other.
7	Very strongly more important	Experience and judgment very strongly favor one over the other.
9	Extremely more important	Evidence that favors one over the other has the highest possible validity.
2,4,6,8	Intermediate values	Values between two consecutive judgments used when consensus is needed.

3.2.1. Determination of criteria weights

The study's criteria for evaluating a building are safety, economy, functionality, durability, aesthetics and sustainability. Therefore, the factors that will determine the decision are clear (Figure 1).

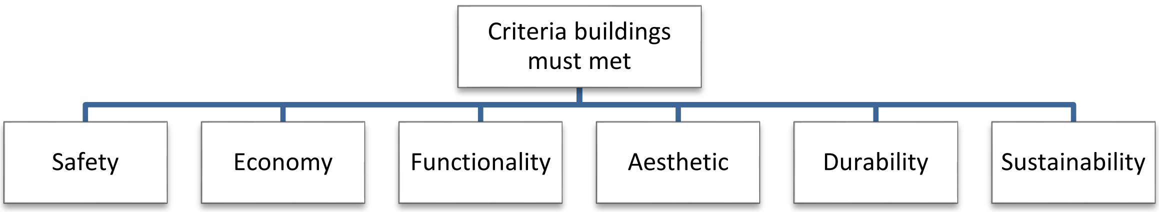

Figure 1. AHP model factor structure (Created by authors)

As seen in the qualitative analysis part of the study, some criteria, particularly safety and durability, were understood differently. In order to enable healthy pairwise comparisons, the questionnaires included the definitions given in Table 2 and various examples of what the respondents should understand from the criteria.

Table 2. Criteria and their definition (Created by authors)

Criteria	Definition
Safety	The structure should not collapse under the loads it bears during its lifetime and should not make excessive deformation; for example, it should not be damaged in mild and moderate earthquakes and should not cause loss of life in severe earthquakes.
Economy	Construction of the building should be done in the most cost-effective way, not spending too much to make it more secure than necessary or for unnecessary productions that can be considered luxurious.
Functionality	The building is suitable for use; room sizes are determined appropriately, kitchen countertops are at the appropriate height, sufficient sockets, etc.
Durability	The building and building elements can fulfill their functions without deteriorating for extended periods; the roof does not leak in a few years, the exterior paint does not fade, and the door and window joinery do not deteriorate.
Aesthetic	The applications in the building are beautiful, correct and properly made; such as the exterior of the building is beautifully designed, the plasters are in alignment, the joints in the ceramics are consistent with each other, the floor coverings are at the same level.

Sustainability	To construct the building in a way that is environmentally sensitive throughout its life cycle minimizes damage to nature, and uses energy, water, materials and land efficiently.

AHP is widely acknowledged as a subjective approach that does not require a statistically significant sample size to produce reliable results (Zhang & Zou, 2007; Hyun, Cho, Koo, Hong & Moon, 2008; Lam, Lam & Wang, 2008; Pan, 2008; Dalal, Mohapatra & Chandra Mitra, 2010; Zou & Li, 2010; Li & Zou, 2011; Pan, Dainty & Gibb, 2012; Akadiri, Olomolaiye & Chinyio, 2013; Baby, 2013; Chou, Pham & Wang, 2013; Kamaruzzaman, Lou, Wong, Wood & Che-Ani, 2018; Darko, Chan, Ameyaw, Owusu, Pärn & Edwards, 2019). One advantage of AHP over other multi-criteria decision-making (MCDM) methods is that it does not require a large sample size to generate sound and statistically robust results (Dias & Ioannou, 1996; Doloi, 2008). For example, Lam & Zhao (1998) note that reliable results can be obtained even with a small sample in AHP studies, and in some cases, a single expert’s judgment may be sufficient to represent broader perspectives (Golden, Wasil & Harker, 1989; Abudayyeh, Zidan, Yehia & Randolph, 2007; Tavares, Tavares & Parry-Jones, 2008). This flexibility is one of the primary reasons AHP is popular in construction management research.

There is no strict minimum sample size requirement in AHP, as evidenced by studies that have employed sample sizes ranging from 4 to 9 participants (Zhang & Zou, 2007; Hyun et al., 2008; Lam et al., 2008; Pan, 2008; Dalal et al., 2010; Zou & Li, 2010; Li & Zou, 2011; Pan et al., 2012; Akadiri et al., 2013; Chou et al., 2013). Only a few studies have involved more than 30 participants (Ali & Al Nsairat, 2009; El-Sayegh, 2009). AHP's ability to produce meaningful decision models with small sample sizes makes it a preferred method in MCDM applications.

Moreover, AHP is known for achieving a high level of consistency, which helps to reduce bias and ensure that subjective judgments are validated through consistency analysis (Saaty, 1980; Saaty & Vargas, 1991). Literature shows that this ability to align subjective judgments from experts with potentially varying perceptions, experiences, and understandings is a significant reason why AHP is often selected for construction-related decision-making (Cheung, Suen, Ng & Leung, 2004; Abudayyeh et al., 2007; Hsu, Wu & Li, 2008). In this study, consistency analysis was applied in AHP to ensure the validity and coherence of the experts' judgments. In this study, AHP analysis was conducted with 22 participants. The demographic data of these participants are presented in Table 3. 15 are male, and 7 are female. 40% of the participants are under 30 and 27% are between the ages of 30-39. Since the AHP analysis requires expert opinion, all participants were selected from people with a university education or above. While 20 participants were university graduates, 2 participants had a master's degree. More than half of the participants are architects and civil engineers, while the rest are electrical, mechanical, computer and material engineers. 50% of the participants have 5 years or less experience, while 23% have 20 years or more of work experience.

Table 3. Demographic data of the participants (Created by authors)

Variable	N	%
Gender		
Male	15	68,2
Female	7	31,8
Age Group		
20-30	9	40,9
30-39	6	27,3
40-49	4	18,2
50-59	2	9,1
> 60	1	4,5
Educational Status		
University	20	90,9
Master's Degree - PhD	2	9,1
Work Experience Duration		

≤ 5	11	50,0
6-10	4	18,2
11-15	2	9,1
16-20	0	0,0
> 20	5	22,7
Profession		
Civil Engineer	8	36,4
Electrical Engineer	5	22,7
Architect	4	18,2
Computer Engineer	2	9,1
Mechanical Engineer	2	9,1
Materials Engineer	1	4,5
Total	22	100,0

Each participant determined the importance of the criteria with pairwise comparisons by the values in Table 1. In this way, 22 comparison matrices were obtained for 22 participants. These matrices were transformed into a single matrix by taking the geometric average of the responses. The consistency of this matrix was checked and weights were obtained for each criterion. The matrix obtained by the participants making pairwise comparisons between the factors regarding the basic expectations from a building is presented in Table 4. This matrix's Consistency Ratio (CR) was found to be 0.039, below the limit value of 0.1.

Table 4. Pairwise comparison matrix (Created by authors)

Factor	SAF.	ECN.	FUN.	DUR.	AES.	SUS.	Eigen Value
SAF.	1,00	6,00	3,12	1,61	4,19	2,58	0,364
ECN.	0,17	1,00	1,18	0,43	1,72	0,78	0,098
FUN.	0,32	0,57	1,00	0,67	2,27	0,74	0,112
DUR.	0,62	2,30	1,49	1,00	4,87	2,25	0,236
AES.	0,24	0,58	0,44	0,21	1,00	1,43	0,078
SUS.	0,39	1,27	1,35	0,44	0,70	1,00	0,112
			CR =	0,039			

The eigenvector values in the matrix's last column indicate the factors' importance level. According to the analysis, in terms of basic expectations from a building, the importance of safety is 36%, economy 10%, functionality 11%, durability 24%, aesthetics 8% and sustainability 11%. It is expected that safety will be given high importance. On the other hand, although a precise definition is given for durability, it is thought that some participants perceived it as safety, which may have affected its reaching the second highest importance. The fact that the other four criteria reached similar importance weights is essential in that one cannot be sacrificed for the sake of the other.

3.3. Fuzzy Analytic Hierarchy Process (FAHP)

FAHP also determined criteria importance levels. FAHP is a multi-criteria decision-making method developed by Thomas L. Saaty in 1971 (Saaty, 1980). This method consists of previously known discrete concepts and techniques such as hierarchical structuring of complexity, pairwise comparison, eigenvector in deriving weights and measurement of consistency. Saaty combined these concepts and techniques with some innovations to create more powerful process than the sum of its parts.

FAHP is a method that integrates fuzzy logic and the analytic hierarchy process and aims to solve complex decision-making problems. Fuzzy logic is a mathematical approach used to handle uncertainty and uncertain information. Although there is no clear superiority of Fuzzy AHP over AHP in terms of solution quality, there has been a significant increase in the use of Fuzzy AHP in the academic literature in the last 20 years, as stated by Chan, Sun & Chung (2019), indicating a growing trend in the field. Within the scope of this study, the workflow for the application of the FAHP method is as follows:

Criteria identification, Fuzzy pairwise comparison matrix generation, Fuzzy weight calculation, and Analysis of results and comments.

The decision hierarchy for FAHP analysis is as given in Figure 1. Pairwise comparison matrices were created, and comparisons were made between the criteria. To check whether these comparisons meet the consistency condition, the criteria were tested with the condition of falling below the 0.10 ratio predetermined in the AHP method. Then, relative weights (eigenvector values) were calculated from the pairwise comparison matrices.

The pairwise comparison matrices created according to the determined criteria were scaled according to the degree of importance using fuzzy numbers (Table 5). In this context, a different approach from the AHP methodology was adopted, which was the fuzzy AHP method. The matrices are expressed as a 3-dimensional fuzzy matrix for each dimension. This means that a matrix value, which is usually 2x2 in the AHP process, is transformed into a (1, 2, 3) x (1, 2, 3) scale in the Fuzzy AHP (FAHP). Triangular Fuzzy Numbers are preferred due to the ease of calculation for decision-makers. Triangular fuzzy numbers are represented as A=(a,b,c). The parameters here indicate the lower limit, peak (mode) value and upper limit value, respectively. Also, b has a membership degree of 1 (Chang, Wu & Lin, 2009). This method allows for a more detailed examination of the relationships between specific criteria, as fuzzified matrices have been used to handle uncertainty more effectively.

Table 5. Importance levels used in comparison (Created by authors)

Fuzzy Number	Explanation	Scale of Fuzzy Number	Reversal of Fuzzy Number
1	Equally important	(1, 1, 1)	(1, 1, 1)
2	Weak advantage	(1, 2, 3)	(1/3, 1/2, 1/1)
3	Not bad	(2, 3, 4)	(1/4, 1/3, 1/2)
4	Preferable	(3, 4, 5)	(1/5, 1/4, 1/3)
5	Good	(4, 5, 6)	(1/6, 1/5, 1/4)
6	Pretty good	(5, 6, 7)	(1/7, 1/6, 1/5)
7	Very good	(6, 7, 8)	(1/8, 1/7, 1/6)
8	Absolute	(7, 8, 9)	(1/9, 1/8, 1/7)
9	Perfect	(9, 9, 9)	(1/9, 1/9, 1/9)

The binary decision matrices created according to the criteria were compared and weighted according to their importance. According to the results obtained, the most effective criterion in building construction is safety, while the least effective factor is aesthetics. As seen in Table 6, the results of the Fuzzy AHP method and the AHP method are quite close to each other as expected.

Table 6. Fuzzy AHP weighting results (Created by authors)

Criteria	Fuzzy AHP Weights	AHP Weights
Safety	0,383	0,363
Economy	0,102	0,100
Functionality	0,106	0,112
Durability	0,227	0,235
Aesthetic	0,071	0,078
Sustainability	0,111	0,113

In addition to using traditional AHP, FAHP was applied to handle the inherent uncertainty and subjectivity in expert judgments. FAHP enables the incorporation of linguistic variables into the pairwise comparisons, allowing for a more nuanced reflection of participants' perceptions where precise numeric judgments might be challenging. By transforming participants' judgments into fuzzy values, FAHP provided a more robust framework to capture the subtle differences in importance assigned to each criterion. This approach not only helped obtain more reliable weights but also improved the consistency of the aggregated matrix by reducing the potential inconsistencies in subjective evaluations.

4. Results and Discussion

Structures are subjected to loads during their lifetime. The loads have the potential to cause the structure to deteriorate, wear down, sustain various types of damage, or collapse entirely or partially, all of which inevitably result in losses. These losses are realized as economic loss, loss of cultural value, injury, and death (Madsen, Krenk & Lind, 2006). Global research has demonstrated that design and manufacturing flaws during the building process are the primary reasons for structural damage and collapse (Terwel & Jansen, 2015). In this respect, the most basic expectation from a structure is to safely carry the loads acting on it and ensure the safety of the life and property of its users. However, it is a fact that all structures and materials deteriorate and disappear over time. Therefore, a building loses its bearing capacity over time, and it is essential to design it to have the intended lifetime (Sundquist, 2010). In this respect, safety also includes being resistant to the environmental effects that the building is exposed to during its lifetime. Again, the usefulness of the structural system of the building according to the structural purpose, such as the floors not vibrating while walking, is also considered within safety. In the AHP analysis conducted within the scope of the study, the safety factor emerged as by far the most essential criterion, with 36%. However, the results of the qualitative research revealed that the respondents considered the concept of safety intertwined with the concepts of strength and durability. Notably, most participants did not refer to natural disasters, especially earthquakes. The difference between the original meanings of the concepts and the meanings attributed by the participants has several consequences. It is both a legal and a conscientious responsibility to fulfill all legal obligations and standards related to uncompromisingly building safety regardless of everything. However, a good understanding of the safety criteria, especially by users and owners, will naturally lead to the realization of a control mechanism. For example, a user who understands the structural system safety relationship at a certain level will avoid operations that damage the structural system, such as column cutting, beam breaking to pass installation elements, and curtain wall drilling, and will prevent such attempts. Thanks to the advances in structural systems and designs and high-strength materials, building weights have significantly decreased and slenderness has increased. This situation causes lateral loads such as earthquakes and wind to dominate the structural design, while vertical loads due to gravity can be carried more easily (Shakir, Jasim & Weli 2021). It is thought that users who are aware of this situation will question the issues related to the safety of the building more and take timely and adequate measures against durability problems that weaken the structural capacity.

The second most important criterion was durability, which was 23%. In its simplest form, durability refers to the ability to withstand damage, decay and deterioration over time (Nireki, 1996). More broadly, it can be defined as the ability of a building or a component of a building to fulfill its functions at the required levels for a certain period in a service environment without unforeseen costs for maintenance or repair, either under the influence of environmental influences or as a result of the self-aging process (Lacasse, Ge, Hegel, Jutras, Laouadi, Sturgeon & Wells, 2018). Although durability is a concept that includes all the materials that make up the detail and protective structure together with the carrier materials, the participants in the qualitative research directly considered durability as safety. Even though the definitions of safety and durability were given in the AHP analysis, it is considered that this idea may also affect pairwise comparisons. In any case, durability covers all building components. Over the years, the performance of the structural system elements also deteriorates. However, the structure should be designed to perform and maintain its structural integrity for a specific expected design life (Blok, Herwijnen, Kozlowski & Wolinski, 2003). Therefore, the structural system elements must exhibit the expected durability for the structure to continue to function without damage. On the other hand, the details or protective components of a building, such as roof or floor covering, exterior paint, and rain gutters, should also be durable. If such materials are not durable, they negatively affect the criteria of function, aesthetics, economy and sustainability. Considering the effects on other criteria, it is a natural consequence that durability has gained high importance.

Although the criteria of economy, functionality, aesthetics and sustainability gained around 10% importance in the AHP analysis, the participants in the qualitative research defined these criteria superficially. For example, while only the initial investment cost was emphasized for the economy, the fact that the operating period costs were not mentioned is a deficiency. However, a building also causes great costs to its users during the period of use. Researchers argue that life cycle cost analysis should be used early in the project to evaluate the economic impact and cost of different design alternatives and to support decision-making (Alshamrani, 2022; Rad, Jalaei, Golpour, Varzande & Guest, 2021). It should be recognized that the most crucial step in achieving economy is the additional acquisition and use cost of each additional m^2. The room/space requirements of houses to be built, purchased or rented should be decided by considering current and future family needs. It should be kept in mind that passive architectural design strategies that are functionally efficient, allow plenty of sunlight in cold climates, prevent direct heat gain in hot and humid climates, provide natural ventilation and optimize abundant daylight reduce the cost of use in buildings (Zaki, Nawawi & Ahmad, 2010).

Functionality is generally defined as being able to meet the need. However, functionality is a concept beyond this. Architecture organizes and structures space by making it comprehensible, understandable and interpretable (Lawson, 2007), as exterior and interior spaces, and the materials and objects within them, can facilitate - or hinder - our activities by the way they imply and represent specific messages (Bels & Branco, 2017). In this context, recognizing that functionality encompasses a wide range of issues, from impractical placement of spaces to rooms that are too small or too large to fit furniture, to misplaced or inadequate sockets, to kitchen countertops that are too low or too high, can lead to more thoughtful design and production.

Assessing an environment typically entails judging its likability or dislikability, which can be a conscious or unconscious process. The cognitive procedure underlying this judgment primarily involves perceiving the visual characteristics of the environment and subsequently conducting an emotional evaluation. In essence, individuals use cognitive and emotional analysis when evaluating an environment, forming opinions about their preferences or aversions based on the perceived visual elements (Kaplan & Kaplan, 1982; Nasar, 2000). From this point of view, it is natural to describe aesthetics as pleasing to the eye and beautiful. However, aesthetics also means that specifications and standards make the productions for the construction sector. Regarding standards, the core of the issue is achieving and maintaining high-quality craft (Louw, 2003). Improving construction craft improves aesthetics, safety, durability and functionality (Gunasinghe, De Silva & De Silva, 2017). In this respect, first of all, it is necessary to look for the production's compliance with the rules of science and art and pay attention to issues such as color, shape, pattern, and texture.

The fact that sustainability is slightly ahead of functionality, economy and aesthetics criteria in AHP analysis shows that such an awareness has been created in the society. This is likely due to the increased awareness of the environmental problems experienced by our country. Although Türkiye has a rapidly increasing energy need and a lack of primary energy resources, energy intensity, which indicates inefficient use of, is very high (Yıldız, Kıvrak & Arslan, 2017). Again, although Türkiye is expected to become a water-poor country shortly, pollution and wastage of water resources continue at full speed (Yıldız, Kıvrak & Arslan, 2018). Many other environmental and economic and social sustainability issues are indirectly related to sustainability in the construction sector, which is extremely important for our country.

If the results are generally evaluated, understanding and explaining what it is expected from the buildings in which we spend most of our days and the built environment, which shapes almost all of our lives, will create a balance and control mechanism for the wide stakeholder mass of the construction sector. Buildings will be shaped according to expectations, directly or indirectly increasing our standard of living and comfort. Safety and durability were emphasized in the AHP and FAHP analyses, while other criteria have been given approximately equal importance. While this is an expected result, it is clear that users need to be taught practical ways and methods how to question whether expectations are met. This is demonstrated by the fact that in the February 2023 earthquake, many newly built houses were not destroyed, but were heavily damaged and had to be demolished later. The fact that the importance levels of the other criteria are close to each other indicates that one of these criteria cannot be sacrificed for the other. For example, the fact that these criteria are as prominent as the economy shows that owners, designers and contractors should not compromise on some things for economic reasons. Since the sustainability criterion is as important as economics, the contractor should not easily give up energy efficiency measures based on the initial construction cost. It is also wise to bear certain costs for a more functional design and aesthetic production.

The research will likely be instructive for a wide range of construction sector stakeholders, from owners to contractors, designers to construction site workers, and authorities to customers. This study is limited to defining the six essential criteria expected from a structure and determining their weights. Determining sub-criteria for each criterion, the importance of these sub-criteria, and concrete indicators for each will ensure that a complete model is obtained. Although the study was conducted with university graduate architects and engineers who are industry stakeholders, similar studies can be conducted for different groups such as contractors, consumers, and public authorities.

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Author Contribution and Conflict of Interest Declaration Information

All authors contributed equally to the article. There is no conflict of interest.

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Botanical Gardens and Arboretums as Regards to Cultural Landscapes: Three Cases from Istanbul

Sümeyra ELMA [1]*, Ayşe DURAK [2], Betül TÜLEK [3], Meryem ATİK [4]

ORCID 1: 0000-0003-1230-280X, **ORCID 2:** 0000-0002-1424-7448
ORCID 3: 0000-0002-6584-041X, **ORCID 4:** 0000-0003-2105-9231
[1,2,4] *Akdeniz University, Faculty of Architecture, Department of Landscape Architecture, 07070, Konyaaltı, Antalya, Türkiye.*
[3] *Çankırı Karatekin University, Faculty of Forestry, Department of Landscape Architecture, 18100, Çankırı, Türkiye.*
**** e-mail**: sumeyraelma@gmail.com*

Abstract

The aim of the study is to examine Istanbul University Alfred Heilbronn Botanical Garden, Atatürk Arboretum and Nezahat Gökyiğit Botanical Garden as examples of cultural landscapes and to determine which cultural landscape criteria they reflect. Study areas were evaluated under UNESCO's criteria: World Heritage Cultural Landscape Classes, Natural and Cultural Landscape Criteria, Complementarity Criteria, and Authenticity Criteria. When the analysed areas are compared with each other according to the UNESCO Cultural Landscape Criteria, it is determined that Nezahat Gökyiğit Botanical Garden stands out with examples of cultural features among the cultural landscape criteria as a result of having two cultural landscape criteria (ii, v) as a result of the presence of Ertuğrul Monument constituting an 'example of monumental art' (ii) and the presence of Istanbul Mansion Garden constituting an 'example of human settlement representing a culture' (v). Alfred Heilbronn Botanical Garden and Atatürk Arboretum stand out with the natural features of the cultural landscape criteria.

Keywords: *Atatürk Arboretum, Istanbul University Alfred Heilbronn Botanic Garden, Nezahat Gokyigit Botanic Garden, UNESCO cultural landscape criteria.*

Kültürel Peyzajlar Bağlamında Botanik Bahçeleri ve Arboretumlar: İstanbul'dan Üç Örnek

Öz

Kültürel peyzaj örnekleri olarak İstanbul Üniversitesi Alfred Heilbronn Botanik Bahçesi, Atatürk Arboretumu ve Nezahat Gökyiğit Botanik Bahçesi'nin incelenerek hangi kültürel peyzaj kriterlerini yansıttıklarının belirlenmesi çalışmanın amacını oluşturmaktadır. Çalışma alanları UNESCO Dünya Mirası Kültürel Peyzajları Sınıfları, Doğal ve Kültürel Peyzaj Kriterleri, Kültürel Peyzajların Tamamlayıcı Kriterleri ve Kültürel Peyzajların Özgünlük Kriterleri kapsamında incelenerek,incelenen alanlar birbiriyle karşılaştırılmıştır. İncelenen alanlar UNESCO Kültürel Peyzaj Kriterlerine göre birbiriyle kıyaslandığında Ertuğrul Anıtı'nın varlığıyla ''anıtsal sanat örneği''ni teşkil etmesi (ii), İstanbul Konak Bahçesi'nin varlığıyla ''bir kültürü temsil eden insan yerleşimi örneği''ni oluşturması (v) sonucu iki kültürel peyzaj kriterine (ii, v) sahip olmasıyla Nezahat Gökyiğit Botanik Bahçesi'nin kültürel peyzaj kriterlerinden kültürel özelliğe sahip örneklerle ön plana çıktığı görülmektedir. Alfred Heilbronn Botanik Bahçesi ve Atatürk Arboretumu ise Kültürel Peyzaj kriterlerinin doğal özellikleri ile ön plana çıkmıştır.

Anahtar kelimeler: *Atatürk Arboretumu, İstanbul Üniversitesi Alfred Heilbronn Botanik Bahçesi, Nezahat Gökyiğit Botanik Bahçesi, UNESCO kültürel peyzaj kriterleri.*

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1. Introduction

Landscape refers both to natural and cultural features of an area and links people to nature recognizing their relation with their environs. The concept of "cultural landscape" has emerged from the expression of human interpretation of natural environment (Mitchell, Rössler, Tricaud & Tricaud, 2009). "Cultural landscape" embraces a diversity of manifestations of the interaction between humankind and its natural environment' (Fowler, 2003).

Botanical gardens and arboretums are among the most exceptional examples of cultural landscapes due to their contribution to biodiversity, harboring endemic and natural species, harboring plant species that express cultural values and beliefs that are similar or different for each society, and being shaped according to the values of the society. The origin of the arboretum derives from the word arbor, which means "tree" in Latin, and the suffix -etum, which means "the area where certain plants are grown". Sites Areas where domesticated and exotic woody plants are exhibited together in ecologically suitable environments with diverse vegetation are called arboretums (Aydın, 2006).

The word botany comes from the Ancient Greek root botanikē βοτανικός, from the word botánē βοτάνη meaning "grass and self- growing plant", transferred into French as "botanique" with the combination of +ikos suffixes. Botanic gardens are characterised by the Botanic Gardens Conservation International (BGCI) as culmination where living plant collections are kept for the purposes of education, teaching, research, conservation and exhibition (BGCI, 2021). Trees, shrubs and all other plants forms are grown in botanical gardens, while, arboretums contain woody plant species (Wyman, 1947; Aydın, 2006; Olkay Şengün, 2011).

Encountered since ancient times, the purpose of botanical gardens is to obtain more economic and medical benefits besides on-site conservation. The first botanical garden was established by Aristotle in Athens in 350 BC to grow fruit trees, vegetables and medicinal plants used in medicine (Müminoğlu, Tahta & Aslan, 2018). Botanical gardens took their present form in Italy during the Renaissance where Botanical Gardens of Pisa near Bologna in 1543 and Padua in 1545 were set up (Önder & Konaklı, 2011).

When botanical gardens are analysed from past to present, their evolving role and settings are evident (Figure 1). In the 16th and 17th centuries, the focus was on growing medicinal plants for educational purposes at universities, while in the 18th and 19th centuries, the scientific and economic role of plants have been blended in exotic gardens. In the 20th and 21st centuries, botanic gardens have undertaken two main functions: conservation and education in response to biodiversity loss and climate change (Yuqi, Ignatieva & Gaynor, 2022).

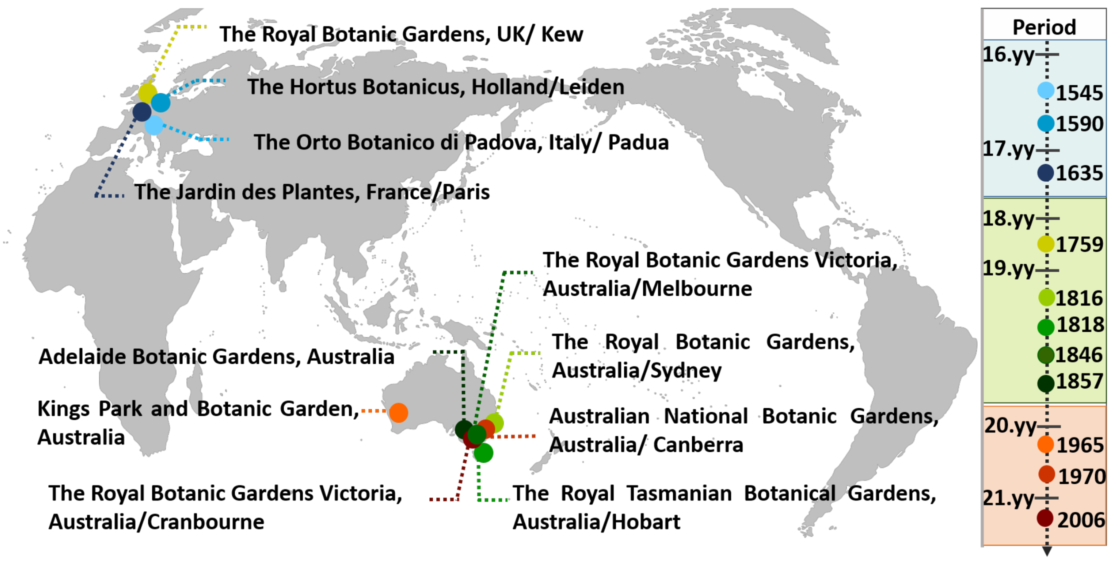

Figure 1. A representation of botanical gardens of different periods around the world (interpreted from McCracken, 1997; Lockwood, Wilson, Fagg & Cundall, 2001; Yuqi et al., 2022)

Through the time botanical gardens have enriched the urban environments and been integrated into urban planning by English style parks with curvilinear shapes, gentle rising hills, bright green lawns, flower beds and scattered groves (Ignatieva, 2010; Ignaiteva, 2011; Ignatieva & Ahrné, 2013; Müller, Ignatieva, Nilon, Werner & Zipperer, 2013).

The first examples of botanical gardens in Türkiye were established during the Byzantine and Ottoman Empires for the cultivation of fruits and vegetables, especially medicinal plants (Müminoğlu et al., 2018). The Galata Palace Botanical Garden was set up in 1839 next to the "Mekteb-i tıbbiye Şahane" building where Galatasaray High School is located today, for the practical training of medicine and pharmacy students in botany courses (Küçüker & Üzen, 1998; Önder & Konaklı, 2011; Müminoğlu et al., 2018). Later on, Istanbul University Alfred Heilbronn Botanical Garden was found in 1935 (Küçüker, 2005; Müminoğlu et al., 2018). On the other hand, the first arboretum was started for scientific purposes in 1720 in Monceau Park, France (Sertkaya, 1997; Olkay Şengün, 2011). In Türkiye, it is the Atatürk Arboretum which established in 1949 under the auspices of Istanbul University Faculty of Forestry (Gültekin & Atik, 2000; Önder & Konaklı, 2011).

Botanical gardens and arboretums have scientific (research and conservation), educational (teaching, culture), recreational, ecological, social and cultural functions (Ekim, 1991; Perçin, 1997; Hepcan & Özkan, 2005; Olkay Şengün, 2011). They also constitute one of the important channels for tourism (Müminoğlu et al., 2018). Botanical gardens embody both exotic and native vegetation and strongly contribute to the formation of environmental awareness by providing information about plants, ecology and on-site learning and conservation for visitors of all age groups (Hepcan & Özkan, 2005).

Botanical gardens are among the world heritage cultural landscapes defined by UNESCO (United Nations Educational, Scientific and Cultural Organisation) since 1992. According to the International Union for Conservation of Nature (IUCN) cultural landscapes are combined works of nature and man and illustrative of the evolution of human society and settlement over time, under the influence of the physical constraints and/or opportunities presented by their natural environment and of successive social, economic and cultural forces, both external and internal (Fowler, 2003; Rössler, 2006; Taylor, 2011; Osipova, Shi, Kormos, Shadie, Zwahlen & Badman, 2014; UNESCO, 2017). Kew Royal Botanic Garden (England), Singapore Botanic Garden (Singapore) and Padua Botanic Garden (Italy) are prominent examples listed in the UNESCO World Heritage Cultural Landscapes.

While a Kew Botanical Garden reflects British culture with its large meadows, ponds, sculptures, shaped plant labyrinths; Singapore Botanic Gardens with includes a rich variety of historic landscape features, plantings and buildings demonstrates the evolution of a British tropical colonial era with English Landscape Style ‘pleasure garden’. Dedicated as world heritage site, the garden incorporates horticultural and botanical research, and plant conservation. World heritage Sítio Roberto Burle Marx botanical garden in Brazil, reflects elements of traditional Portuguese-Brazilian folk culture in its design focusing on tropical plants (UNESCO, 2024). Kirstenbosch National Botanical Garden (Cape Town) in South Africa, Montreal Botanical Garden in Canada, Royal Botanical Gardens in Australia, Nong Nooch Botanical Garden in Thailand, Dahlem Botanical Garden and Botanical Museum in Germany, Trauttmansdorff Castle and Botanical Gardens in Italy, Lutaret Alpine Botanical Graden in France, Karaca Arboretum and Bursa Botanical Park in Türkiye are some examples that potentially meet cultural landscape criteria and have important significance also at international scale.

In this study, the examples of Istanbul University Alfred Heilbronn Botanical Garden (AHBB), Atatürk Arboretum and Nezahat Gökyiğit Botanical Garden (NGBB), which provide important benefits for the city of Istanbul, were evaluated in the light of UNESCO World Heritage Cultural Landscapes criteria, and their natural and cultural heritage values as well as being important urban open green spaces were examined in the light of Cultural Landscapes Criteria.

2. Material and Method

The material of the study consists of AHBB, Atatürk Arboretum and NGBB, which is a member of the International Botanical Gardens Conservation Association (BGCI) in Istanbul, Türkiye (Figure 2). Located in the north-west of Türkiye as well as between Asia and Europe, Istanbul has the characteristics of the warm and rainy climate and encourages diversity in vegetation and allows convenient settings for the adaptation of plant species brought from other regions to botanical gardens and arboretums.

Figure 2. Location of the study sites (Authors, 2024)

The study method is based on the comparative analysis of selected arboretums and botanical gardens in Istanbul based on the natural and cultural criteria for UNESCO world heritage sites.

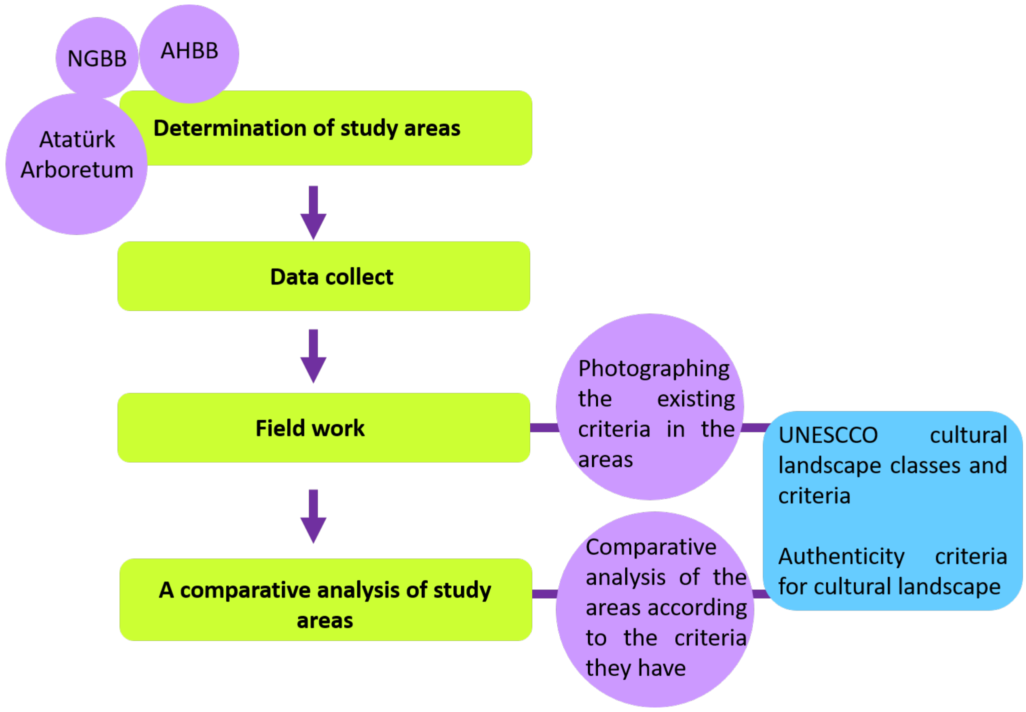

Figure 3. Flow chart of the research methodology (Authors, 2024)

The research method consists of 4 stages (Figure 3). In the first stage, the study areas were determined. In the second stage, data about the study areas were collected from sources such as articles, theses and books. In the third stage, the study areas were visited and photographed separately in the light of UNESCO's definition of cultural landscape categories and cultural and natural criteria (Table 1). In addition, botanical gardens and arboretums were evaluated and photographed in terms of authenticity criteria (Table 2), and their cultural and biocultural values were revealed. The land where AHBB is located was transferred to Istanbul Mufti's Office in 2015 and is closed to visitors. Therefore, photographs for this study area were accessed via the internet. In the last stage, a comparative analysis of selected arboretums and botanical gardens in Istanbul was made on the basis of natural and cultural criteria for UNESCO world heritage sites.

Table 1. UNESCCO cultural landscape classes and criteria (Fowler, 2003; Rössler, 2006; WHC, 2008)

UNESCO Cultural Landscape Categories		
1. Easily Definable Landscapes (*2a. Relict (or Fossil) Landscapes; 2b. Landscapes in Development)*		
2. Organically Formed Landscapes		
3. Composite Cultural Landscapes		
	Cultural	***Natural***
UNESCO Cultural Landscape Criteria	**i.** Reflecting the work of a talented artist **ii.** To have left a mark on a cultural region in the world during a period of time and to have greatly influenced developments in the fields of monumental arts, architecture, or urban planning and landscape design **iii.** Carrying a unique proof of a civilisation or cultural tradition that lived in ancient times, **iv.** Being a unique example of a building form or landscape indicating one or more important stages in human history **v.** Being an important example of traditional human settlement or land use representative of a culture: in particular, being under threat of irreversible degradation **vi.** The existence of artistic or written works of universal value that are directly or indirectly linked to events or living traditions	**vii.** Contain outstanding natural phenomena and sites or have unique natural beauty **viii.** To represent one of the important developmental stages of the earth and world history, such as geologic, geomorphologic and physiographic formations that are effective in the development of surface forms **ix.** To represent important ecological and biological processes that influence the formation of terrestrial, freshwater, coastal and marine ecosystems and plant and animal communities **x.** Contain habitats important for in situ conservation of biodiversity, such as endangered species.
Other Complementary Criteria	**B –** Areas with mostly large buildings, **C-** Past and present life styles/land uses are an important part of the landscape **F-** Farming / agricultural activities have been the main element in the past or present landscapes **G-** Decorative parks / gardens as a basic element **I-** Industrial areas **L-** Elements that form the identity of a community **P-** Landscape areas shaped by local settlement **R-** Areas where religious / sacred sites are located **Ra-** Stone art (ancient reliefs or sculptures) **S-**Site of a battle or an archaeological monument **T-** Defined landscape areas such as village, towns **Wi-** Irrigation canals or other water structures	**Jf-** Forest, afforestation areas **M-** Landscape areas with a mountain fragment in it **N-** Landscape areas with a Nature Park or containing a Nature Park **W-** Water forms part of the landscape **Wl-** Landscape areas with part of a lake **Wr-** Landscape areas with a part of rivers **Ws-** Landscape areas with a part of the sea

Table 2. Authenticity criteria for cultural landscape (Engelhardt & Rumball Rogers, 2009; Taylor, 2011; Atik & Tülek, 2013; Atik & Tülek, 2016)

Location and Settlement	**Design and Form**	**Use and Function**	**Spiritual Values**
• Area • Applications • “Sense of place” • Ecological location • Landforms • Surrounding environment • Living materials • Degree of protection	• Spatial arrangements • Design • Material • Building techniques • Handicrafts • Engineering • Layer / geoscience • Regional networks	• Users • Using • Unions • Changes in usage over time • Spatial distribution of use • Usage effects	• Artistic İnteractions • Values • Spirit • Emotional ties • Religious context • Historical impacts • Sounds, smells, tastes • Creative process

3. Findings and Discussion

3.1. Istanbul University Alfred Heilbronn Botanical Garden (AHBB)

The establishment of AHBB corresponds to the period of university reform in Türkiye. Ord. Prof. Dr Alfred Heilbronn, was invited to Istanbul during the 2nd world war, where he established the Istanbul University Botanical Garden in 1935 with the contributions of the university administration and his friends. In 2003, the garden was renamed 'Istanbul University Alfred Heilbronn Botanical Garden' (Güner, 2006; Küçüker, 2011; Erkılıç, 2019). The garden consists of 4 terraces overlooking the Golden Horn of Bosphorus (Figure 4), and is divided into 6 sections as systematic of plants, stone garden, medicinal plants, plants of Türkiye, experimental areas and arboretum with an area of 15,000 m² (Yılmaz, 2017; Erkılıç, 2019).

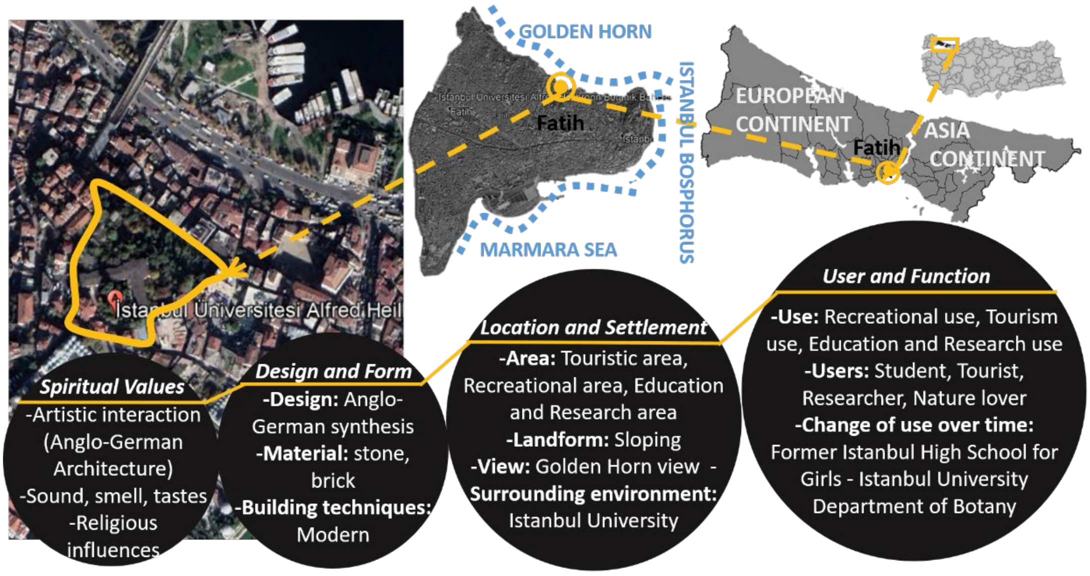

Figure 4. Istanbul University Alfred Heilbronn Botanical Garden with authentic features (Authors, 2024)

The AHBB has 6 greenhouses (research, cactus, orchid, rainforest, tropical fruit, cycas) and 23 ponds (Figure 5) (Bayçu, Yazgan & Üzen, 2013). In the open areas, there are 400 woody plant species including trees and shrubs, 3500 herbaceous plants from 160 families as well as rare and endemic plants from the flora of Türkiye. A total of 6000 native and non-native plant species are on display in the garden besides 2500 exotic species contained in greenhouses from different tropical regions. In addition to the herbarium; seed bank, botanical library and botanical research laboratories are dedicated to the ex situ conservation and propagation of bulbous plants at risk in Anatolia (Bayçu et al., 2013; Erkılıç, 2019).

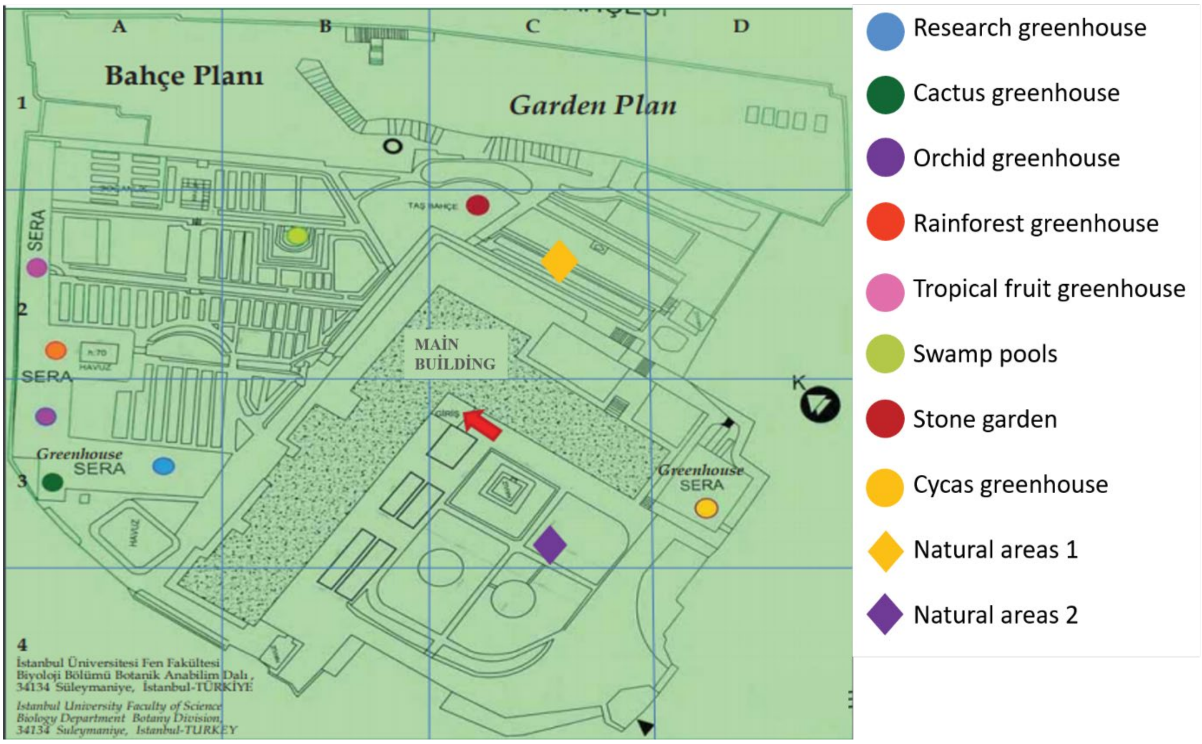

Figure 5. Plan of Alfred Heilbronn Botanic Garden (Bayçu et al., 2013)

Regarding to UNESCO criteria, AHBB has the feature of ‘’(x) containing habitats important for the protection of biological diversity in situ, such as endangered species’’ due to its sections for the protection of rare and endemic taxa of Istanbul and both for the protection and reproduction of endangered bulbous plants that unique to Anatolia. As a result of the coexistence of a large number of natural and endemic plant species in the garden, with combined natural and aesthetic beauty fulfils the natural criteria of cultural land ''(vii) containing extraordinary natural phenomena and areas or having unique natural beauty and aesthetic value'' (Figure 6).

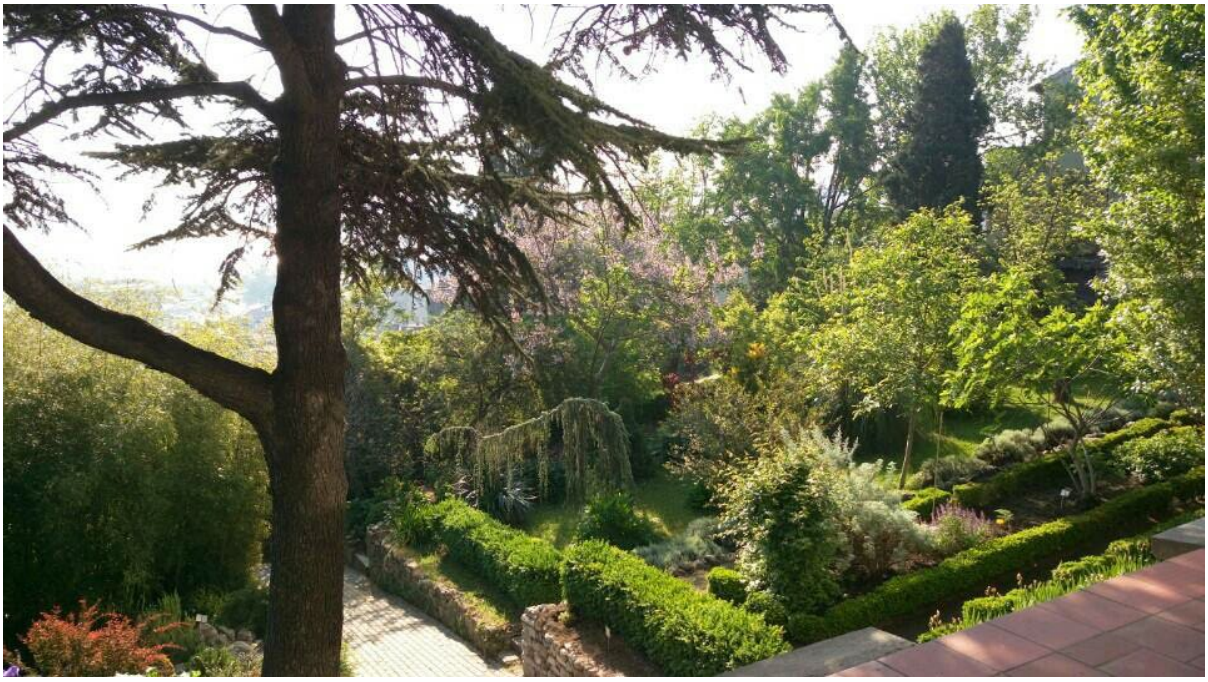

Figure 6. AHBB, which has unique natural beauty and aesthetic value (Parlak, 2016)

The presence of ponds and water in the garden where aquatic plants, water lilies and marsh plants are grown reflects the W - Water as an integral part of the landscape, and serves habitat for most plants, adds aesthetic value and contributes to biodiversity by attracting many wildlife species such as butterflies, birds, etc (Figure 7).

Figure 7. Presence of ponds and water in AHBB where aquatic plants, water lilies and marsh plants are grown (Parlak, 2016)

AHBB has a spectacular a view of the Golden Horn of Bosphorus with regard to authentic criteria of location and settlement (Figure 8). Its location in the historical peninsula of Istanbul, the most visited area the city shows that the site has been potentially preferred for tourism and recreation. Until recently, the garden was affiliated with the Botany Department of Istanbul University and its proximity encouraged education, training and practice, especially for departments such as biology and botany. However, the land where the garden is located is now owned by the Istanbul Mufti's Office.

Figure 8. Golden Horn view from AHBB (CNN, 2017)

In reference to design and form the Botany Department building in the garden was built in accordance with the western modern architecture during the republic period and symbolizes the foundation of the Turkish Republic. Although the garden was designed in an Anglo-Saxon synthesis since British scientists took part in its design and planning in cooperation with German scientists.

Looking at AHBB in terms of use and function the garden presents attractions for tourism and recreation for visitors and tourists, besides opportunities for education and research for departments of medicine, biology, landscape architecture. The building of the Department of Botany located in the garden, was former Istanbul High School for Girls, and was used for education.

3.2. Atatürk Arboretum

Following the visit the Des Barres and Vilmorin Arboretums in France in the 1949, upon the suggestion of Prof. Dr. Hayrettin Kayacık, Isyanbul University Faculty of Forestry and the General Directorate of Forestry in Bahçeköy started to work jointly to designate an arboretum in 38 hectares land bordering the Büyükdere - Bahçeköy - Kemerburgaz road as the Arboretum Site (Yaltırık, 1988; Güner, 2006; Olkay Şengün, 2011) (Figure 9).

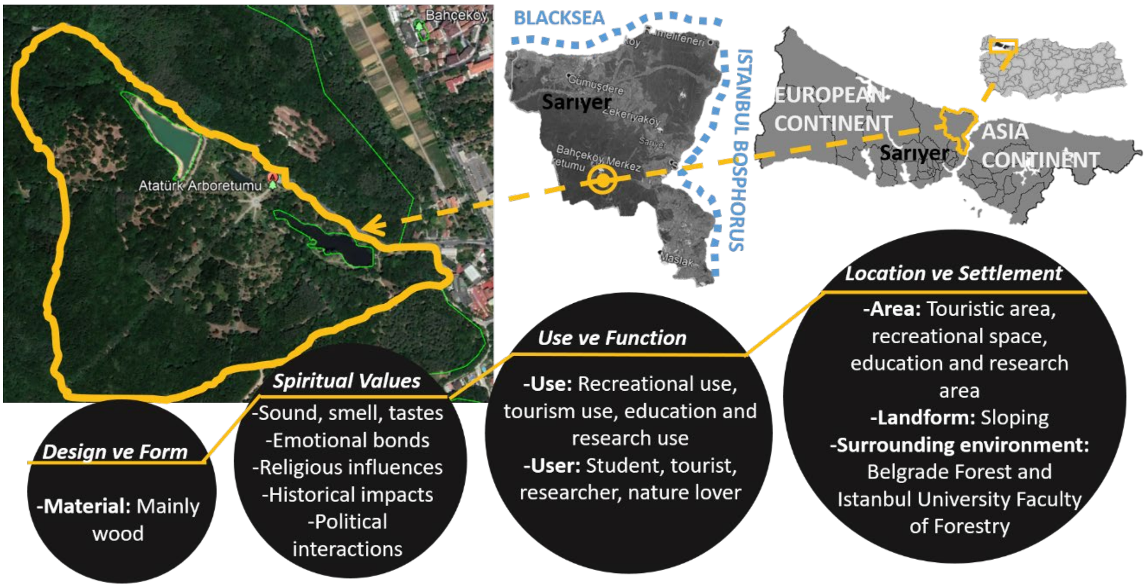

Figure 9. Atatürk Arboretum with authentic features (Authors, 2024)

M. Camille Guinet, one of the inspectors of the Botanical Garden of Sorbon University was invited to Istanbul to prepare project of arboretum arrived in Istanbul at 1958 and started to work. Work continued intermittently between 1959 and 1961. However, due to lack of funds needed, the plan was left unfinished. Only a draft preliminary plan of the arboretum with the roads, plant parterres and sections allocated for special tree groups was completed (Figure 10). The arboretum was renamed the Atatürk Arboretum in 1982 as part of the 100th anniversary celebrations of Atatürk's day of birth (Yaltırık, 1988; Güner, 2006; Olkay Şengün, 2011).

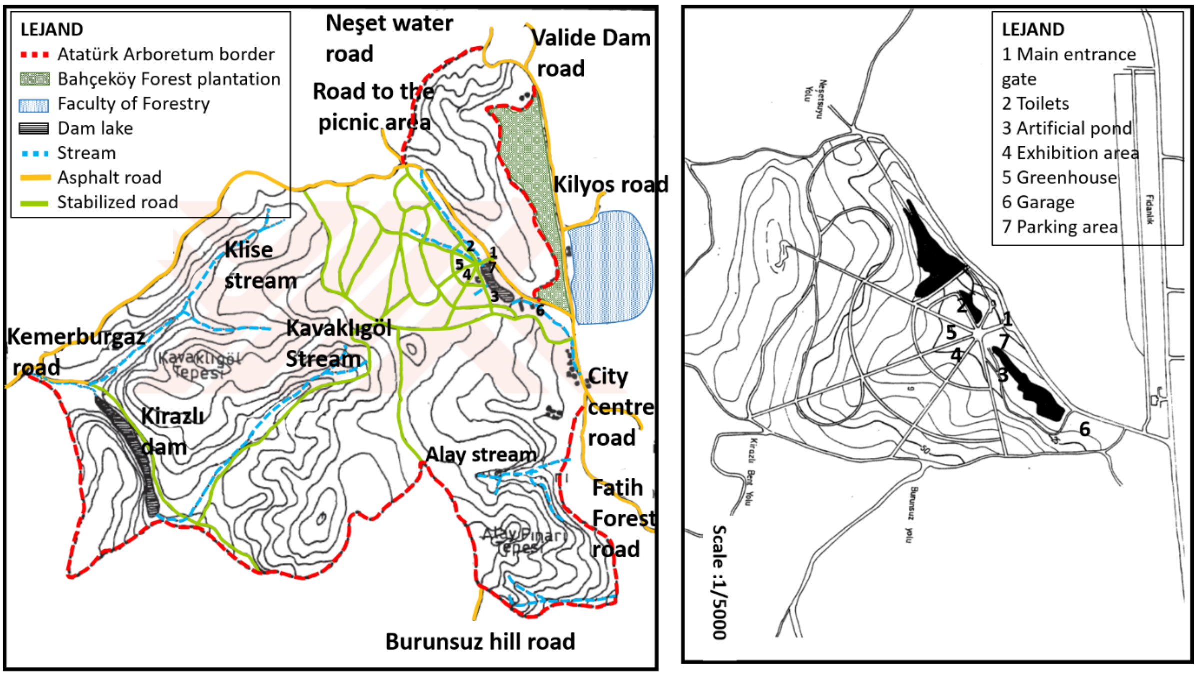

Figure 10. Location and plan of Atatürk Arboretum (Şat, 2002; Olkay Şengün, 2011)

Referring to UNESCO criteria, Atatürk Arboretum as the characteristic (vii) contain outstanding natural phenomena and sites or have unique natural beauty with high plant diversity including both native and exotic species as well water landscapes created by the pond in the arboretum (Figure 11). It also (ix) represents important ecological and biological processes by having a freshwater ecosystem, influencing the formation of animals such as frogs, turtles, fish, ducks, swans and plant communities such as Taxodium distichum in the arboretum.

Figure 11. Plant diversity in the arboretum and the water landscapes created by the pond (Authors, 2024)

Atatürk Arboretum is located in a 345 hectare of forest just in the southeast of the Belgrade Forest, Sarıyer one of the most important natural site in Istanbul metropolitan area. Accordingly, Jf - Forest, afforestation areas and Wl - Landscape example where lake or lakes are part of the landscape are the prominent features. In addition, the ecological diversity in the arboretum by the presence of many flora and fauna species offer an on-site-open laboratory and since Kirazlıbent, a natural park (Yener 2021), is located within the boundaries of the arboretum, it has the characteristic of landscape areas with N- Natural park or containing natural areas that evidently form the characteristic of N - Natural Park (Figure 12).

Figure 12. Landscape area with forest and part of the lake (Authors, 2024)

In terms of authenticity, location and settlement, Atatürk Arboretum has a setting of sloping land. Walking paths in the arboretum, that organically link with Belgrade Forest are a great importance in the north of Istanbul.

Great diversity of species in such landscapes create beautiful scenes throughout the year with the seasonal colours of vegetation are used as touristic and recreational ground by inhabitants of the city as well as by nature lovers and photographers (Figure 9).

In terms of design and form, the design of the buildings in the arboretum and the piers on the ponds resemble the foundation of the site.

In terms of use and function, Atatürk Arboretum has multifunctionality of being a collection of woody plants, hotspot of ecological diversity, a tourist and recreation site in such a metropolitan city.

Founded in 1949 on an area of 38 hectares, the arboretum today hosts 2000 different plant taxa from different corners of the world on an area of 296 hectares. The main basis for the establishment of the arboretum was to enable scientific research, development and observations on *Quercus ssp.* and the overall Fagaceae family. For this aim, an area of 2.5 hectares, is reserved as an oak area. An oak project was established and saplings grown from seeds sent from different countries were planted on site and a large collection of 100 oak taxa was created. The theme and form of 'Oak' was also used in the design of the arboretum and a fountain in the shape of an acorn is located in the arboretum square. Besides a diverse set of oaks, Pinaceae collections are also given special attention.

In addition ornamental plants, dwarf conifers, native of the Belgrade Forest, species from Cupressaceae, Altingiaceae, Ginkgoaceae, Sapindaceae, Magnoliaceae, Ericaceae, Styracaceae, Malvaceae, Rosaceae, Betulaceae families and *Acer ssp.* are among the species commonly seen in the arboretum (İstanbul Orman Bölge Müdürlüğü, Bahçeköy Orman İşletme Müdürlüğü, Atatürk Arboretumu, 2013). The arboretum could be visited with a membership system. In 2011 it was partially open to visitors only for weekends, but in 2013, fully open to visitors for weekdays and weekends. The Arboretum is an operation chiefdom under the Bahçeköy Forest Management Directorate of the General Directorate of Forestry, Istanbul Regional Directorate of Forestry. It is managed by an advisory board with the scientific authority of the Faculty of Forestry of Istanbul University and the administrative authority of the General Directorate of Forestry (Atatürk Arboretumu, 2024). Arboretum has the functional property of being used for educational purposes for the applied courses of the departments such as Landscape Architecture and Forest Engineering of the Faculty of Forestry of Istanbul University, also by the institutions affiliated to the Ministry of Agriculture and Forestry (Figure 9).

The variety of plants (fragrant, fruit-bearing, etc.) in the arboretum attracts wildlife species such as birds and insects thus meet the characteristics of sound, smells and tastes, from spiritual value, while the tranquility and calmness of nature reflects such interactions between people and urban environment. The presence of some species as Ginkgo biloba, Prunus serrulata, Cupressus sempervirens, Platanus orientalis, Salix babylonica, Cupressus sempervirens, Fagus orientalis, Pinus nigra, Quercus sp. in the arboretum shows the presence of cultural heritage qualities with myths and intangible values (Figure 9). In Turkish culture, Platanus orientalis symbolizes long life and power with its large leaves, height and crown and outstanding forms, while in Greek culture, Quercus sp. represents endurance and strength. Cupressus sempervirens stricta is the reminiscent of the minaret of the mosque towards to the sky, symbolise reaching the God, evoking death and used extensively in cemeteries (Özarslan, 2003; Güneroğlu, Şahin & Aktürk, 2018).

3.3. Nezahat Gökyiğit Botanical Garden (NGBB)

NGBB was established in 1995 for the memory of Nezahat Gökyiğit with an initial planting and afforestation plan and opened for the public in 2002 as a first private botanical garden in Türkiye (NGBB, 2021). NGBB, a member of BGCI (Botanic Gardens Conservation International), is typically located in an intersection of a highway (Figure 13). Botanical garden consists of eight islands, namely Central Island, Ertuğrul Island, Mesire Island, Istanbul Island, Arboretum Island, Oak Island, Anatolia Island and Thrace Island (Figure 14).

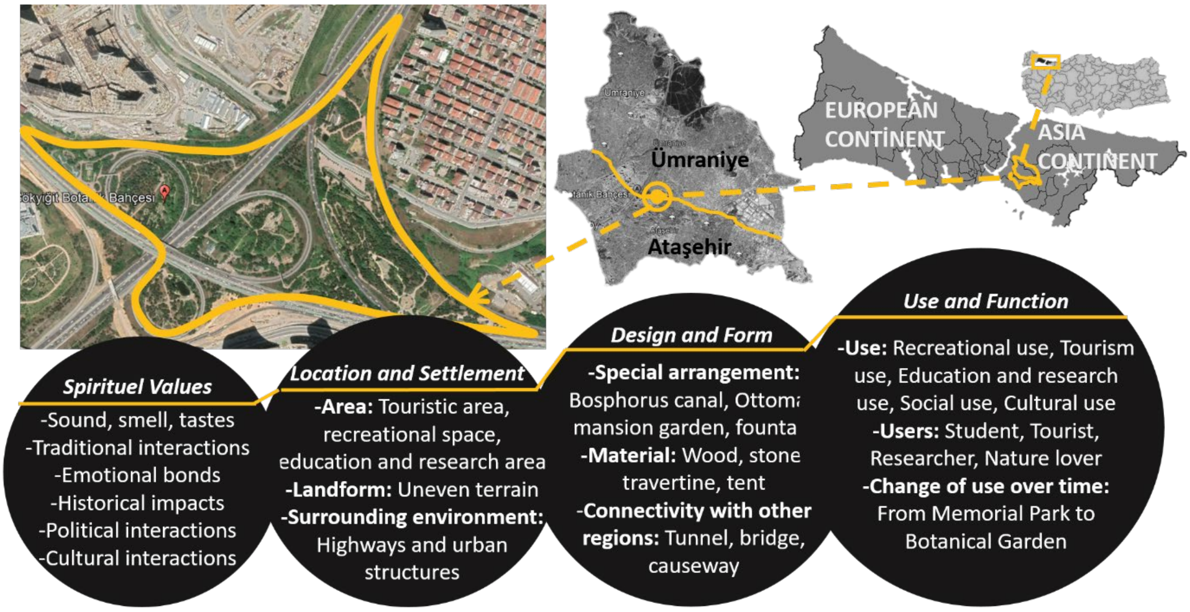

Figure 13. Nezahat Gökyiğit Botanical Garden with authentic features (Authors, 2024)

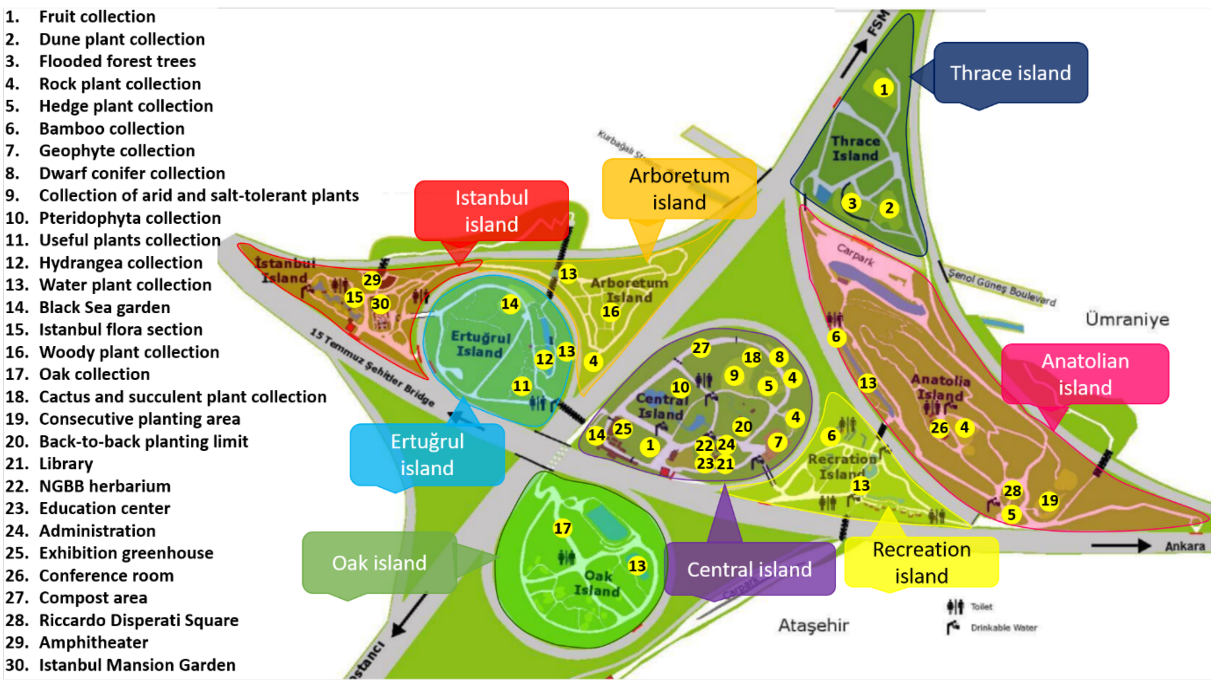

Figure 14. Plan of Nezahat Gökyiğit botanical garden (NGBB, 2021)

Monuments on Ertuğrul Island, in memory of the 527 sailors aboard the Ertuğrul Frigate, that sank in a storm on the return from Japan during the reign of Abdülhamit II, indicates the presence of (II) having left a mark in a cultural region in the world in a period and having greatly influenced the developments in the field of monumental arts (Figure 15a). Based on 18th century Ottoman style, the Istanbul Mansion Garden design in NGBB has significantly influenced both urban planning and landscape design with regard to plants and elements used, where transformation of both native and endemic plant species given special attention. Accordingly, as the garden includes all the structural and vegetative features of Istanbul mansion gardens, that were common in the 18th century Ottoman period but which are quite rare today, reflect (v) being an important example of traditional human settlement or land use representative of a culture (Figure 16).

a **b** **c**

Figure 15. a. Ertuğrul Frigate Monument (Göçebe, 2018), **b** and **c.** NGBB's plant diversity (Authors, 2024)

Figure 16. Istanbul mansion gardens in the 18th century Ottoman period at NGBB (Authors, 2024)

Ottoman garden in NGBB symbolizes G- Areas with decorative gardens as the main element with standing and flowing waters and flower parterres with vegetative features especially tulips and cypress trees of 18th century mansion gardens (Figure 16). Ottoman marquee with grand tent used by a sultan or grand vizier on the same island is the case L- landscape elements that form the identity of a community creating an example of nomadic lifestyle (Figure 17). The presence of a water bend on Oak Island shows Wi- irrigation channels or other water structures by creating a mini dam where rainwater is collected to help irrigate the garden. Nypheum pools on Anadolu and Merkez islands, the Bosphorus canal on Istanbul island and the fountains of the 18th century Istanbul meets W - water forms part of the landscape (Figure 18 and Figure 19).

Figure 17. Ottoman marquee on Istanbul Island (Authors, 2024)

Figure 18. Water bend on Oak island and Nypheum pools on Merkez and Anadolu islands (Authors, 2024)

Figure 19. Bosphorus canal and the fountains of the 18th century Istanbul (Authors, 2024)

Referring to its location, NGBB is an exceptional case as the first botanical garden to be established between motorway junctions and in the heart of public transport between Ümraniye and Ataşehir directions in İstanbul. Although the garden is located in the middle of the transport network, it is a kind of barrier to shield noise and air pollution with well maintained and diverse vegetation (Figure 15b and c).

In terms of setting, the undulating topography with ups and downs offers landscape diversity. On cultural bases an educational and scientific research area with its library provide seminars, courses and workshops for students and educators, publications such as magazines and books, and exhibitions of plants. The fact that NGBB is also visited by tourists reflects the Japanese-Turkish cultural interaction, especially on Ertuğrul Island.

The fact that the garden is located on the transportation network of the city of Istanbul and reveals the important contribution to the urban open green space system in terms of its location and functions and offer easily accessible open green spaces for the public in the middle of highway and high-rise buildings of urban fabric (Figure 13).

In terms of design and form NGBB has authentic special arrangements such as the Bosphorus Canal symbolizing the Bosphorus, the Ottoman Mansion Garden and the fountains located here, the bamboo labyrinth on the promenade island, the Ertuğrul Martyrs Monument, and the rock garden. In terms of materials, wood was used in the pergolas, stone was used mainly in the Ottoman mansion on the island of Istanbul, tents were used in the Ottoman marquee and travertine was used in the fountains in this area. Since the garden is located between the islands between the highways, the connections between these islands are provided by tunnels, bridges and passages.

In terms of use and function NGBB is authenticity character with bamboo labyrinth for children and discovery garden on the promenade island; educational use with seminars, training, courses and workshops; research use with the presence of library, publications and species conservation projects; social, cultural and tourism use with the organization of exhibitions and festivals. In addition, the garden was established as a memorial park and later converted into a botanical garden, indicating a change in use over time (Figure 13).

In terms of spiritual values, the Japanese Cherry saplings donated by the Japanese Sakura Foundation at the 115th anniversary of the Ertuğrul Frigate Disaster, and planted in memory of each sailor, and the Frigate Monument reflect the historical and political interactions between Türkiye and Japan in terms of spirit and expression. The fact that the Sakura trees symbolize love and passion in Japanese culture, which shows the existence of emotional ties from spiritual values, and the festivities organized in Japan representing the arrival of spring and renewal, and the fact that the festivals organized in Japan are also organized in the botanical garden shows the existence of cultural interaction among intangible cultural heritage qualities. The fact that the spiritual value attributed to these trees is a Japanese tradition again shows the traditional interaction feature of spiritual values. In addition, the fact that the garden attracts many creatures with its plant diversity makes it possible to experience many sounds, smells and tastes (Figure 13).

4. Conclusion and Suggestions

Botanical gardens have been recognized as signage of nature and social wealth in many countries (Hepcan & Özkan, 2005). In addition they have great contribution to urban green network supporting urban ecosystems and urban biodiversity. Referring to botanical gardens, urban design and planning approaches have been adopted all over the world (Ignatieva & Ahrné, 2013) to extend ecological dimensions of the cities. Ultimately, botanical gardens play an important role in preserving the identity of the city and passing it down from generation to generation.

With their multiple functions and features, botanical gardens and arboretums have great values for megacity Istanbul. Arboretums and botanical gardens respond to the needs of people working in this city where life is very busy. They provide opportunities and space for spending time in nature, in particular for children growing up in the city bonding with plants and animals, learning about nature.

Atatürk Arboretum is a kind of escape from the chaotic mess of İstanbul metropolis especially on weekends, which serves as a habitat with the large part of the Belgrade forest that contributing to the protection for many animal species such as roe deer and squirrels. From an educational point of view, Atatürk Arboretum hosts students for some courses at Istanbul University Faculty of Forestry, serving as a living lab for national and international studies on many woody species, but especially on oaks. NGBB offers possibilities for the inhabitants of Istanbul to get in touch with nature together with rich plant diversity, recreation areas, playgrounds for children.

With a number of prominent species of *Astragalus beypazaricus, Astragalus yildirimli, Rhaponticoides mykalea, Pyrus serikensis, Tulipa sprengeri baker, Iris aschersonii*, NGBB serves ex-situ conservation, contributing biodiversity in the urban ecosystem.

NGBB offers seminars, trainings, courses and practices in order to raise awareness of the community of the city in particular for school children. Located in the historical peninsula, which is one of the touristic hot spots in the city and surrounded by universities and institutions, AHBB provides the chances for both learning and exploration of many plant species and contact with nature in the heart of the İstanbul. In addition, AHBB contributes to the green patches such as Gülhane Park, the Garden of the Faculty of Law of Istanbul University, and the Garden of Topkapı Palace in the historical peninsula, which has a very dense settlement pattern.

The need for arboretums and botanical gardens along with urban green spaces has increased even more due to the recent Covid-19 pandemic. Arboretums and botanical gardens have made a great contribution to reduce stress and provide psychological relief during and after Covid times (Önder & Polat, 2012; Ortaçeşme, Yıldırım & Zeğerek, 2020). For this reason, presence and accessibility of arboretums and botanic gardens are of vital for cities with a dense structural texture such as Istanbul.

Botanical gardens and arboretums are shaped by the geographical conditions; climate, location and cultural features of the country. The protection and reproduction of plant species and endemics in the arboretums and botanical gardens in particular, reflect the principles of UNESCO cultural landscape criteria, with the presence of plants with mythological value in the society, the presence of cultural history as well as functional visual elements like fountains and other cultural reflections such as the sakura site in NGBB. Botanical gardens can also host memorial gardens that help to remember and perpetuate events in history that are important to society and raise awareness of the past (Demir, Pouya & Demirel, 2016), such as the memorials erected on NGBB's Ertuğrul Island in memory of the sailors who died on the Ertuğrul Frigate and the Japanese Cherry saplings planted in memory of each sailor.

However, priorities in biodiversity protection and our cultural values attached to the public green spaces may change over time in line with our needs. For this reason, botanical gardens and arboretums established in the same city differentiate.

In this study, NGBB, AHBB and Atatürk Arboretum in Istanbul province were evaluated in terms of natural and cultural criteria for the UNESCO cultural landscapes. Interpreting the foundation, development, and planning of botanical gardens in Türkiye from past to present would be helpful multiple functions, their characteristics and their role in the most populated city of Istanbul such as education, research, tourism, recreation and also signpost of the country.

NGBB stands out with examples of cultural features among the UNESCO Cultural Landscape Criteria as a result of having two cultural landscape criteria (ii, v) as a result of the presence of Ertuğrul Monument constituting an ‘example of monumental art’ (ii) and the presence of Istanbul Mansion Garden constituting an ‘example of human settlement representing a culture’ (v).

On the other hand, AHBB fits the criteria for the protection of biodiversity such as endangered species as a result of having sections for the protection of rare and endemic taxa of Istanbul and bulbous plants under risk in Anatolia (x), and the combination of natural and aesthetic beauty as a result of the combination of many natural and endemic plant species in the garden (vii). Atatürk Arboretum, on the other hand, potentially meets criterion vii due to the aesthetic appearance created by the natural and endemic plant diversity around the pond in the garden, and criterion ix of representing important ecological and biological processes by influencing the formation of animals such as frogs, turtles, fish, ducks, swans and plant communities such as Taxodium distichum in the arboretum by having a freshwater ecosystem.

As a result, NGBB has cultural characteristics among the cultural landscape criteria because it was established to serve many purposes and the garden was created by land reclamation. Atatürk Arboretum and AHBB, on the other hand, have natural features among the cultural landscape criteria since their purpose of establishment was to serve the higher education of the universities in the neighbourhood and they have natural areas (Table 3).

Table 3. A comparative analysis of AHBB, Atatürk Arboretum and NGBB as regard to cultural landscape characteristics

Cultural Landscape Features	**AHBB**	**Atatürk Arboretum**	**NGBB**
Cultural Landscape Category	Easy to Identify	Easy to Identify	Easy to Identify
Natural-Cultural Criteria	vii, x,	Vii, ix	ii, v,
Complementary	W	Jf, N, Wl	G, L, Wi, W
Authentic Features	**Location and Settlement**	**Location and Settlement**	**Location and Settlement**

	-Area: Touristic area, Recreational area, Education and Research area **-Landform:** Sloping **-View:** Golden Horn **Surrounding environment:** Istanbul University **<u>Design and Form</u>** **-Design:** Anglo-Sakson synthesis **-Material:** stone, brick **-Building techniques:** Modern **<u>Use and Function</u>** **-Use:** Recreational use, Tourism use, Education and Research use **-Users:** Student, Tourist, Researcher, Nature lover **-Change over time:** Former Istanbul High School for Girls -Istanbul University Department of Botany **<u>Spiritual Values</u>** -Artistic interaction (Anglo-German Architecture) -Sound, smell, tastes -Religious influences	**-Area:** Touristic area, Recreational space, Education and Research area **-Landform:** Sloping -**Surrounding environment:** Belgrade Forest and Istanbul University Faculty of Forestry **<u>Design and Form</u>** **-Material:** Mainly wood **<u>Use and Function</u>** **-Use:** Recreational use, Tourism use, Education and Research use **-Users:** Student, Tourist, Researcher, Nature lover **<u>Spiritual Values</u>** -Sound, smell, tastes -Emotional bonds -Religious influences -Historical impacts -Political interactions	**-Area:** Touristic area, Recreational space, Education and Research area **-Landform:** Uneven terrain **- Surrounding environment:** Highways and urban structures **<u>Design and Form</u>** **-Special arrangement:** Bosphorus canal, Ottoman mansion garden, fountain... **-Material:** Wood, stone, travertine, tent -**Connectivity with other regions:** Tunnel, bridge, causeway **<u>Use and Function</u>** **-Use:** Recreational use, Tourism use, Education and research use, Social use, Cultural use **-Users:** Student, Tourist, Researcher, Nature lover **-Change over time:** From Memorial Park to Botanical Garden **<u>Spiritual Values</u>** -Sound, smell, tastes -Emotional bonds -Historical impacts -Political interactions -Cultural interactions -Traditional interactions

As a result, the reflections of the cultural interaction in the botanical gardens that has existed in many parts of Istanbul from the past to the present. For example, Sakura festival in spring held in NGBB is typically evoking such interaction between city and botanical gardens. In some cases, architectural remains dated to special design can be added value to sites. Foundation of AHBB began in the old Istanbul Girls' High School built by a synthesis of British and German design. NGBB was a memorial garden when it was first established and added by further design elements of Ottoman Mansion Garden. It may offer opportunities for the city of Istanbul and its citizens in strengthening the city image, recognizing destinations.

Regarding biocultural dimensions NGBB, Atatürk Arboretum and AHBB emphasize how the historical and cultural identity of the city is reflected in the landscape. The presence of native and endemic plants also helps to explore Türkiye's richness in terms of floristic diversity. NGBB expresses landscape design patterns of Turkish culture with fountains, bridges, pergolas, river elements, plant parterres decorated by tulips and roses. The transformation of the tunnels that provide passage between the sections in the garden into various exhibitions such as the introduction of trees and plants in Istanbul with photographs, the use and meanings of plants in Turkish culture from the past to the present is a successful example of how each site can be utilised appropriately. The presence of rich woody plants in Atatürk Arboretum shows that Istanbul has a suitable for many species, and it is a good example of which plant species can be grown in the landscape from the past to the present.

The fact that AHBB is surrounded by cultural context such as Istanbul University and Süleymaniye Mosque on the historical peninsula, framing the view of the Golden Horn Strait with beautifully decorated garden, allows us to see not only the historical and cultural texture can be combined finely.

Different design approaches ranging from the republican period to western modern architecture structure and the garden designed in the Anglo-Saxon synthesis, together with the historical environment have high value.

The arboretums and botanical gardens can contribute positively to the education in the universities in the city by providing learning environmental, practice, documentation as well training courses, events, exhibitions, and publications. Istanbul is a metropolis where urbanization highly intense. For this reason, botanical gardens and arboretums are of vital importance and greater role in protection of biodiversity in urban environment and ex-situ conservation for many plant species.

NGBB, Atatürk Arboretum and AHBB potentially comply with the number of the UNESCO's World Heritage Cultural Landscape criteria. However besides their cultural, scientific, historic, educational, biological characteristics these three sites are highly important for the inhabitants of Istanbul metropolis as well as the city itself as the crucial part of urban ecosystem.

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Determination of The Physical Carrying Capacity of The Günpınar Waterfall Nature Park in Malatya Province

Halit KOÇAK [1*], Metin DEMİR [2]

ORCID 1:0000-0003-1419-0944
ORCID 2:0000-0001-9374-6079
[1] *Atatürk University, Graduate School of Natural and Applied Sciences, Department of Landscape Architecture, 25000, Erzurum, Türkiye.*
[2] *Atatürk University, Architecture and Design Faculty, Department of Landscape Architecture, 25000, Erzurum, Türkiye.*
*** e-mail**: *khalitkocak@hotmail.com*

Abstract

In determining the physical carrying capacity of Günpınar Waterfall Nature Park; initially, a survey was conducted to ask visitors how many hours they spend in the area on average. The physical carrying capacities of the Controlled Use Zones of the Nature Park, the Landscape Viewing Terrace, and the walking paths and stairs within the nature park have been calculated. According to the findings, the Physical Carrying Capacity for Controlled Use Area-1 is 319 visitors/day, for Controlled Use Area-2 is 469 visitors/day, and the total is 788 visitors/day. The physical carrying capacity for the Landscape Viewing Terrace is 26 people, for Walking Paths is 760 people, and for Stairs is 66 people. Considering the balance between conservation and use, and considering the quality of recreation in the area, solution proposals have been presented for Günpınar Waterfall Nature Park.

Keywords: *Recreation, nature park, carrying capacity, physical carrying capacity.*

Malatya İli Günpınar Şelalesi Tabiat Parkının Fiziksel Taşıma Kapasitesinin Belirlenmesi

Öz

Günpınar Şelalesi Tabiat Parkı'nın fiziksel taşıma kapasitesi hesaplanırken; öncelikle ziyaretçilere anket çalışması uygulanarak alanda ortalama kaç saat süre harcadıkları sorulmuştur. Tabiat Parkı'nın Kontrollü Kullanım Bölgeleri'nin, Manzara Seyir Terasının ve tabiat parkı içerisindeki yürüyüş yolları ve merdivenlerin fiziksel taşıma kapasiteleri hesaplanmıştır. Elde edilen bulgulara göre, Kontrollü Kullanım Alanı-1 için Fiziksel Taşıma Kapasitesi 319 ziyaretçi/gün, Kontrollü Kullanım Alanı-2 için fiziksel taşıma kapasitei-2 469 ziyaretçi/gün ve toplam da 788 ziyaretçi/gün olarak hesaplanmıştır. Manzara Seyir Terası için fiziksel taşıma kapasitesi 26 kişi, Yürüyüş Yolları için fiziksel taşıma kapasitesi 760 kişi ve Merdivenler için fiziksel taşıma kapasitesi 66 kişi olarak hesaplanmıştır. Koruma-kullanma dengesine dikkat edilerek ve alandaki rekreasyon kalitesi göz önünde bulundurularak Günpınar Şelalesi Tabiat Parkı için çözüm önerileri sunulmuştur.

Anahtar kelimeler: *Rekreasyon, tabiat parkı, taşıma kapasitesi, fiziksel taşıma kapasitesi.*

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1. Introduction

Rapid industrialization and increasing urbanization have led to negative changes in both the society's own life dynamics and the physical environment they inhabit, directing individuals towards activities where they can be motivated and rejuvenate their energy. Recreation refers to the activity's individuals engage in to temporarily escape the pace of daily life and contribute positively to their physical and mental health (Mansuroğlu, 2002; Can, 2015; Koçak, 2023).

Recreation should be considered not only as an activity that individuals enjoy in their leisure time but also as a concept that contributes to the economic potential of society and represents a significant area of responsibility for governments. Furthermore, it should be regarded as a field that offers employment opportunities for the local population depending on their geographical location. In this context, the importance of recreation in terms of strategic planning, management, and sustainability becomes prominent (Bakır, 1990; Kaplan, 2019).

The concept of 'Carrying Capacity,' frequently used today, was initially employed in the maritime transportation industry to denote the load a ship could carry. The application of this concept in the natural sciences began with Malthus's work on the population principle, dating back approximately 200 years from today (Yılmaz, Yılmaz & Demircioğlu Yıldız, 2003). The concept of carrying capacity, which started to be used in natural areas following studies by Hadwen & Palmer in 1922 for pasture management, is not limited to these fields but is also employed in disciplines focused on recreation and tourism (McCool & Lime, 2001; Clarke, 2002; Göktuğ et al., 2017).

Carrying capacity refers to the number of people that can be present in the same tourist space at the same time without causing damage to the physical, economic, and socio-cultural values of the area, and without causing a decrease in visitor satisfaction levels that would lead to concern (Vujko et al., 2017; Suana et al., 2020).

Recreational carrying capacity is a concept aimed at determining the optimum number of visitors for activities conducted in natural areas, protected areas, or national parks. This concept, which includes ecological, physical, social, and managerial dimensions, aims to enhance the sustainability of biological and physical resources and the quality of visitors' recreational experience by accurately determining the carrying capacity of the used areas. Therefore, recreational carrying capacity is considered an important tool for providing suitable conditions and opportunities for recreation (Sayan & Ortaçeşme, 2005; Göktuğ, Bulut, Demircioğlu Yıldız & Demir, 2011).

Recreational carrying capacity is generally examined under four main headings: physical carrying capacity, social carrying capacity, ecological carrying capacity, and management capacity. Physical carrying capacity refers to the threshold beyond which a destination's natural and cultural values may be damaged due to intensive use (Rüzgar, Koçak & Demir, 2022). The physical carrying capacity of a destination is determined through the analysis of environmental components such as the amount of water, availability of water, presence of air pollution sources, etc., and the analysis of existing facilities required for visitors and local users (Castellani, Sala & Pitea, 2007).

Exceeding the physical carrying capacity limit can be exemplified by the deterioration of textures in historical structures, the inadequacy and neglect of roads, parking lots becoming unable to accommodate vehicles, and the difficulties experienced at intersections. From these statements, it is observed that the concept of physical carrying capacity encompasses the maximum number of visitors that can be hosted within the physical limits of a destination used for recreational purposes, as well as the degradation resulting from the use of facilities, infrastructure, and systems intended for service in the destination (Ceballos-Lascuráin, 1996; Cifuentes, 1992; Erdemir, 2018).

The purpose of this study is to determine the physical carrying capacity of Günpınar Waterfall Nature Park, which is located within the boundaries of Darende District in Malatya Province and was granted the status of a Nature Park on 26.06.2018 due to its natural resource values and recreational potential. The conscious use and management of protected areas, whose importance is increasing day by day in our developing world, are of great significance both for the living standards of the current era and for the assurance of future generations' quality of life. This study aims to foster individual and societal awareness of protected areas.

2. Material and Method

The material for this study is Günpınar Waterfall Nature Park, located within the boundaries of Darende District in Malatya Province. Geographically, it lies between 38°33′35″-38°32′34″ north latitude and 37°24′16″-37°25′8″ east longitude. Günpınar Waterfall Nature Park was designated as a Nature Park on 26.06.2018 due to its natural resource values and recreational potential. The Development Plan prepared by the General Directorate of Nature Conservation and National Parks (GDNCN) in 2019 was examined, and based on this plan, the physical carrying capacity was calculated within the boundaries defined as the 'Controlled Use Zone' of the Nature Park. The geographical location of the area is presented in Figure 1 (Koçak, 2023).

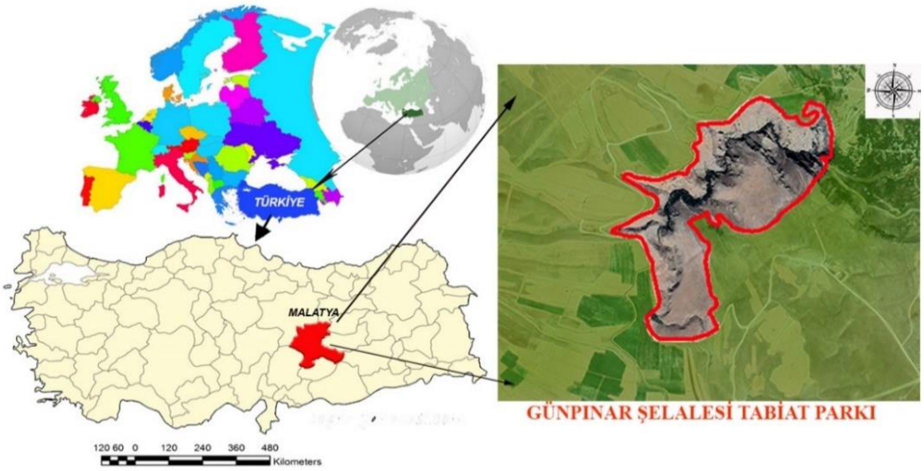

Figure 1. Günpınar Waterfall Nature Park Location Map (Original and created by the authors)

Günpınar Waterfall Nature Park covers an area of 135.20 hectares and was declared a Nature Park by the former Ministry of Forestry and Water Affairs due to its natural resource values and recreational potential, as per the Official Decree numbered 1312 on June 26, 2018 (DKMP, 2019).

The Nature Park does not contain any private property or pasture land; it is entirely state forest status and is under the responsibility of the Ministry of Agriculture and Forestry, General Directorate of Nature Conservation and National Parks, XV. Regional Directorate, Malatya Branch Office. The Nature Park, located approximately 8 km west of Darende District, is situated on the right side of the 4th kilometer of the Elbistan-Darende road, which diverges westward from the D300 highway that passes through the district center (Türkoğlu & Demir, 2020; Koçak, 2023).

Günpınar Waterfall Nature Park, named after the waterfall within its boundaries, encompasses three distinct ecosystems: aquatic, rocky, and terrestrial. Due to the dynamic topography of the region, the highest point of the Nature Park reaches an elevation of 1,506 meters, while the lowest point is at 1,240 meters, with an average elevation of 1,408 meters (Karakaş, 2009; Şahin, Vural & Varol, 2012). To ensure the protection of its resource values, to allow the use of the area while maintaining a conservation-utilization balance, and to effectively transmit its natural values to future generations, a Development Plan (Table 1) has been prepared by the GDNCN.

Table 1. Spatial Distribution of Usage Zones According to the Development Plan (DKMP, 2019)

Protection-Use Zone	Area (ha)	Percentage (%)
Sensitive Protection Zone	5,48	4,05
Sustainable Use Zone	128,14	94,78
Controlled Use Zone	1,58	1,17
Total	**135,20**	**100,00**

In the Development Plan, the boundaries of the area have been determined by considering the conservation-utilization balance, the values of flora and fauna, and the structure of natural resources (Figure 2).

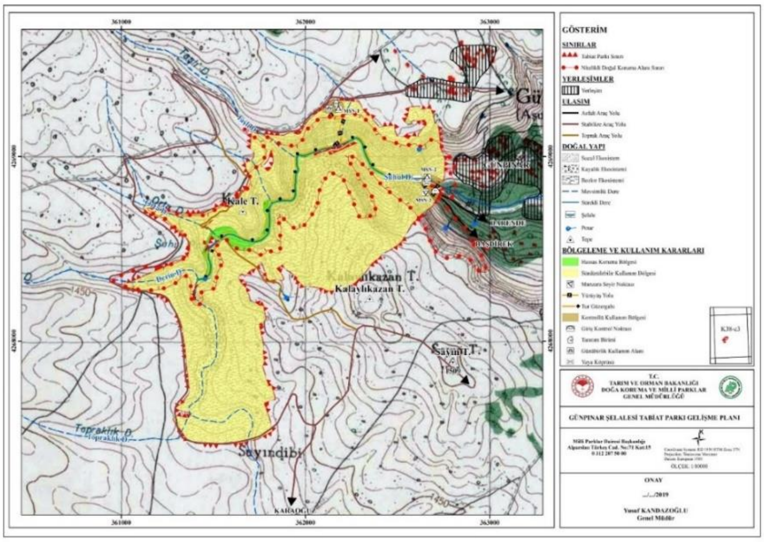

Figure 2. Günpınar Waterfall Nature Park Development Plan (DKMP, 2019)

In the establishment of the zoning system of the Nature Park; the resource values of the site, ecosystem integrity, threats, the level of intervention in the natural structure, traditional uses and socio-cultural values, land use status, and legal and administrative constraints have been considered (DKMP, 2019).

Sensitive Protection Areas are terrestrial, aquatic, and marine areas that are to be preserved with special measures for scientific research, education, or environmental monitoring purposes, where the use of the area and all impacts on it are restricted, and where human access may be prohibited when necessary. These are areas that must be absolutely protected, declared by the Council of Ministers' decision, and where construction is prohibited (Official Gazette, 2017).

Sustainable Use and Controlled Use Areas are regions that permit activities, tourism, and settlements which are compatible with nature and culture, contribute to conservation, and are in harmony with strictly protected sensitive areas or qualified natural conservation areas. These areas allow low-intensity activities that do not affect the integrity of the conservation zones (Official Gazette, 2017).

Considering the definitions and conditions of conservation and use, construction has been prohibited in areas declared as Sensitive Protection Zones, and human use of these areas has been restricted. Only in areas declared as Sustainable Use and Controlled Use Zones are construction, recreation, and tourism activities permitted. Observations in the field have concluded that within the boundaries of the Sustainable Use Zone defined by the Development Plan, there are no facilities that actively allow for recreational activities, and the area is closed to visitors. Taking all these developments into account, work has been conducted within the boundaries of Controlled Use Zone-1 (0.64 ha) and Controlled Use Zone-2 (0.94 ha) as shown in Figure 3 (Koçak, 2023).

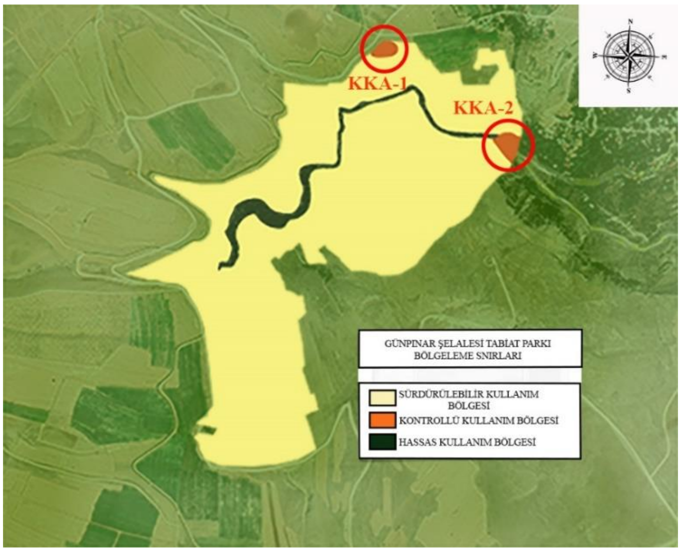

Figure 3. Working Area Boundaries (Original and created by the authors)

In the first step, a survey was conducted among the visitors of Günpınar Waterfall Nature Park. In the survey study, the value obtained by taking the average of the visitor numbers for the years 2019-2022, with the help of data provided by the GDNCN 15th Regional Directorate, was accepted as the Universe Size. The distribution of visitor numbers by months and years is given in Table 2.

Table 2. Spatial Distribution of Usage Zones According to the Development Plan (DKMP, 2019)

Months	2019	2020	2021	2022
January	0	788	642	286
February	0	1.344	632	343
March	0	205	5.589	5.398
April	0	1	11.780	20.495
May	0	1	14.912	24.425
June	30.196	32.518	17.217	25.646
July	31.911	40.925	26.307	55.143
August	40.688	95.605	20.213	19.194
September	25.971	37.438	2.015	15.200
October	8.477	12.116	1.537	4.559
November	4.104	4.033	1.115	1.117
December	834	1.450	951	1.037
Total	142.181	226.424	102.910	172.843
Grand Total	644.358			

According to the data obtained; in 2019, 142,181 people, in 2020, 226,424 people, in 2021, 102,910 people, and in 2022, 172,843 people visited the Nature Park. When the average of these four years is taken, the number obtained, 161,089, is accepted as the Universe Size for the method. The formula used for calculating the sample size is the one used by Esin et al. (2001). The formula is as follows:

n=(N.P.Q.Z_a^2)/((N-1).d^2)

According to the formula:

n: Sample Size

N: Population Size

P: Proportion of X observed in the Population

Q (1-P): Proportion of X not observed in the Population

Za: Z-value for a=0.05 is 1.96

d: Margin of Error

Based on this; the sample size n is calculated as follows:

n=161,088×0.052161,089×0.5×0.5×1.962=384.16

Considering the sample size and the result obtained from the formula; in this developed method, the minimum number of surveys to be applied with a 95% confidence interval and a ±5 margin of error is 384. Following discussions with users of the study area, a survey was conducted with 386 individuals, and the results have been analyzed in the findings section based on this number.

The physical carrying capacity of the areas suitable for visitor use within the study area (CUZ-1 and CUZ-2) has been calculated. Physical Carrying Capacity refers to the maximum number of people that can physically fit into an accepted area at the same time and is calculated using the following formula (Ceballos-Lascurain, 1996; Göktuğ, Bulut, Demir & Demircioğlu Yıldız, 2011):

PCC=A x Z/a x Rf

PCC: Physical Carrying Capacity

A: Area (Area or trail suitable for visitor use)

V/a: Visitor/Area (Area or trail length per visitor) (1 visitor/m², on the trail 1 visitor/m)

Rf: gs/zs (Rotation Factor: The duration of time an area is open daily / The average duration of a visit)

In calculating the physical carrying capacity of the Landscape Viewing Points within the Nature Park (CUZ-2 boundaries), the method developed by Itami (2002) for pedestrian flow in protected areas was used. According to this method, the physical carrying capacity of landscape viewing areas is defined as the maximum number of individuals that can fit without interfering with any individual’s personal space. The personal circle area is defined as the circular space that allows an individual to turn a full circle without any obstruction while having their arms extended. A visual representation of the personal circle area is presented in Figure 4.

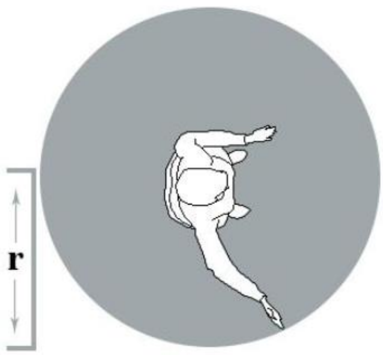

Figure 4. Minimum Personal Circle Area (Itami, 2002)

In the final step, the physical carrying capacity of the walking paths and stairs located within the Nature Park (CUZ-2 boundaries) has been calculated. The ‘Highway Capacity Manual’ published by the United States Federal Highway Administration in 1998 included ‘Capacity Analyses for Pedestrian and Bicycle Pathways.’ These analyses were later reinterpreted by Itami (2002) to be applicable to protected areas. In this phase of the study, the method revised by Itami (2002) was used. According to this method, a formula has been developed for calculating the basic pedestrian flow parameters (Rouphail et al. 1998; Chu &Baltes, 2003; Sisiopiku & Byrd, 2006; Hubbard et al. 2007):

a=H / M

a: Flow

H: Speed

M: Pedestrian Area (Area) = 1 / density

According to Itami (2002), the Level of Services (LOS) classes for relative value measurements of the variables in the formula are given in Table 3 for pedestrian pathways, and in Table 4 for stairs. These classes facilitate the transformation of factors such as speed, density, and type of pathway into a formula. The concept of 'Flow Intensity' in the tables refers to the number of visitors present at any time on a road with continuous flow. 'Unit Area,' on the other hand, represents the amount of space available for each visitor (Table 3), (Table 4).

Table 3. LOS Values for Walking Paths (Rouphail et al., 1998; Itami, 2002)

LOS	Unit Area (m2/visitor)	Current Density (Visitor/min/m)	Average Speed	
			(m/min) (m/s)	(m/min) (m/s)
A	>5.6	<14	>78	>1
B	3.7-5.6	14-21	76.2-78	1.27-1.30
C	2.2-3.7	21-33	73.2-76.2	1.22-1.27
D	1.4-2.2	33-49	68.4-73.2	1.14-1.22
E	0.75-1.4	49-60	45-68.4	0.75-1.14
F	<0.75	>60	<45	<0.75

Table 4. LOS Values for Stairs (Rouphail et al., 1998; Itami, 2002)

LOS	Unit Area (m2/visitor)	Current Density (Visitor/min/m)	Average Speed	
			(m/min) (m/s)	(m/min) (m/s)
A	1.9	16	32	0.53
B	1.6-1.9	16-20	32	0.53
C	1.1-1.6	20-26	29-32	0.48
D	0.7-1.1	26-36	25-29	0.42
E	0.5-0.7	36-49	24-25	0.42
F	<0.5	>49	<24	<0.40

In pedestrian usage, as in vehicle traffic, the following distance increases with speed. The quality of service is directly proportional to this situation. Visitors make less contact with each other as the unit area increases, allowing them to observe the natural and cultural landscape more extensively. Consequently, an increase in service quality is observed. However, an increase in unit area leads to a decrease in flow intensity. In the LOS classification, A represents the best, while F represents the worst. LOS standards are actively used in many countries, including America, Europe, the United Kingdom, and Australia, due to their proven reliability (Itami, 2002; Muraleetharan et al. 2004; Göktuğ et al., 2013; Caner, 2018).

3. Findings and Discussion

In the conducted survey, participants were asked, "How much time do you spend at Günpınar Waterfall Nature Park?" The responses were as follows: 13.7% spent 1 hour (53 individuals), 34.7% spent 2 hours (134 individuals), 32.6% spent 3 hours (126 individuals), 12.7% spent 4 hours (49 individuals), 3.6% spent 5 hours (14 individuals), 1.6% spent 6 hours (6 individuals), 0.8% spent 7 hours, and 0.3% spent 8 hours (1 individual) (Table 5). When calculating the average of all these values, a result of 2.67 is obtained. This figure is significant for the calculation of the area's physical carrying capacity.

Table 5. Stay Duration of Günpınar Waterfall Nature Park Visitors (According to the survey results)

How much time do you spend at Günpınar Waterfall Nature Park?	Number of People	Percentage (%)
1 Hour	53	13,7
2 Hours	134	34,7
3 Hours	126	32,6
4 Hours	49	12,7
5 Hours	14	3,6
6 Hours	6	1,6
7 Hours	1	0,8
8 Hours	1	0,8

Günpınar Waterfall Nature Park, Physical Carrying Capacity is calculated separately for Controlled Use Area-1 and Controlled Use Area-2. Accordingly (Table 6);

Table 6. Physical Carrying Capacity for Controlled Use Areas (Koçak, 2023)

Physical Properties	CUZ-1	CUZ-2
zs: Average Visit Time of the Area (Hours)	2,67	2,67
A: Recreation Area (m^2)	6.400 m2	9.400 m^2
gs: Daily time the area is open to visitors (Hours)	8	8
Z/a: Optimum Picnic Area per Person (person/m2)	1/60 Person/m^2	

In this context;

z: Represents the average value of responses to the survey question “How much time do you spend within the Nature Park?”

A: Denotes the area allocated for the Controlled Use Zone as determined within the Development Plan obtained through the Directorate of Conservation of Natural Heritage (GDNCN) 15th Regional Directorate.

g: Indicates the duration for which the Nature Park is open to daily visitors.

Z/a: This value is accepted according to the Forest Parks Regulation.

Rf: Recreation Factor = gs/zs

When the collected data is converted into numerical values according to the formula;

PCC=A×aZ×Rf

For CUZ-1:

6,400×(601)×(2.678)=319visitors

9,400×(601)×(2.678)=469visitors

When the results are combined, a total of 788 individuals can perform recreational activities within the boundaries of the Günpınar Waterfall Nature Park Controlled Use Zone in a single day.

At this stage, the physical carrying capacity of the Landscape Observation Terrace, located within the borders of CUZ-2, which actively enables recreational activities, was calculated.

Based on anthropometric characteristics, the distance between the tip of the right hand and the tip of the left hand when a person stretches their arms out to both sides corresponds to their height. Half of this length represents the radius of the circle that denotes the personal space of individuals at scenic viewing points. To calculate this circle, the average heights of female and male individuals are required.

According to statistical data, the average height for women living in Turkey is 164 cm, and for men, it is 176 cm (Caner, 2018; Rüzgar, 2022).

164/2=82 cm personal space radius of female individuals

176/2=88 cm personal space radius of male individuals

When averaged, the calculation is as follows:

282+88=85 cm(0.85 m)

According to the Turkish average, the circumference of the personal space circle for individuals has been determined to be 0.85 m. According to the formula for the area of a circle;

$A=\pi r^2 (\pi=3)$

3×(0.85)2=2.17 m^2. (The average area accepted for an individual at a scenic viewing point is 2.17 m²).

According to the studies conducted in Günpınar Waterfall Nature Park, the area of the scenic viewing terrace within the park has been determined to be 57 m². Consequently,

Carrying Capacity Calculation=Personal Area Size

57 m^2/2,17 m^2=26 individuals.

This value represents the maximum number of people that the scenic viewing terrace can accommodate (Figure 5).

Figure 5. Landscape Observation Terrace in the Nature Park (Original and created by the authors)

In the method, the quality levels of the walking paths are expressed using Service Level (LOS) grades. These levels are denoted as A-B-C-D-E-F (Unobstructed-Semi Obstructed-Restricted-Crowded-Very Crowded-Congested), where A represents the best conditions and F represents the worst conditions (Table 7).

Table 7. LOS Values for Walking Paths (Rouphail et al., 1998; Itami, 2002)

LOS	Unit Area (m2/visitor)	Current Density (Visitor/min/m)	Average Speed	
			(m/min) (m/s)	(m/min) (m/s)
A	>5.6	<14	>78	>1
B	3.7-5.6	14-21	76.2-78	1.27-1.30
C	2.2-3.7	21-33	73.2-76.2	1.22-1.27
D	1.4-2.2	33-49	68.4-73.2	1.14-1.22
E	0.75-1.4	49-60	45-68.4	0.75-1.14
F	<0.75	>60	<45	<0.75

Itami (2002), based on his literature research, surveys, and field measurements, concluded that standards C and D are more suitable for protected areas. In the study area, the C Standards have been adopted for the physical carrying capacity calculations of walking paths and stairs.

The pedestrian paths within the study area have been classified according to their slope grades, and area calculations have been performed. Accordingly, the paths with a slope of 0-5% cover an area of 284.9 m², those with a slope of 10-20% cover 130.6 m², paths with a slope of 20-40% cover 145.2 m², and paths with a slope of over 40% cover 277.4 m². The total area of pedestrian paths is 838.1 m² (Figure 6).

Since the evaluation is conducted according to C Standards.

838.1/2.2=380 individuals

The maximum number of individuals that can simultaneously use the pedestrian paths within the area is 380. Considering the visitors' round-trip movements, this number will be considered as 760 individuals.

Figure 6. Pedestrian Paths in the Nature Park (Original and created by the authors)

According to the method, the quality levels of the stairs are expressed using Service Level (LOS) grades. These levels are denoted as A-B-C-D-E-F (Unobstructed-Semi Obstructed-Restricted-Crowded-Very Crowded-Congested), where A represents the best conditions and F represents the worst conditions (Table 8). In the study area, the C Standards have been adopted for calculating the physical carrying capacities of the stairs.

Table 8. LOS Values for Stairs (Rouphail et al., 1998; Itami, 2002)

LOS	Unit Area (m2/visitor)	Current Density (Visitor/min/m)	Average Speed (m/min) (m/s)	(m/min) (m/s)
A	1.9	16	32	0.53
B	1.6-1.9	16-20	32	0.53
C	1.1-1.6	20-26	29-32	0.48
D	0.7-1.1	26-36	25-29	0.42
E	0.5-0.7	36-49	24-25	0.42
F	<0.5	>49	<24	<0.40

According to the examinations conducted in the study area, it has been determined that there are three sets of stairs within the area (Figure 7). The area of each step has been measured, and by multiplying these values by the number of steps, it has been found that they have a total area of 36.4 m². Based on the C Standards, this translates to: 36.4/1.1=33 individuals.

This figure represents the number of people who can use the stairs simultaneously. Since there will be a round-trip circulation like the pedestrian paths, this number will be considered as 2 x 33 = 66 individuals.

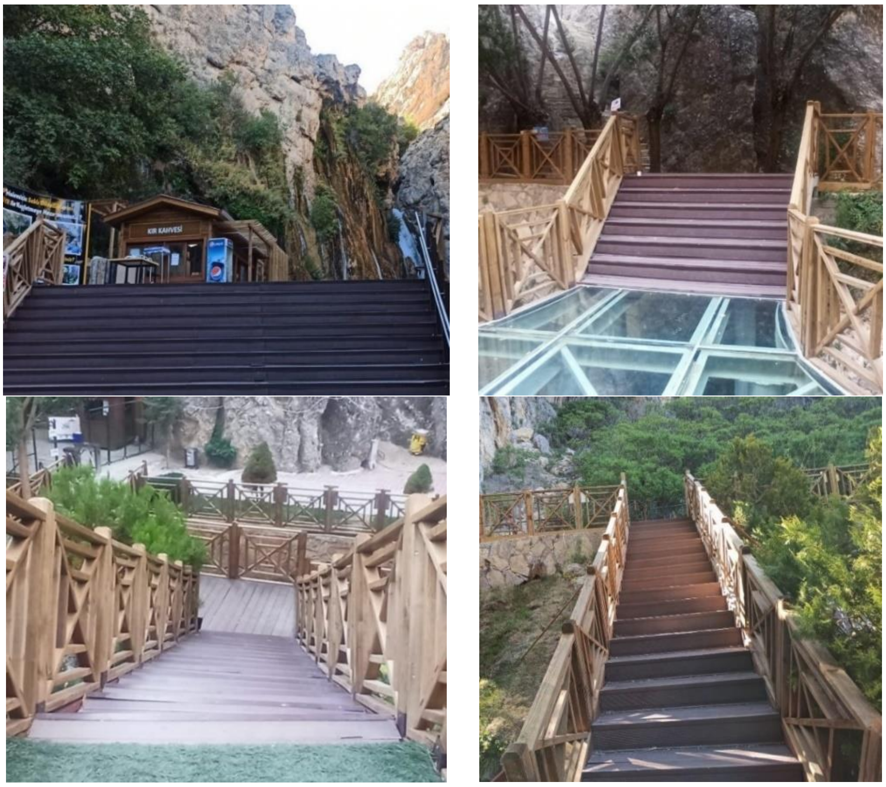

Figure 7. Stairs in the Nature Park (Original and created by the authors)

4. Conclusion and Suggestions

In the planning process of recreational areas, determining the behaviors and tendencies individuals exhibit during their leisure time is of great importance. These determinations provide planners with the necessary data, enabling them to understand the preferences and likes of the users. Consequently, this contributes to the development of physical plans and programs that achieve the most suitable balance between natural resources and the recreational needs of individuals. This process is crucial for ensuring the effective and efficient use of recreational areas (Demircan, Aytatlı & Yıldız, 2018).

Recreational areas serve not only to enhance environmental quality and provide aesthetically pleasing spaces but also offer a range of benefits to urban ecology. These areas contribute to the mental and physical health development of the urban community, as well as carry significant value by offering opportunities for rest, entertainment, and socialization. In this context, recreational areas are an integral part of urban life and play a vital role in the sustainability of city ecosystems and human well-being. The sustainability of recreational areas can be achieved through controlled visitor acceptance based on the results of carrying capacity calculations (Göktuğ et al., 2011).

The Controlled Use Zones of the Nature Park have undergone a physical carrying capacity assessment. According to the calculations, the physical carrying capacity for CUZ-1 is determined to be 319 visitors/day, and for CUZ-2, it is 469 visitors/day. In the second step, the physical carrying capacity of the scenic viewing terrace located within the Nature Park has been calculated. Measurements conducted in the Nature Park have revealed that the scenic viewing terrace occupies an area of 57 m². Consequently, when utilized considering a personal circular space for everyone, the terrace can simultaneously serve 26 people. In the final step, the carrying capacity for the walking paths and stairs within the area has been calculated. The area sizes for the walking paths, based on their slope categories, have been computed, and the number of people they can accommodate has been determined according to the total area. The calculations indicate that the carrying capacity for the walking paths is 760 individuals. Similarly, for the stairs, the method applied involved calculating the total area of the stairs in the field, and the carrying capacity has been determined based on this value. According to the data obtained, the carrying capacity for the stairs is concluded to be 66 individuals.

When all these numerical data are compared with the monthly visitor numbers for Günpınar Waterfall Nature Park, obtained from the Directorate of Nature Conservation and National Parks 15th Regional Directorate, it has been determined that, especially during the summer months, the area is subjected to usage far exceeding its carrying capacity.

Although Günpınar Waterfall Nature Park spans an area of 135 hectares, active recreational activities are permitted only within a portion measuring 0.94 hectares. In consideration of the Development Plan prepared by the Directorate of Nature Conservation and National Parks (GDNCN) for the Nature Park, new recreational facilities should be created within the Controlled Use and Sustainable Use zones of the area. Within these zones, amenities such as trail walking paths, bicycle lanes, new picnic areas, camping sites, parking facilities, and the like could be offered. Considering that Darende District is situated at a junction point of the Eastern Anatolia, Central Anatolia, and Mediterranean Regions, the diversity of recreational activities could be enhanced. In planning these new recreational spaces, the carrying capacity calculations conducted for CUZ-1 and CUZ-2 in this study can be referenced.

The four-year visitor numbers for the Nature Park (2019-2020-2021-2022), obtained from the Directorate of Nature Conservation and National Parks 15th Regional Directorate, have been compared with the calculated physical carrying capacity of the area. When comparing the annual user average with the carrying capacity, it can be said that the park has an ideal number of visitors. However, when the monthly values are compared, it has been observed that, particularly during the heavily frequented spring and summer months, the area is exposed to a number of visitors far exceeding its carrying capacity. For this reason, particularly during the summer months, an appointment system for entry to the area could be implemented, or the duration of the area's availability for visitation could be extended.

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The article complies with national and international research and publication ethics.

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Author Contribution and Conflict of Interest Declaration Information

All authors contributed equally to the article. There is no conflict of interest.

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Bibliometric Analysis of Studies on Urban Identity in Web of Science (WoS) Database

Murat YEŞİL [1], Rabia Nurefşan KARABÖRK [2*]

ORCID 1: 0000-0002-3643-5626
ORCID 2: 0009-0002-1722-023X
[1] *Ordu University, Faculty of Agriculture, Department of Landscape Architecture, 52000, Ordu, Türkiye.*
[2] *Ordu University, Faculty of Agriculture, Department of Landscape Architecture, 52000, Ordu, Türkiye.*
**** e-mail**: rabiakarabork9@gmail.com*

Abstract

In this study, it is aimed to examine the bibliometric characteristics of studies on urban identity and to determine the current situation. In this context, studies on 'urban identity' published in the Web of Science database between 1999 and 2024 were evaluated. Access to the database was provided on 08.03.2024 and bibliometric analysis of 2303 publications on the subject was carried out through the VOSviewer 1.6.20 program. In the research conducted, it was found that the most studies on the subject were published in 2020 (209); the studies were mostly in article type (1941); the studies were mostly conducted in the USA (397) and the UK (267) and the language of publication was predominantly English (2072); the most frequently repeated keywords in the published studies were place identity (514), place attachment (289), urban identity (151).

Keywords: *Bibliometric analysis, urban identity, VOSviewer, Web of Science (WoS).*

Web of Science (WoS) Veri Tabanında Yer Alan Kent Kimliği Konulu Çalışmaların Bibliyometrik Analizi

Öz

Bu çalışmada kent kimliği konulu çalışmaların bibliyometrik özelliklerinin incelenmesi ve mevcut durumun tespit edilmesi amaçlanmaktadır. Bu bağlamda, Web of Science veri tabanında 1999-2024 yılları arasında yayınlanan "kent kimliği" ile ilgili çalışmalar değerlendirilmiştir. Veri tabanına erişim 08.03.2024 tarihinde sağlanmıştır ve VOSviewer 1.6.20 programı aracılığı ile konuyla ilgili 2303 adet yayının bibliyometrik analizi gerçekleştirilmiştir. Yapılan araştırmada, konuyla ilgili en fazla çalışmanın 2020 yılında (209) yayınlandığı; çalışmaların en fazla makale türünde (1941) yapıldığı; çalışmaların çoğunlukla ABD (397) ve İngiltere'de (267) yürütüldüğü ve yayın dilinin ağırlıklı olarak İngilizce (2072) olduğu; yayınlanan çalışmalarda en sık tekrar eden anahtar kelimelerin place identity (514), place attachment (289), urban identity (151) olduğu saptanmıştır.

Anahtar Kelimeler: *Bibliyometrik analiz, kent kimliği, VOSviewer, Web of Science (WoS).*

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1. Introduction

Urbanization and globalization has been two important phenomenas in the reshaping of social, economic, cultural landscapes and physical environments. These phenomenas have raised major concerns about issues related to urban life, particularly environmental sustainability (Brahmasrene & Lee, 2017; Saud et. al., 2020). These two phenomena cause problems resulting from rapid and unplanned construction, insufficient open green space, water, air and transport infrastructure. These are seen as the main factors triggering environmental sustainability concerns. There have been many recent studies that have examined the impact of such problems on the social life and the psychology of people (Jenerette & Wu, 2001; Lam, 2008; Checa & Neli, 2021). Nevertheless, it is noteworthy that there is relatively limited research on the sustainability of urban identity.

In recent centuries, there have been major breakthroughs in industry and commerce, which have resulted in large numbers of people moving from rural to urban areas. Today, according to the United Nations, about 56.5% of the world's population lives in cities, and this percentage is expected to reach 68% by 2050 (UN, 2018). This projected population growth will require urban areas to expand to accommodate more users. In this respect, the natural and cultural landscape resources of cities and their surroundings are likely to face various pressures in the future. Therefore, this raises concerns about the image and identity of cities.

As a co-production of different societies and cultures, today's cities have a multi-dimensional and dynamic structure. This heterogeneous system of cities have changed and transformed their identities. This situation demonstrates the significance of approaches to managing and safeguarding the local values of cities in the context of urban design and planning, with consideration to the long-term sustainability of urban identity.

The concept of urban identity plays a significant role in the social and cultural dynamics of urban environments. This closely intertwined with the phenomenon of place attachment and the sense of belonging that users experience in a particular setting. In this regard, the field of environmental psychology posits that humans possess a profound inclination to forge connections with their surroundings (Scannel & Gifford, 2017). The attachment and belonging to a place are essential for the establishment of a strong emotional and perceptual connection, which in turn promotes a sense of security and community. As a field of study, these concepts, which encompass the interconnection between the environment and human beings, have attracted the attention of various researchers (Anton & Lawrence, 2014; Boley et. al., 2021). In fact, the identity of a place encompasses more than its physical characteristics; it is given special meaning for individuals and communities. In other words, the concept of urban identity encompasses not only the physical characteristics of the space but also the experiences and relationships of the community living in it. For this reason, studies from disparate academic disciplines that focus on the city are valuable in understanding not only the physical aspects but also the social, cultural, and psychological dimensions of urban spaces. The methodology of this study is based on the bibliometric analysis of the researches in international database with the keywords identified. By analyzing the bibliometric characteristics of the studies in the literature on urban identity, the article seeks answers to the following questions:

- Who have been the most influential authors in the literature on urban identity and where have been the most influential institutions and collaborative networks?
- What is the geographical distribution of these studies, and which countries demonstrate a greater interest in the subject matter?
- Which keywords have been these studies produced in relation to?

In accordance with the aforementioned, this study presents an analysis of the bibliometric data of the aforementioned studies in the Web of Science (WoS) database. This analysis aims to guide researchers by clarifying important trends and focal points in the scientific literature on urban identity in the period 1999-2024. This analytic approach can provide a comprehensive research perspective that is objective in nature, thereby revealing information on how urbanization processes and urban identity are shaped through scientific publications.

2. Material and Method

Bibliometric analysis is an analytical method that is employed to obtain formal and quantitative data on the current state of a discipline. Furthermore, it facilitates the monitoring of academic trends through the use of visualization software (Dirik et. al., 2023). The method is preferred by researchers for reasons such as discovering the trends of studies conducted on a specific topic, the components of the research, the intellectual capacity of the literature such as country, author, university, journal productivity, and the gaps in the current literature (Wallin, 2005; Donthu et al., 2021). This method is used by different disciplines such as gastronomy (Ayaz &Türkmen, 2018), marketing (Zeren & Kaya, 2020), architecture (Park & Lee, 2022), medicine (Chen et al., 2023), and landscape architecture (Çelik & Şekeroğlu, 2023). The transparency, reliability and ease of reproduction of bibliometric analysis, together with the visualization of data, increase the advantages and understandability of this method (Rama et al., 2023). This method allows for the meaningful evaluation of large volumes of data such as citations, number of authors and frequency of keywords (Donthu et al., 2021). The bibliometric analysis method is a preferred approach for identifying current publication trends and academic interactions related to scientific research, in contrast to the more commonly utilized review articles. Review articles usually involve researchers summarizing, comparing and evaluating past studies on a particular topic. Therefore, review articles can be influenced by the academic background and orientations of the researcher on the topic. On the other hand, articles dealing with bibliometric analysis studies stand out as analysis articles that aim to objectively evaluate large data groups of past studies in a particular field. Therefore, there has been a noticeable increase in the number of studies using bibliometric analysis method (Çelik & Şekeroğlu, 2023; Gönüllüoğlu & Arslan Selçuk, 2024).

In bibliometric research, various databases such as Google Scholar, Web of Science (WoS), Scopus, PubMed, Dimensions, Semantic Scholar are used to access scientific studies. Among these databases, WoS is a comprehensive database with over 21,000 refereed journals indexed by Science Citation Index Expanded (SCI-Expanded), Social Sciences Citation Index (SSCI), Arts & Humanities Citation Index (A&HCI) (Clarivate, 2024). WoS has features such as peer-reviewed journals and access to bibliometric information of publications and is widely used (Fang et al., 2018; Thompson, 2018).

In this context, a bibliometric analysis was applied to reveal the status of studies on urban identity published in the WoS database in the last 25 years.

In the study, WoS database was used to access the studies conducted on urban identity between 1999-2024. Access to the database was provided on 08.03.2024. In this direction, it was aimed to obtain the data of the studies containing the keywords “urban identity” or “city identity” or “place identity” by selecting all fields in the database. In the research conducted, 2303 scientific studies were reached.

The data was exported in “.txt” format to make it suitable for visualization. VOSviewer 1.6.20 program, which is one of the analysis tools used to visualize the networks of bibliometric data and to reveal the relationship patterns between word-word phrases in texts, was used. The data obtained from the studies were evaluated through author-citation-journal-country-institution-keyword analysis. With this method, it is aimed to better understand the current state of the academic literature on urban identity and the prominent trends. The aim of this study is to gain a clearer insight into the current state of the academic literature on urban identity and the most prominent trends.

3. Findings and Discussion

According to the WoS database query with the keywords “urban identity”, “place identity”, “city identity”, the oldest study in the database was published in 1982 (1). This study concentrated on one of the most significant issues of that era: the transformation of the industrial sector and the stark contrast between the social classes. Subsequently, the text turned its attention to the failure to cultivate a conscious sense of community and identity (Accampo & Auzias, 1982).

In the context of the present study, the studies included in the database were limited to those published in 1999 and the initial two months of 2024. In this context, it was observed that there were 11 publications in the WoS database in 1999 and 187 publications in 2023. Therefore, it can be stated that there has been a notable trend in the literature on this subject in recent years. It is particularly striking that the largest number of publications (209) were published in the aftermath of the pandemic, the effects of which largely emerged in 2020.

According to the selected range, scientific studies were mostly articles (2112). Information on these numbers is presented in Table 1.

The fact that a document type could be marked as more than one type caused the number of document types to exceed the number of documents analyzed (2303) (Table 1).

Table 1. Types and number of studies published in the WoS database

Type of Publication	Number of Publication
Article	2112
Proceeding Paper	236
Book Chapters	104
Book Review	80
Others	246

The studies published in the last 25 years are generally included in the categories of 'Environmental Studies' (387), 'Hospitality Leisure Sport Tourism' (301) and 'Urban Studies'(290). The distribution of the studies into categories is given in detail in Table 2. Similar to the problem with study types, the option to include studies in more than one research category by the authors causes the number of studies in the categories to be higher than the total number of documents analyzed (2303).

Table 2. Categories of documents published in the WoS database

Research Categories	Number of Publication
Environmental Studies	387
Hospitality Leisure Sport Tourism	301
Urban Studies	290
Geography	273
Architecture	186
Environmental Sciences	174
Regional Urban Planning	163
Psychology Multidisciplinary	138
Green Sustainable Science Technology	126
History	122
Others	1667

The studies on urban identity in the WoS database were published in 20 different languages. It is seen that the predominant language of the published studies is English (89%). The studies have been published in 1266 different publication venues. On the other hand, 'Sustainability' (2.7%), Journal Of Environmental Psychology (2.1%), Procedia Social And Behavioral Sciences (1%) journals stand out as the journals with the most studies on the subject. Published studies are mostly indexed in SSCI (47.3%), ESCI (28.6%) and A&HCI (12.5%) (Table 3).

Table 3. Journal-publication language published in WoS database

Feature	Type	Number of Publication
Publication Language	English	2072
	Spanish	67
	Turkish	42
	Russian	24
	French	19
	Others	79
Publication Titles	Sustainability	64
	Journal Of Environmental Psychology	49
	Procedia Social And Behavioral Sciences	25

	Journal Of Place Management And Development	24
	Cities	22
	Others	2119
Index	Social Sciences Citation Index (SSCI)	1091
	Emerging Sources Citation Index (ESCI)	658
	Arts & Humanities Citation Index (A&HCI)	289
	Science Citation Index Expanded (SCI-EXPANDED)	285
	Conference Proceedings Citation Index–Social Science & Humanities (CPCI-SSH)	163
	Others	233

When the citation relationships of the journals in which the studies were published were examined with the criteria of at least 1 published study belonging to a source and at least 1 citation belonging to 1 source, 761 journals were found to be linked to each other. Figure 1 shows a visualization of the network relationships of the 50 journals with the highest interconnectivity. The Journal of Environmental Psychology is the most cited journal for studies on urban identity. The total number of citations of the studies (49) published in the journal is 6802 and the total link strength is 628. Among all journals, the total number of citations of the journal 'Sustainability', in which studies on the subject are published the most (64), is 539 and the link strength is 198.

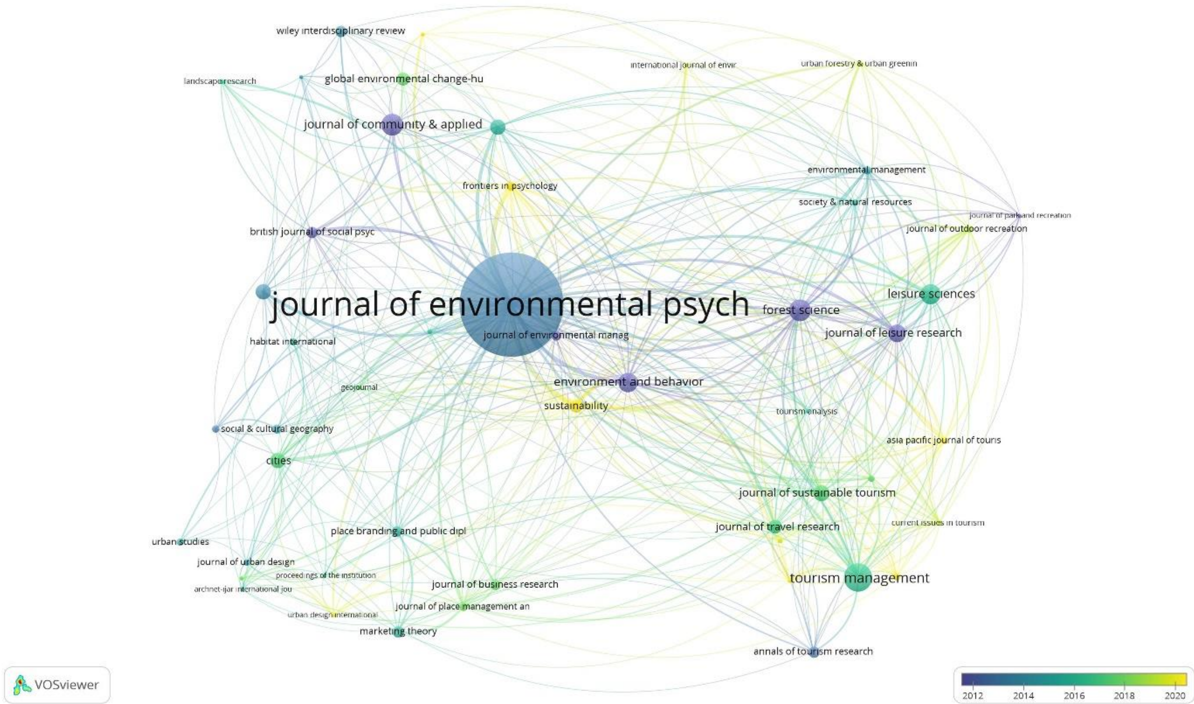

Figure 1. Journal citation links

In accordance with the established criteria, which required that at least one study be conducted in each country and that at least one citation be received from each country, it was determined that 90 countries established citation links with one another (Figure 2). It was observed that the most studies were produced in the United States, with 397 studies receiving a total of 11307 citations and having a link strength of 1733. The other country that has contributed the most to the literature on the subject is the UK. In the UK, 267 studies were conducted with a total number of 8545 citations and 1232 link strength, in Australia 117 studies were conducted with a total number of 7105 citations and 1190 link strength.

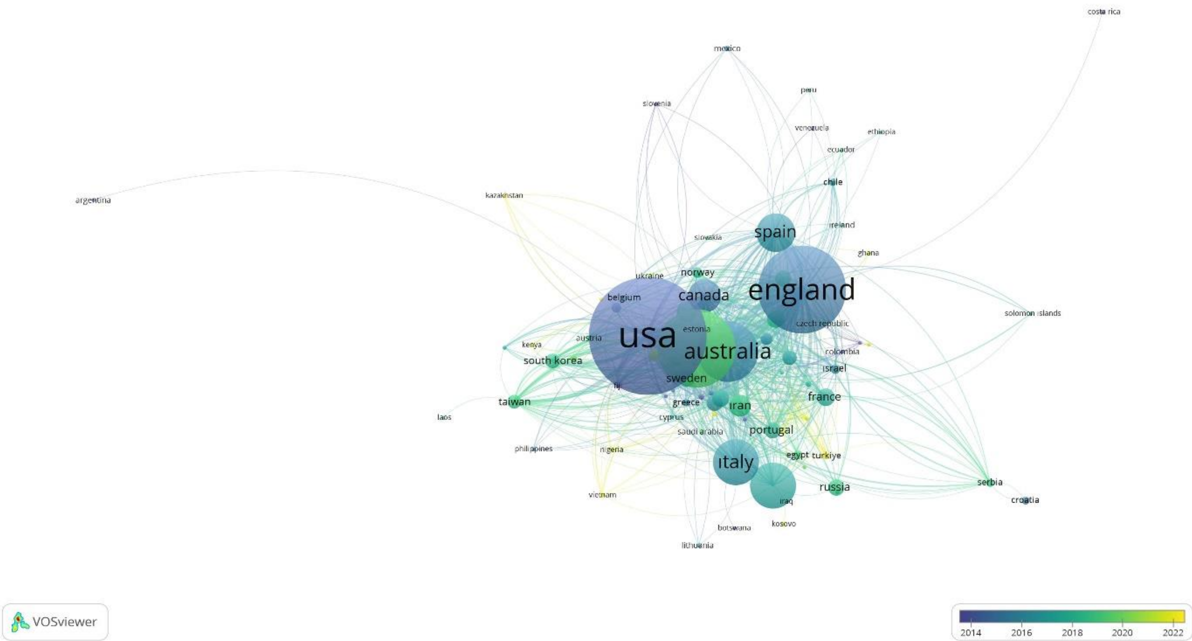

Figure 2. Country citation links

When author citation links were analyzed based on the fact that each author had at least 1 study and 1 citation, it was determined that there were linking relationships between 3276 authors. Figure 3 shows the connection networks of the 500 authors with the highest interconnectivity. Among the studies on urban identity, Patrick-Wright, who conducts scientific studies in the field of geography, has reached the highest number of citations by receiving a total of 1686 citations in 9 studies on the subject, and the total link strength of the author is 200. Alan Graefe, Gerard T. Kyle and Robert Manning, among the other authors who conducted studies on the subject, published 5 studies each, receiving 1231 citations and reaching a link strength of 553.

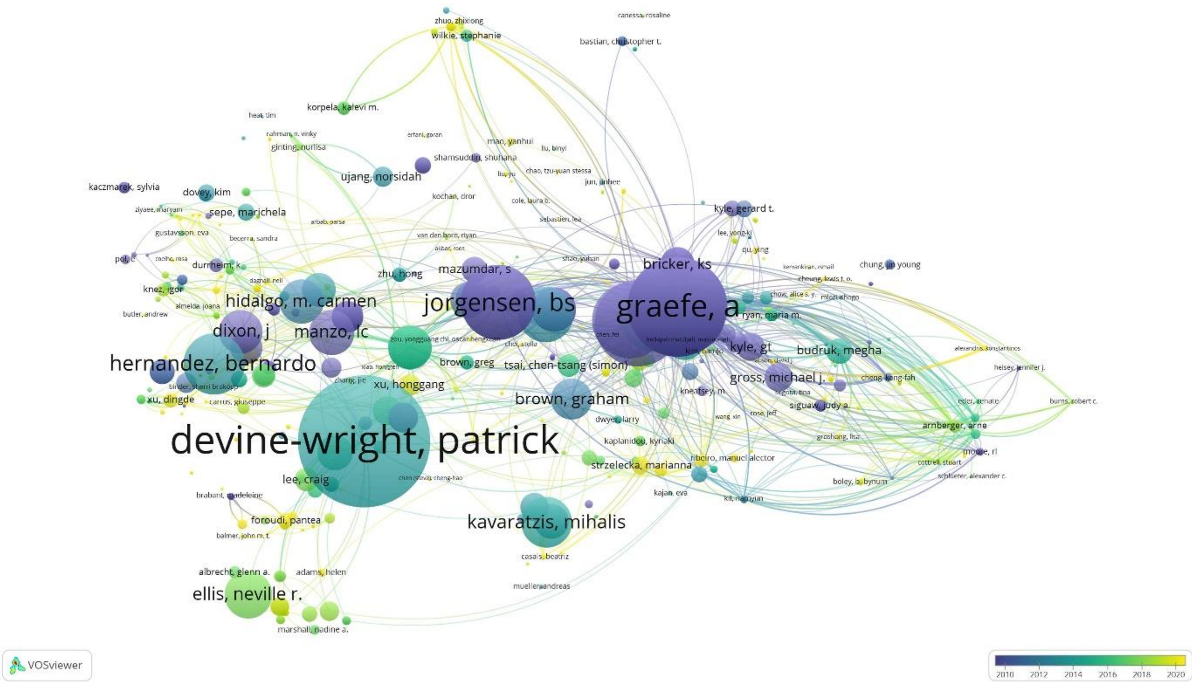

Figure 3. Author citation links

When the co-authorship relationships between authors were analyzed in line with the criteria of 1 author having at least 1 study and 1 citation, co-authorship links were identified between 3276 authors. The network relationships of the 500 authors with the highest connection strength among these connections are shown in Figure 4. Accordingly, Siren Lan and Qunyue, two of the authors with the highest link strength, produced 3 publications and reached 86 citations and 23 link strengths. Patrick-Wright, who has the highest number of citations, has a link strength of 13.

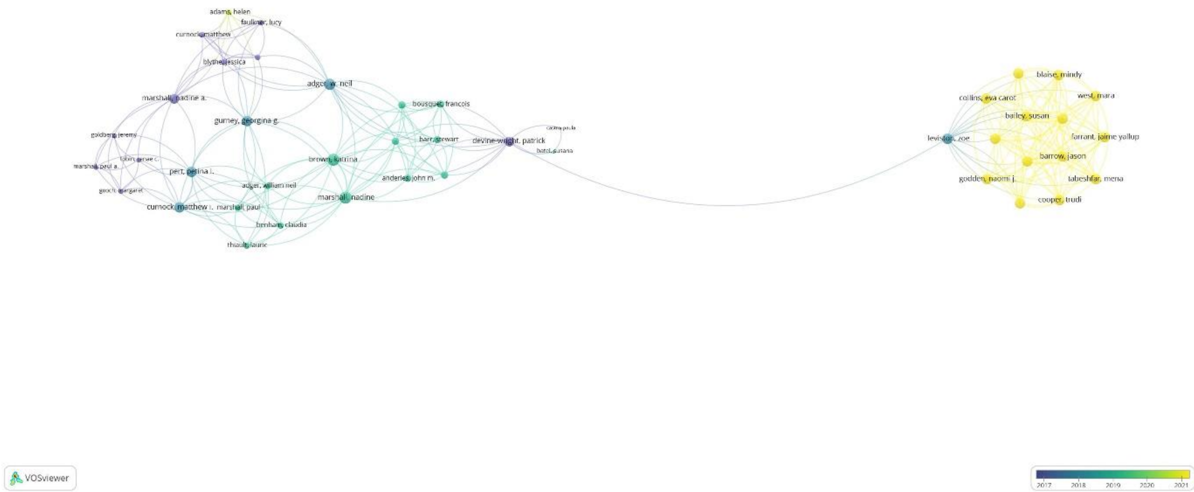

Figure 4. Authors' co-authorship links

When the institutions to which the authors are affiliated and the number of citations were analyzed based on the criteria that at least 1 publication was produced from each institution and cited 1 time, 1457 institutional citation links were identified. Accordingly, Penn State University has made the largest contribution to the literature on urban identity. The highest number of citations and links was reached by producing 18 publications in the institution. At the same time, the total number of citations to the relevant publications of the institution is 2329 and the total number of links is 1159. Among other institutions with high contribution to the literature, 6 publications of the University of Vermont had 1380 citations and 690 links, and 10 studies conducted at Colorado State University had 1333 citations and 574 links. (Figure 5).

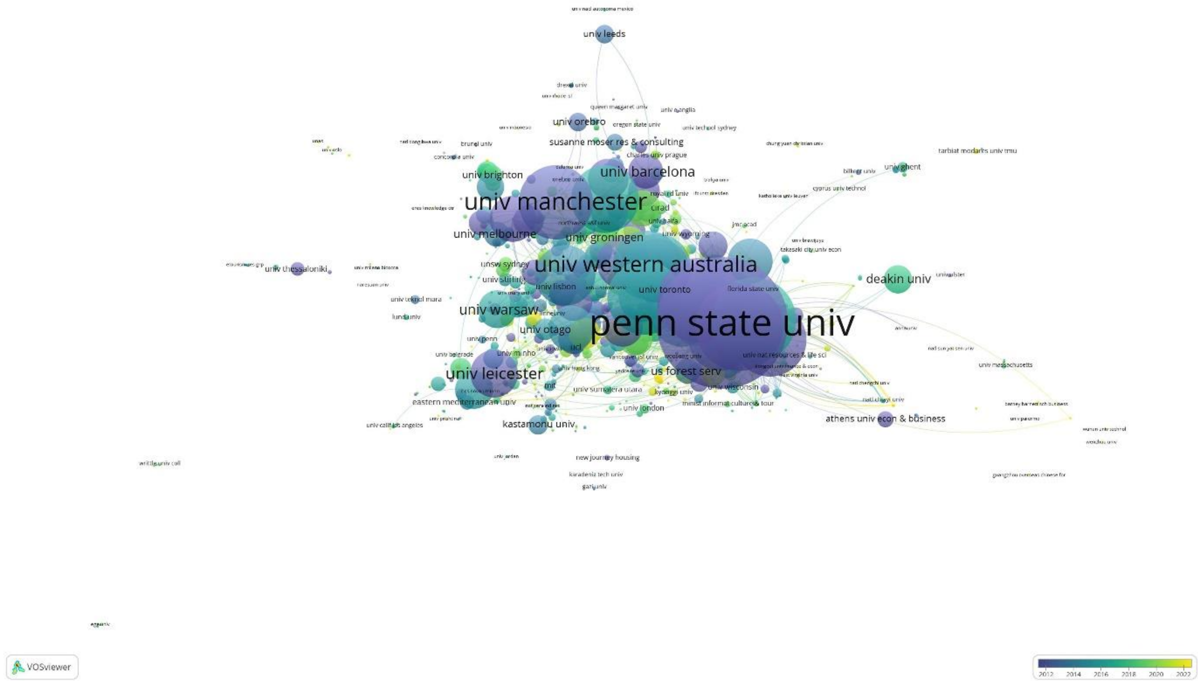

Figure 5. Inter-institutional citation links

An analysis was made based on the criterion that a source has at least 3 keywords, and in this direction, it was determined that there was a linking relationship between 473 keywords. Figure 6 shows the visualization of keywords based on their link strength.

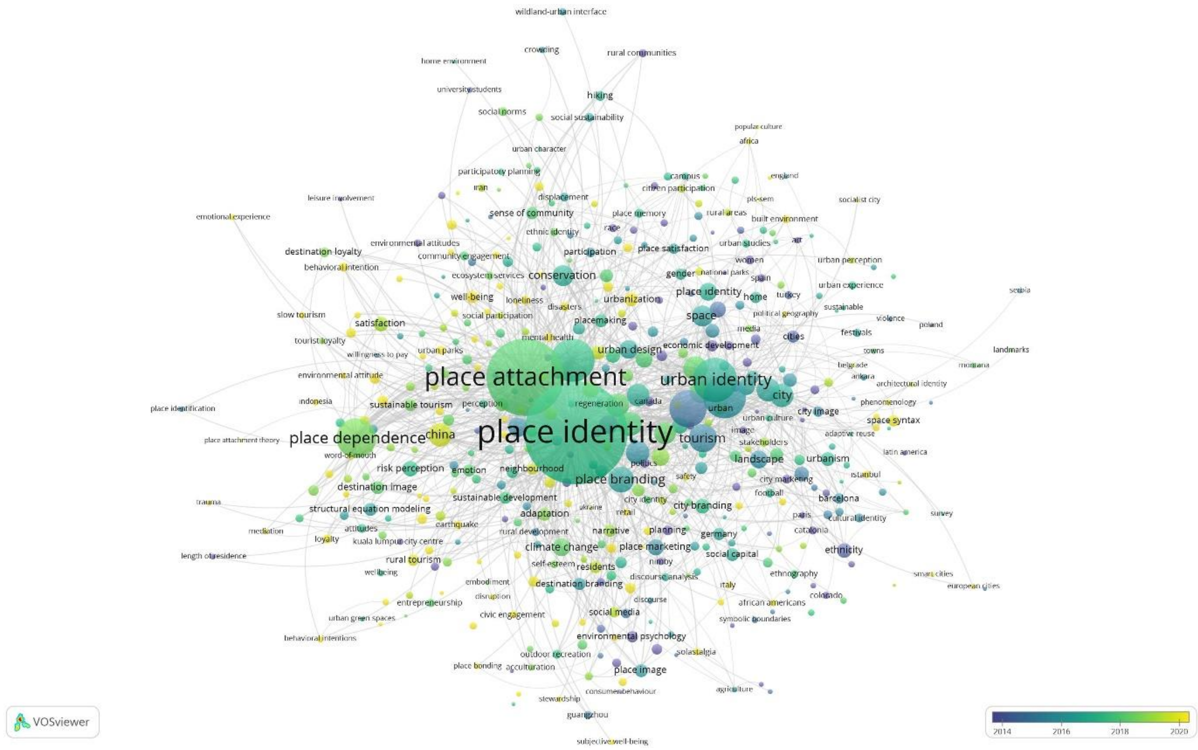

Figure 6. Links to keywords

When the keywords used in scientific studies on urban identity were analyzed, it was found that the most frequently used word 'place identity' was repeated 514 times and had a link strength of 2373. Accordingly, the keyword 'place attachment' has 289 repetitions and 581 link strength, the keyword 'urban identity' has 151 repetitions and 214 link strength, the keyword 'sense of place' has 91 repetitions and 207 link strength, and the keyword 'identity' has 99 repetitions and 207 link strength.

4. Conclusion and Suggestions

Environmental pressures, especially with urbanization and globalization, have led to a gradual loss of the characteristics that distinguish cities from each other. These factors, which also deeply affect human life, create an identity problem in cities. This situation reveals the importance of scientific studies on the identity of cities that have become the living space of people. The present study aims to identify the most influential authors, institutions, and collaborations in the field of urban identity over the past 25 years. The date 03/08/2024 was selected as the limit for the analysis. In accordance with the parameters of the study, a bibliometric analysis of 2,303 studies on urban identity published in the WoS database between 1999 and 03/08/2024 was presented.

The studies on the subject were evaluated and found to have been predominantly scanned through the SSCI, ESCI, and A&HCI indexes, and to have been primarily published in article form. Furthermore, it was noted that the authors made significant contributions to the existing literature by conducting studies across a range of scientific disciplines, including articles, proceedings, and book chapters. The subject is of significant interest, particularly within the social sciences, and developments in urban identity have a considerable impact on these disciplines. However, the literature on urban identity, which is addressed by other professional disciplines with its physical, social, cultural, and psychological dimensions, continues to expand with a comprehensive perspective on a daily basis.

In urban identity studies, the keywords “place identity”, “place attachment” and “urban identity” are the most commonly used words by authors. In addition, concepts such as “sense of place” and “place depence” also come to the fore. Ujang and Zakariya (2015), for example, addressed urban renewal environments based on the principles of sense of place and environmental psychology (place attachment) in the context of the continuity of psychological well-being of urban residents. This study evaluated the definition and importance of place in urban regeneration studies and the effects on the continuity of the meaning and identity of place. Another study examined the collective memory of two cities after World War II and its relationship with place identity and place attachment (Lewicka, 2008). The USA and the UK have contributed the most to the literature on the subject. However, the general trend shows that other countries are also becoming more interested in the issue and that the issue has become a global area of interest. In conclusion, the issue of urban identity is becoming increasingly important. Therefore, researchers need to strengthen their collaborative networks, encourage the accumulation of knowledge in the field, and develop more effective strategies to preserve and emphasize the unique character of cities.

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The article complies with national and international research and publication ethics. Ethics Committee approval was not required for the study.

Author Contribution and Conflict of Interest Declaration Information

All authors contributed equally to the article.

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Investigation of Feeding Activities for Red Pine and Yellow Pine Species Grown in Turkish Forest Nurseries

Hakan LEVENTOĞLU [1*]

ORCID 1: 0000-0001-8028-0759
Dr. Higher Agricultural Engineer, Self-employed, Sakarya, Türkiye
** **e-mail:** hleventolu@gmail.com*

Abstract

In agricultural activities carried out in our country, one of the main items that increase the cost of production is fertilizer and fertilization activities. In the researches and studies conducted, it is known that the majority of the productions in private and public areas are based on traditional understanding and far from scientific methods and methods. This is a factor that both increases the cost during the production period and causes the lack of quality and desired amount of production. The aim of this study is to understand the level of plant nutrition activities and fertilizer use during the production phase for coniferous seedlings produced in Turkish Forest Nursery production facilities. Fertilizer is a commodity that we are completely dependent on foreign countries for raw materials. Every year, millions of dollars in our budget go abroad for fertilizer supply. It should be our national duty and main goal to carry out feeding activities by bringing our own resources to the forefront and to ensure that the amount of fertilizer used is used as much as needed. The aim of the study is to prevent excessive fertilizer consumption and to ensure that these activities are carried out with scientific methods and to make suggestions to the interlocutors regarding the results.

Keywords: *Sapling morphology and physiology, plant nutrition, plant nutrients, fertilization, coniferous tree species.*

Türkiye Orman Fidanlıklarında Yetiştirilen Kızılçam ve Sarıçam Türlerine Yönelik Gerçekleştirilen Besleme Faaliyetlerinin İncelenmesi

Öz

Ülkemizde gerçekleştirilen tarımsal faaliyetlerde, üretim maliyetini arttıran ana kalemlerden biride gübre ve gübreleme faaliyetleridir. Yapılan araştırma ve çalışmalarda özel ve kamu alanlarındaki üretimlerin büyük çoğunluğunun gelenekçi anlayışa bağlı, bilimsel yöntem ve metotlardan uzak olarak uygulandığı bilinmektedir. Bu da üretim periyodu boyunca hem maliyeti arttıran bir unsur olarak karşımıza çıkmakta hem de kaliteli ve istenilen miktarda üretim yapılamamasına neden olmaktadır. Bu çalışmada ki amaç, Türkiye Orman Fidanlık üretim tesislerinde üretilen iğne yapraklı fidanlara yönelik, üretim aşamasında gerçekleştirilen bitki besleme faaliyetleri ve gübre kullanımının hangi seviyede olduğunu anlamaya yöneliktir. Gübre hammadde anlamında tamamen dışa bağlı olduğumuz bir emtiadır. Her yıl bütçemizde milyonlarca dolar gübre tedariği için yurtdışına gitmektedir. Kendi öz kaynaklarımızın ön plana çıkarılarak besleme faaliyetlerinin gerçekleştirilmesi ve kullanılan gübre miktarlarının ihtiyaç olduğu kadar kullanılmasını sağlamak milli görevimiz ve temel hedefimiz olmalıdır. Çalışmanın amacı, aşırı gübre tüketiminin önüne geçmek ve bilimsel metotlarla bu faaliyetlerin yapılmasını sağlamak ve sonuçlarına ilişkin muhataplarına önerilerde bulunmaktır.

Anahtar kelimeler: *Fidan morfolojisi ve fizyolojisi, bitki besleme, bitki besin maddeleri, gübreleme, iğne yapraklı ağaç türleri.*

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1. Introduction

Since our country has 7 different geographical regions, it has made it necessary to act according to the microclimate structure and ecological conditions of these different regions during the plant production phase. This diversity in both soil and climate conditions of our geographical regions has caused the methods and methods in plant production to be applied in a unique way. The nutrient needs of different species in growing conditions and the amount of nutrients removed from the soil differ at the same rate, so these amounts are not known exactly. The lack of knowledge and experience in plant nutrients and plant nutrition can have a serious impact on the production, quality and results of the seedlings on which the study is based, and unconscious efforts can cause unnecessary labor and costs. Within the scope of cultivation, all inputs available in all kinds of activities, both commercial and non-commercial, are a whole and should be evaluated within the same framework. Whether it is the production of saplings for a stand to be established in an industrial sense, or in all kinds of activities carried out in a closed greenhouse environment to meet the need for vegetables, it is useful to evaluate the basic inputs as a whole. Because our main material is firstly the soil (growing medium) and secondly the requirements of the grown plant material. The stages and processes to be passed through in the process from the seed stage to the sapling are the same. The only difference here is that the variety you are dealing with has different ecological requirements according to its morphological structure.

The forest structure of our country and the diversity of species produced in nurseries have made it necessary to carry out studies on this subject with more accurate methods and methods. Therefore, the aim of this study is to determine the plant nutrition methods applied in forest nurseries, especially in the sapling production phase, to compare these activities with technical, economic, and scientific methods, and to prevent uniform nutrition methods in nurseries located in different geographical regions and to determine and recommend new nutrition methods (Leventoğlu, 2024).

Nurseries have continuously increased their numerical capacity since their establishment. Today, there are 84 Nursery Management Directorates and 102 Forest Nursery Chiefs under 28 Regional Directorates of Forestry under the General Directorate of Forestry (OGM, 2021). Forest nurseries continue to meet and produce seedlings and seeds demanded by the Ministry of Forestry and society. Sapling production programs are determined by the units to which they are affiliated, except for the nurseries.

The first establishment date of the State Forest Nursery Enterprises coincides with the first years of the Republican Period (Tolunay & Çavuşoğlu, 2015). With the Nursery Law No. 682 dated 14.02.1925, the first state forest nursery enterprise in accordance with scientific and technical principles was established in Ankara in 1925 by the order of Atatürk. In our country, the duty of forest tree seed production and sapling cultivation was assigned to the state forest nursery enterprises in accordance with the relevant legislation (Gül & Gül, 2023). Forest nurseries can be defined as "an open and/or closed piece of land used to grow the seedlings needed for a specific purpose, to be transferred and planted in other places later" (Yahyaoğlu, 1993; Anonim, 1996). There are two different types of state forest nurseries under the General Directorate of Forestry: permanent forest nurseries and temporary forest nurseries (Ürgenç, 1991).

State forest nurseries have an important place in the production of forest tree seedlings, so it is very important to determine the plant nutrition practices carried out in forest nurseries and to understand their compatibility with current practices. In addition to bare-root sapling production for afforestation, production was carried out with the classical covered sapling production technique in polyethylene tubes and bags in open field conditions until the 1990s. Grown in various types of containers through and its container to the afforestation or planting site brought and planted with soil (Ayan, 2007). State Forest Nurseries, on the one hand, produce the sapling material required for afforestation, and on the other hand, they enable the production of new information on species, origins, growing environment, etc. through various researches (Gültekin, 2005).The fact that the forest structure of our country and the diversity of species produced in nurseries are very high has made it necessary to carry out studies on this subject with more accurate methods and methods. Changing economic conditions, increasing demand for forest products and afforestation, the fact that afforestation is generally carried out on soils poor in plant nutrients and on rugged terrain due to the preference of fertile soils in cultivated agriculture have made modern nursery and tree growing obligatory (Brohi et al., 2012).

The production of quality, healthy, and cost-effective saplings is of great importance in the sapling production phase. It is not enough to produce saplings only in quantity but it should be the main objective to produce saplings in accordance with the standards in order to be successful both in afforestation works and in park gardens and landscaping (Kalıpsız, 1970). Tolay (1983), The success of saplings in afforestation studies is measured by sapling quality. This situation emerges as a result of the interaction of environmental conditions. Şimşek (1987). Quality sapling means a sapling that shows high retention success in afforestation studies, which shows very good development by maintaining its life actively during the period when growth is very fast and at the same time is in economic balance.

In the measurements carried out for the determination of morphological characteristics, sapling height, root collar diameter, stem/root fresh and dry weight ratio, sapling height/root collar diameter ratio, root percentage measurements were determined and data belonging to the analyzed sapling species were obtained.

Root development potential, plant water potential and plant water tension, mineral nutrient content, resistance to stress factors (uprooting, transportation, transplanting, cold, frost and drought etc.), bud dormancy (Ürgenç, 1986; Tolay, 1986; Ürgenç et al., 1991; Yahyaoğlu & Genç, 2007; Deligöz, 2007). The main element that forms the basis of plant nutrition is the delivery of plant nutrients to the plants by various means during the periods when the plants need them. If there is not enough nutrients in the soil to meet the needs of the plants grown in the soil, plant nutrients must be given to the soil through fertilization. If the soil is not fed, after a while the yield decreases due to the lack of nutrients. For this reason, the soil must be nourished in order to grow sufficient and high quality seedlings (Karaöz, 1992; Gezer & Gül, 2009).

The main purpose of this study is to understand the level of plant nutrition activities and fertilizer use during the production phase for coniferous seedlings produced in Turkish Forest Nursery production facilities

2. Material and Method

In order to determine the development and nutritional status of Red pine and Yellow pine seedlings produced in nurseries, evaluations were made on seedling samples. In the selection of the nurseries included in the study, attention was paid to the fact that the nurseries were located in the regions where Red pine and Yellow pine sapling cultivation is intensive and that the production capacity of these species produced in these nurseries was high in terms of production amounts.

2.1. Sampled Nurseries

Saplings were sampled from 12 forest nurseries geographically selected among the forest nurseries in our country, as shown in.

Figure 1. Distribution of the nurseries where seedlings were sampled in the geographical regions of Türkiye

2.2. Method

In order to make the saplings comparable in the study, 1+0 aged Red Pine and Yellow Pine saplings, which are the most produced species in our country, were preferred. Saplings were sampled as bare-rooted, tubed and enso-coated saplings. While determining these species and the nurseries where the samples were to be taken, it was paid attention to the species that are widely and abundantly produced throughout the country or in its region. For this, OGM Sapling Stocks database records for 2019 were used. Each species was sampled from 6 different nurseries.

2.2.1. Sapling sampling

Sapling samples of these 2 species, which are the most widely produced in forest nurseries, were taken and measurements and evaluations were made regarding their morphological and physiological characteristics.

a. Sapling morphological measurements: Some morphological measurements of the 1+0 year old coniferous saplings, which are the subject of the research, were started in 2019. Sampling was carried out in August-September when the needles reached full maturity at the end of summer. For each sapling type, 20 plant samples were taken from 3 different nurseries. Sampling of bare-root saplings was carried out by uprooting the saplings at a depth of at least 25 cm with the help of a worker using a waist shovel without damaging the roots. The uprooted saplings were wrapped in this to prevent moisture loss and transported to the laboratories for measurements. In the case of polyethylene tubes and enso-coated samples, 20 samples of each species were taken from the production pad and transported to the laboratory. In total, morphological measurements were carried out on 360 sapling samples of 2 species. The roots of the plant samples collected in the laboratories of Gübre Fabrikaları A.Ş. Samsun Regional Plant were first cleaned from soil and mortar materials in medium-pressure water. Root collar diameter measurements were taken with a digital caliper with a precision of 0.1 mm while the sapling samples were still fresh (Figure 2). The stem length of the plant was measured and noted. Leaves were then manually removed from the stem. After the morphological measurements, the seedling samples, which were divided into three parts as root, stem and leaf, were labeled and subjected to drying to determine their dry weights. They were dried in a drying cabinet at 65°C for about 48 hours until they reached constant weight (Yahyaoğlu & Genç, 2007).

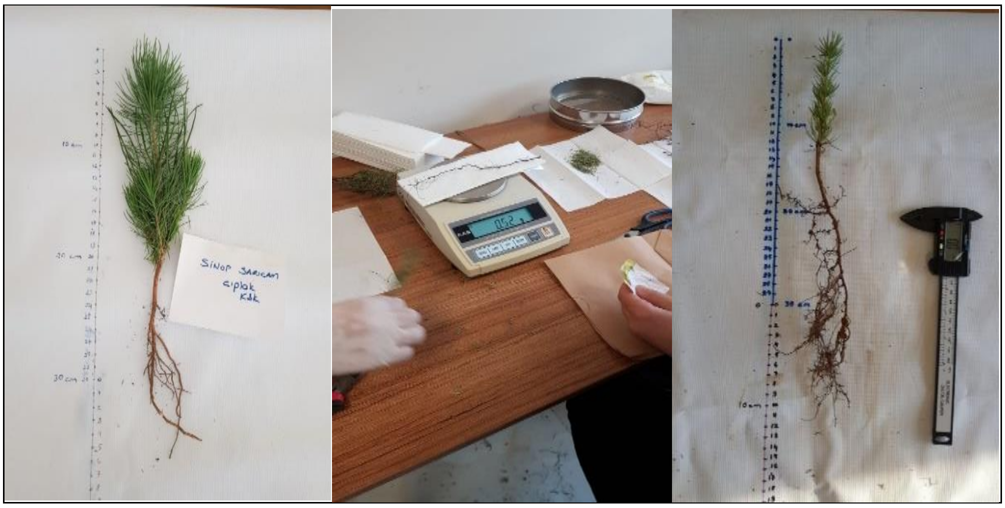

Figure 2. Morphology measurement procedures of seedlings to be analyzed before drying

Seedling height (SH), root collar diameter (CRD), stem dry weight (SDW), root dry weight (RDW), leaf dry weight (DWW) and whole seedling dry weight (FDW) were measured. Based on these measurements, the SDW/RDW ratio and LDW/SDW values were measured or calculated for each seedling separately and recorded. Abbreviated definitions of sapling morphological characteristics are as follows: (Dirik, 1994; Ürgenç et al., 1991; Semerci, 2002; Deligöz, 2007; Yahyaoğlu & Genç, 2007; Tüfekçi, 2007). Sapling Height (SL): Length between root collar and top bud (cm), Root Collar Diameter (CRD): Diameter measured at the point just above the root closest to the stem (mm),

Stem Dry Weight (SDW): Oven-dry (48 h at 65°C) weight (g) of the above-ground organs of the seedling,

Root Dry Weight (RWW): Oven-dried (48 h at 65°C) weight (g) of the root parts cut at the root collar diameter and separated from the stem,

Leaf Dry Weight (LDW): Oven dry (48 hours at 65°C) weight of the leaf (g).

Sapling Dry Weight (DWW): SDW + RDW + LDW , Stem/Root Ratio: SDW / RDW, Leaf Ratio LDW / SDW

b. Sapling nutrient analysis: After all morphological measurements were performed, root, stem and leaf samples were ground in a grinder, placed in plastic ziplock bags, labeled and sent to the laboratories of Eskişehir Forest Soil and Ecology Research Institute Directorate for chemical analysis. Plant nutrient analyses of root, stem and leaf organs of 20 seedlings of each species were performed. The proportional results obtained from the nutrient analyses were multiplied by the mass value of the relevant sapling organ and the nutrient content taken by the root, stem and leaf parts of each sapling was calculated. The nutrient content of these 3 organs was summed and the amount of nutrients taken from the soil by the whole sapling was calculated on an element basis. The plant analysis methods in Table 1 are as follows.

Table 1. Plant analysis methods

Abbreviation	Analysis Name	Analysis Method
N	Nitrogen	Kjeldahl Method
P	Phosphorus	Ammonium Meta Vanadate Yellow Color Method in P Spectrophotometer
K	Potassium	Flame Photometric Method
Ca	Calcium	AAS Method
Mg	Magnesium	AAS Method
S	Sulfur	Turbidimetric barium sulfate method

N determination: Kjeldahl Method (Kacar, 1972). The method is based on the principle that nitrogen in the form of organic compounds in the sample is converted into ammonium nitrogen by reduction by wet combustion with concentrated H2SO4 in the presence of a catalyst. After the nitrogen is converted into ammonium nitrogen, the ammonia released by distillation in a strong alkaline medium is kept in an acid and the amount is determined by titration.

P determination: Spectrometric vanadate molybdate phosphoric acid yellow color method (Kacar & Inal, 2008). The method is based on the principle of determination of the yellow color formed by the replacement of the oxygens of vanadate and molybdate with PO_4 by spectrophotometer at 430 nm.

K determination: Fleym photometer method (Kacar & Inal, 2008). Fleym Photometer is a mineral analysis method based on the measurement of the intensity of rays of a certain wavelength emitted from the flame of an element.

Determination of Ca and Mg: AAS method (Kacar & Inal, 2008). Atomic absorption spectroscopy is a technique used to determine the concentration of a metal element in a liquid solution. This technique is based on the principle of measuring the amount absorbed as a result of the transition from the ground state to the excited state by the absorption of light in the UV and visible region by free atoms.

S determination Turbidimetric barium sulfate method (Kacar, 1972). It is determined in Spectronic 20D colorimeter device. This is a method of determining the degree of turbidity of a solution by measuring the amount of light passing through the solution (the part of the light that does not undergo absorption and the part of the diffraction light) with a photometer and the concentration of the substance that forms the turbidity.

2.2.2. Data analysis and evaluation

Considering the data obtained from the measurement of the morphological characteristics of the seedlings, the analysis of variance technique was used to determine the differences between the seedlings with different packaging types using the SPSS package program. After the analysis of variance, Tukey test, one of the multiple comparison methods, was used to determine which species with different packaging types were different from each other at p<0.05 level of significance. Differences were indicated with Latin letters on averages (Kalıpsız, 1981; Özdamar, 2002, 2004).

3. Findings and Discussion

3.1. Coniferous Sapling Species Analysis Findings

3.1.1. Morphology results

In Table 2, which includes the average morphological data of red pine seedlings, the highest values in terms of diameter and height were 2.36 mm and 37.40 cm in enso-pot and bare root seedlings from Balıkesir and Dursunbey nurseries. In terms of root weight, the highest value was found in enso-covered seedlings with 2.09 g. When analyzed in terms of stem weight, it is seen that the red pine sapling obtained from Torbalı nursery and the enso-pot packaging type red pine sapling obtained from the same nursery have more weight than the other saplings with 1.69 g. In terms of leaf weight, the highest value was found in the red pine sapling obtained from Sındırgı nursery with 2.38 g.

Table 2. Average morphological data of red pine sapling species

Packaging	Nursery	Quantity	Diameter (mm)	Height (cm)	Root (g)	Stem (g)	Leaf (g)	Whole Plant	Stem/ Root	Leaf Ratio
Bare root	Dursunbey	20	2,04	37,40	1,76	1,50	1,81	5,07	0,85	0,36
Bare root	ceyhan	20	1,95	36,14	1,50	1,54	1,58	4,63	1,03	0,34
Bare root	Torbalı	20	1,94	35,21	1,46	1,37	1,42	4,25	0,94	0,33
Tube	Torbalı	20	1,82	30,21	1,73	1,69	1,47	4,88	0,98	0,30
Tube	Sındırgı	20	2,17	36,28	1,79	1,51	2,38	5,68	0,84	0,42
Tube	ceyhan	20	1,96	33,46	1,95	1,67	1,44	5,07	0,85	0,28
Enso-pot	Balıkesir	20	2,36	34,09	2,09	1,56	2,11	5,75	0,75	0,37
Enso-pot	Denizli	20	1,79	31,66	1,80	1,65	1,28	4,73	0,92	0,27
Enso-pot	Torbalı	20	1,82	33,23	1,73	1,69	1,47	4,88	0,98	0,30

In Table 3 shows the average morphological data of yellow pine seedlings, and the highest values in terms of diameter and height were 2.66 mm and 33.95 cm for enso-pot seedlings from Erzurum and Of nurseries. In terms of root weight, the weight of enso-pot seedlings was higher than bare root and tubular seedlings (1.57 g.-1.63 g.). In terms of stem weight, enso-pot type yellow pine sapling obtained from Of nursery and bare root packaging type yellow pine sapling obtained from Sarıkamış nursery were observed. The highest leaf weight value (2.32 g) was obtained from the enso-pot type yellow pine sapling obtained from Erzurum nursery.

Table 3. Average morphological data of yellow pine saplings

Packaging	Nursery	Quantity	Diameter (mm)	Height (cm)	Root (g)	Stem (g)	Leaf (g)	Whole Plant	Stem/ Root	Leaf Ratio
Bare root	A.madeni	20	1,07	17,40	1,50	1,09	1,50	4,09	0,73	0,37
Bare root	Erzurum	20	1,25	28,25	1,14	1,05	1,20	3,39	0,92	0,35
Bare root	Sinop	20	1,42	22,85	1,33	1,43	2,26	5,02	1,07	0,45
Bare root	Sarıkamış	20	1,20	18,55	1,31	1,49	1,38	4,17	1,14	0,33
Tube	A.madeni	20	1,01	22,45	1,13	1,02	1,07	3,22	0,90	0,33
Tube	Vezirköprü	20	1,88	32,85	1,12	1,14	2,08	4,34	1,02	0,48
Enso-pot	Of	20	2,45	33,95	1,57	1,57	1,73	4,88	1,00	0,35
Enso-pot	A.madeni	20	1,89	25,30	1,48	1,19	1,64	4,31	0,81	0,38
Enso-pot	Erzurum	20	2,66	31,65	1,63	1,44	2,32	5,39	0,88	0,43

In Table 4, where the Tukey test results of the species with different packaging types included in the study are presented, while the differences between the species without similar letters are different from each other, the differences between the species with similar letters are not statistically significant. When analyzed in terms of diameter, height, root and whole seedling, the differences between bare root, enso-pot and tubular packaging types were found to be statistically significant ($p<0.05$).

When examined in terms of stem, the differences between the bare root and tubular packaging types were not statistically significant ($p>0.05$), while the differences between the seedlings with these packaging types and the enso-coated seedlings were statistically significant ($p<0.05$).

When analyzed in terms of leaf organs, the differences between the seedlings with enso-pot and tube packaging types were not statistically significant ($p>0.05$), while the differences between the seedlings with these packaging types and bare-rooted seedlings were statistically significant ($p<0.05$).

Table 4. Tukey test results of seedling averages in different packaging types

Diameter					**Stem**				
Tukey HSD[a,b,c]					**Tukey HSD[a,b,c]**				
Packaging	Quantity	Subset			Packaging	Quantity	Subset		
		1	2	3			1	2	3
Bare root	140	1,55c			Bare root	140	1,35b		
Tube	100		1,78b		Tube	100	1,36b		
Enso-pot	120			2,16a	Enso-pot	120		1,51a	
Height					**Leaf**				
Tukey HSD[a,b,c]					**Tukey HSD[a,b,c]**				
Packaging	Quantity	Subset			Packaging	Quantity	Subset		
		1	2	3			1	2	3
Bare root	140	27,96c			Bare root	140	1,59b		
Tube	120		31,14b		Tube	100		1,70a	
Enso-pot	100			33,18a	Enso-pot	120		1,75a	
Root					**Whole plant**				
Tukey HSD[a,b,c]					**Tukey HSD[a,b,c]**				
Packaging	Quantity	Subset			Packaging	Quantity	Subset		
		1	2	3			1	2	3
Bare root	140	1,42c			Bare root	140	4,37c		
Tube	100		1,55b		Tube	100		4,62b	
Enso-pot	120			1,71a	Enso-pot	120			4,98a

3.1.2. Analysis findings

The amounts of plant nutrients in the leaves of the species in the study are given in Table 5. Yellow pine has the highest amount of N in its leaves. When analyzed in terms of P, it is seen that the Red pine species with Enso-coated packaging type has the highest amount taken by the leaves. In terms of K, the species with the highest amount of K is enso-coated Yellow pine with 16.18 g/1000 saplings. In terms of Mg element, the highest amount was taken by the leaves of bare-rooted Red pine with 4.59 g/1000 saplings. In terms of Ca, although Ca element was taken by the leaves of both species in the study at similar levels, especially bare-rooted Red pine was differentiated with 18,29 g/1000 saplings compared to other packaging types and species. The highest uptake of sulfur by the leaves of the species was observed in Red pine with tubular packaging type (2.52 g/1000 seedlings)

Table 5. Average amounts of plant nutrients in the leaves of different species (g/1000 saplings)

Packaging	Sapling	Organ	N	P	K	Mg	Ca	Sulphur
Bare root	Red pine	Leaf	20,99	2,72	9,31	4,59	18,29	2,25
Tube	Red pine	Leaf	23,59	3,71	10,20	3,70	9,82	2,52
Enso-pot	Red pine	Leaf	25,71	4,26	10,44	3,99	19,20	1,77
Bare root	Yellow pine	Leaf	27,58	2,85	8,70	2,59	15,06	1,90
Tube	Yellow pine	Leaf	27,45	2,84	9,55	2,41	10,48	1,45
Enso-pot	Yellow pine	Leaf	27,69	3,78	16,18	2,06	12,72	2,21

Based on the average values of the species, the amounts of plant nutrients in their stems are given in Table 6. The species with the highest amount of N in their stems are enso-covered Yellow pine and Red pine with the same packaging type, respectively. In terms of P, the highest amounts were taken up by the leaves of enso-coated Scots pine and Red pine species. In terms of K, the highest K uptake was 9.16 g/1000 seedlings of scuba Red pine and 9.08 g/1000 seedlings of Yellow pine with enso-pot packaging type. The species with the highest amount of magnesium in the stem organ was bare-rooted Red pine with 3.06 g/1000 saplings, while the species with the highest amount of Ca and S in the stem organ was Red pine with bare root packaging type.

Table 6. Average amounts of plant nutrients in the stems of different species (g/1000 seedlings)

Packaging	Sapling	Organ	N	P	K	Mg	Ca	Sulphur
Bare root	Red pine	stem	10,45	1,76	7,60	3,06	27,47	3,14
Tube	Red pine	stem	12,69	2,54	9,16	2,54	12,49	1,14
Enso-pot	Red pine	stem	13,97	2,68	8,87	2,52	19,74	1,25
Bare root	Yellow pine	stem	11,47	1,69	5,05	2,55	12,32	1,60
Tube	Yellow pine	stem	13,54	1,65	5,91	1,87	5,77	0,84
Enso-pot	Yellow pine	stem	15,56	3,22	9,08	1,59	4,54	2,33

Based on the average values of the species, the amounts of plant nutrients in the roots are given in Table 7. The species with the highest amount of N in the root organ are Yellow pine and Red pine with enso-pot packaging type, respectively. In terms of P, the highest amount of P was taken up by the roots of the species with the same packaging type. In terms of K, the species with the highest K uptake were Red pine with scuba packaging type with 10.26 g/1000 seedlings and the same species with enso-coated packaging type with 9.64 g/1000 seedlings. The species with the highest amount of magnesium element in the root organ (5.20 g/1000 saplings) was bare-rooted Red pine, while the species with the highest amount of Ca element in the root organ was bare-rooted Red pine. When the similar situation was examined in terms of S element, it was determined that the species with the highest amount of S element in the roots was bare-rooted Red pine with 7.52 g/1000 saplings.

Table 7. Average amounts of plant nutrients in the roots of different species (g/1000 saplings)

Packaging	Sapling	Organ	N	P	K	Mg	Ca	Sulphur
Bare root	Red pine	root	9,02	1,79	6,87	5,20	31,77	7,52
Tube	Red pine	root	12,70	3,11	10,26	4,87	16,18	1,20
Enso-pot	Red pine	root	14,78	3,26	9,64	4,78	27,36	1,69
Bare root	Yellow pine	root	12,09	1,87	5,18	2,63	12,34	2,00
Tube	Yellow pine	root	14,48	1,59	5,63	1,74	6,15	1,06
Enso-pot	Yellow pine	root	18,26	3,93	8,26	1,68	5,57	2,28

3.1.3. Nutrient element ratios in leaves

The nutrient concentration ratios in the leaves of coniferous species are given in Table 8.

Table 8. Nutrient concentration ratios in the leaves of coniferous species average

Nursery	Packaging	Species	Organ	N(%)	P(%)	K(%)	Mg(%)	Ca(%)	Sulphur(%)
Dursunbey	Bare root	Red pine	leaf	100	16	51	12	41	11
Ceyhan	Bare root	Red pine	leaf	100	10	42	31	147	6
Torbalı	Bare root	Red pine	leaf	100	12	39	25	91	14
Torbalı	Tube	Red pine	leaf	100	17	61	16	54	12
Sındırgı	Tube	Red pine	leaf	100	14	36	7	27	7
Ceyhan	Tube	Red pine	leaf	100	16	30	30	49	15
Balıkesir	Enso-pot	Red pine	leaf	100	14	41	11	37	9
Denizli	Enso-pot	Red pine	leaf	100	17	41	14	78	6
Torbalı	Enso-pot	Red pine	leaf	100	20	41	24	118	6
Akdağmadeni	Bare root	Yellow pine	leaf	100	9	27	5	64	10
Erzurum	Bare root	Yellow pine	leaf	100	10	33	15	40	7
Sinop	Bare root	Yellow pine	leaf	100	11	36	14	55	5
Sarıkamış	Bare root	Yellow pine	leaf	100	11	32	7	52	6
Akdağmadeni	Tube	Yellow pine	leaf	100	13	47	10	50	6
Vezirköprü	Tube	Yellow pine	leaf	100	8	23	8	27	5
of	Enso-pot	Yellow pine	leaf	100	13	46	6	45	6
Akdağmadeni	Enso-pot	Yellow pine	leaf	100	17	100	7	52	7
Erzurum	Enso-pot	Yellow pine	leaf	100	12	41	9	43	10

The values in the table are elemental ratios calculated based on 100 units of N. Across all nurseries and species, leaves contain 8-20 units of P, 23-100 units of K, 5-31 units of Mg, 27-147 units of Ca and 5-15 units of S for 100 units of N. When species averages are taken, it is seen that there are 10-17 units P, 32-58 units K, 7-22 units Mg, 38-87 units Ca and 5-11 units S for 100 units N (Table 9).

Table 9. Proportional distribution of nutrient concentrations in leaves of coniferous species (for 100 units of nitrogen)

Species	Packaging	Organ	Nursery	N(%)	P(%)	K(%)	Mg(%)	Ca(%)	Sulphur(%)
Red pine	Bare root	leaf	average	100	13	44	22	87	11
Red pine	Tube	leaf	average	100	16	43	16	42	11
Red pine	Enso-pot	leaf	average	100	17	41	16	75	7
Yellow pine	Bare root	leaf	average	100	10	32	9	55	7
Yellow pine	Tube	leaf	average	100	10	35	9	38	5
Yellow pine	Enso-pot	leaf	average	100	14	58	7	46	8

3.1.4. Discussion

Although it is stated that the results of soil analysis are effective on fertilization programs, it has been observed that fertilization is made with the traditional understanding that has been going on for years rather than the results of the analysis. Reich et al. (1997) proved that "the amount of available nitrogen (N) in the soil is a very important limiting factor in the growth of forest trees". Sayman et al. (2002) determined that 28.93 g nitrogen (N); 44.18 g phosphorus (P2O5); 51.18 g potassium (K2O) per unit area (315 seedlings/m2) would be sufficient for fertilization in the cultivation of scuba red pine seedlings under the same conditions, considering economic factors. Ayan (1998), in a study carried out in Yellow Pine (*Pinus silvestris L.*), it was concluded that the seedlings produced in systems with slow-acting fertilizer additives showed sufficient growth only in terms of height in terms of compliance with TSE standards, but not in terms of crotch diameter. Fertilization needs will also vary according to the type of seedlings produced (broadleaf or coniferous) and the type (bare-root or tubed/closed). Leaf analysis as well as soil analysis is necessary to determine these needs (Landis et al., 2005).

4. Conclusion and Suggestions

Afforestation activities are significant investments for the development of our forests. Our nurseries, which provide the most critical input of these investments, must be developed and made functional at scientific and technical levels. Considering the amount of fertilizer used by the nurseries in the nursery production phase, it is seen that especially nitrogen fertilizers are used in excessive amounts. It is understood that the soil analysis results of the related nurseries and the fertilizer types and dosages used do not scientifically coincide with each other. Fertilizers that accumulate in the soil due to excessive use create residues in the environment and increase costs.

In particular, more organic-based fertilizers should be preferred than inorganic fertilizers. The adverse effects of chemical fertilizers containing excessive salt on both physical and chemical structure are seen from the nursery analysis results. The types of fertilizers preferred by nurseries generally consist of generic products. Using new generation fertilizers, slow-release, organomineral, multi-component water-soluble composites should be encouraged and product trial areas should be established in pilot regions.

Variables such as different seedling densities, irrigation, fertilization types, and dosages applied by nurseries directly affect the quality of the seedlings produced. Large saplings eventually take much more nutrients from the soil, while small saplings take much less. Therefore, instead of standard fertilization, it would be appropriate for each nursery to apply different feeding programs depending on the species produced and the quality characteristics targeted in each species.

The values in the study will at least partially inform the implementing producers about how much fertilizer should be applied in the cultivation of Red pine and Yellow pine sapling species. By relating the nutrient values removed from the soil by a certain number of saplings in the study to the number of saplings per unit area, it can be estimated how much nutrients the saplings receive on an area basis and how much nutrients should be replaced after uprooting.

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Author Contribution and Conflict of Interest Declaration Information

The author declares that there is no conflict of interest in the article.

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Self-Identification Phenomenon in A Temporary Shelter Unit After A Disaster: AFAD Containers

Betül İrem TARAKÇI [1*], İsmail Emre KAVUT [2]

ORCID 1: 000-0003-2381-6873
ORCID 2: 000-0003-2672-4122
[1] *İskenderun Technical University, Faculty of Architecture, Department of Interior Architecture, 31200, Hatay, Türkiye.*
[2] *Mimar Sinan Fine Arts University, Faculty of Architecture, Department of Interior Architecture, 34000, İstanbul, Türkiye.*
***** ***e-mail**: : betul.temiz@iste.edu.tr*

Abstract

Container homes used to meet the shelter needs of disaster victims in the post-disaster period are often foreign environments, which can create psychological challenges. The process of individuals adapting to a space begins with personalization. This study examines the physical and psychosocial needs of disaster victims through the 'phenomenon of personalization.' Implementing different forms of personalization to overcome alienation from the space can facilitate the acceptance process by making the environment familiar. The research addresses the personalization processes of disaster victims in containers and their user requirements, collecting data through observations and semi-structured interviews in the AFAD container city in İskenderun. As a result, the personalization that disaster victims engage in within the container contributes to psychological, social, and physical recovery processes. Therefore, it is essential that post-disaster shelter spaces are designed to allow for personalization and adopt a user-centered approach.

Keywords: *Self-identification, phenomenon of self-identification, disaster, temporary shelter, AFAD containers.*

Afet Sonrası Geçici Barınma Biriminde Kendileme Olgusu: AFAD Konteynerları

Öz

Afet sonrası dönemde afetzedelerin barınma ihtiyacını karşılamak için kullanılan konteyner evler, genellikle yabancı mekanlardır ve bu durum psikolojik zorluklar yaratmaktadır. İnsanların bir mekâna alışması, kendileme süreciyle başlar. Bu çalışma, afetzedelerin fiziksel ve psiko-sosyal gereksinimlerini 'kendileme olgusu' üzerinden incelemektedir. Mekâna yabancılaşmayı aşmak için farklı kendileme biçimlerinin uygulanması, mekanın tanıdık hale gelmesini sağlayarak kabullenme sürecini hızlandırabilir. Araştırma, afetzedelerin konteynerde kendileme süreçlerini ve kullanıcı gereksinimlerini ele almakta; İskenderun'daki AFAD konteyner kenti üzerinde gözlem ve yarı yapılandırılmış görüşmelerle veri toplamaktadır. Sonuç olarak, afetzedelerin konteynerde yaptığı kendileme, psikolojik, sosyal ve fiziksel iyileşme süreçlerine katkı sağlamaktadır. Bu nedenle, afet sonrası barınma mekânlarının, kendilemeye olanak tanıyacak şekilde tasarlanması ve kullanıcı odaklı bir yaklaşım benimsenmesi önemlidir.

Anahtar kelimeler: *Kendileme, kendileme olgusu, afet, geçici barınma, afad konteynerları.*

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1. Introduction

Disasters deeply affect people's living spaces and daily practices. Especially earthquakes force individuals away from their homes and direct them to temporary shelter areas. In this process, disaster victims must adapt to new and limited environments. Container homes, which are frequently used to meet the urgent shelter needs of disaster victims in the post-disaster period, are often unfamiliar and unusual for them. Regardless of the reasons, being away from their homes and surroundings and adapting to a new place is psychologically challenging for them. The behaviors and actions exhibited by disaster victims in temporary shelter units reflect their relationship with that space. Disaster victims reshape container-type temporary shelters through their bodily experiences, sensory perceptions, and cognitive interpretations, transforming these limited spaces into livable and familiar areas. This process is explained by the concept of "self-identification." "Self-identification" is a process in which disaster victims play an active role as subjects, and spatial transformation occurs over time. The process of adapting to a space begins when individuals feel a sense of belonging to that space. The most effective way to feel a sense of belonging is through the process of self-identification. Disaster victims adapt container-type temporary shelters to their living spaces through their daily practices, routines, and personal belongings. In this way, unfamiliar and limited spaces become familiar and livable areas. Actions such as creating a kitchen corner, displaying personal belongings, and hanging photographs make the space feel like their own. Additionally, social practices such as developing neighborhood relationships and using common areas make temporary shelter spaces more livable. This study discusses how disaster victims make sense of and transform spaces through their physical and psycho-social needs, daily movements, actions, and perceptions, focusing on the phenomenon of self-identification. Evaluating the self-identification process in terms of its potential to create more familiar and adopted, livable areas to overcome alienation from the space and the psychological difficulty of adaptation forms the main argument of this study. In this context, applying different forms of self-identification to address physical and psycho-social user requirements in the space has been hypothesized to facilitate the transformation of the space into a more familiar environment, speeding up the process of acceptance and creating more long-term livable areas. There has not been sufficient attention in the literature to the investigation of the reasons behind the interventions made by disaster victims in their self-identification processes. Therefore, this research is important as a descriptive study to highlight the significance of self-identification in space, identify the forms and methods of self-identification, and determine how user requirements affect self-identification and housing formation. The aim of the research is to evaluate the relationship between self-identification forms and interventions and user requirements beyond merely examining the adaptation to space in the self-identification process of disaster victims. The topic is limited to studies addressing the phenomenon of self-identification in space, its forms, interventions, and user requirements in container-type temporary shelter units following disasters. The structure of the study consists of three phases. In the first phase, publications related to the topic were reviewed to establish a conceptual framework. In the second phase, field research was conducted to provide data for the study. In the final phase, information about the selected area was presented, and identity cards were created to make the examination clearer and more readable. Additionally, this phase explains how to read the identity cards. At this point, the theoretical framework established through the literature review will be explained.

1.1. Conceptual Framework

In the thesis database of the Higher Education Council (YÖK), The DergiPark Academic Database, The Architecture Web Database, Google Academic Turkey, Google Scholar, Scopus, and ScienceDirect Databases, the keywords "self-identification of space, user requirements, forms of self-identification, post-disaster shelter, container and self-identification, temporary shelter and self-identification, user interventions" were searched. As a result of the research, publications within the scope of the topic were examined to establish a conceptual framework.

1.1.1. The phenomenon of self-identification

People develop various forms of interaction with time and space. One of these forms of interaction is a phenomenon expressed in Turkish as "kendileme," which corresponds to the concept of "appropriation" in English (Bilgin, 1990). The self-identification process refers to people's behaviors of claiming and personalizing spaces. In this process, no one positions a space merely as a signifier. On the contrary, people organize, arrange, and differentiate the spaces they feel belong to them compared to other spaces or the environment. This phenomenon is generally referred to by the concept of self-identification (appropriation) (Bilgin, 1990). Self-identification can be seen as an indicator of authority or control that emerges from the transformation of a place or space (Bilgin, 1997). An individual organizes and differentiates a space that they consider their own dialectically in relation to others' spaces and/or the environment. At this point, the phenomenon of self-identification refers to "the act or process of a person perceiving something as belonging to themselves or making it their own" (Graumann, 1976). In other words, self-identification can be viewed as the entirety of efforts to make something foreign, uncontrollable, and unowned familiar, known, and meaningful (Karasu, 2021). The definition of the self-identification concept has varied before and after the 20th century: In earlier periods, self-identification behavior was defined as "truly owning" a place through actions such as defending and protecting it (Altman and Zube, 1989; Aubert-Gamet, 1997; Kärrholm, 2007; Mehta, 2013). However, starting from the 20th century, researchers began to redefine self-identification as "symbolic ownership" through the short or long-term alteration and transformation of space by people (Mehta, 2013). The concept of self-identification (from the Latin appropriare, "to make one's own") is a concept developed in Marxist thought (Marx, 1893/1994). Karl Marx (1818-1883) borrowed this concept from G. W. Friedrich Hegel (1770-1831) (Esteban-Guitart, 2014). In this context, self-identification has been developed as a Hegelian and Marxist concept to understand the dialectical nature of human-environment interaction, that is, how people change by altering their environments (Graumann, 2002). The concept of self-identification is a rich concept used in various fields by prominent thinkers and researchers from philosophy (e.g., Karl Marx) to literature (e.g., Mikhail Mikhailovich Bakhtin), from psychology (e.g., Carl Graumann, Lev Vygotsky) to environmental psychology (e.g., Perla Korosec-Serfaty, Enric Pol). According to Graumann (1976), self-identification can be defined as "the act or process of a person perceiving something as belonging to themselves or making it their own." The process of self-identifying with space can be argued to arise from the need to experience one's existence and the uniqueness of one's self by emphasizing the difference between "self" and "other" (Göregenli, 2021). Here, a person's existence in this world is considered to be embedded in their place in space, in other words, their spatiality (Korosec-Serfaty, 1985). According to Marx, people reproduce themselves by affecting and even transforming their environments and the world through the objects they produce or design, thus renewing and developing their potentials. When people cannot claim the products they produce or design as their own, experiences of alienation may arise (Marx, 2013). Self-identification is one of the ways individuals can overcome the experience of alienation (Graumann, 1976) and exist as themselves. The behavior of self-identification has a significant impact on the transformation and change of communication among individuals (Henk de Haan, 2005). Feldman and Stall (2004) also emphasized that self-identification behavior is an interactive process that changes both the physical environment and group-individual relationships. In this respect, self-identification can be considered an individual, social, and spatial need (Lara-Hernandez, 2020). The relationship between self-identification and space was established in the 1970s. The concept of self-identification has been examined in many theoretical and empirical studies (Brunson et al., 2001; Korosec-Serfaty, 1976) regarding an object or space. The concept of self-identifying with space has been explained in various ways. For example, the Space Self-Identification Scale developed by Morval & Judge (2000) and validated for its French version by Rioux (2004) consists of three sub-dimensions: Knowledge of the environment (French: connaissance de l'environnement), free circulation (French: libre circulation), and stimulation of the environment (French: stimulation de l'environnement). Similarly, Brunson and colleagues (2001) approached self-identification in space as physical (being physically present in the space), social (conversing with people in the space, etc.), and regional self-identification (behaviors indicating ownership, control, etc., in the space). In summary, the concept of self-identifying with space can be conceptualized in different ways according to the aims and scope of the research (Karasu, 2021). Some studies address self-identification with space in terms of cognitive, behavioral, and social dimensions, while others examine it through more specific indicators. This diversity reflects the multifaceted nature of the phenomenon of self-identification with space. Lefebvre (1995) described the self-identification of space as a transformed natural space where needs are met and regarded it as the most essential condition for reaching a sense of belonging. At this point, self-identification with space can be defined, in its simplest terms, as the psychological process of making a space (space) one's own and transforming it into a place (place) (Graumann 1976; Rioux et al., 2017). Through self-identification behavior, people create "places" (place) that belong to them by making changes within the "space" (space) according to their needs, whether short-term or long-term (Mehta, 2013). The most significant difference between space and place lies in the relationship people establish with that space (Cresswell, 2004; Özkan, 2017). At this stage, a unique bond is formed between the individual and the space. This bond is reciprocal: on one hand, the individual undergoes change and transformation while producing new experiences and meanings related to that space; on the other hand, through ownership, different aspects of that space (for example, the emergence of new areas through new activities in the space) can arise, leading to changes and transformations in the space itself (Modh, 1998). Self-identification behavior is a structure that emerges as a result of this relationship with the environment and has a significant impact on the transformation of space into "place." Kärrholm (2005) also noted that, along with self-identification behavior, the same spaces can transform into "places" that allow for different uses at different times or even simultaneously. The self-identification of space is one of the ways a space can be transformed into a personal place (Benages-Albert et al., 2015; Rioux et al., 2017). This process requires acceptance and willingness towards the space to be owned (Göregenli, 2021). With the transformation of space into "place," that space ceases to be a limited void and becomes meaningful, lively places where needs are met (Tuan, 1977; Kyle, 2009; Cilliers et al., 2015). In other words, the relationship people establish with that space and their self-identification behaviors transform spaces into meaning-laden "places."

As a result, self-identification behavior is a process that emerges from the relationships people have with their environment and plays a crucial role in the transformation of spaces into "places." Pol (2002) indicated that self-identifying with space enhances the sense of responsibility over it, thereby strengthening belonging and attachment to place. At this point, it can be said that self-identification behavior serves two important purposes. The first is that it contributes to the transformation of space into "place," facilitating high levels of usage and diversity of activities in that space (Fischer, 1981; Bonnes & Secchiaroli, 1995; Aubert-Gamet, 1997; Bonnin, 2006; Mehta 2013). The second is that it allows for the establishment of strong social interactions by increasing the diversity of relationships among people (Moser et al., 2002; Feldman and Stall 2004; Henk de Haan, 2005; Noorian, 2009; Mehta 2013). The process of self-identifying with space corresponds to the entirety of processes where individuals claim ownership of space, actively use it, produce meaning within it, and attach themselves to it (Rioux et al., 2017). In this context, self-identifying with space can have implications for daily life. For example, it can be expected that a person who self-identifies with a particular space may give it more importance and consequently exhibit more positive behaviors towards its preservation or development (Benages-Albert et al., 2015; Moser et al., 2002).

Wineman & Peponis (2010), in their study on how architecture is experienced and understood by users, addressed the concept of "self-identification" in the context of spatial experience; Seamon (1980) defines the process of "self-identifying with space" as the way people make sense of their environments through their subjective experiences, movements, and actions. Dovey (1985) describes the concept of "self-identification" in the context of "spatial practices," where people shape spaces with their daily experiences, habits, and actions, endowing them with their own subjective meanings. According to these approaches, users "self-identify" their spaces in unique ways through their perceptual, cognitive, bodily, and daily experiences. This process plays a significant role in the formation of the identity of space. Self-identifying with space can manifest in two types of relational forms: rootedness and wandering (Vidal et al., 2010). Rootedness indicates a deep and intrinsic connection between a person and a space, identifying that space with oneself and its history (Tuan, 1977); wandering refers to a more transient and fragmented relationship with spaces, indicating an experience focused on "here and now." Additionally, ownership is not a necessary condition for the self-identification process to occur (Graumann, 1976; Bilgin, 1991; Göregenli, 2021; Bilgin, 2011). Complete ownership rights over cities, streets, or common spaces cannot be claimed. However, people can add personal touches to such spaces, incorporating elements of themselves and feeling a sense of belonging to those spaces. Even in the absence of formal ownership, individuals can feel attached to those spaces, use them according to their needs, transform them, and personalize them. In the self-identification process, full ownership is not required. What is essential is that individuals develop a sense of ownership and belonging towards those spaces.

1.1.2. Forms of self-identification

The process of people becoming accustomed to a space begins with feeling a sense of belonging to that space. The most effective way to feel a sense of belonging to a space is through the process of self-identification. If spaces lack the characteristics suitable for self-identification, disaster survivors struggling to adapt to the space gradually become alienated and cannot feel that they belong there. Şahiner Tufan (2019) explains that self-identification occurs in two different ways (Table 1). The first is spatial self-identification, which can be organized in various ways, and the second is elemental self-identification, which involves the elements of the space.

Table 1. Classification of Self-Identification Forms (Şahiner Tufan, 2019)

Forms of Self-Identification	Spatial Self-Identification	Organization of the space
		Space Surface
	Surface Self-Identification	Furniture
		Electrical Equipment
		Accessory (Daily/Functional)
		Accessory (Visual/Ornament)

Space organization refers to the situation where an event takes place in a location organized according to the individual's purpose (Gür, 1996). The surface of the space, which determines its identity and is the first point of contact for the user, is crucial. According to Brooker and Stone (2011), a well-executed surface or a well-chosen material adds meaning to the space and establishes a relationship with the user. The surfaces of a space consist of three sections: walls, floors, and ceilings. Özdemir (1994) uses the term "element" for the furnishings and items within the space, noting that they can carry symbolic or meaningful values. In this context, furniture, electrical appliances, visual/decorative items, and daily/functional accessories belonging to the user are defined as "elemental self-identification." The most significant factor and component in the formation of space identity is the behavior of self-identification. Self-identification is the clearest and simplest expression of the dialogue between the individual and the space. People change their spaces to distinguish themselves from others (Twigger & Uzzell, 1996). This behavior stems from the need to control one's living area, the desire to reflect aesthetic preferences, and the wish to align activity patterns with the space (Wells, 2000). With self-identification, which also brings a sense of responsibility, the individual adopts, protects, cares for, and loves the space. According to Bilgin (1997), interventions that are primarily involved in self-identification include organizing the space by placing items, controlling the opening and closing of the space, and removing certain elements of the space.

1.1.3. Self-identification and user interventıons in the post-disaster sheltering process

Every year, millions of people around the world face various natural disasters due to the geographical locations of the cities they live in, resulting in loss of life and property. This situation constitutes a significant risk factor in terms of the frequency and impact of disasters (Ertaş Beşir and Dereci, 2021) .Unexpected disasters that occur suddenly and leave people homeless bring about a significant issue: the problem of sheltering. In this extraordinary situation, temporary housing solutions are provided. One of these solutions, containers, becomes the new homes for disaster survivors. Adapting to this process and embracing their new homes requires time. During this process, individuals communicate with the space. In the post-disaster period, temporary housing solutions frequently used to meet the urgent shelter needs of disaster survivors are often unfamiliar and unusual spaces for them. However, disaster survivors tend to reshape these spaces according to their needs, habits, and experiences. This process is referred to as "self-identification."

To understand why disaster survivors feel the need to self-identify with temporary housing areas, it is essential to consider their experiences and psychological states after the disaster. Disasters are traumatic experiences for survivors and deeply affect their daily routines, habits, and social relationships. After a disaster, survivors feel cut off from their familiar environments, homes, and daily living spaces. This situation creates feelings of insecurity, alienation, and loss of control. At this point, disaster survivors feel the need to reshape temporary housing areas according to their needs, habits, and experiences, creating familiar and livable spaces. Through the self-identification process, temporary housing areas not only serve the physical function of shelter but also transform into livable, familiar spaces. Through their bodies, senses, and minds, disaster survivors organize their living spaces based on the relationships they establish with their environments.According to Turgut (2014), disaster survivors reshape temporary housing units like containers and tents according to their needs, habits, and experiences. In this process, the bodies, senses, and minds of disaster survivors transform temporary housing areas into livable spaces. This process reduces feelings of insecurity, alienation, and loss of control experienced by survivors in the post-disaster period, providing them with a sense of belonging and security. Ayataç & Güney (2016) state that disaster survivors transform their temporary shelters by understanding them through their sensory, bodily, and cognitive experiences. Thus, through the self-identification process, disaster survivors create their living spaces. Çavdar and Çabuk (2016) emphasize that disaster survivors make sense of and transform tent spaces through their daily actions, habits, and experiences. Movements within the confined space of the container increase survivors' awareness, contributing to the expansion and transformation of spatial boundaries (Doan & Yamazaki, 2020). Disaster survivors interpret and transform container spaces through their sensory, bodily, and cognitive experiences. For example, a family may rearrange the interior layout of the container according to their daily life rituals. They can adapt the kitchen area to their cooking habits and reorganize the sitting area to accommodate family members (Turgut, 2014). Similarly, disaster survivors can personalize the space by hanging family photos or their children's drawings on the walls of the container (Çavdar & Çabuk, 2016). In this way, the container transforms from an extraordinary and foreign space into a familiar and livable area through the sensory, bodily, and cognitive experiences of disaster survivors. Additionally, disaster survivors also self-identify with these spaces by carrying out their daily routines, habits, and social interactions within the container. For instance, small gardens set up in front of the containers meet the survivors' need to connect with the outdoors while also reflecting their relationship with the environment. Similarly, common areas created within the container spaces support social interactions and solidarity among disaster survivors (Çavdar & Çabuk, 2016). While self-identifying within the container, users can utilize intervention methods similar to those used in standard housing, depending on social change (Perker & Akıncıtürk, 2011). The first of these methods is the addition method. This is an important type of intervention at the level of building materials, components, or systems. It can be spatially and volumetrically significant. In traditional housing, the areas where the most additions are made include wet areas, rooms, entrances, etc. These areas can be added outside the structure or individually within the space (Perker & Akıncıtürk, 2011). In this study, all interventions made at the scale of the space (including or creating new areas) and at the scale of space elements (furniture, accessories, electrical appliances, etc.) are considered "addition." The second method is cancellation/modification. This involves changes or cancellations made to space elements, components (doors, windows, etc.), or areas according to user needs. In some examples, the removal of walls and the expansion of spaces can be cited (Perker & Akıncıtürk, 2011). Thirdly, the transformation method can be considered as adapting according to usage situations. Fourthly, expansion can be viewed from two aspects: interventions made due to insufficient space for requirements (expanding rooms, enlarging the facade, etc.) and transformations in the size of existing elements. The final method is the division intervention, which involves dividing the existing area horizontally or vertically according to needs. The additions, cancellations/modifications, transformations, expansions, and divisions made in this study are referred to as "user interventions."

In this study, to understand the forms of self-identification carried out through the interventions of people living in containers, it is essential to explain what the self-identification needs of users might be.

1.1.4. User requirements and their classification

Need can be defined as the requirement for something. User needs are the environmental conditions that help users maintain their lives comfortably within a space from social, psychological, and physiological perspectives and assist them in being efficient in their tasks (Atasoy, 1973; Günal, 2006). Built environments must adapt to the constantly changing needs of their users. If built environments remain limited in the face of people's dynamic and changing requirements, it can reduce the user's comfort level, disrupt the use of the structure, and lead to abandonment. The relationship between humans and the built environment can be understood through the behaviors and actions exhibited by people in that environment (Alsibaai & Özcan, 2022). In this context, at the core of needs are people and their changing desires. The concepts of need and desire are often confused (Günal, 2006). However, while need refers to the conditions necessary for individuals to effectively carry out their actions within society, desire is a more subjective and variable concept (Atasoy, 1973). The characteristics expected from a space by individuals are a result of user needs. These needs represent the minimum qualities and conditions that the physical environment must possess for space users to perform their actions. Maslow (1943) addressed the basic needs of people in a social context in a hierarchical order. These needs include physiological, safety, belonging, esteem-prestige, self-actualization, intellectual, sensory, and aesthetic satisfaction needs (Günal, 2006). User needs are defined as all environmental and social conditions that enable people to live without discomfort from physiological, social, and psychological perspectives and to be efficient in their work. Researchers have classified user needs in various ways. According to Bayazıt (1982), there are technical, environmental, and human needs; while Buğday (1991), Gül (1993), and Dönmez and colleagues (2015) categorize them as physical and psycho-social needs (Korur et al., 2006). Physical user needs involve providing the necessary physical conditions for users to carry out their actions comfortably and efficiently (Armağan, 1997). These needs can be addressed under the following categories: spatial, health, physical environment conditions, and safety needs (Buğday, 1991; Gül, 1993; Korur, 2006; Dönmez et al., 2015). Spatial Needs: These are the provisions of adequate space, equipment, and furnishings in the environments where users operate. Spatial user needs are the characteristics that the space must possess for users to perform their actions comfortably, effectively, and efficiently. These needs include dimensions and proportions, color, and lighting elements (Buğday, 1991). Dimensions and Proportions: These refer to the sizes of spaces that meet the user's dimensional needs and provide psychological comfort (Ateş, 1988). Color and Lighting: The lighting level and color characteristics of the space are determined by factors such as the number of users, age, and cultural differences. When the user's dimensional needs are met, they can experience comfort in terms of space dimensions. Lighting and color characteristics also play a significant role in the perception of the space. In conclusion, spatial user needs encompass the physical and visual characteristics that the space must possess for users to carry out their actions comfortably and efficiently. Health Needs: These include meeting users' health and hygiene requirements and providing appropriate temperature, light, and ventilation conditions. The environment must have qualities that do not harm user health, such as the provision of clean water, drainage of wastewater, and disposal of waste and other refuse (Korur, 2006). Physical Environment Conditions: These refer to the absence of negative effects from physical environmental factors such as climate, noise, and pollution on users. They encompass the necessary temperature, humidity, visual, and auditory conditions for users to maintain a comfortable life within the space (Korur, 2006). Particularly in buildings located in cold climate regions, inadequate thermal insulation may lead to unsuitable temperature and humidity levels for user comfort. This situation can cause visual and health issues, such as mold on wall surfaces. Safety Needs: These involve ensuring the safety of users regarding life and property and taking precautions against potential dangers. This includes the structural integrity of the space and protective features against risks such as fire, natural disasters, theft, and accidents. Ensuring the safety of users' lives and properties is possible through the fulfillment of these needs. Psycho-Social User Needs: These needs encompass the environmental conditions necessary for users to have a comfortable and satisfying experience from psychological and social perspectives (Güremen, 2016). These needs can be classified into privacy, behavioral, aesthetic, and social needs (Buğday, 1991; Gül, 1993). Privacy Needs: This refers to the need for users to protect their private areas visually and auditorily (Buğday, 1991). Visual privacy includes the non-visibility of action areas from other spaces, while auditory privacy involves preventing sound transmission (Korur et al., 2006; Uzunoğlu & Özer, 2014). Behavioral Needs: These are the spatial characteristics that align with users' personal preferences and lifestyles. For example, some users may prefer spacious and open environments, while others may prefer smaller and more private spaces (Korur et al., 2006; Uzunoğlu and Özer, 2014). Aesthetic Needs: These are the spatial characteristics that visually satisfy users psychologically. Elements that appeal to visual effects, such as dimensional ratios, colors, and textures, meet aesthetic needs. The concept of aesthetics can vary from person to person and can also be shaped according to the purpose the space will serve (Korur et al., 2006). Social Needs: These are the spatial characteristics that reflect users' family structure, lifestyle preferences, and social relationships (Korur et al., 2006).

2. Material and Method

First, a field study was conducted to provide data for the research. The research population was selected as Turkey's Hatay province, which has historically been exposed to many earthquakes and experienced the most devastating effects of the earthquake on February 6, 2023. In this earthquake, known as the "disaster of the century," there were significant losses of life and property in Hatay. Many people lost their homes and were relocated to tent cities or container cities. The accessibility of the Hatay region for researchers for observation and interviews facilitated the selection of this area (Duruel, 2023). The container cities surrounding the central campus of İskenderun Technical University in İskenderun district of Hatay form the boundary of this study. The sample is limited to the AFAD container city. The reason for selecting this area is that disaster survivors have been living in the containers, which were put into use after the earthquake, for nearly 1.5 years. Despite having the same spatial and structural characteristics as other container cities, there are spatial differences created by the interventions of disaster survivors on the building envelope and the use of the space. The AFAD container city consists of 270 containers. Figure 1 shows the location of the container city, the settlement plan, and the external interventions and changes made by the disaster survivors to their containers.

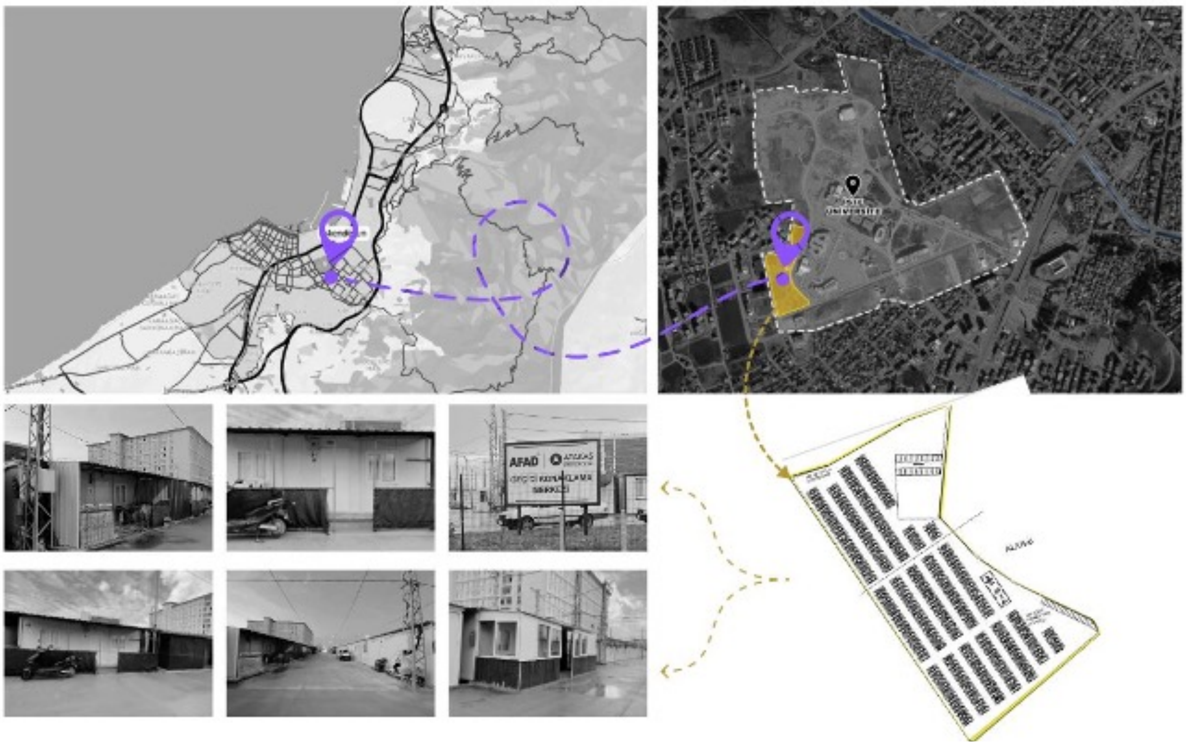


Figure 1. Iskenderun AFAD Container City (Tarakçı, 2024)

In this study, the descriptive model from quantitative research methods was preferred as the research method to establish a generalizable judgment by revealing the existing situation of the problem. The main problem identified is the necessity for individuals to feel a sense of belonging to the space they are forced to live in. This problem is addressed through defining the user group, understanding their relationship with the space, identifying user needs, and analyzing how they personalize the space via semi-structured interviews conducted with the selected group. In this context, the AFAD container city in İskenderun was examined, and data were obtained using observation, information collection, and semi-structured interview techniques. The observation method provided additional information about users, housing, and the surrounding environment that could not be obtained through the survey form, thus allowing for a more accurate assessment of the survey data. Observations were carried out through photographs, videos, audio recordings, drawings, and written notes. The use of the interview form and the observation method was considered to be closely related, and an evaluation was made accordingly. The combined use of surveys and observation methods provided a more comprehensive opportunity for data collection and analysis.

The criteria for inclusion in the study group included being directly affected by the earthquake and living in the container city, having made any changes to their containers, being able to express themselves verbally, being over 18 years old, and allowing photography of both indoor and outdoor spaces for the study. In this context, 52 out of 110 containers that were interviewed met the inclusion criteria. However, 5 containers were selected for detailed analysis where internal and external assessments could be conducted most effectively. Based on the analyses conducted, an effort was made to determine how the relationship between disaster survivors and containers was established through personalization.

At this point, the study was shaped by the theoretical framework obtained from the literature review and the interviews conducted in the selected area. With the information obtained from the literature and the interviews conducted in the selected area, sub-parameters related to personalization methods, user interventions, and user needs were created. The sub-parameters formed through the semi-structured interviews were supported. The two main principles of personalization methods were examined in accordance with spatial and elemental personalization and their sub-parameters. The two fundamental principles of user needs were studied according to physical and psycho-social needs and their sub-parameters. User interventions were also addressed with the parameters of addition, cancellation/modification, transformation, expansion, and division. Identity cards were created for the containers to be analyzed with these parameters.

Identity cards have been created to provide information about the selected area and to make the examination clearer and more readable. Instructions on how to read the tables related to the identity cards are explained in Figure 2.

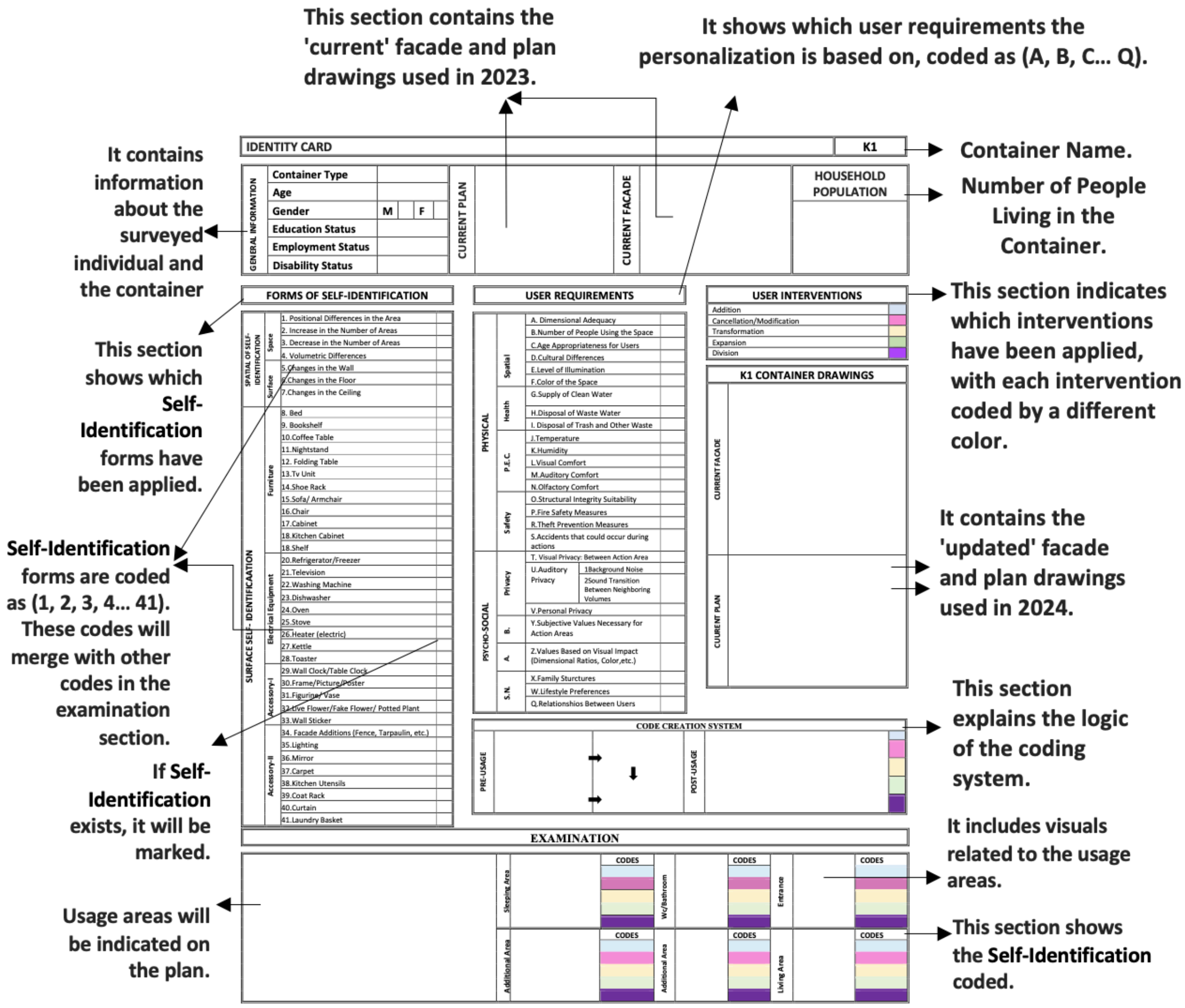


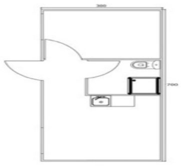
Figure 2. Explanation of the identity card (created by the author)

The container to be analyzed will be shown with the identity card depicted in Figure 2. The identity card consists of 8 sections within its own system. These sections include: the section where the container name is given, the section explaining general information, the section coding the forms of personalization, user needs, and user interventions with their sub-parameters, the section providing post-use drawings of the container, the section explaining the coding system, and the section where the examination is conducted visually and through coding.

Section where the container name is given: The names of the containers have been changed for confidentiality reasons and are labeled in the top right corner as "K1, K2, K3, K4, and K5," using the first letter of the word "Container." The actual container names are not disclosed.

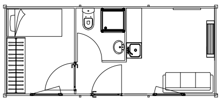
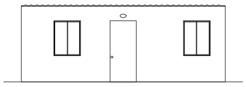
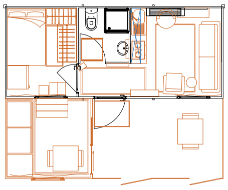
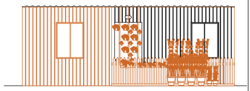
Section explaining general information: This section is divided into three parts. The first part includes data on the age, gender, education level, employment status, and disability status of the disaster survivor surveyed, along with information about the type of container (Table 2). Following various disasters like earthquakes, public institutions in Turkey have provided emergency and temporary housing units, one of which is containers. Different types of containers were observed in the selected study area.

Table 2. Shows the types of containers considered in this study (Tarakçı, 2023)

CONTAINER TYPES (TYPE-1)			
İskenderun Container City		7m x 3m	
			
Image	Plan	Front View	Side View

The information about the types of containers in the study area is included in the general information section. These containers, which started being used in 2023, were supplied by AFAD. The second part includes the "existing plan" and "existing facade" drawings to understand the current condition of the containers at the time they were put into use (2023). As seen in Table 3, the provided containers contain a sofa, TV, air conditioning, mini refrigerator, two-burner stove, bunk bed, and wardrobe.

Table 3. Shows the types of containers considered in this study (Tarakçı, 2023)

CONTAINER TYPES-1			
	Pre-Usage Plan	Pre-Usage Facade	Pre-Usage Container
PRE-USAGE			
	Current Plan	Current Facade	Current Container
POST-USAGE			

The drawings of the same containers still in use in 2024 are referred to as "current plan" and "current facade." To better visualize the interventions made by disaster survivors in the containers over 1.5 years, they are drawn in orange in the current plan and facade drawings. The third part (top right corner) contains household information, indicating the number of people living in the container.

Section where personalization forms are applied: When examining the phenomenon of personalization in the containers, coding will be done using numbers, letters, and colors. The purpose of this coding is to make the understanding of personalization in the space clearer. Personalization forms are represented by numbers. The two principles of personalization examined are spatial and visual, addressed with their sub-parameters. Each parameter is coded from 1 to 41, allowing for an understanding of the type of personalization being analyzed through the code. For example, the code "6O" corresponds to the parameter "spatial personalization-surface-floor change." The letter "O" relates to user needs.

Section where user needs are identified: This section explains the user needs that led to the forms of personalization. They are considered under two principles: physical and psycho-social, with these two principles further divided into sub-parameters. These parameters are coded with letters A, B, C, D…Q, allowing for an understanding of which need prompted the form of personalization. The reasons for personalization were identified through data from interviews with users, photographs, observations, and drawings. For example, the code "6O" indicates that the "6" refers to the parameter "spatial personalization-surface-floor change," while "O" corresponds to the parameter "physical needs-security-structural soundness."

Section where user interventions are identified: After determining the user needs that prompted the forms of personalization, this section identifies the interventions made using color coding. Light blue (Addition), pink (Cancellation/Modification), light yellow (Transformation), light green (Expansion), and purple (Division) are randomly selected colors. During analysis, the determined codes will be written in the section corresponding to the intervention made. For example, if the code "6O" indicates a floor change, and if this change was made by canceling or modifying the existing floor, it will be written in the pink section; if it was made by adding to the floor, it will be written in the light blue section. Different codes may appear in the same color, and the same codes may also appear in different colors.

Section where container drawings are found: This section will provide the plan and facade drawings of the current state of the container used by the users who have lived in it since 2023, based on interviews conducted on June 5-6-7, 2024. Visuals will also support this section as per space availability.

Section explaining the coding system: This section will explain the coding process of the analyzed container using visuals before and after use. This is intended to clarify the logic behind the coding.

Section where the examination is conducted: In this area, the current plan will be provided, and the spatial areas will be shown on the plan. Visuals of the areas provided as plans will also be included, followed by separate codings related to the personalization process for each area. Each coding will be written in the row corresponding to the intervention made with that color.

3. Findings and Discussion

In this section, the phenomenon of personalization observed in five containers has been examined through interviews, observations, and photographs, using the created identity cards.

K1 Container: Through the conducted interviews, the interventions made by the disaster survivor in the container have been observed. The reasons for these changes were specified by the survivor during the discussions. Figure 3 shows the changes made to the facade and the interior of K1 container, as well as another container located right next to it.

Figure 3. Examples of personalization in the facade and interior of the container (Tarakçı, 2024)

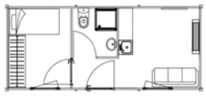
Despite living with two people, due to space constraints, they extended the front facade of the container to match its original dimensions, thereby creating two additional areas. They explained in the discussions that they changed the flooring, acquired new furniture/items/accessories, and returned the provided furniture without using it. All examples of personalization in the container are shown in Table 4 through the identity card.

Table 4. Examination of the the Phenomenon Of Self-Identification in the "K1" Container (Tarakçı, 2024)

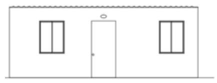
IDENTITY CARD	K1

GENERAL INFORMATION		
	Container Type	TYPE1
	Age	42
	Gender	M ■ F
	Education Status	License
	Employment Status	Security
	Disability Status	-

PRE-USAGE PLAN



PRE-USAGE FACADE



HOUSEHOLD POPULATION
2

FORMS OF SELF-IDENTIFICATION

SPATIAL OF SELF-IDENTIFICATION	Space	1. Positional Differences in the Area	√
		2. Increase in the Number of Areas	√
		3. Decrease in the Number of Areas	
		4. Volumetric Differences	√
	Surface	5.Changes in the Wall	
		6.Changes in the Floor	√
		7.Changes in the Ceiling	√
SURFACE SELF- IDENTIFICAATION	Furniture	8. Bed	√
		9. Bookshelf	
		10.Coffee Table	√
		11.Nightstand	
		12. Folding Table	√
		13.Tv Unit	√
		14.Shoe Rack	√
		15.Sofa/ Armchair	√
		16.Chair	√
		17.Cabinet	√
		18.Kitchen Cabinet	√
		18.Shelf	√
	Electrical Equipment	20.Refrigerator/Freezer	√
		21.Television	
		22.Washing Machine	√
		23.Dishwasher	
		24.Oven	√
		25.Stove	
		26.Heater (electric)	
		27.Kettle	√
		28.Toaster	
	Accessory-I	29.Wall Clock/Table Clock	√
		30.Frame/Picture/Poster	√
		31.Figurine/ Vase	√
		32.Live Flower/Fake Flower/ Potted Plant	√
		33.Wall Sticker	√
	Accessory-II	34. Facade Additions (Fence, Tarpaulin, etc.)	√
		35.Lighting	
		36.Mirror	
		37.Carpet	√
		38.Kitchen Utensils	√
		39.Coat Rack	√
		40.Curtain	√
		41.Laundry Basket	√

USER REQUIREMENTS

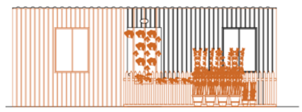
PHYSICAL	Spatial	A. Dimensional Adequacy		√
		B.Number of People Using the Space		√
		C.Age Appropriateness for Users		
		D.Cultural Differences		
		E.Level of Illumination		
		F.Color of the Space		
	Health	G.Supply of Clean Water		√
		H.Disposal of Waste Water		
		I. Disposal of Trash and Other Waste		
	P.E.C.	J.Temperature		√
		K.Humidity		
		L.Visual Comfort		√
		M.Auditory Comfort		√
		N.Olfactory Comfort		
	Safety	O.Structural Integrity Suitability		√
		P.Fire Safety Measures		
		R.Theft Prevention Measures		√
		S.Accidents that could occur during actions		√
PSYCHO-SOCIAL	Privacy	T. Visual Privacy: Between Action Area		√
		U.Auditory Privacy	1Background Noise	√
			2Sound Transition Between Neighboring Volumes	√
		V.Personal Privacy		√
	B.	Y.Subjective Values Necessary for Action Areas		√
	A.	Z.Values Based on Visual Impact (Dimensional Ratios, Color,etc.)		√
	S.N.	X.Family Sturctures		
		W.Lifestyle Preferences		√
		Q.Relationshios Between Users		

USER INTERVENTIONS

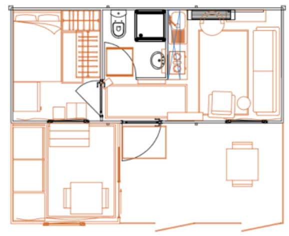
Addition	√
Cancellation/Modification	√
Transformation	
Expansion	√
Division	

K1 CONTAINER DRAWINGS

CURRENT FACADE

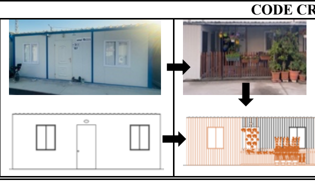


CUURENT PLAN



CODE CREATION SYSTEM

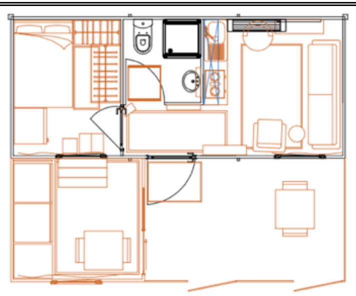
PRE-USAGE



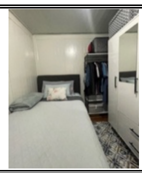
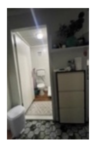
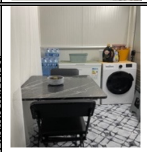
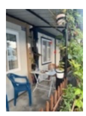
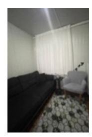
POST-USAGE

The container, which has been used for more than 1.5 years, shows the interventions made by the user. For the facade, areas highlighted with hair have been created. This situation shows that there is a volumetric difference (4) from the self-assembly forms. New space was needed due to its small square meters. Therefore, the reason for self-contouring is that the dimensional adequacy (A) of the user requirements is not suitable. While emphasizing the façade, the space was expanded by adding user interventions to the existing container. Coding is shown on the right

EXAMINATION



Note: The facade is included in the additional area inspections.

		CODES
Sleeping Area		30Z,37W,20A,40V,41Y, 41W,39B,30A,17B,8A,7L, 7M,7J,5Z / 8A,17A, / - / - / -
Wc/Bathroom		37W, 19Y, 7L,7M,7J / - / - / - / -
Entrance		7L,7M,7J,37W,37Y,14B,19Z,32Z,30Z,31Z, 14Y,5Z / - / - / - / -
Additional Area		4A,6O,2A,33Z,40V,30Z,31Z,20A,5U,5V,22G,22Y,39Y, 37Y,16A,16B,12A, 12B,7U,17A,17Y, 5Z / 6O / - / 4A,7L,7M,7J,7A / -
Additional Area		4A,7L,7M,7J, 32Z,16B,12B,2A,7U,34Z,34R,34T,5Z / - / - / 4A,7L,7M,7J, 7A / -
Living Area		7M,7L,7J,33Z,17A,10Y,29Y,15Z,37Y,37W,13Z,18A,27Y, 14Y,38B,24Y,5Z / 15Z,1S / - / - / -

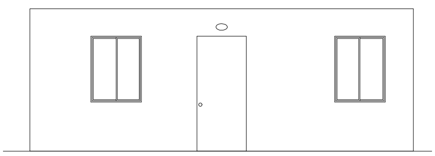
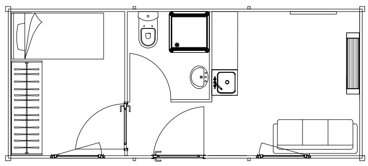
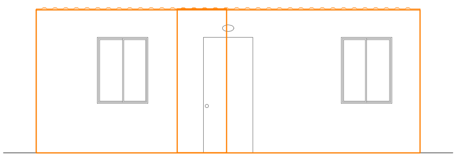
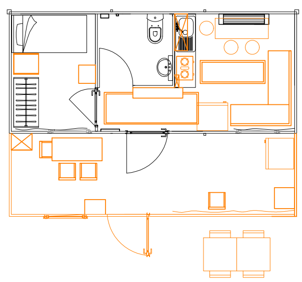
K2 Container: Through the conducted interviews, the interventions made by the disaster survivor in the container have been observed. The main reasons for these changes were specified by the survivor during the discussions. The changes made are shown in Figure 4.

Figure 4. Examples of personalization in the facade and interior of the container (Tarakçı, 2024)

The household consists of three people. They have covered the upper part of the container with a roof to extend it forward. Additionally, they explained in the discussions that they changed the flooring, acquired new furniture/items/accessories, and returned some of the provided furniture without using it. All examples of personalization in the container will be shown through the identity card.

All examples of personalization by the disaster survivor in the container are shown in Table 5, highlighted in the facade and plan.

Table 5. Facade and plan change drawings of K2 container (Tarakçı, 2023)

Pre-Usage Plan	Pre-Usage Facade
	
Current Plan	Current Facade
	

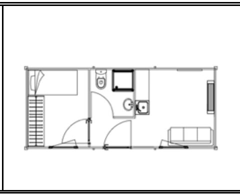
All examples of personalization in the container are shown in Table 6 through the identity card.

Table 6. Examination of the the Phenomenon of Self-Identification in the "K2" Container (Tarakçı, 2024)

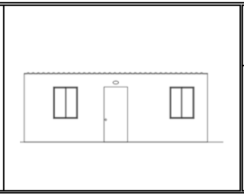
IDENTITY CARD	K2

GENERAL INFORMATION		
	Container Type	TYPE1
	Age	46
	Gender	M / F
	Education Status	-
	Employment Status	Retirement
	Disability Status	-

PRE-USAGE PLAN



PRE-USAGE FACADE



HOUSEHOLD POPULATION
3

FORMS OF SELF-IDENTIFICATION

SPATIAL OF SELF-IDENTIFICATION	Space	1. Positional Differences in the Area	√
		2. Increase in the Number of Areas	√
		3. Decrease in the Number of Areas	
		4. Volumetric Differences	√
	Surface	5.Changes in the Wall	
		6.Changes in the Floor	√
		7.Changes in the Ceiling	√
SURFACE SELF- IDENTIFICAATION	Furniture	8. Bed	
		9. Bookshelf	
		10.Coffee Table	
		11.Nightstand	
		12. Folding Table	√
		13.Tv Unit	
		14.Shoe Rack	√
		15.Sofa/ Armchair	√
		16.Chair	√
		17.Cabinet	√
		18.Kitchen Cabinet	√
		18.Shelf	√
	Electrical Equipment	20.Refrigerator/Freezer	√
		21.Television	
		22.Washing Machine	√
		23.Dishwasher	
		24.Oven	
		25.Stove	
		26.Heater (electric)	
		27.Kettle	
		28.Toaster	√
	Accessory-I	29.Wall Clock/Table Clock	
		30.Frame/Picture/Poster	
		31.Figurine/ Vase	
		32.Live Flower/Fake Flower/ Potted Plant	√
		33.Wall Sticker	
	Accessory-II	34. Facade Additions (Fence, Tarpaulin, etc.)	√
		35.Lighting	
		36.Mirror	√
		37.Carpet	√
		38.Kitchen Utensils	√
		39.Coat Rack	√
		40.Curtain	√
		41.Laundry Basket	√

USER REQUIREMENTS

PHYSICAL	Spatial	A. Dimensional Adequacy	√
		B.Number of People Using the Space	√
		C.Age Appropriateness for Users	
		D.Cultural Differences	
		E.Level of Illumination	
		F.Color of the Space	
	Health	G.Supply of Clean Water	√
		H.Disposal of Waste Water	
		I. Disposal of Trash and Other Waste	
	P.E.C.	J.Temperature	√
		K.Humidity	
		L.Visual Comfort	√
		M.Auditory Comfort	√
		N.Olfactory Comfort	
	Safety	O.Structural Integrity Suitability	√
		P.Fire Safety Measures	
		R.Theft Prevention Measures	√
		S.Accidents that could occur during actions	√
PSYCHO-SOCIAL	Privacy	T. Visual Privacy: Between Action Area	√
		U.Auditory Privacy: 1Background Noise	√
		U.Auditory Privacy: 2Sound Transition Between Neighboring Volumes	√
		V.Personal Privacy	√
	B.	Y.Subjective Values Necessary for Action Areas	√
	A.	Z.Values Based on Visual Impact (Dimensional Ratios, Color,etc.)	√
	S.N.	X.Family Sturctures	
		W.Lifestyle Preferences	√
		Q.Relationshios Between Users	

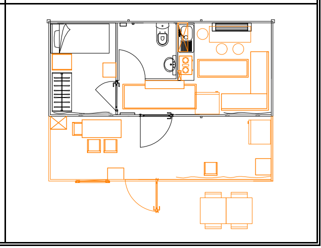
USER INTERVENTIONS

Addition	√
Cancellation/Modification	√
Transformation	
Expansion	√
Division	

K1 CONTAINER DRAWINGS

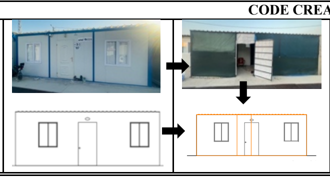
CURRENT FACADE

CUURENT PLAN



CODE CREATION SYSTEM

PRE-USAGE

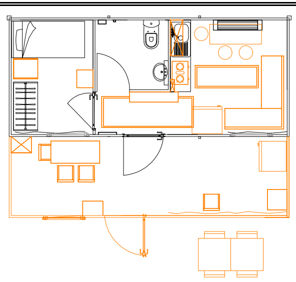


POST-USAGE

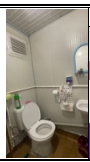
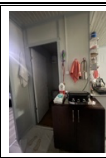
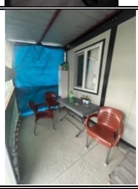
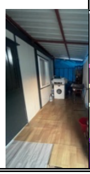
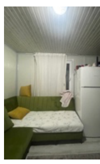
The container, which has been used for more than 1.5 years, shows the interventions made by the user. For the facade, areas highlighted with hair have been created. This situation shows that there is a volumetric difference (4) from the self-assembly forms. New space was needed due to its small square meters. Therefore, the reason for self-contouring is that the dimensional adequacy (A) of the user requirements is not suitable. While emphasizing the façade, the space was expanded by adding user interventions to the existing container. Coding is shown on the right

4A
4A

EXAMINATION



Note: The facade is included in the additional area inspections.

Area		CODES
Sleeping Area		6O,17B,17A,36Y / 6O / - / / -
Wc/Bathroom		6O,19Y / 6O / - / - / -
Entrance		17B,28Y,39Y, 37Y,6O,32Z / 6O / - / - / -
Additional Area		16B,12B,17B, 34R,34V, 2A, / - / - / 7L,7M,7J,4A,7A / --
Additional Area		2A,34R,34V, 40T,40V,14B 6O,22G,29Y / 60 / - / 4A,7L,7M,7J, 7A / -
Living Area		19Y,38Y,38B, 37Y,12B,16B, 6O,20A,20B, 20Y,15A / 6O,15A,1S / / - / -

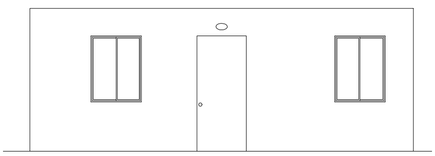
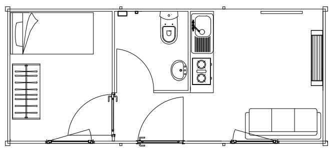
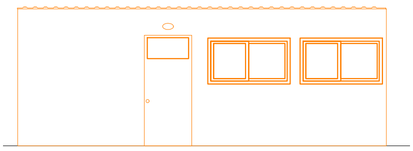
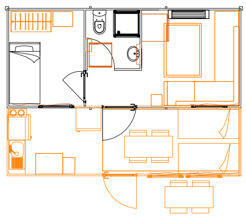
K3 Container: Through the conducted interviews, the interventions made by the disaster survivor in the container have been observed. The main reasons for these changes were specified by the survivor during the discussions. The interventions can also be understood from the interior and exterior visuals (Figure 5).

Figure 5. Examples of personalization in the facade and interior of the container (Tarakçı, 2024)

The household consists of six people. They have covered the upper part of the container with a roof to extend it forward. Additionally, they explained in the discussions that they changed the flooring, acquired new furniture/items/accessories, and returned some of the provided furniture without using it. There are two individuals in the household aged 23 and 25 who have mobility issues due to being trapped under rubble during the earthquake. All examples of personalization in the container will be shown through the identity card.

All examples of personalization by the disaster survivor in the container are shown in Table 7, highlighted in the facade and plan.

Table 7. Facade and plan change drawings of K3 container (Tarakçı, 2023)

Pre-Usage Plan	Pre-Usage Facade
	
Current Plan	**Current Facade**
	

All examples of personalization in the container are shown in Table 8 through the identity card.

Table 8. Examination of the Phenomenon of Self-Identification in the "K3" Container (Tarakçı, 2024)

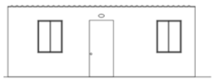
IDENTITY CARD	K3

GENERAL INFORMATION

Container Type	TYPE1
Age	45
Gender	**M** / **F** ■
Education Status	-
Employment Status	Retirement
Disability Status	-

PRE-USAGE PLAN

PRE-USAGE FACADE



HOUSEHOLD POPULATION

6

FORMS OF SELF-IDENTIFICATION

SPATIAL OF SELF-IDENTIFICATION	Space	1. Positional Differences in the Area	√
		2. Increase in the Number of Areas	√
		3. Decrease in the Number of Areas	
		4. Volumetric Differences	√
	Surface	5.Changes in the Wall	√
		6.Changes in the Floor	√
		7.Changes in the Ceiling	√
SURFACE SELF- IDENTIFICAATION	Furniture	8. Bed	√
		9. Bookshelf	
		10.Coffee Table	
		11.Nightstand	
		12. Folding Table	√
		13.Tv Unit	
		14.Shoe Rack	√
		15.Sofa/ Armchair	√
		16.Chair	√
		17.Cabinet	√
		18.Kitchen Cabinet	√
		18.Shelf	√
	Electrical Equipment	20.Refrigerator/Freezer	√
		21.Television	
		22.Washing Machine	
		23.Dishwasher	√
		24.Oven	
		25.Stove	
		26.Heater (electric)	
		27.Kettle	
		28.Toaster	
	Accessory-I	29.Wall Clock/Table Clock	√
		30.Frame/Picture/Poster	
		31.Figurine/ Vase	
		32.Live Flower/Fake Flower/ Potted Plant	
		33.Wall Sticker	
	Accessory-II	34. Facade Additions (Fence, Tarpaulin, etc.)	√
		35.Lighting	√
		36.Mirror	
		37.Carpet	√
		38.Kitchen Utensils	√
		39.Coat Rack	
		40.Curtain	√
		41.Laundry Basket	

USER REQUIREMENTS

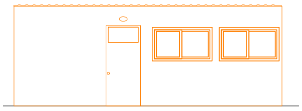
PHYSICAL	Spatial	A. Dimensional Adequacy	√
		B.Number of People Using the Space	√
		C.Age Appropriateness for Users	
		D.Cultural Differences	
		E.Level of Illumination	√
		F.Color of the Space	
	Health	G.Supply of Clean Water	
		H.Disposal of Waste Water	
		I. Disposal of Trash and Other Waste	
	P.E.C.	J.Temperature	√
		K.Humidity	
		L.Visual Comfort	√
		M.Auditory Comfort	√
		N.Olfactory Comfort	√
	Safety	O.Structural Integrity Suitability	√
		P.Fire Safety Measures	√
		R.Theft Prevention Measures	√
		S.Accidents that could occur during actions	√
PSYCHO-SOCIAL	Privacy	T. Visual Privacy: Between Action Area	√
		U.Auditory Privacy: 1Background Noise	√
		U.Auditory Privacy: 2Sound Transition Between Neighboring Volumes	√
		V.Personal Privacy	√
	B.	Y.Subjective Values Necessary for Action Areas	√
	A.	Z.Values Based on Visual Impact (Dimensional Ratios, Color,etc.)	√
	S.N.	X.Family Sturctures	
		W.Lifestyle Preferences	
		Q.Relationshios Between Users	

USER INTERVENTIONS

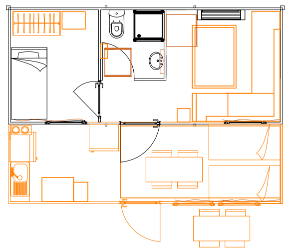
Addition	√
Cancellation/Modification	√
Transformation	
Expansion	√
Division	

K1 CONTAINER DRAWINGS

CURRENT FACADE

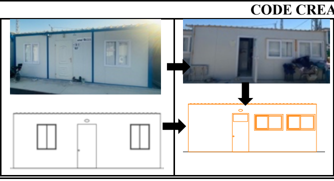


CUURENT PLAN



CODE CREATION SYSTEM

PRE-USAGE

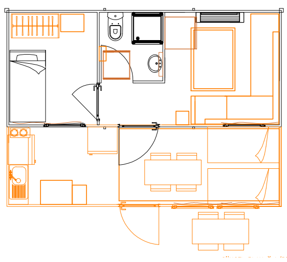


POST-USAGE

The container, which has been used for more than 1.5 years, shows the interventions made by the user. For the facade, areas highlighted with hair have been created. This situation shows that there is a volumetric difference (4) from the self-assembly forms. New space was needed due to its small square meters. Therefore, the reason for self-contouring is that the dimensional adequacy (A) of the user requirements is not suitable. While emphasizing the façade, the space was expanded by adding user interventions to the existing container. Coding is shown on the right

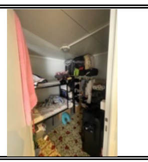
4A
4A

EXAMINATION



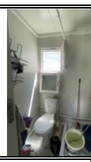
Note: The facade is included in the additional area inspections.

Sleeping Area



CODES
7U,6O,5M,5U ,17B,37Y
6O,
-
-
-

Wc/Bathroom



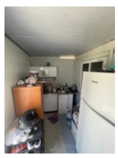
CODES
7U,6O,5M ,5U,19Y
6O,
-
-
-

Entrance

-

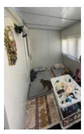
CODES
7U,6O,5M,5U
6O
-
-
-

Additional Area



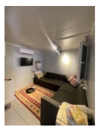
CODES
34V,7U,6O,5 M,5U, 2A,14B,17A,1 8A,20B,20A,2 3B,36Y,38B, 37Y
6O
-
4A,7L,7M,7J,7 A
--

Additional Area



CODES
34V,34E,34N ,34R,7U,6O, 5M,5U,2A,4 0V,5E,8B,12 B,16B,29Y,3 5E,37Y,40T
6O,
-
4A,4B,7L,7M ,7J,7U,7A,
-

Living Area



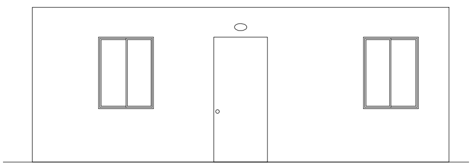
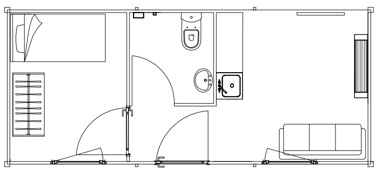
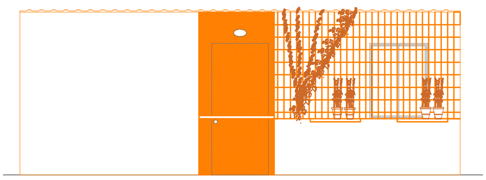
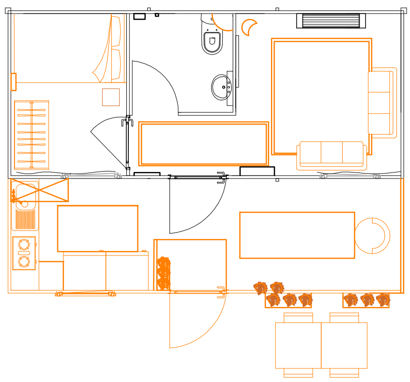
CODES
7U,6O,5M,5U ,15B,15A,35E, 37Y
6O,1N,1P,1B, 1S,15A
-
-
-

K4 Container: Through the conducted interviews, it has been observed that there were several interventions made to the container by the disaster survivor. The main reasons for these changes were specified by the survivor based on their needs. The personalization behavior resulting from the interventions in the interior and exterior is shown in Figure 6.

Figure 6. Examples of personalization in the facade and interior of the container (Tarakçı, 2024)

The household consists of five people. They have covered the upper part of the container with a roof to extend it forward. Additionally, they explained in the discussions that they changed the flooring, acquired new furniture/items/accessories, and returned some of the provided furniture without using it. There are three small children in the household. The user mentioned that many of the personalization behaviors in the container were done for their children, and all examples of personalization in the container are shown in Table 9, highlighted in the facade and plan.

Table 9. Facade and plan change drawings of K3 container (Tarakçı, 2023)

Pre-Usage Plan	Pre-Usage Facade
	
Current Plan	**Current Facade**
	

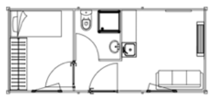
All examples of personalization in the container are shown in Table 10 through the identity card.

Table 10. Examination of the the Phenomenon of Self-Identification in the "K4" Container (Tarakçı, 2024)

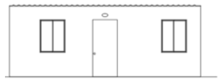
IDENTITY CARD	K4

GENERAL INFORMATION		
	Container Type	TYPE1
	Age	45
	Gender	M / F
	Education Status	-
	Employment Status	P.Sector
	Disability Status	-

PRE-USAGE PLAN



PRE-USAGE FACADE



HOUSEHOLD POPULATION
5

FORMS OF SELF-IDENTIFICATION

SPATIAL OF SELF-IDENTIFICATION	Space	1. Positional Differences in the Area	√
		2. Increase in the Number of Areas	√
		3. Decrease in the Number of Areas	
		4. Volumetric Differences	√
	Surface	5.Changes in the Wall	√
		6.Changes in the Floor	√
		7.Changes in the Ceiling	√
SURFACE SELF- IDENTIFICAATION	Furniture	8. Bed	√
		9. Bookshelf	
		10.Coffee Table	
		11.Nightstand	
		12. Folding Table	√
		13.Tv Unit	
		14.Shoe Rack	√
		15.Sofa/ Armchair	√
		16.Chair	√
		17.Cabinet	√
		18.Kitchen Cabinet	√
		18.Shelf	√
	Electrical Equipment	20.Refrigerator/Freezer	
		21.Television	
		22.Washing Machine	√
		23.Dishwasher	√
		24.Oven	√
		25.Stove	
		26.Heater (electric)	
		27.Kettle	√
		28.Toaster	
	Accessory-I	29.Wall Clock/Table Clock	√
		30.Frame/Picture/Poster	√
		31.Figurine/ Vase	√
		32.Live Flower/Fake Flower/ Potted Plant	√
		33.Wall Sticker	√
	Accessory-II	34. Facade Additions (Fence, Tarpaulin, etc.)	√
		35.Lighting	√
		36.Mirror	√
		37.Carpet	√
		38.Kitchen Utensils	√
		39.Coat Rack	√
		40.Curtain	√
		41.Laundry Basket	

USER REQUIREMENTS

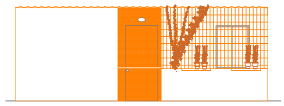
PHYSICAL	Spatial	A. Dimensional Adequacy	√
		B.Number of People Using the Space	√
		C.Age Appropriateness for Users	
		D.Cultural Differences	
		E.Level of Illumination	√
		F.Color of the Space	
	Health	G.Supply of Clean Water	√
		H.Disposal of Waste Water	
		I. Disposal of Trash and Other Waste	
	P.E.C.	J.Temperature	√
		K.Humidity	
		L.Visual Comfort	√
		M.Auditory Comfort	√
		N.Olfactory Comfort	
	Safety	O.Structural Integrity Suitability	√
		P.Fire Safety Measures	√
		R.Theft Prevention Measures	√
		S.Accidents that could occur during actions	√
PSYCHO-SOCIAL	Privacy	T. Visual Privacy: Between Action Area	√
		U.Auditory Privacy: 1Background Noise	√
		U.Auditory Privacy: 2Sound Transition Between Neighboring Volumes	√
		V.Personal Privacy	√
	B.	Y.Subjective Values Necessary for Action Areas	√
	A.	Z.Values Based on Visual Impact (Dimensional Ratios, Color,etc.)	√
	S.N.	X.Family Sturctures	
		W.Lifestyle Preferences	
		Q.Relationshios Between Users	

USER INTERVENTIONS

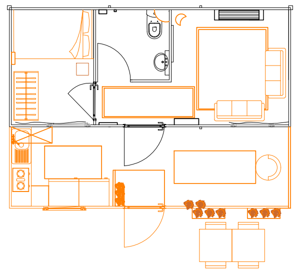
Addition	√
Cancellation/Modification	√
Transformation	
Expansion	√
Division	

K1 CONTAINER DRAWINGS

CURRENT FACADE

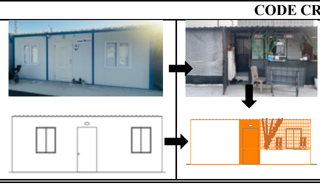


CUURENT PLAN



CODE CREATION SYSTEM

PRE-USAGE

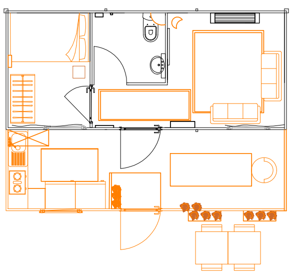


POST-USAGE

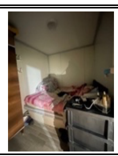
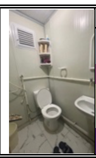
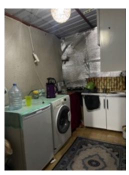
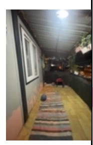
The container, which has been used for more than 1.5 years, shows the interventions made by the user. For the facade, areas highlighted with hair have been created. This situation shows that there is a volumetric difference (4) from the self-assembly forms. New space was needed due to its small square meters. Therefore, the reason for self-contouring is that the dimensional adequacy (A) of the user requirements is not suitable. While emphasizing the façade, the space was expanded by adding user interventions to the existing container. Coding is shown on the right

4A
4A

EXAMINATION



Note: The facade is included in the additional area inspections.

		CODES
Sleeping Area		6O,7U,8B,19Z,31Z / 6O,8A,8B,17A / - / - / -
Wc/Bathroom		6Z,19B / 6O / - / - / -
Entrance		7U,6O,36Y,37Y,36Z / 6O / - / - / -
Additional Area		2A,5J,5L,5T,5V,5P,5Z,5A, 60,4A,7U,18A,18B,22G,27Y,34T,34V,35E,37Y,38B,24B,24Y / 6O, / - / 4A,7Y,7J, / -
Additional Area		4A,2A,7U, 14B,32Z,39B,16B,12B,37Y,34Y,34T,34V, 34R,39B / 6O, / - / 4A,7Y,7J, / -
Living Area		5Z,6O,7U,10Y,15B,15A,19Y, 19Z,29Y,30Z, 31Z,33Z,37Y, 40Z,40T,40V, 5Z / 1P,1S,6O, / - / - / -

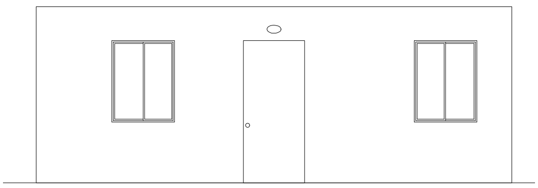
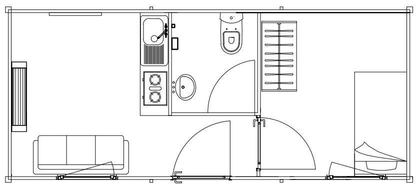
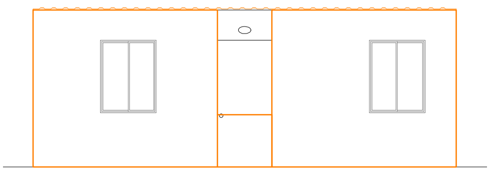
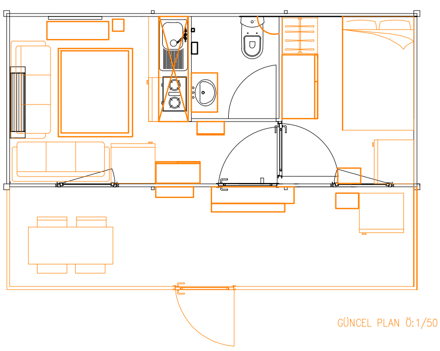
K5 Container: Through the conducted interviews, it has been observed that there were several interventions made to the container by the disaster survivor. The main reasons for these changes were specified by the survivor based on their needs. The changes made are shown in Figure 7.

Figure 7. Examples of personalization in the facade and interior of the container (Tarakçı, 2024)

The household consists of five people. They have covered the upper part of the container with a roof to extend it forward. Additionally, they explained in the discussions that they changed the flooring, acquired new furniture/items/accessories, and returned some of the provided furniture without using it. There are three small children in the household. The user mentioned that many of the personalization behaviors were done for their children, and all examples of personalization in the container will be shown through the identity card.

All examples of personalization by the disaster survivor in the container are shown in Table 11, highlighted in the facade and plan.

Table 11. Drawings of the facade and plan changes of the K5 container (Tarakçı, 2023)

Pre-Usage Plan	Pre-Usage Facade
	
Current Plan	**Current Facade**
	

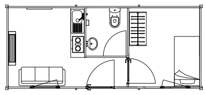
All examples of personalization in the container are shown in Table 12 through the identity card.

Table 12. Examination of the the Phenomenon of Self-Identification in the "K5" Container (Tarakçı, 2024)

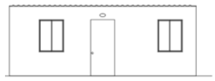
IDENTITY CARD	K5

GENERAL INFORMATION		
	Container Type	TYPE1
	Age	41
	Gender	M | F (F marked)
	Education Status	Licence
	Employment Status	Housewife
	Disability Status	-

PRE-USAGE PLAN



PRE-USAGE FACADE



HOUSEHOLD POPULATION
5

FORMS OF SELF-IDENTIFICATION

SPATIAL OF SELF-IDENTIFICATION	Space	1. Positional Differences in the Area	√
		2. Increase in the Number of Areas	√
		3. Decrease in the Number of Areas	
		4. Volumetric Differences	√
	Surface	5.Changes in the Wall	√
		6.Changes in the Floor	√
		7.Changes in the Ceiling	√
SURFACE SELF- IDENTIFICAATION	Furniture	8. Bed	√
		9. Bookshelf	
		10.Coffee Table	
		11.Nightstand	√
		12. Folding Table	√
		13.Tv Unit	
		14.Shoe Rack	√
		15.Sofa/ Armchair	√
		16.Chair	√
		17.Cabinet	√
		18.Kitchen Cabinet	√
		18.Shelf	√
	Electrical Equipment	20.Refrigerator/Freezer	√
		21.Television	
		22.Washing Machine	√
		23.Dishwasher	√
		24.Oven	√
		25.Stove	
		26.Heater (electric)	√
		27.Kettle	
		28.Toaster	
	Accessory-I	29.Wall Clock/Table Clock	√
		30.Frame/Picture/Poster	√
		31.Figurine/ Vase	√
		32.Live Flower/Fake Flower/ Potted Plant	√
		33.Wall Sticker	√
	Accessory-II	34. Facade Additions (Fence, Tarpaulin, etc.)	√
		35.Lighting	
		36.Mirror	√
		37.Carpet	√
		38.Kitchen Utensils	√
		39.Coat Rack	√
		40.Curtain	√
		41.Laundry Basket	

USER REQUIREMENTS

PHYSICAL	Spatial	A. Dimensional Adequacy	√
		B.Number of People Using the Space	√
		C.Age Appropriateness for Users	
		D.Cultural Differences	
		E.Level of Illumination	
		F.Color of the Space	
	Health	G.Supply of Clean Water	√
		H.Disposal of Waste Water	
		I. Disposal of Trash and Other Waste	
	P.E.C.	J.Temperature	√
		K.Humidity	
		L.Visual Comfort	√
		M.Auditory Comfort	
		N.Olfactory Comfort	
	Safety	O.Structural Integrity Suitability	√
		P.Fire Safety Measures	
		R.Theft Prevention Measures	√
		S.Accidents that could occur during actions	
PSYCHO-SOCIAL	Privacy	T. Visual Privacy: Between Action Area	√
		U.Auditory Privacy: 1Background Noise	√
		U.Auditory Privacy: 2Sound Transition Between Neighboring Volumes	√
		V.Personal Privacy	√
	B.	Y.Subjective Values Necessary for Action Areas	√
	A.	Z.Values Based on Visual Impact (Dimensional Ratios, Color,etc.)	√
	S.N.	X.Family Sturctures	
		W.Lifestyle Preferences	
		Q.Relationshios Between Users	

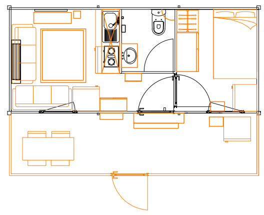
USER INTERVENTIONS

Addition	√
Cancellation/Modification	√
Transformation	
Expansion	√
Division	

K1 CONTAINER DRAWINGS

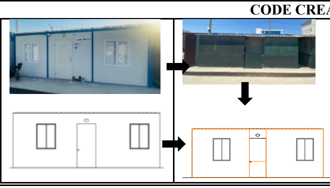
CURRENT FACADE

CUURENT PLAN



CODE CREATION SYSTEM

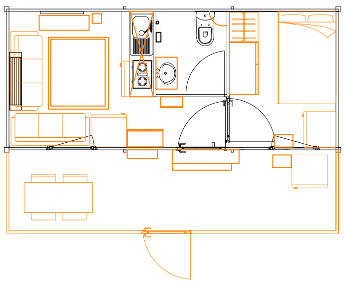
PRE-USAGE / POST-USAGE



The container, which has been used for more than 1.5 years, shows the interventions made by the user. For the facade, areas highlighted with hair have been created. This situation shows that there is a volumetric difference (4) from the self-assembly forms. New space was needed due to its small square meters. Therefore, the reason for self-contouring is that the dimensional adequacy (A) of the user requirements is not suitable. While emphasizing the façade, the space was expanded by adding user interventions to the existing container. Coding is shown on the right

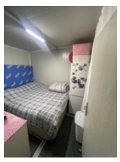
4A
4A

EXAMINATION



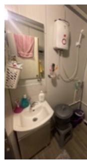
Note: The facade is included in the additional area inspections.

Sleeping Area



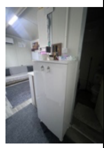
CODES
6O,5Z,8B,11Y,17B,17A,19B,19A,20B,31Z,36Z,36Y,40Z,40T,40V,41B,41Y,37Y, 39B,
6O,8A,8B,17A
-

Wc/Bathroom



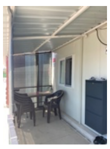
CODES
6O,19B,19Y,17A,17Y,17Z
6O

Entrance



CODES
6O,17B,31Z,37Y,38A
6O

Additional Area

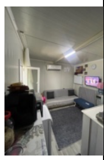


CODES
2A,7U,12B,14B,15B,34T,34V,34R,4A
4A,7J,7A,7Y

Additional Area

CODES
2A,7U,6S,18B,18Y,20B,22G,34T,34V,34R,39B,37Y,4A
4A,7J,7A,7Y,

Living Area



CODES
5Z,6O,7U,10Y,15B,15A,19Y,19Z,29Y,30Z,31Z,33Z,37Y,40Z,40T,40V,5Z
1P,1S,6O,
-
-
-

When examining the personalization phenomena in the K1, K2, K3, K4, and K5 containers:

In the K1 container, it is observed that various forms of personalization are present. These forms include frames, paintings, television units, folding tables, coffee tables, shoe racks, sofas, armchairs, changes on the wall, changes on the ceiling, changes in the flooring, cabinets, volumetric increases, beds, kitchen cabinets, shelves, refrigerators, freezers, washing machines, kettles, wall clocks, number of areas, figurines, vases, live flowers, artificial flowers, wall stickers, fences, carpets, various kitchen utensils, curtains, and laundry baskets. Looking at user interventions, the added elements are as follows: frames, paintings, television units, folding tables, coffee tables, shoe racks, sofas, armchairs, changes on the wall, changes on the ceiling, changes in the flooring, cabinets, volumetric increases, beds, kitchen cabinets, shelves, refrigerators, freezers, washing machines, kettles, wall clocks, number of areas, figurines, vases, live flowers, artificial flowers, wall stickers, fences, carpets, various kitchen utensils, curtains, and laundry baskets. The canceling or changing interventions occurred in the form of beds, cabinets, sofas/armchairs, changes in the flooring, and positional differences in the area. The area where the change intervention was made is the kitchen; the location of the kitchen sink has been changed. In the expansion intervention, volumetric differences with an increase in square meters and the extension of the ceiling forward with a roof have been observed. There were no transformation or partitioning interventions made. It has been determined that the needs for personalization are related to dimensional adequacy, the number of people using the space, clean water supply, temperature/rainfall, visual comfort, auditory comfort, structural integrity, theft prevention, accidents that may occur during actions, visual privacy, auditory privacy, personal privacy, subjective values necessary for the action areas of individuals, values based on visual impact, and lifestyle preferences.

In the K2 container, various forms of personalization are also present. These forms include chairs, changes in the flooring, cabinets, mirrors, shelves, toasters, drying racks, number of areas, changes on the ceiling, live flowers or artificial flowers, folding tables, facade additions, curtains, shoe racks, washing machines, wall clocks or table clocks, kitchen utensils, carpets, sofas or armchairs, and refrigerators or freezers. Looking at user interventions, the added elements include chairs, changes in the flooring, cabinets, mirrors, shelves, toasters, drying racks, number of areas, changes on the ceiling, live flowers or artificial flowers, folding tables, facade additions, curtains, shoe racks, washing machines, wall clocks or table clocks, kitchen utensils, carpets, sofas or armchairs, and refrigerators or freezers. The canceling or changing interventions occurred in the form of sofas, positional differences in the area, and on the flooring. The area where the change intervention was made is the kitchen; the location of the kitchen sink has been changed. The expansion interventions involve volumetric differences with an increase in square meters and the extension of the ceiling forward with a roof. There were no transformation or partitioning interventions made. It has been determined that the needs for personalization are related to dimensional adequacy, the number of people using the space, clean water supply, temperature/rainfall, visual comfort, auditory comfort, structural integrity, theft prevention, accidents that may occur during actions, visual privacy, auditory privacy, personal privacy, subjective values necessary for the action areas of individuals, values based on visual impact, and lifestyle preferences. In the K3 container, various forms of personalization are observed. These forms include positional differences in the area, an increase in the number of areas, volumetric differences, changes on the wall, flooring, and ceiling, beds, folding tables, shoe racks, sofas/armchairs, chairs, cabinets, shelves, kitchen cabinets, refrigerators/freezers, dishwashers, wall clocks/table clocks, facade additions (fences, tarpaulins, etc.), lighting, carpets, kitchen utensils, and curtains. Looking at user interventions, the added elements are as follows: positional differences, an increase in the number of areas, volumetric differences, changes on the wall, flooring, and ceiling, beds, folding tables, shoe racks, sofas/armchairs, chairs, cabinets, shelves, kitchen cabinets, refrigerators/freezers, dishwashers, wall clocks/table clocks, facade additions (fences, tarpaulins, etc.), lighting, carpets, kitchen utensils, and curtains. The canceling or changing interventions occurred in the form of changes in the flooring, positional changes in the area, and sofas/armchairs. The area where the change intervention was made is the kitchen; the location of the kitchen has been changed and moved outside. In the expansion intervention, volumetric differences with an increase in square meters and the extension of the ceiling forward with a roof have been observed. There were no transformation or partitioning interventions made. It has been determined that the needs for personalization are related to dimensional adequacy, the number of people using the space, lighting levels, temperature/rainfall, visual comfort, auditory comfort, olfactory comfort, structural integrity, fire prevention, theft prevention, accidents that may occur during actions, visual privacy, auditory privacy, personal privacy, subjective values necessary for the action areas of individuals, and values based on visual impact.

In the K4 container, various forms of personalization are also present. These forms include positional differences in the area, an increase in the number of areas, volumetric differences, changes on the wall, flooring, and ceiling, beds, coffee tables, folding tables, shoe racks, sofas/armchairs, chairs, cabinets, shelves, kitchen cabinets, washing and dishwashing machines, kettles, wall clocks/table clocks, frames/posters, figurines/vases, live flowers, wall stickers, facade additions (fences, tarpaulins, etc.), lighting, mirrors, carpets, kitchen utensils, coat racks, and curtains. Looking at user interventions, the added elements are as follows: positional differences in the area, an increase in the number of areas, volumetric differences, changes on the wall, flooring, and ceiling, beds, coffee tables, folding tables, shoe racks, sofas/armchairs, chairs, cabinets, shelves, kitchen cabinets, washing and dishwashing machines, kettles, wall clocks/table clocks, frames/posters, figurines/vases, live flowers, wall stickers, facade additions (fences, tarpaulins, etc.), lighting, mirrors, carpets, kitchen utensils, coat racks, and curtains. The canceling or changing interventions occurred in the form of changes in the flooring, positional changes in the area, and beds and cabinets. The area where the change intervention was made is the kitchen; the location of the kitchen has been changed and moved outside. In the expansion intervention, volumetric differences with an increase in square meters and the extension of the ceiling forward with a roof have been observed. There were no transformation or partitioning interventions made. It has been determined that the needs for personalization are related to dimensional adequacy, the number of people using the space, lighting levels, clean water supply, temperature/rainfall, visual comfort, auditory comfort, structural integrity, fire prevention, theft prevention, accidents that may occur during actions, visual privacy, auditory privacy, personal privacy, subjective values necessary for the action areas of individuals, and values based on visual impact.In the K5 container, various forms of personalization are also observed. These forms include positional differences in the area, an increase in the number of areas, volumetric differences, changes on the wall, flooring, and ceiling, beds, folding tables, shoe racks, sofas/armchairs, chairs, cabinets, shelves, kitchen cabinets, refrigerators, washing and dishwashing machines, kettles, ovens, stoves, wall clocks/table clocks, frames/posters, figurines/vases, live flowers, wall stickers, facade additions (fences, tarpaulins, etc.), mirrors, carpets, kitchen utensils, coat racks, curtains, and laundry baskets. Looking at user interventions, the added elements are as follows: positional differences in the area, an increase in the number of areas, volumetric differences, changes on the wall, flooring, and ceiling, beds, folding tables, shoe racks, sofas/armchairs, chairs, cabinets, shelves, kitchen cabinets, refrigerators, washing and dishwashing machines, kettles, ovens, stoves, wall clocks/table clocks, frames/posters, figurines/vases, live flowers, wall stickers, facade additions (fences, tarpaulins, etc.), mirrors, carpets, kitchen utensils, coat racks, curtains, and laundry baskets. The canceling or changing interventions occurred in the form of changes in the flooring, beds, and cabinets. In the expansion intervention, volumetric differences with an increase in square meters and the extension of the ceiling forward with a roof have been observed. There were no transformation or partitioning interventions made. It has been determined that the needs for personalization are related to dimensional adequacy, the number of people using the space, clean water supply, temperature/rainfall, visual comfort, structural integrity, theft prevention, visual privacy, auditory privacy, personal privacy, subjective values necessary for the action areas of individuals, and values based on visual impact. These five containers, various forms of personalization are observed, including positional differences in the area, an increase in the number of areas, volumetric differences, and changes on the wall, flooring, and ceiling. Additionally, various items such as beds, folding tables, shoe racks, sofas/armchairs, chairs, cabinets, shelves, kitchen cabinets, kitchen utensils, carpets, facade additions (fences, tarpaulins, etc.), and curtains have been added. Among the most frequently added items are kitchen utensils and furniture, particularly kitchen cabinets, refrigerators, and washing machines, which have been added frequently by users. The interventions made in these containers include common practices such as additions, changes in the flooring, and changes on the wall and ceiling. Furthermore, expansion interventions such as volumetric increases and increases in square meters have also been observed. However, transformation and partitioning interventions have generally not been made. In terms of personalization needs, factors such as dimensional adequacy, the number of people using the space, clean water supply, temperature/rainfall, visual comfort, auditory comfort, structural integrity, theft prevention, accidents that may occur during actions, visual privacy, auditory privacy, personal privacy, and individual lifestyle preferences have been collectively identified.

4. Conclusion and Suggestions

The ability of disaster victims to maintain their daily routines and habits in temporary housing areas contributes to their resilience and adaptability in rebuilding their lives after disasters. These factors reduce feelings of insecurity, alienation, and loss of control, providing a sense of belonging and security. This research demonstrates that the personalization phenomena in containers are shaped by various factors such as users' needs, aesthetic preferences, security concerns, and social interactions. It is evident that disaster victims transform standard container units according to their needs, habits, and cultural expectations. In this process, disaster victims create familiar and personal living spaces by transforming the limited spatial conditions in line with their daily needs, habits, and expectations. In this context, it is understood that living spaces are in a constant state of change and transformation as dynamic structures. These findings emphasize the importance of a user-centered approach in architectural and interior design. Containers with the same spatial characteristics can exhibit different forms of personalization and interventions. The differing physical and psychosocial requirements play a significant role here. The additions made in the containers reflect users' needs to enhance their daily living comfort. The frequent addition of kitchen utensils and furniture indicates users' desire to make the space functional. This situation reveals that users continuously make changes to make their living spaces more functional and comfortable. The observed positional differences and volumetric changes in the containers demonstrate the flexibility of the space and its openness to change. This indicates that living spaces can be dynamically restructured and shaped according to users' needs. Particularly, expansion interventions signify users' desire to utilize the space more efficiently. Aesthetic interventions such as changes to walls, flooring, and ceilings are also included among the forms of personalization. It is understood that users are making efforts to personalize their living spaces while prioritizing visual comfort. This situation shows that aesthetic concerns are as important as functionality. The inclusion of elements such as theft prevention, visual, and auditory privacy among personalization needs indicates that users place importance on security and privacy issues. This suggests that living spaces should be evaluated not only in terms of functionality but also in terms of security and privacy. It can be said that the changes made in the containers reflect users' sensitivity to resource management and sustainability. Particularly, the emphasis on clean water supply and structural integrity indicates users' awareness of environmental factors. The increase in the number of areas in the containers highlights the importance of social interaction and space sharing. Users organize their living spaces not only for individual needs but also to enhance social interactions. This situation illustrates how social life interacts with spatial arrangements.

In conclusion, the phenomenon of personalization by disaster victims in containers significantly contributes to their psychological, social, and physical recovery processes. In this context, it is essential that post-disaster housing spaces are designed to allow for personalization. A user-centered approach should be adopted in the design of container living spaces, taking into account the needs and expectations of disaster victims. Proactive measures should be taken before designing temporary housing units. These measures should be based on the experiences of disaster victims without overlooking their needs. At this point, the strategies to be implemented in the designs of temporary housing units are crucial. More livable spaces should be designed by combining existing strategies in the literature with the experiences of disaster victims. It should be noted that while fundamental requirements such as livability and functionality are met, creating common areas that enhance social interaction and increasing security measures will improve the quality of life for disaster victims.

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All authors contributed equally to the article. There is no conflict of interest.

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A Research on Street Design from Public Landscapes; Van (Turkiye) Winter City Example

Betül YILMAZ ASLANOĞLU[1], Feran AŞUR[2]*
ORCID 1: 0000-0001-8210-2446
ORCID 2: 0000-0001-9480-5536
[1] *University of Van Yüzüncü Yıl, Institute of Science , 65080, Van, Türkiye*
[2] *University of Van Yüzüncü Yıl, Faculty of Architecture Design, Department of Landscape Architecture, 65080, Van, Türkiye*
**** e-mail**: feranasur@yyu.edu.tr*

Abstract

The aim of this study is to reveal whether the relationship between the city and climate can be directed with a landscape design approach in order to make the use of public open spaces streets attractive and lively in winter months in the winter city example of Van (Turkey). In this context, Cumhuriyet Street and Maraş Street, which are the busiest and oldest streets of the winter city of Van/Turkey, were determined as the study area. In the method, questions of 17 sub-criteria within the scope of 4 main criteria, which are imageability, visual scale, ephemera and complexity, which are effective in urban design, were directed to experts with a survey study. According to the analysis result, "Imageability" and "Complexity" criteria were significantly perceived as" unfavorable*" for Cumhuriyet Street. However, "Visual Scale" criterion was also significantly perceived as "*unfavorable*" for Maraş Street, apart from "Imageability" and "Complexity" criteria. However, in terms of "Ephemera" criterion, the expert's opinion emerged that it was at "Medium" level for both streets. In line with the evaluations made, landscape design proposals were developed by selecting 7 featured areas for the landscape design proposal projects of Cumhuriyet and Maraş Streets, aiming to improve the public landscape in a climate-based, functional and aesthetically compatible way with the winter city in order to increase the quality of urban life.*

Keywords: *Public open space, urban landscape, winter city, landscape design.*

Kamusal Peyzajlardan Cadde Tasarımı Üzerine Bir Araştırma; Van (Türkiye) Kış Kenti Örneği

Öz

Bu çalışmanın amacı,Van (Türkie) kış kent örneğinde kamusal açık alanlardan caddelerin kullanımını kış aylarında çekici ve canlı kılmak için kent ve iklim arasındaki ilişkinin peyzaj tasarımı yaklaşımıyla yönlendirilip yönlendirilemeyeceğini ortaya koymaktır. Bu bağlamda kış kenti olan Van/Türkiye'nin en işlek ve en eski caddeleri olan Cumhuriyet Caddesi ve Maraş Caddesi çalışma alanı olarak belirlenmiştir.Yötemde ise kentsel tasarımda etkili olan görsel peyzaj kalite kriterlerinden imgelenebilirlik, görsel ölçek, efemera ve karmaşıklık toplamda 4 ana kriter kapsamında 17 alt kriterin soruları anket çalışmasıyla uzmanlara yöneltilmiştir. Analiz sonucuna göre Cumhuriyet Caddesi için "İmgelenebilirlik" ve "Karmaşıklık" kriterleri önemli derecede "olumsuz" algılanmıştır. Ancak Maraş Caddesi için "İmgelenebilirlik" ve "Karmaşıklık" kriterleri dışında "Görsel Ölçek" kriteri de önemli derecede "olumsuz" algılanmıştır. Bununla birlikte "Efemera" kriteri bağlamında uzman tarafından her iki cadde için de "Orta" düzeyde olduğu görüşü ortaya çıkmıştır. Yapılan değerlendirmeler doğrultusunda kentsel yaşam kalitesinin artırılmasına yönelik kamusal peyzajın iklim temelli, işlevsel ve estetik açıdan kış kentiyle uyumlu olarak iyileştirilmesine yönelik Cumhuriyet ve Maraş Caddeleri peyzaj tasarım öneri projeleri için 7 özellikli alan seçilerek peyzaj tasarım önerileri geliştirilmiştir.

Anahtar kelimeler: *Kamusal açık alan, kentsel peyzaj, kış kenti, peyzaj tasarımı.*

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1. Introduction

Urban design is an action that should be handled within team discipline as an element of planning with the physical structure of the city, together with the art of creating a place within the city (Çubuk, 2015). In this context, Moughtin (2003) stated that urban design, similar to art and architecture, is the organization of urban spaces in order to organize and protect the environment for economic and social needs. Tveit et al., (2006) define nine basic concepts and visual quality characters to describe the visual aspects of landscape in general and relate quantitative pattern analysis to qualitative landscape preferences. These nine concepts are historicity, consistency, complexity, management, deterioration, visual scale, naturalness, imageability and ephemera.

The growth of urbanization and the cold climate restrict pedestrian mobility in the city (Yılmaz et al., 2021). If the appropriate building materials are selected in multifunctional designs that allow different activities to take place in public open spaces in winter cities, these areas will also be actively used in winter months (Erskine, 1986; Urban Systems, 2000; Yannas, 2001; Bergum & Beaubien, 2009). For example, if more comfortable materials such as wood, polyethylene or metal covered with vinyl are chosen for urban furniture in parks and squares, the use of these spaces will increase in winter (City of Minneapolis, 2011; Pressman, 2015; Pressman, 2016; Tan & Giresun, 2016).

Plant species in winter cities have important roles in determining the livability level of urban areas in terms of aesthetic, ecological and functional characteristics. Open and green spaces also affect air temperature and surface temperatures (Stathopoulou & Cartalis, 2009; Hu & Jia, 2010; Dimoudi & Nikolopoulou, 2003; Johansson & Emmanuel, 2006; Coleman, 2009; Shashua Bar, et al., 2009; St. Clair, 2010; Gencer & Akpınar Külekçi, 2023).

The first quantitative classification of world climate was developed by Wladimir Köppen in 1900 (Kottek et al., 2006). With the development of different classifications since then, modifications based on Köppen's original approach are still one of the most used classifications (Belda et al., 2014). As a result of the research on the study area, the Ministry of Agriculture and Forestry, General Directorate of Meteorology (2018) and Öztürk et al. (2017) it is revealed that Van/Türkiye is in the Dcbo climate class in Climate Type and Climate Characteristics According to Köppen-Trewartha. In this context, Cumhuriyet Street and Maraş Street, which are located in the city center of Van, are one of the oldest streets in Van, have very intense usage and are known by the public, have been examined. In the study; Within the scope of landscape design for public open spaces, within the scope of visual landscape quality criteria, in line with expert opinions, it is the development of suggestions for making the open spaces on these streets attractive in the winter months and revitalizing them. At the same time, it draws attention to the climate-effective design principles that must be followed for public open spaces in winter cities during the urbanization process and reveals alternative landscape design proposals for winter city life quality standards.

2. Material and Method

The main material of this study consists of Cumhuriyet and Maraş streets, which are located in the İpekyolu district and are important streets in the İpekyolu central district of Van (Figure 1).

On Cumhuriyet Avenue, which is approximately 3 km long, there are important structures such as the Tekel building, one of the civil architectural structures of Van's early Republican period, the Government House and the Central Bank from the recent past. Located in the city center of Van, Maraş Street is a street with heavy pedestrian and vehicle traffic and its length is approximately 1.80 km. Since most of the commercial activities in the city are located here and shopping areas are located on this street, it is a public space that serves the city's users.

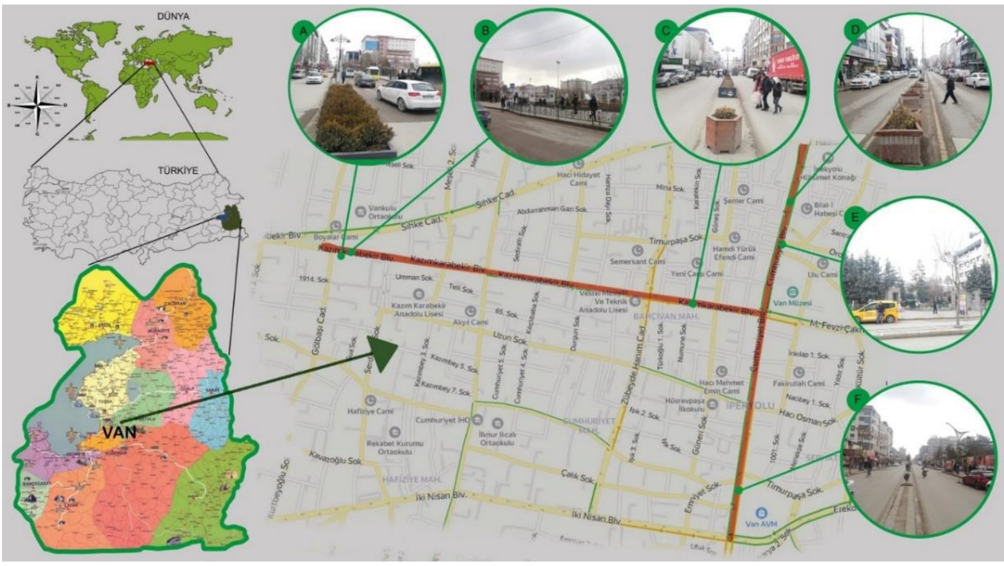

Figure 1. Location of the study area (original)

In laying out the method Hanyu (2002), Ewing (2006), Tveit et al. (2006), Rehan (2013), Hansen (2014); Bereitschaft (2017), Cengiz & Keçecioğlu (2017), Cengiz et al. (2018), and Yazici & Aşur (2021) studies were used. In line with the urban design visual quality criteria, from the relevant occupational groups living in Van; Survey questions were applied to a total of 25 experts, including Landscape Architect (10 persons), Architect (6 persons), City Planner (5 persons), Survey Engineer (4 persons) and so on.

The questionnaires were arranged according to the 5-point Likert scale. Experts made their selection based on a rating between very unfavorable and extremely beautiful with corresponding photos. Questionnaires were conducted via e-mail and oral interviews. The questionnaires were evaluated with Frequency Analysis in SPSS 22 package program. The questionnaire consists of two parts, a total of 22 questions. The first part consists of 5 questions about the demographic structure for experts, and the second part consists of a total of 17 questions about the quality criteria of urban design. In this evaluation, questions of 17 sub-criteria were asked within the scope of 4 main criteria in total: imaginability (5 questions), visual scale (4 questions), ephemera (4 questions) and complexity (4 questions).

3. Findings and Discussion

3.1. Expert Evaluation According to Urban Design Visual Quality Criteria

The survey results of the expert evaluation of the selected photographs for 17 sub-criteria within the scope of the definitions of the urban design quality criteria “Imageability”, “Ephemera”, “visual scale” and “complexity” are given in this section.

The images related to “Imaginability” of Cumhuriyet Street are given in Table 1. The table includes areas that express an urban area, unique identity or “sense of space”.

Table 1. Images of Cumhuriyet Street according to the "Imaginability" criteria (original)

	1st Section of Cumhuriyet Street	2nd Section of Cumhuriyet Street
Vitality		
Spirit of place		
Structures with identity		
landscape element attribute		
Square, pocket park		

The images related to “Visual Scale” of Cumhuriyet Street are given in Table 2. The table includes areas that reflect visibility and openness experience with perceptual units, visibility dimensions, number of objects that block depth of view, displayed size, potential indicators.

Table 2. Images of Cumhuriyet Street according to the "Visual Scale" criteria (original)

	1st Section of Cumhuriyet Street	2nd Section of Cumhuriyet Street
Openness		
Visibility		
Perspective fields		
Average building height		

The images related to “Ephemera”” of Cumhuriyet Street are given in Table 3. The table includes images that reflect short-term effects that contribute to landscape perception in response to landscape changes and seasons and weather conditions throughout the year.

Table 3. Images of Cumhuriyet Street according to the "Ephemera" criteria (original)

	1nd Section of Cumhuriyet Street	2nd Section of Cumhuriyet Street
Winter images		
Spring images		
Night images		
Daytime images		

Some images related to “Complexity” of Cumhuriyet Street are given in Table 4. The table provides images of regular complexity or irregular complexity in terms of the number of different visual elements from the area.

Table 4. Images of Cumhuriyet Street according to the "complexity" criteria (original)

	1st Section of Cumhuriyet Street	2nd Section of Cumhuriyet Street
Color harmony of buildings		
Distribution of structures		
Artistic elements		
Harmony of structures		

The visuals related to “Imaginability” of Maraş Street are given in Table 5. The table includes areas that express an urban area, unique identity or “sense of space”. The visuals related to “Visual Scale” of Maraş Street are given in Table 6.

Table 5. Images of Maraş Street according to the "Imaginability" criteria (original)

Maraş Street			
Vitality		Spirit of place	
Structures with identity		Landscape elements	
Square, pocket park			

Table 6. Images of Maraş Street according to the "Visual scale" criteria (original)

Maraş Street			
Openness		Visibility	
Perspective fields		Average building height	

The images related to "ephemera" of Maraş Street are given in Table 7. Some images related to "Complexity" of Maraş Street are given in Table 8.

Table 7. Images of Maraş Street according to the "Ephemera" criteria (original)

Maraş Street			
Winter images		Spring images	
Night images		Daytime images	

Table 8. Images of Maraş Street according to the "complexity" sub-criteria (original)

Maraş Street			
Color harmony of buildings		Distribution of structures	
Artistic elements		Harmony of structures	

3.2. Evaluation Results For Cumhuriyet And Maraş Streets

Regarding the expert evaluation of urban design quality criteria, landscape architects participated in the survey at the highest rate with 40%, and survey engineers at the lowest rate with 16%.

-***Reviews results for Cumhuriyet Street***: One of the sub-criteria of the imaginability criterion for Cumhuriyet Street; According to the answers given in the categories of vitality, spirit of place (Genius loci), adequacy of the number of buildings with an identity on the street, quality of landscape elements, square on the street, pocket park, adequacy of parks, it was evaluated as “unfavorable” with a rate of 41% in terms of imageability. The spirit of place (Genius loci), one of the sub-criteria, was perceived as "moderate" with a high rate of 68%. Likewise, with a high rate of 68%, the adequacy of squares, crossroads, pocket parks and parks on the street were described as " unfavorable" in terms of sub-criteria. One of the sub-criteria of the visual scale criterion for Cumhuriyet Street: openness, visibility, distribution of the areas forming perspective, according to the answers given in the categories of average building height on the street, in terms of visual scale, 43% were evaluated at "moderate" level. In terms of the distribution of the perspective areas, among the sub-criteria, as high as 60% were described as “unfavorable”.

According to the answers given in the sub-criteria of the ephemera (temporariness) criterion for Cumhuriyet Street: spring images, winter images, night images, day images, it was evaluated as "moderate " in terms of Ephemera with a rate of 47%. Among the sub-criteria, Seasonal change: spring images were perceived as "moderate" by 64%. In the scoring made according to the "Night images" sub-criterion among the images for Cumhuriyet Street, the "beautiful" option was marked at the highest rate of 44%.

According to the answers given in the sub-criteria of the complexity criterion for Cumhuriyet Street: color harmony of the buildings in the whole street, distribution of the buildings in the whole street, number of artistic elements, general combination/harmony of the buildings with each other, it was evaluated as "unfavorable" with a rate of 63% in terms of complexity. Among the sub-criteria: distribution of buildings in the whole street, number of artistic elements, and general harmony of buildings with each other, 64% were perceived as " unfavorable".

Review results for Maraş Street: One of the sub-criteria of the imageability criterion for Maraş Street; According to the answers given in the categories of liveliness, spirit of place (Genius loci), adequacy of the number of buildings with identity on the street, quality of landscape elements, adequacy of squares, crossroads, pocket parks and parks on the street, it was evaluated as "unfavorable" with a rate of 58% in terms of imageability. Among the sub-criteria, the adequacy of squares, crossroads, pocket parks and parks on the street was perceived as "unfavorable" with a high rate of 84%. For Maraş Street, the sub-criterion of the imaginability criterion, "vitality", was marked as "moderate" at the highest rate of 40%. At the same time, in the scoring made according to the "spirit of the place" sub-criterion, the "unfavorable" option was marked at the highest rate of 48%.

According to the answers given in the sub-criteria of the visual scale criterion for Maraş Street: openness, visibility, distribution of areas creating perspective, and average building height on the street, it was evaluated as "unfavorable" with a rate of 53% in terms of Visual Scale. Among the visual scale sub-criteria, visibility was perceived as "unfavorable" with a rate of 53%.

According to the answers given in the sub-criteria of the ephemera criterion for Maraş Street: spring images, winter images, night images, day images, it was evaluated as "moderate" in terms of Ephemera with a rate of 41%. Among the sub-criteria, the highest rate was night images perceived as "moderate" with 52%. In the scoring made according to the "winter images" criterion from Maraş Street, the "beautiful" option was marked at the highest rate of 36%. According to the answers given in the sub-criteria of the complexity criterion for Maraş Street: color harmony of the buildings in the whole street, distribution of the buildings in the whole street, Number of artistic elements, general combination/harmony of the buildings with each other, it was evaluated as "unfavorable" with a rate of 57% in terms of complexity. Among the sub-criteria, the highest rate was the number of artistic elements, which was evaluated as "unfavorable" with 76%.

4. Evaluations For Cumhuriyet And Maraş Street Landscape Design

It has been revealed that both streets lack an open public space in the form of a square where people can gather and carry out various social activities. In this context, the lack of streets and social activity areas where street users can gather alienates city people. Designing and implementing the area as a square, which can appeal to the whole city, will be able to meet the needs of city users in this regard. In this sense, if the structural and vegetal design of the square is designed taking into account the winter city design criteria, an area will be provided that will ensure the city user's desire to spend time in the open public area and increase the quality of life during the winter months.

4.1. Expert Opinion Evaluations in The Context of Urban Design Quality Criteria

When expert opinions were evaluated in the context of urban design quality criteria, it was revealed that none of the main criteria "Imagability", "Visual Scale", "Ephemera" and "Complexity" were perceived as very unfavorable, but neither were they perceived as very good. Van winter city landscape design recommendations have been developed in line with the deficiencies that emerged as a result of expert opinion evaluations in the context of urban design visual quality criteria.

For Cumhuriyet Street, the “Imagability” and “Complexity” criteria were perceived significantly poorly. However, for Maraş Street, apart from the "Imaginability" and "Complexity" criteria, the "Visual Scale" criterion was also perceived as significantly "unfavorable". However, in the context of the "Ephemera" criterion, the expert concluded that it was at a "moderate" level for both streets.

It has been revealed that the "Square, Junction, Pocket Parking, Adequacy of Parks" sub-criterion of the imageability criterion is perceived as "unfavorable" at a high rate for Cumhuriyet and Maraş streets. Therefore, the creation of spaces such as squares and pocket parks will play an effective role in eliminating this important deficiency for both streets.

Regarding the complexity criterion; It is meaningful that all of the sub-criteria such as the color harmony of the buildings in the street and the distribution of the buildings, the number of artistic elements, and the general harmony of the buildings with each other are stated as "unfavorable" in the opinion of the experts for both streets.

Since the "Distribution of areas that create perspective" sub-criterion from the visual scales was perceived as "unfavorable" at a high rate for both streets, it became clear that a design should be made to increase this effect positively. Regarding the ephemera criterion, important data was obtained for both streets, such as seasonal changes in "spring images" and "winter images". For this reason, designs aimed at increasing the quality of images in the winter months of Van winter city have led to the designs that will be very effective for the two streets.

4.3. Cumhuriyet And Maraş Street Landscape Design Proposal

In the study, the parks on the street were a factor that guided the design. For this reason, designs related to the City Park, Feqiye Teyran and Art Park in the study area were carried out. The landscape design proposal was made for the following strategies:

• Preservation of the living texture of the landscape on both sides of the streets for four seasons,

•Making a green band arrangement that will separate pedestrian and vehicle paths,

• Including lighting elements with high visual impact on the right and left sides of the streets,

• Using materials that are adapted to cold seasons on pedestrian paths,

• Elimination of negative images on the street by placing appropriate billboards at bus stops.

- Structural Design Models: In the study, floor covering, facade covering materials and reinforcement elements were proposed in the context of structural design, taking into account adaptation to Van's cold climate conditions and urban texture (Figure 2 and Figure 3). For these two streets, which do not have sufficient seating units, a series of sculptural seating units and armchairs were designed to provide passers-by with places to rest and gather (Figure 4).

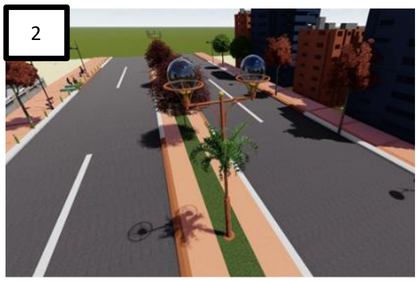

Figure 2. Lighting element design example. **Figure 3.** Bus stop design example. **Figure 4**. Example of seating unit and flooring (original).

-Planting Design: Equally important is the selection of species that ensure a lively landscape in all seasons in the green strip and median arrangement that will separate pedestrian and vehicle paths on the sidewalks on the street. Ornamental plants that can be used in plant design for Cumhuriyet and Maraş streets are: Deciduous (tree/shrush): *Acer platanoides, Acer saccharinum, Betula pendula, Buxus sempervirens, Crataegus orientalis, Forsythia* intemedia, *Malus floribunda, Cornus alba, Cotinus coggyrigra*. And evergreen (tree/shrush): *Abies concolor, Pinus sylvestris, Thuja occidentalis, Picea orientalis, Pinus mugo compacta, Juniperus oxycedrus, Juniperus communis nana, Juniperus communis.*

5. Conclusion and Recommendation

Landscape design proposals and 3D visuals were produced for Cumhuriyet and Maraş Streets based on the results of spatial analysis and expert evaluation. 7 featured areas were selected for the landscape design proposal projects of Cumhuriyet and Maraş Avenues. An example design of a square, a pocket park and a landscape unit in selected areas is included. The locations of these 7 areas are presented in Figure 5.

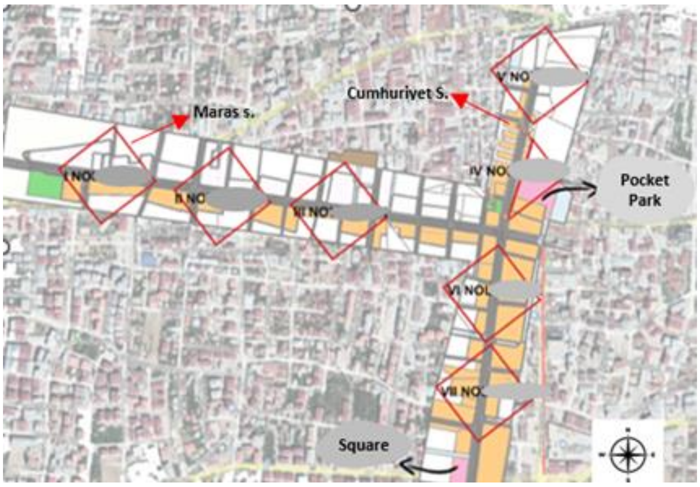

Figure 5. Locations of featured areas selected for landscape design proposals.

Area No. 1: The current status and recommendation visual is presented in Figure 6.

Figure 6. 3d simulation of Maraş Street 1 area (original).

Area No. II: The current status and recommendation visual is presented in Figure 7.

Figure 7. 3d simulation of Maraş Street II area (original).

Area No. III: The current status and recommendation visual is presented in Figure 8.

Figure 8. 3d simulation of the landscape unit of Cumhuriyet Street No. III. (original)

Area No. IV: The current status and recommendation visual is presented in Figure 9.

Figure 9. 3d simulation of Cumhuriyet Street No. IV. (original)

Area No. V: The current status and recommendation visual is presented in Figure 10.

Figure 10. The 3d simulation of Cumhuriyet Street No. V. (original)

Area VI: The current status and recommendation visual is presented in Figure 11. The plan and 3d simulation winter image of the landscape design proposal of Area VI on Cumhuriyet Street is presented in Figure 12.

Figure 11. 3d simulation of the square belonging to Cumhuriyet Street No. VI. (original)

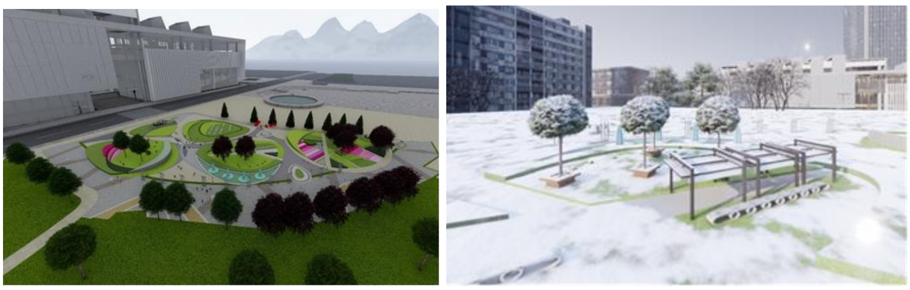

Figure 12. 3d simulation winter image of the square belonging to Cumhuriyet Street No. VI. (original)

Area No. VII: The suggestion visual for the current status of the pocket park and the current status of the empty space in Section 2 of Cumhuriyet Street is given in Figure 13.

Figure 13. 3d simulation of the pocket park belonging to Cumhuriyet Street No. VII. (original)

In line with the results, harmonious structural design models and plant design elements were proposed within the scope of the winter city, and landscape design proposals for 7 featured areas for Cumhuriyet and Maraş Avenues were developed. Among these areas, a landscape design was proposed in the place where the suitability of a square in the city of Van was determined. It is also thought to be a potential solution to the lack of urban open space as a pocket park and a pedestrian stop.
A number of common concepts and results focused in this study are seen in the studies of Alper and Yılmaz (2004). Accordingly, in the winter city of Erzurum, for the correct and purposeful coloring of public landscapes, the use of attractive urban furniture, lighting, traffic lights and signs, building facades and surfaces, green areas, commercial areas, billboards and billboards and all these formations; landscape architects, urban designers, architects and environmental designers, urban furniture designers should be designed in cooperation. In a similar study, Tandoğan and Şişman (2018) emphasized that public spaces designed with the right plant design and compatible with the climate conditions in winter cities will encourage urban users to spend more time outdoors due to their spatial activities and make it possible to provide more livable urban areas. However, Yılmaz et al. (2020) followed a different path in creating public landscapes in their work. In this study, they designed a new indoor landscape area within the scope of Year-round Landscape / Landscape 12 concept, since there are no recreational areas to be used in every period of the year in Erzurum, where winter conditions are difficult. They argued that this area would create an important brand for the city, bring a new breath, serve all regions in the city, provide an important tourism opportunity to the city, and close the city's need for recreation. The methods, findings and design process applied in this study partially overlap with the studies of Özden and Velibryoğlu (2023). They also applied an urban design project by combining objective indicators and subjective perception in their studies in the joint design process. The experimental collaborative urban design process was carried out on a democratic platform based on the participants' tendencies and expectations.

This study constitutes important stages in determining the problems, examining international and national practices, producing appropriate spatial solutions, and landscape design proposals made within the scope of landscape architecture principles. Landscape designs have been developed in line with the principles of sustainability, functionality and increasing visual quality. Thus, it is thought that open public spaces will be more attractive, high quality, livable, social and cultural activities can be done in winter as in other seasons, and will provide vitality.

As a result, this study, which is important for the quality of urban life in winter cities; For regions with similar characteristics, it is thought that the existing public landscapes will be improved in terms of climate-based functional and aesthetic and it will create a base that will increase the quality of life in open public spaces in the region. To get the full payoff for the proposed work on the public landscape, public infrastructure projects need to work year-round, not just for our summer conditions. In this context, the need for local municipalities to prepare urban design guides in this direction also arises. It is also recommended to work on winter design brochures that will be widely distributed to residents to ensure that all city users also understand the benefits of designing for the winter. In this context, the relevant managers and stakeholders in the winter cities will be able to ensure the active use of the open public spaces in these cities in all seasons of the year by complying with the design criteria.

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Ethics Committee approval was not required for the study.

Author Contribution and Conflict of Interest Declaration Information

All authors contributed equally to the article. There is no conflict of interest.

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Impact of Change in Tree Canopy Cover on Ecosystem Services in Desert Cities: A Case in Phoenix, USA

Rifat OLGUN [1*], Nihat KARAKUŞ [2]

ORCID 1: 0000-0002-5396-057X
ORCID 2: 0000-0002-6924-1879
[1,2] *Akdeniz University, Vocational School of Serik G-S. Sural, 07500, Antalya, Türkiye.*
*** e-mail**: *rifatolgun@akdeniz.edu.tr*

Abstract

The study aims to answer the question of how the change in tree canopy cover in desert cities due to the urbanization process affects ecosystem services. The city of Phoenix, which is located in the northern part of the Sonoran Desert in the southwestern United States, was determined as the study area. The i-tree canopy software was used to assess the 20-year (2004-2023) change in the tree canopy cover of the Phoenix and to calculate the ecosystem services and benefits obtained from trees. The findings show that the tree canopy cover in the study area decreased by 58.26 km^2 (4.34%) in 20 years. Therefore, the amount of carbon sequestration, the rate of removing air pollution, and the hydrological benefit values of trees decreased. The results obtained from the study will contribute to decision-makers and planners in urban planning processes in regions with similar ecological characteristics.

Keywords: *Urbanization, ecosystem services, desert city, i-tree canopy.*

Ağaç Kanopi Örtüsündeki Değişimin Çöl Kentlerindeki Ekosistem Hizmetleri Üzerine Etkisi: Phoenix, ABD Şehri Örneği

Öz

Çalışma, kentleşme sürecine bağlı olarak çöl kentlerindeki ağaç örtüsünde meydana gelen değişimin ekosistem hizmetlerini nasıl etkilediği sorusuna cevap bulmayı amaçlamaktadır. Bu kapsamda Amerika Birleşik Devletleri'nin güneybatısındaki Sonoran Çölü'nün kuzey kesiminde yer alan Phoenix şehri çalışma alanı olarak belirlenmiştir. Phoenix'in ağaç örtüsündeki 20 yıllık (2004-2023) değişimi değerlendirmek ve ağaçların ekosistem hizmetlerini ve ekonomik fayda değerlerini hesaplamak için i-tree canopy yazılımı kullanılmıştır. Çalışmanın bulguları çalışma alanındaki ağaç örtüsünün 20 yılda 58,26 km^2 (%4,34) azaldığını göstermektedir. Buna bağlı olarak ağaçların karbon tutma miktarı, hava kirliliğini giderme oranı ve hidrolojik fayda değerleri azalmıştır. Çalışmadan elde edilen sonuçlar, benzer ekolojik özelliklere sahip bölgelerdeki kentsel planlama süreçlerinde karar vericilere ve planlamacılara katkı sağlayacaktır.

Anahtar kelimeler: *Kentleşme, ekosistem hizmetleri, çöl kenti, i-tree canopy.*

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1. Introduction

Ecosystems are a whole in which each component is interdependent and interacts with each other (Yılmaz Kaya & Uzun, 2019). Ecosystems provide many benefits to humans and other living things in their environments (Dinç, 2023). These benefits, which occur as part of the natural processes that continue in ecosystems, are defined as ecosystem services. Regulatory ecosystem services provided by ecosystems have an important role in reducing the impacts of climate change in cities and increasing the resilience of cities against these impacts (Tzoulas et al., 2007; Hansen et al., 2019). Among the services that ecosystems provide as regulators; are improvement of air and soil quality, climate regulation, mitigation of natural disasters such as floods and landslides, disease control, water purification, waste management, pollination/pollination, biodegradation or control of harmful species, etc. (Benedict & McMahon, 2002; Davis et al., 2009; Pugh et al., 2012; Wagner & Breil, 2013; Eckart et al., 2017). However, in the last quarter century, natural areas are being damaged and forests, agricultural, and wetlands areas are decreasing or disappearing due to rapidly increasing urbanization and population density in the world (Liu et al., 2023; Esendağlı & Selim, 2024; Moazzam & Lee, 2024). Thus, these changes in land cover and land use over time lead to degradation and damage of ecosystems at local and regional levels.

The green areas in cities including parks, recreation areas, urban forests and agricultural areas are land uses that provide important ecosystem services (Eyileten et al., 2022; Çakır & Gül, 2024). The vegetation in these areas contributes to the sustainability of ecosystem services such as reducing air pollution, controlling rainwater, storing carbon, reducing land surface temperature, providing bioclimatic comfort and protecting biodiversity (Ekwe et al., 2021; Tuğluer & Çakır, 2021; Dadashpoor et al., 2024). Especially in desert cities, trees are of great importance because they reduce the reach of solar radiation to the land surface, provide a cooling effect on the urban environment through evaporation and transpiration, and are home to many living species (Wang et al.; 2018; Yu et al., 2020; Shahfahad et al., 2022).

There are various mathematical methods for quantifying the ecosystem services provided by trees (Ahern et al., 2014). One of these methods is the “i-tree canopy model”, which is based on tree canopy cover to calculate the benefits of trees for ecosystem services such as air pollution, hydrological impacts and carbon balance. This model is used to obtain statistical data on the benefits of trees to the ecosystem and to calculate the economic value of these ecosystem services to the region (Coşkun Hepcan & Hepcan, 2017; Ersoy Tonyaloğlu & Atak, 2021; Alpaidze & Salukvadze, 2023). In this context, the i-tree canopy software was developed by the U.S. Department of Agriculture Forest Service to create the necessary data infrastructure and perform statistical analyses (Cakmak & Can, 2020). Thus, the measurement and calculation of tree canopy cover, which is difficult and costly to measure through software, has become both economical and faster (Parmehr et al., 2016; Riemann et al., 2016; Atasoy, 2020).

It is observed that i-Tree Canopy software has been used in many of the recent academic studies on mapping tree canopy cover and estimating ecosystem services. In this context, the study conducted by Ersoy Tonyaloğlu and Atak (2021) in Aydın/Turkey has evaluated the effects of land cover change on urban tree cover and the ecosystem services they provide in the case of Efeler District of Aydın Province between 2004-2021. Costemalle et al. (2023) estimated the ecosystem services provided by urban and peri-urban forests of Juiz de Fora/Brazil. In Suwon, Republic of Korea, Kim and Kang (2022) assessed the impact of the change in tree canopy on ecosystem services between 2003 and 2021. They evaluated the contribution of green roofs to the ecosystem services of the tree canopy. Atasoy (2020) estimated urban tree cover and impervious surface cover density using i-tree canopy software and assessed how these affect forest gain and loss in Turkey. Tbilisi's green cover was estimated and surface cover classes, volumes and ecosystem services were determined by Alpaidze and Salukvadze (2023). While evaluating the impact of residential cover and urban growth form on runoff in urban areas, Xu et al. (2020) quantified the surface cover characteristics of Munich/Germany through 'i-Tree Canopy' based on high-resolution aerial imagery. The i-tree canopy software was utilized to determine the regulatory ecosystem services for improving air quality in Ankara/Turkey by Cakmak and Can

(2020), to measure the ecosystem services of Mirador Sur Park/Santo Domingo park by Mancebo and Liz (2022), and to determine the benefits of urban trees for improving air quality in Curitiba and São Paulo cities of Brazil by Ribeiro et al. (2023). Moreover, Tülek (2022) evaluated the contribution of the vegetation cover of trees and shrubs in Wageningen/Netherlands to regulatory ecosystem services for air quality improvement.

The impact of urbanization on ecosystem services and ecological structure depends on the climatic conditions of the region, even if the land uses of the regions are similar. Because, there are significant differences between the natural land cover in humid regions with heavy rainfall and the natural land cover in desert cities. Therefore, the impact of urbanization in desert cities and the ecosystem benefits provided by natural vegetation are not similar to those in regions with other climate types.

The Earth's surface is about 29% covered by land and about 33% of this land surface is covered by deserts (Alsharif et al., 2020). Therefore, understanding the functions, global roles and values of deserts and managing them sustainably is important for biodiversity, geodiversity and ecosystem services (United Nations, 2010; Durant et al., 2012; Lortie et al., 2020). Major deserts in the world are distributed in the Sahara, Arabian Peninsula, Western Asia, Southwest Africa, Central and Southern Australia, Argentina, Southwestern United States and Northern Mexico (Keith et al., 2020). In this context, Phoenix, which is located in the northern part of the Sonoran Desert in the southwestern United States and is the hottest city in America, was determined as the study area. The study aims to answer the question of how the change in tree cover due to the urbanization process affects ecosystem services and what its economic value is.

2. Material and Method

2.1. Study Area

The City of Phoenix, located at the northern edge of the Sonoran Desert and the capital of the state of Arizona, is determined as the study area. Its latitude and longitude coordinates are 33.448376 and -112.074036 respectively (Anonymous, 2024). Although much older than its colonial founding, European settlers founded Phoenix in 1867 as an agricultural community and it became a city in 1881 (Figure 1). In 1889, Phoenix became the capital of Arizona. Especially until the 2nd half of the 20th century, agricultural activities were the main source of income for the region. Phoenix had a low population growth rate for many years. However, the development of air conditioning along with other technologies has led to rapid population growth and urbanization in recent years (Falcone et al., 2020; Helmrich et al., 2023; Olgun et al., 2024a).

Figure 1. Aerial view of downtown Phoenix, Arizona (Kwak, 2016)

Phoenix is the most populous city in the state of Arizona, with 1,608,139 residents as of 2020. The female population living in the region is 49.7% of the city's population. The city's population consists of 25.3% of people under the age of 18 and 11.1% of people aged 65 and over. Moreover, 42.7% of the population is Hispanic (U.S. Census Bureau, 2020).

Phoenix has a subtropical desert climate with very hot and dry summers and mild winters. Therefore, it is one of the hottest regions in the United States (Arizona State Climate Office, 2023). The average temperature in Phoenix exceeds 38 °C for 110 days during the year and reaches 43 °C or higher for 18 days (Zhang et al., 2017). The average annual rainfall is approximately 210.82 mm. Most of the rainfall occurs during the winter season and the summer monsoon season (Meerow et al., 2021; Helmrich et al., 2023; National Weather Service, 2023). Due to the rapid urbanization in Phoenix over the last 50 years, the average daily air temperature has increased by 3.1°C and the night minimum temperature by 5°C (Brazel et al., 2000). Studies have shown that the urban heat island effect will increase in the next decades due to climate change and increasing urbanization, and water withdrawals will also occur (Zhang et al., 2017; Dinç, 2024) (Figure 2).

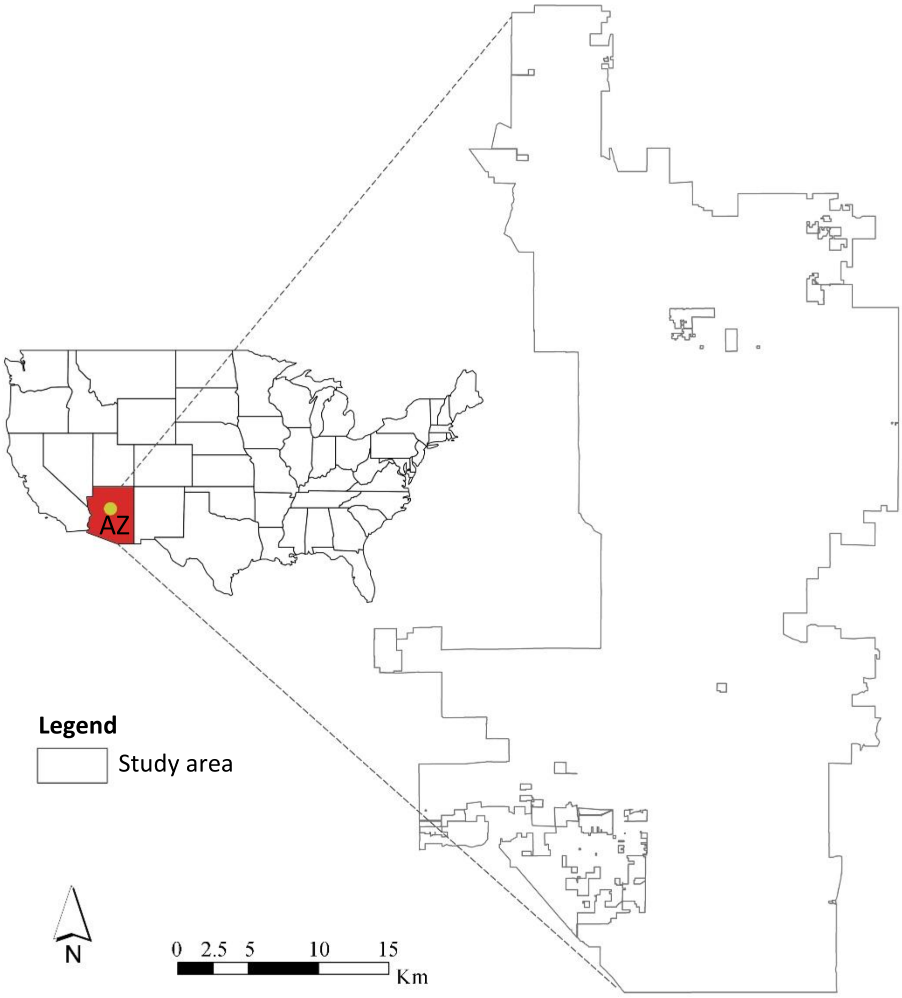

Figure 2. Map of the study area boundary in Phoenix, AZ, USA (Olgun et al., 2024a)

2.2. Method

The study was carried out in 3 stages. In the first stage of the study, the literature on the study topic and the study area was reviewed and systematically evaluated. In the second stage of the study, the land cover in the study area was classified using a random point sampling approach using satellite images from 2004 and 2023. Then, the percentage of land cover types, ecosystem services (carbon storage and sequestration, air pollution removal and hydrological benefits) and economic benefits of trees were statistically calculated for two different years. In the last stage of the study, the results obtained were evaluated and recommendations were developed.

The i-Tree Canopy 7.1 software, originally designed by the USDA Forest Service and later updated by The Davey Tree Expert Company, was used to assess tree cover in the study area. This tool uses current Google Maps aerial imagery to assess land cover. Several land cover types were identified in the study, including Tree, Grass/Herbaceous, Impervious Buildings, Impervious Road, Impervious Other, Bare

Land Cover and Water (Table 1). The software then randomly placed points in the study area and the researcher classified each point according to the respective land cover type.

Table 1. Cover classes used for land cover assessment (i-Tree Canopy, 2024)

Abbr.	Cover Class	Description
T	Tree	This cover class is used to identify plants with canopy cover
H	Grass/Herbaceous	This cover class is used to define areas covered with grass or ground cover vegetation
IB	Impervious Buildings	This cover class is used to define buildings.
IR	Impervious Road	This cover class is used to define roads (streets, sidewalks or other paved surfaces).
IO	Impervious Other	This cover class includes areas with other impervious surfaces excluding buildings and roads.
S	Soil/Bare Ground	This cover class is used to define soil, non-tree, non-grass/crops
W	Water	This cover class is used to define water body

Approximately 500-1000 survey points are recommended by software developers to assess any region (i-Tree Canopy, 2024). Endreny et al. (2017) state that 500 random points are adequate to survey megacities. In the study carried out by Doick et al. (2017) in the UK, the survey points were determined according to the spatial sizes. It was determined as 400 survey points for areas under 600 ha, 500 survey points for 600-10000 ha, 1000 survey points for areas over 10000 ha, and 3000 survey points for much larger areas. Moreover, Selim et al. (2023) found that 760±32 survey points were sufficient for a 1 ha area and that more than 800 survey points in any area made no statistically significant difference. However, increasing the survey points is important to increase the accuracy of land cover estimation (Parmehr et al., 2016). Therefore, a total of 3000 survey points were assigned throughout the study area (Figure 3).

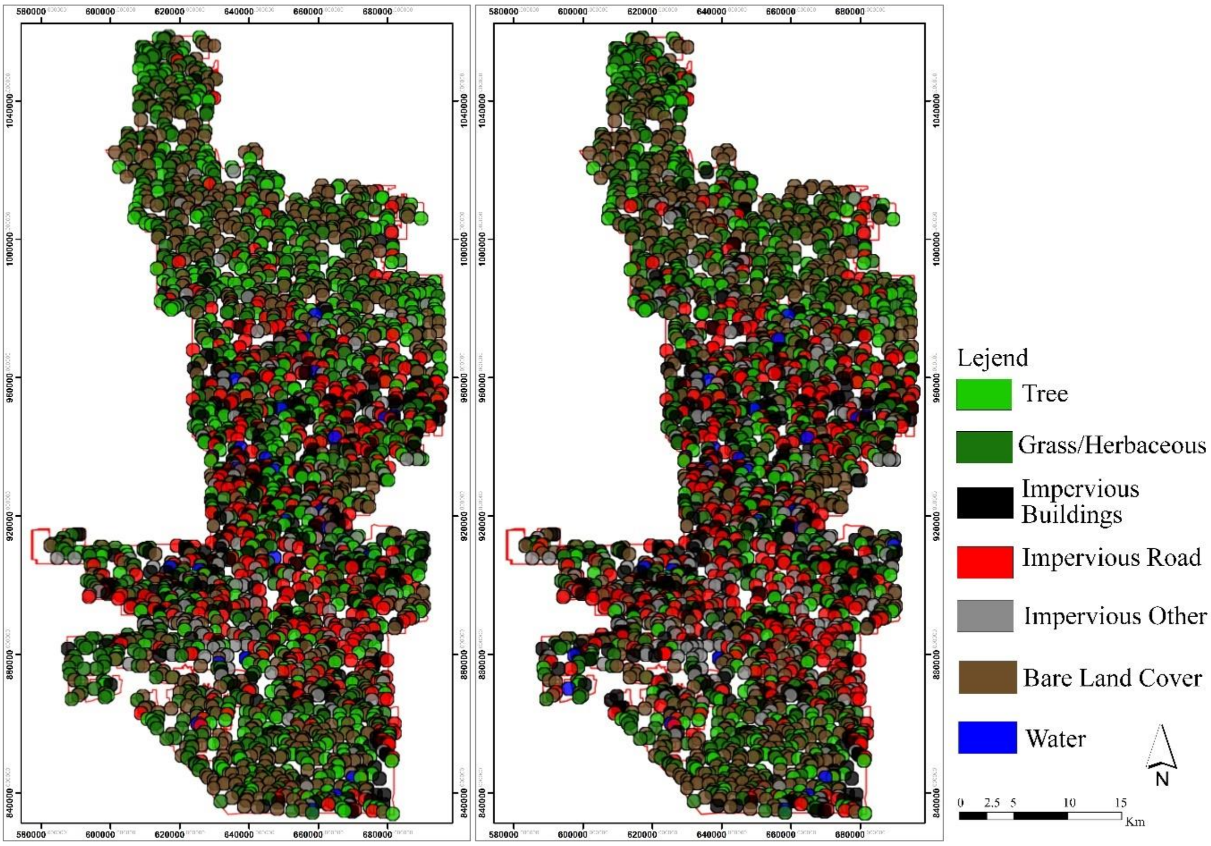

Figure 3. Map of the study area boundary in Phoenix, AZ, USA (Prepared by authors)

To calculate the percent tree cover and Standard Error (SE) using Eq. 1 (i-Tree Canopy, 2024).

$p = n/N \quad q = 1 - p \quad SE = \sqrt{(pq/N)}$ (1)

Where; N represents the total number of sampled points, n represents the total number of points identified as trees.

After determining the current land cover, Google Earth Pro software was used to classify the past land cover. In this context, the geographical coordinates of the existing measurement points were transferred to Google Earth Pro software without changing them. In the software, the land cover classes of the study area in 2004 were compared with 2023. If there was a change in land cover, this change was recorded in the database of i-tree canopy software. Following the 2004 and 2023 land cover classifications, tree benefit values (air pollution benefits, hydrological benefits and carbon benefits) were calculated. The coefficients used in the calculation of tree benefit values differ by region. Therefore, the location of the study area was defined in the program. Then, the benefit values of the tree cover in the study area for 2 periods were calculated through the coefficients defined by region.

3. Findings and Discussion

Increasing population growth in cities and the related increasing rate of urbanization cause changes in the land cover of cities. In the study area, which has a surface area of 1344.56 km^2, the largest land cover was soil in 2023 (368.86 ± 10.95 km^2, 27.43 ± 0.81%) and 2004 (376.03 ± 11.02 km^2, 27.97 ± 0.82%). Tree canopy cover was 15.13 ± 0.65% (203.48 ± 8.80 km^2) in 2023 and it was 19.47 ± 0.72% (261.74 ± 9.72 km^2) in 2004. Tree canopy cover in the study area decreased by 58.26 km^2 (4.34%) over a 20-year period (Table 2).

Table 2. Distribution of land cover classes for 2004 and 2023

Cover Class	2004			2023		
	Points	% Cover ± SE	Area (km²) ± SE	Points	% Cover ± SE	Area (km²) ± SE
T	584	19.47 ± 0.72	261.74 ± 9.72	454	15.13 ± 0.65	203.48 ± 8.80
H	581	19.37 ± 0.72	260.40 ± 9.70	467	15.57 ± 0.66	209.30 ± 8.90
IB	330	11.00 ± 0.57	147.90 ± 7.68	422	14.07 ± 0.63	189.14 ± 8.53
IR	433	14.43 ± 0.64	194.07 ± 8.63	498	16.60 ± 0.68	223.20 ± 9.13
IO	203	6.77 ± 0.46	90.98 ± 6.17	307	10.23 ± 0.55	137.59 ± 7.44
S	839	27.97 ± 0.82	376.03 ± 11.02	823	27.43 ± 0.81	368.86 ± 10.95
W	30	1.00 ± 0.18	13.45 ± 2.44	29	0.97 ± 0.18	13.00 ± 2.40
Total	3000	100.00	1344.56	3000	100.00	1344.56

3.1. Ecosystem services

3.1.1. Carbon storage and sequestration

One of the main causes of climate change and global warming is carbon emissions from activities including deforestation, transportation, industry, and urbanization. Emissions of carbon trap heat, leading to ozone depletion, air pollution, global warming, and ecological destruction. More than 70% of the anthropogenic carbon dioxide (CO_2) emissions that result in greenhouse gasses are emitted by cities, according to studies. However, the effects of these gases are reduced by carbon sinks such soils, forests, and oceans (Hu et al., 2018; Han et al., 2020; Sandoval et al., 2023). Since they store carbon as biomass and use photosynthesis to convert carbon dioxide (CO_2) into oxygen, trees in particular help to mitigate the effects of carbon emissions (Letter & Jäger, 2020).

The amount of carbon and equivalent CO_2 stored by trees, as well as the annual carbon and equivalent CO_2 sequestration in 2023, decreased compared to 2004. In 2004, trees sequestering 92.66 kt of carbon (339.74 CO_2 Equiv.) annually provided $17,419,421 of added value to the city economy. However, in 2023, trees sequestering 72.03 kt of carbon (264.11 CO_2 Equiv.) annually provided

$13,541,810 of added value to the city's economy. Additionally, while in 2004, trees stored 2,011.43 kt of carbon (7,375.26 kt CO_2 Equiv.) and added $378,149,465 to the city's economy, in 2023 they stored 1,563.68 kt of carbon (5,733.50 kt CO_2 Equiv.) and added $293,972,358 to the city's economy (Table 3).

Table 3. The amount of C and CO_2 sequestered and stored by trees and their economic value

Description	Carbon (kt ± SE)		CO_2 Equiv. (kt ± SE)		Value ($ ± SE)	
	2004	2023	2004	2023	2004	2023
Sequestered annually in trees	92.66±3.44	72.03±3.11	339.74±12.62	264.11±11.42	$17,419,421±646,867	$13,541,810±585,487
Stored in trees*	2,011.43±74.69	1,563.68±67.61	7,375.26±273.88	5,733.50±247.89	$378,149,465±14,042,515	$293,972,358±12,710,047

*Note: this benefit is not an annual rate. Amount sequestered is based on 0.354 kt of Carbon, or 1.298 kt of CO_2, per km²/yr. Amount stored is based on 7.685 kt of Carbon, or 28.178 kt of CO_2, per km². Value (USD) is based on $188,000.00/kt of Carbon, or $51,272.73/kt of CO_2. (Metric units: kt = kilotonnes, metric kilotons, km^2 = square kilometers).

Trees offer numerous indirect benefits to cities, in addition to their ecological and economic advantages. For instance, the study area's climate leads to the frequent use of cooling systems throughout much of the year. This high energy demand increases carbon emissions, harming the environment and causing economic strain. By implementing energy-efficient landscape designs with strategic tree planting, the need for cooling systems can be reduced, leading to savings on electricity costs ranging from $4 to $166 per tree each year (Song et al., 2018; Oliveira et al., 2022).

3.1.2. Air pollution removal

Air pollutants and greenhouse gas emissions affect human health, productivity of agricultural crops, disruption of ecological balance, reduced rainfall and increased air temperature (Guerreiro et al., 2014; Oliveira et al., 2022). Trees play a sustainable and effective role in mitigating these air pollution and greenhouse gas emissions that increase with urbanization and industrialization (Letter & Jäger, 2020).

Using i-tree canopy 7.1 software, the annual amount of air pollution removed by trees and its contribution to the economic value of the region were calculated for the years 2004 and 2023. Air pollutants considered are Carbon Monoxide (CO), Nitrogen Dioxide (NO_2), Ozone (O_3), Sulfur Dioxide (SO_2), Particulate Matter less than 2.5 microns ($PM_{2.5}$) and Particulate Matter greater than 2.5 microns and less than 10 microns (PM_{10}).

In 2004, the study area's trees removed 2,328.71 t of air pollution, providing $1,690,728 in value to the city's economy each year. Nevertheless, the decrease in tree canopy cover by 58.26 km^2 over the 20-year period resulted in a decrease of 518.37 t of air pollution removed by trees and a decrease of $376,361 in the contribution to the city economy. In both 2004 (1,316.51 tons) and 2023 (1,023.45 tons), trees removed the most ozone pollution. This was followed by the removal of PM_{10}, NO_2, SO_2, CO, and $PM_{2.5}$ air pollutants (Table 4).

Table 4. The amount and economic value of air pollution removed by trees annually

Abbr.	2004				2023			
	Amount (t)	±SE	Value (USD)	±SE	Amount (t)	±SE	Value (USD)	±SE
CO	40.86	±1.52	$10,556	±392	31.76	±1.37	$8,207	±355
NO_2	144.53	±5.37	$14,487	±538	112.36	±4.86	$11,262	±487
O_3	1,316.51	±48.89	$312,447	±11,603	1,023.45	±44.25	$242,895	±10,502
SO_2	47.09	±1.75	$707	±26	36.61	±1.58	$549	±24
$PM_{2.5}$	15.40	±0.57	$566,834	±21,049	11.98	±0.52	$440,655	±19,052

PM_{10}*	764.32	±28.38	$785,697	±29,177	594.18	±25.69	$610,799	±26,408
Total	2,328.71	±86.48	$1,690,728	±62,785	1,810.34	±78.27	$1,314,367	±56,827

Air Pollution Estimates are based on these values in t/km²/yr and $/t/yr: CO 0.156 and $258.38 | NO_2 0.552 and $100.23 | O_3 5.030 and $237.33 | SO_2 0.180 and $15.01 | $PM_{2.5}$ 0.059 and $36,797.65 | PM_{10}* 2.920 and $1,027.97 (Metric units: t =tonnes, metric tons, km² = square kilometers)

3.1.3. Hydrological benefits

Impervious surfaces (buildings, roads, etc.) are one of the major factors impacting the hydrological structure of cities. Because impervious surfaces reduce the infiltration of water and increase surface runoff. Thus, the quality of water decreases due to surface runoff, the groundwaters are not supplied and flood disasters may occur. However, the vegetation in cities reduces the surface runoff of stormwater through permeable surfaces and allows water to infiltrate into the soil without contamination (Kim & Coseo, 2018). Phoenix is not a city that has intense precipitation throughout the year due to its location in an arid region. However, at certain times of the year, instantaneous heavy rainfall causes floods (Meerow et al., 2021; Helmrich et al., 2023; National Weather Service, 2023). Therefore, trees and green spaces are needed to reduce flash flooding in areas with a high density of impervious surfaces, to recharge groundwater, and to relieve the burden of gray infrastructure.

Reduced tree canopy cover and an increase in the percentage of impervious surface have led to a decrease in added value to the region's economy of $129,533 and a decrease of 54.87 Ml in avoided runoff (AVRO). With a decrease in tree canopy cover, so did the amount of hydrological benefits (Ml) that trees provided, such as transpiration (T), potential evapotranspiration (PET), evaporation (E), interception (I), and transpiration (T). However, it was not possible to calculate the additional value of these hydrological benefits to the region's economy because the monetary value multipliers of the yearly Ml the amount of these benefits were uncertain (Table 5).

Table 5. The amount and economic value of hydrological benefits provided by trees annually

Abbr.	2004				2023			
	Amount (Ml)	**±SE**	**Value (USD)**	**±SE**	**Amount (Ml)**	**±SE**	**Value (USD)**	**±SE**
AVRO	246.50	±9.15	$581,905	±21,609	191.63	±8.29	$452,372	±19,559
E	6,005.89	±223.03	N/A	N/A	4,668.96	±201.87	N/A	N/A
I	6,013.70	±223.32	N/A	N/A	4,675.03	±202.13	N/A	N/A
T	76,263.48	±2,832.03	N/A	N/A	59,287.02	±2,563.31	N/A	N/A
PE	246,037.84	±9,136.57	N/A	N/A	191,269.14	±8,269.62	N/A	N/A
PET	208,738.85	±7,751.48	N/A	N/A	162,273.01	±7,015.96	N/A	N/A

Hydrological Estimates are based on these values in Ml/km²/yr and $/Ml/yr: AVRO 0.942 and $2,360.64 | E 22.946 | I 22.976 | T 291.369 | PE 940.003 | PET 797.500 (Metric units: Ml = megaliters, km² = square kilometers)

Trees are one of the most important keystone structures for the sustainability of ecosystem services in the City of Phoenix. However, due to the scarcity of water resources in the study area, located in an arid desert city, the selection and positioning of tree species should be carefully considered. Otherwise, overconsumption of water leads to high economic costs for local governments and deterioration of the ecological structure (Gage & Cooper, 2017). Therefore, preferring arid-tolerant tree species (low-water-use trees) in afforestation projects will make a significant contribution to the sustainability of ecosystem services and water conservation (Olgun et al., 2024b).

4. Conclusion

Today, rapidly increasing urbanization has caused more negative effects of climate change to be felt. Because, population density and the expansion of urban areas have led to the emergence of problems that negatively affect human health and comfort, such as deterioration of the natural structure, increase in the urban heat island effect, deterioration of air quality, insufficient water resources, and climate injustice. Therefore, the ecosystem services provided by trees have become much more important in urban areas, particularly in this century.

The natural structure of the city of Phoenix, located in the north of the Sonoran desert, has the characteristics of a desert ecosystem. However, due to population growth and urbanization in the region over the last 20 years, there has been an increase in impervious surfaces and a decrease in tree cover. For this reason, ecosystem services, which are directly related to the presence of trees, have decreased in this process.

To increase the ecosystem services provided by trees in Phoenix, it is necessary to promote tree cover throughout the city. In this context, The Tree and Shade Master Plan was prepared by the City of Phoenix, which aims to increase the amount of green space in the city (The City of Phoenix, 2010). This master plan focuses on increasing the tree canopy from 10% to 25% by 2030. Moreover, with the increase in tree canopy cover, the planning of the green infrastructure system throughout the city will increase the benefit value of ecosystem services.

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The article complies with national and international research and publication ethics. Ethics Committee approval was not required for the study.

Author Contribution and Conflict of Interest Declaration Information

All authors contributed equally to the article. There is no conflict of interest.

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Post-Earthquake Urban Planning in Türkiye: Evaluating Disaster Refuge Systems in Hatay and Istanbul

Gizem DİNÇ[1]*, Büşra Nur GÖK [1]

ORCID 1: 0000-0003-2406-604X
ORCID 2: 0000-0002-8964-216X
[1] *Süleyman Demirel University, Faculty of Architecture, Department of Landscape Architecture, 32260, Isparta, Türkiye.*
*** e-mail**: *gizemdinc@sdu.edu.tr*

Abstract

Countries prone to significant earthquakes often develop disaster refuge and relief urban park systems to enhance urban open green spaces, which serve as temporary shelters for evacuation after seismic events. This paper examines the disaster refuge sites and urban open green space system in the center of Hatay following the February 6, 2023 earthquake. The findings provide insights into the resilience of Turkish cities after seismic events. Subsequently, the refuge sites and green space systems in Istanbul, a metropolis expected to experience a major earthquake, were analyzed in light of the Hatay example. Using ArcGIS, the service areas of shelter sites and urban open green spaces (within a 15-minute walking distance) were calculated and compared. Results indicate that the service areas for emergency shelters in the center of Hatay and Istanbul's Fatih district are insufficient. This highlights the need for better-planned urban open green spaces for evacuation purposes. This study makes significant contributions to improving shelter and evacuation processes after earthquakes in the fields of disaster management and urban planning.

Keywords: *Earthquake, resilient cities, green space systems, urban planning, emergency shelter.*

Türkiye'de Deprem Sonrası Kentsel Planlama: Hatay ve İstanbul'daki Afet Sığınak Sistemlerinin Değerlendirilmesi

Öz

Büyük depremlerle karşılaşan ülkeler, kentsel açık yeşil alanları güçlendirmek amacıyla, afet sığınakları ve yardım parkı sistemleri geliştirmekte; bu alanlar, sismik olaylar sonrasında tahliye için geçici sığınaklar olarak hizmet etmektedir. Bu çalışma, 6 Şubat 2023 tarihinde meydana gelen depremin ardından Hatay merkezindeki afet sığınakları ve kentsel açık yeşil alan sistemini incelemektedir. Elde edilen bulgular, Türkiyey'deki şehirlerin sismik olaylar sonrasındaki dayanıklılığına dair önemli bilgiler sunmaktadır. Ardından, büyük bir depreme maruz kalması beklenen İstanbul'daki sığınak alanları ve yeşil alan sistemleri, Hatay örneği dikkate alınarak analiz edilmiştir. ArcGIS kullanılarak, sığınak alanlarının ve kentsel açık yeşil alanların (15 dakikalık yürüme mesafesindeki) hizmet alanları hesaplanmış ve karşılaştırılmıştır. Sonuçlar, Hatay merkezindeki ve İstanbul'un Fatih ilçesindeki acil sığınaklar için hizmet alanlarının yetersiz olduğunu göstermektedir. Bu durum, tahliye amacıyla daha iyi planlanmış kentsel açık yeşil alanların gerekliliğini vurgulamaktadır. Bu çalışma, afet yönetimi ve şehir planlaması alanında, depremler sonrası sığınma ve tahliye süreçlerinin iyileştirilmesine yönelik önemli katkılar sağlamaktadır.

Anahtar kelimeler: *Deprem, dayanıklı şehirler, yeşil alan sistemleri, kentsel planlama, acil toplanma alanları.*

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1. Introduction

Cities are shaped by the history, culture, and geography inherited from the past by civilizations (Ilgar, 2008). However, because of natural disasters, the structure of cities is significantly disrupted. One of the most destructive natural disasters in cities is earthquakes. Earthquakes originate from movements within the Earth's crust. These movements have the potential to devastate villages, towns, and even cities, causing effects such as fires and flooding (Altun, 2018). Earthquakes that cause loss of life and property are particularly impactful in countries located in earthquake-prone zones, and researchers are increasingly focusing on disaster risk assessment and mitigation planning (Mabon, 2019; Uehara et al., 2022). Türkiye, one of these countries, has seen tens of thousands of people lose their lives due to earthquakes, and cities have suffered destruction.

Türkiye is located at a geographical junction between the continents of Europe and Asia, where two major fault lines exist. Researchers are closely examining the aftermath of the 7.7 and 7.6 magnitude earthquakes that struck the eastern part of Türkiye on February 6, 2023. The substantial loss of life and property has underscored the importance of Türkiye taking crucial steps in creating safe living spaces before earthquakes and addressing the essential needs of survivors afterward. In Türkiye, measures related to earthquakes primarily focus on constructing more resilient buildings and post-disaster intervention, with only a few detailed provisions. According to the Spatial Plans Construction Regulation dated 2014, goals, strategies, and implementation principles related to making the building stock more resilient and secure against disasters such as earthquakes, floods, landslides, fires, rockfalls, and similar events will be determined during the preparation of protection-oriented zoning plans (SPCR, 2014). The Türkiye Building Earthquake Regulation of 2018 outlines the principles for designing buildings under the influence of earthquakes (TBER, 2018). In 2022, revisions were made to the Türkiye Disaster Response Plan. The purpose of the plan is to define the roles and responsibilities of working groups and coordination units involved in disaster and emergency response efforts, as well as to establish the fundamental principles of intervention planning before, during, and after disasters (TDRP, 2022). However, there is no specific approach to the development of an urban green space system for creating a city resilient to disasters.

In urban areas, disruptions in the physical environment post-earthquakes pose challenges in meeting vital needs such as transportation, housing, food, and healthcare. Post-earthquake housing is a significant requirement, initially addressed in Türkiye through temporary shelters (Uzuner & Akıncıtürk, 2020). However, the insufficient number and functional features of these facilities contribute to various issues during disasters. Survivors not only grapple with economic and psychological consequences but also face deprivation of necessities like food, shelter, and healthcare. Therefore, cities need to be made resilient to earthquakes in all aspects. However, one of the most crucial components needed during and after an earthquake, especially in risk-prone cities, is the presence of emergency shelter sites. Despite numerous disasters in Türkiye, the significance of urban green spaces as a refuge system remains underappreciated. Current earthquake-related measures primarily emphasize building resilient structures and focus on post-disaster interventions. There is a lack of planning approaches and legal provisions specifically addressing the design, implementation, and utilization of urban green spaces for this purpose.

In this context, the authors believe that the data and experience obtained from Hatay, one of the places with the highest loss of life and property during the earthquake on February 6, provide valuable information for improving cities against other potential earthquakes and natural disasters in Türkiye. The temporary shelter needs that arose after this earthquake (tent cities spreading across various parts of the city and even temporary shelter sites consisting of a few tents in the rural areas of the city) are a scenario that could occur in cities located in Türkiye's first-degree earthquake zone, and precautions need to be taken. Especially after this earthquake, experts unanimously agree that there is a high probability of a major earthquake occurring in Istanbul, which is not only Türkiye's largest metropolis but also its cultural capital, located along the North Anatolian Fault (Erdik et al., 2003; Erberik, 2010). However, unlike Hatay, Istanbul has a dense urban structure and limited open spaces in its immediate vicinity that could be used as refuge sites. The city's only assurance in this regard is the urban open green space system.

Therefore, in this study, considering the data obtained from the earthquake on February 6, 2023, the city's emergency shelter sites and urban open green space system in Istanbul were examined to better understand the opportunities the city offers as a refuge in the event of an earthquake. In the study area in Hatay (study area 1), the spatial data of the emergency shelter sites designated by DEMA (Disaster and Emergency Management Authority), open green spaces, and temporary shelter cities (tent cities) used after the earthquake were collected, and the service areas of these locations were calculated using the Network Analyst tool of ArcGIS. Similarly, in the designated study area in Istanbul (study area 2), the service areas of the emergency shelter sites designated by DEMA and the Istanbul Metropolitan Municipality, as well as the city's open green spaces, were calculated. These data were compared with the populations of the study areas. In both study areas, it was observed that the service areas of emergency shelter sites did not cover all neighborhoods (as they were not within a 15-minute walking distance). Furthermore, in study area 2, it was revealed that the urban open green spaces were not designed as a system and were not within a 15-minute walking distance for everyone, making them insufficient to meet the refuge and evacuation needs in the event of a major earthquake. According to these results, suggestions were presented to decision-makers to create cities that are more resistant to earthquakes.

This study highlights the importance of developing the urban open green space system to meet the refuge and evacuation needs encountered after disasters. The information obtained from this study provides valuable insights for developing disaster-resilient cities based on lessons learned from past experiences.

2. Study Area

In this article, which focuses on research related to post-earthquake refuge sites, the study areas include Hatay and Istanbul. Hatay, which includes study area 1, is a constant crossroads where Eastern and Western cultures intersect, fostering continuous cultural exchange (Hatay Governorship, 2023). Hatay province is located between the latitudes of 35° 52' and 37° 4' and the longitudes of 35° 40' and 36° 35' (Figure 1). Hatay is situated on the eastern coast of the Gulf of Iskenderun in the southern part of Türkiye. It is bordered by the Mediterranean Sea to the west, Syria to the south and east, Adana to the northwest, Osmaniye to the north, and Gaziantep to the northeast (Hatay Governorship, 2023). The province experiences a Mediterranean climate, characterized by hot and dry summers, and mild and rainy winters. Although the province's natural vegetation primarily consists of forests, many forested areas have been depleted over time, and have been replaced by shrubland types, in line with its climatic conditions.

A significant portion of the city is situated in a geomorphologically unsuitable area and is exposed to natural risks (Tonbul & Sunkar, 2008; Özşahin, 2010). In the center of Hatay, there is a risk of floods and mass movements due to geomorphological features, as well as earthquake risk arising from ground characteristics (Hatay Governorship, 2023). The study area 1 is primarily located within the Eastern Anatolian Fault, the Dead Sea Fault, and the Hellenic-Cyprus Arc. In connection with these fault lines, this region has experienced significant earthquakes in its history, resulting in significant loss of life and property (Korkmaz, 2006; Özşahin, 2010). Based on the city's structural development, during its initial establishment, a grid plan was implemented, with main streets running in a southwest-northeast direction to take advantage of the prevailing winds, and between these main streets, building blocks were formed (Demir, 1996; Kaypak, 2010). The study area 1 encompassing these features consists of 61 neighborhoods covering an area of 116 km^2 in the center of Hatay that were most affected by the earthquake that occurred in Kahramanmaraş on February 6, 2023. It includes the regions where buildings collapsed and refuge sites were used. According to the data from the year 2002, the study area 1, identified before the major earthquake, was determined to have a population of 419490 (TSI, 2022).

Study area 2 is the Fatih district of Istanbul, which has a population of 368227 and consists of 57 neighborhoods. The Fatih district covers an area of 15 km^2. Istanbul is the only metropolis in the world that spans two continents, Europe and Asia (Istanbul Governorship, 2023). One of the districts on the European side of Istanbul, Fatih, is known as the Historic Peninsula, encompassing the Byzantine walls, the Golden Horn, and the area surrounded by the Sea of Marmara. The area also suffered damage in the devastating earthquake known as the "1894 Istanbul earthquake," commonly referred to as the "Three Hundred and Ten Earthquake" among the locals. Based on research conducted by various scholars, a consensus has been reached on the most significant fault line that could trigger an earthquake affecting Istanbul and its surroundings. This potential earthquake source is the fault line that extends east-west within the Marmara Sea, following the northern branch of the North Anatolian Fault, originating from the North Marmara region (Bianet, 2020).

Fatih, Eyüp district to the north, the Golden Horn to the northeast, the Sea of Marmara to the south, Zeytinburnu to the west, and Bayrampaşa to the northwest are its neighboring districts, giving it the appearance of a peninsula surrounded by the sea on three sides (Fatih Governorship, 2023). The district is situated between 41° 1' 3.7740" north latitude and 28° 56' 25.4220" east longitude (Figure 1).

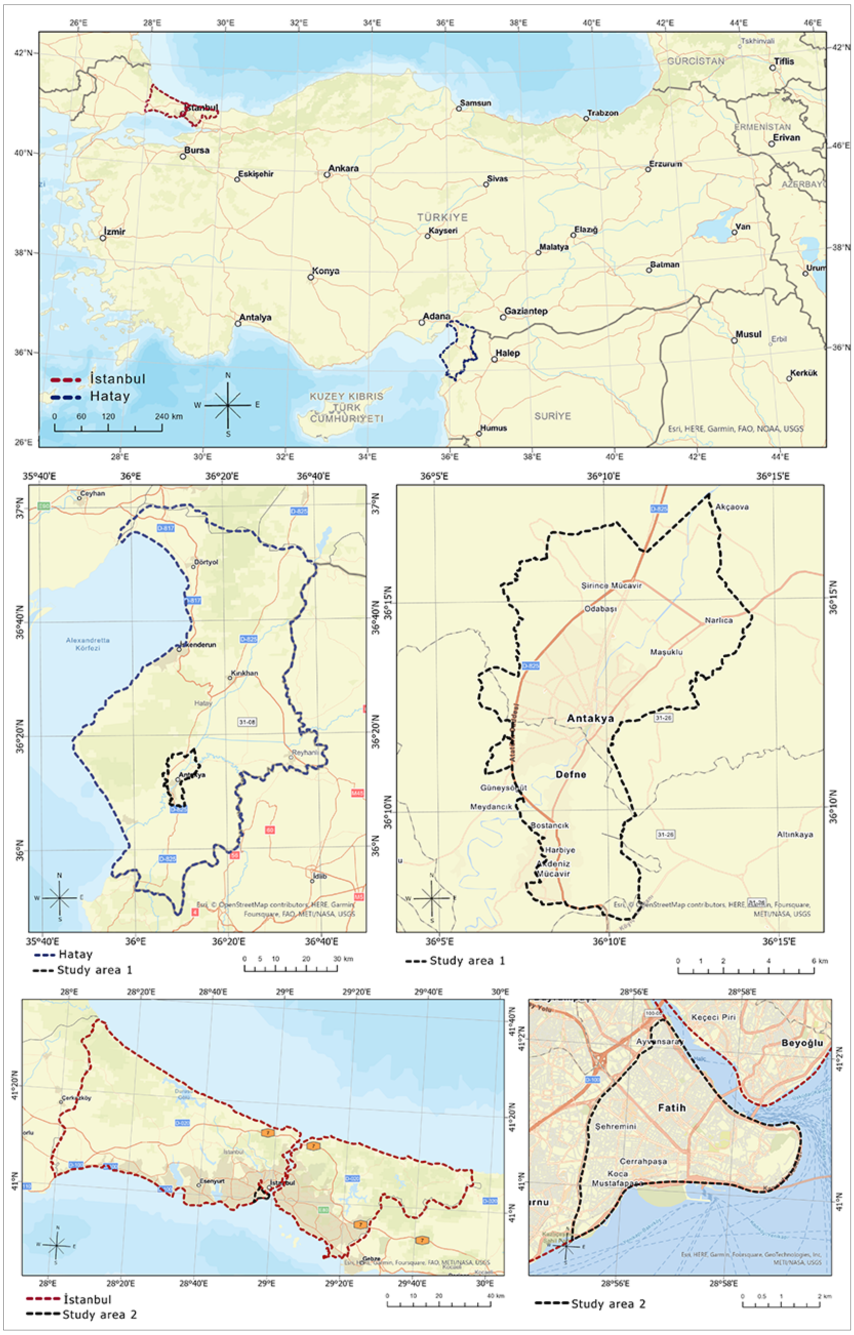

Figure 1 . Study area 1 and study area 2

Fatih district is located at an elevation of 60 meters above sea level (IMM, 2020). Fatih is influenced by a transitional type of climate known as the Marmara climate, which combines Mediterranean, Black Sea, and continental characteristics. Summers are hot and dry, while winters are mild and rainy. The coastal areas have higher humidity levels. The vegetation in the region resembles Mediterranean climate plants. The most observed plant species in the area is maquis, which is adapted to the long and dry summer season. Forested areas are sporadically present in the region (Istanbul Governorship, 2023).

The selection of these areas was based on the idea that, after the earthquake on February 6, earthquake survivors in central neighborhoods in Hatay started living in tent cities and tents in the rural areas of Hatay due to the inadequacy of shelter sites. This was because, as revealed by satellite imagery examined after the earthquake, it became evident that the city's open green space system was not sufficient to serve as a shelter site for earthquake survivors. Consequently, they had to move away from the city center to more rural areas around the city to meet their housing needs in tent cities and tents. However, in the designated area in Istanbul, the urban fabric would not allow for such a situation, primarily due to population density. Therefore, evaluating these two areas together serves to provide a clearer understanding of the potential problems related to refuge and evacuation in the event of an earthquake in Istanbul.

3. Methodology and Data Collection

In this paper, three different spatial datasets related to Hatay province have had their service areas measured. The first dataset covers Hatay's open green spaces, the second includes emergency shelter sites determined by DEMA, and the third encompasses all temporary shelter sites. These datasets were analyzed using the Network Analyst tool in ArcGIS software to determine service areas within a 5, 10, and 15-minute walking distance.

The three different datasets mentioned above were imported as facilities in the Service Area Analysis. Hatay's urban road system also served as the walking network. Similarly, service areas for open green spaces in Istanbul Fatih and DEMA's designated emergency shelter sites were calculated. These two datasets were used as facilities, and the urban road system served as the walking network. The data used in the research, the conducted analyses, and the data sources are listed in Table 1. nThe data related to roads and green spaces were obtained from the OpenStreetMap (OSM) open-access database. Data regarding emergency shelter sites in Türkiye were obtained from AFAD's open-access database. Additionally, for Istanbul data, the Istanbul City Map database provided by the Istanbul Metropolitan Municipality was used. Data on temporary shelter sites or tent cities used in Hatay after an earthquake were identified from satellite images obtained from Google Earth. Data related to buildings and water surfaces were obtained from OSM. After collecting these data, they were organized and analyzed using the ArcGIS software to compare the refuge sites in study area 1 and study area 2.

Table 1. Data and analysis table

Data	Spatial analysis	Dataset
Roads	Servis area(network)	OSM
Green areas	Servis area(facilities)	OSM
Emergency shelter sites	Servis area(facilities)	DEMA, Istanbul City Map
Temporary shelter sites	Servis area(facilities)	DEMA, Gooogle earth
Buildings	Buffer (3.5m)	OSM
Water surfaces	Buffer (100m)	OSM

The primary analysis method used the Service Area calculation tool in ArcGIS. To do this, a pedestrian network dataset was first created, considering the routes pedestrians could use to reach refuge sites in the event of an earthquake. As the OSM data provided road connectivity, road segments that pedestrians cannot use, such as the primary, trunk, and their links, were not considered. Subsequently, through a literature review, road segments with a high probability of becoming impassable due to earthquakes, such as those near riverbeds and coastlines, were excluded (Table 2).

Table 2. Areas are not suitable for walking after an earthquake

	Not walkable	Reference
Road class of OSM data	Primary, trunk, and their links	Gaglione, Gargiulo & Zucaro, 2019
Riverside	0–100 m	Walker et. al., 2024
Coastline	0–100 m	Mague, McFarland & Borrelli, 2020; Masuda, 2014
Building collapse zone	0-3.5m	Golla, 2020

In urban areas, primary roads, trunk roads, and their connecting links are typically not well-suited for pedestrian movement. These types of roads are generally designed to prioritize vehicular traffic, focusing on efficiency and high-speed transit, rather than providing safe or comfortable environments for pedestrians. Such roads often lack features that enhance pedestrian safety and comfort, such as wide sidewalks, pedestrian crossings, and adequate signage (Gaglione, Gargiulo & Zucaro, 2019).

It is stated that residential areas located within 100 meters of riverbeds in cities show higher vulnerability to flood risks (Walker et al., 2024). Additionally, riverbeds can experience displacements or flooding effects during earthquakes. For example, in the urban axis along the Asi River in Hatay, there is significant damage from the riverbank towards the embankments (KHER, 2023). This results in a greater impact on the structures around the riverbed compared to the earthquake itself. Coastal areas also have a high probability of collapses or flooding events due to earthquakes. The 9.0 magnitude earthquake that occurred in the northeastern Sea of Japan in 2011 is a good example of this. The large earthquake raised the seawater level by as much as nine meters and caused a Tsunami with a wave height of 40.5 meters in some areas (Masuda, 2014). Some of these coastal areas may be filled lands, and being in these areas poses a considerable risk in the event of a tsunami caused by an earthquake. The Massachusetts Coastal Resilience Program report states that a 100-meter buffer zone has been applied in certain cases to protect coastal areas. This measure aims to reduce the risks of environmental changes, such as flooding and erosion(Mague, McFarland & Borrelli, 2020). Therefore, these areas have been designated as unsuitable for walking after an earthquake. Additionally, building debris reduces the capacity of roads, significantly impacting post-earthquake emergency operations, especially in situations with low resilience (Golla, 2020). After the earthquake in Hatay, 215,255 heavily damaged or collapsed, 25,957 moderately damaged, and 189,317 slightly damaged structures were identified (KHER, 2023). The second study area is generally comprised of 4 or 5-story buildings. However, many of these structures are old, and in this historically settled area, the roads are narrow and surrounded by buildings. Therefore, if structures closer to the road collapse, there is a high probability of rendering the road unusable. Additionally, even if the road is not blocked by debris, buildings that suffer damage from the earthquake may collapse after some time, and pedestrians may encounter collapsing moments while walking. It is emphasized that especially on single-lane roads, the designated width is 3.5 m, and even the slightest debris extending onto the road can cause complete closure (Golla, 2020). Even if the road is wide, pedestrians are likely to prefer walking in the middle, away from buildings. Therefore, areas with debris risk extending within 3.5 m of structures are designated as non-walkable areas due to the high risk. Moreover, in the event of an earthquake, there is a possibility of roads being damaged due to the quake itself, as well as factors such as panic-induced traffic and chaos created by people, which may affect the usability of roads. For example, according to the Kahramanmaraş and Hatay Earthquakes Report (2023), the assessment of road damage, including highways, roads, tunnels, viaducts, and other road infrastructure, revealed a total of 12.2 billion Turkish liras in damages.

After these processes, source features and attributes have been organized for the walking network. During this process, walking time has been calculated according to Formula 1.

$$t_{min} = 60 * \frac{d}{s} \qquad (\mathbf{1})$$

Here, $s = 5\,km/h$ (equivalent to approximately 1.39 m/s) represents the walking speed, and d represents the distance in kilometers. Using this formula, service areas accessible within 5, 10, and 15 minutes were determined in the network analysis. After creating the walking network, service areas for the identified facilities were calculated with the service area tool. The findings were then presented in maps and tables, and finally, these data were interpreted in relation to the population.

4. Results

Emergency shelter sites, temporary shelter sites, and service areas of the urban open green space system were determined, and maps were created for study area 1 and study aea 2. In study area 1, where 419490 people reside in Hatay, 74 emergency shelter sites were identified by DEMA. According to the service area analysis, the service area of these emergency shelter sites is 118 km² (Figure 2).

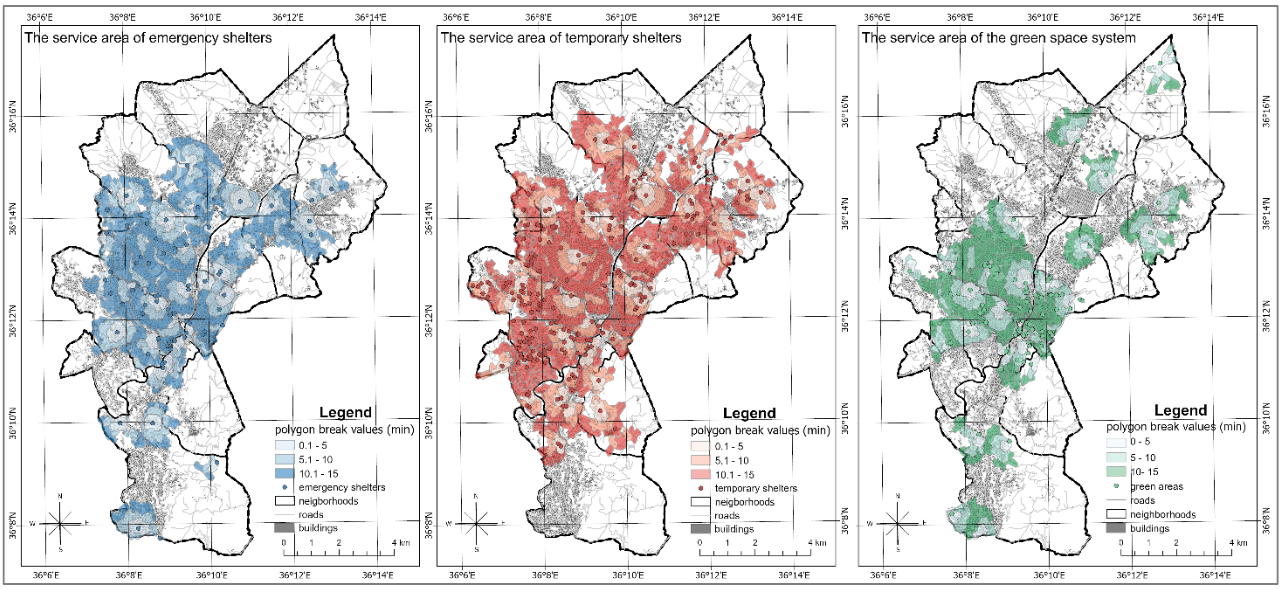

Figure 2. The service area of emergency shelters, temporary shelters, and green space system (study area 1)

In some areas of the study region, there is no emergency shelter site within a 15-minute walking distance. In other words, in certain neighborhoods, emergency shelter sites are not strategically located to serve the entire neighborhood. For instance, the Dursunlu neighborhood with a population of 8773, the Subaşı neighborhood with a population of 6001, and the Hasanlı neighborhood with a population of 44 have no emergency shelter sites. Additionally, in Harbiye, Kuzeytepe, Narlıca Güzelburç, Maşuklu, Ekinci, and Küçükdalyan neighborhoods, the service area of emergency shelter sites does not cover the entire neighborhood.

In study area 1 located in Hatay, a total of 221 temporary shelter sites have been identified. These areas encompass tent cities containing facilities for shelter and areas where 2 or 3 tents are clustered together but lack other necessary amenities for housing. Some of these tent areas are situated in emergency shelter sites, some in the yards of undamaged residences, some in open areas where debris has been cleared, and some are located along the roadsides. Simultaneously, these temporary shelter sites show an increasing trend as they move away from the city center, spreading more towards the surrounding rural areas, and staying away from riverbeds. In study area 1, a total area of 1106249 m^2 is utilized as tent space (temporary shelter site). The service area covered by this tent area is 321 km^2 (Figure 2). This indicates that in study area 1, with a population of 419490, there is a need for 1106249 m^2 of temporary shelter area after an earthquake.

The city's open green space system is observed to consist of patches. In the event of a natural disaster, there is no green road network that could provide evacuation to shelter sites by avoiding collapsed structures and roads. These patches cover an area of 1968887 m^2, with a service area of 116 km^2. Many of these areas have not been used as temporary shelter sites (Figure 2). Some of these areas may not have been utilized due to their distance from the city center or topographical conditions.

In study area 2, there are 191 emergency shelter sites covering an area of 1167484 m^2. The service area of these emergency shelter sites encompasses a 10 km^2 area (Figure 3). Similar to study area 1, emergency shelter sites in some neighborhoods of study area 2 are not appropriately located. In certain neighborhoods, there are no shelter sites at all, and residents of these neighborhoods do not have access to any shelter sites within a 15-minute distance. These neighborhoods include Sururi, Tahya Hatun, Muhsine Hatun, Tahtakale, Mimar Hayrettin, and Katip Kasım. Emergency shelter sites largely overlap with the open green space system in the Fatih district (study area 2). The 212 open green areas in the Fatih district cover an area of 983863 m^2, and the service area of these green areas is 683725 m^2 (Figure 3).

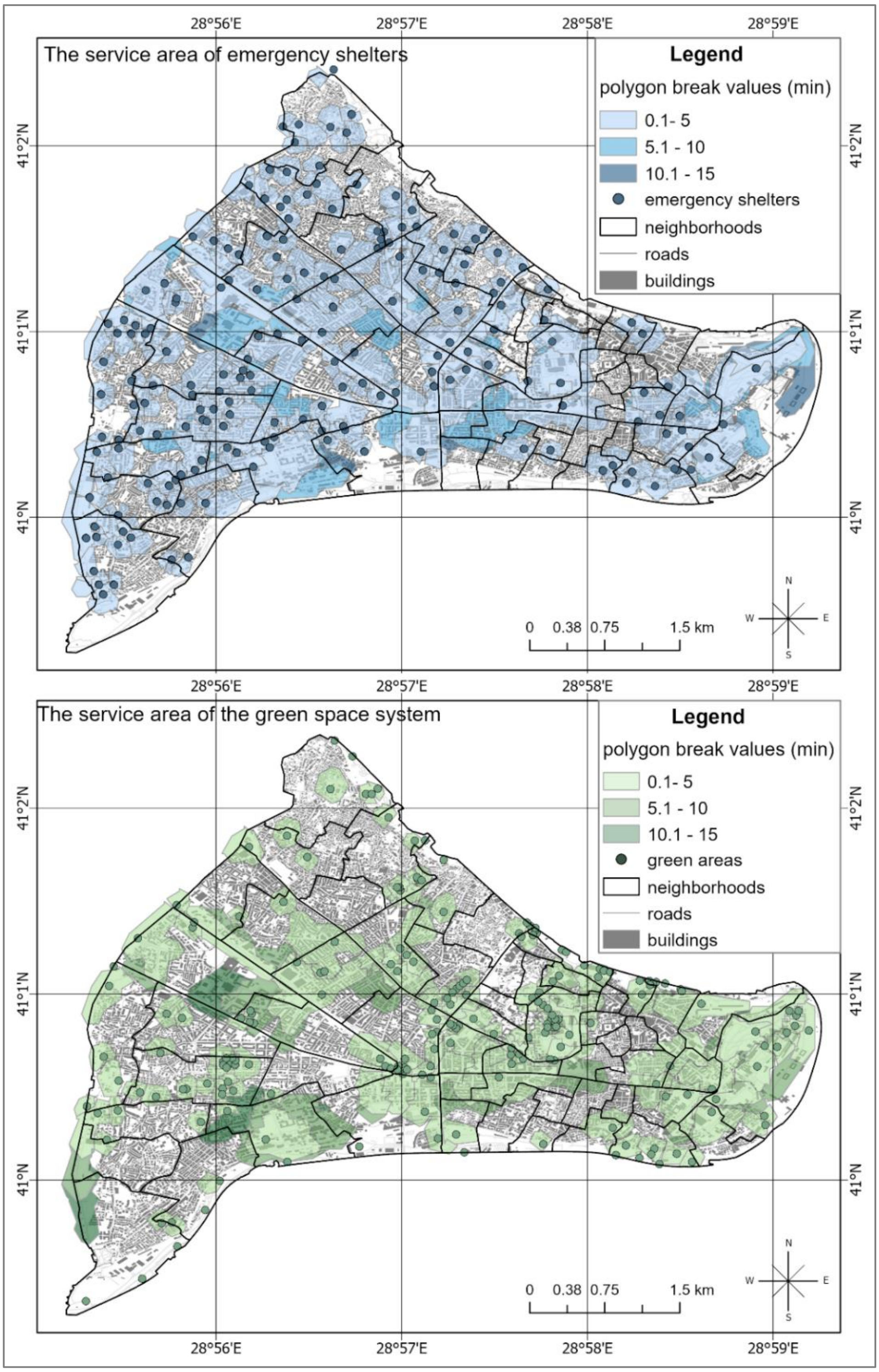

Figure 3. The service area of emergency shelters and the green space system (Study Area 2)

5. Discussion

According to the findings of the study, in Study Area 1 in Hatay, where 419490 people live, neighborhoods are spread over an area of approximately 116 km². In these neighborhoods, there are 74 emergency shelter sites covering a service area of 118 km². However, it has been observed that the service area of emergency shelter sites does not cover the entire neighborhood or there are no emergency shelter sites in some neighborhoods. After the earthquake on February 6th, which caused significant loss of life and property in Hatay, there emerged a need for approximately 1.1 km² of temporary shelter sites, covering a service area of 321 km². Temporary shelter sites are generally located far from the city center. No available data indicates that these temporary shelter sites were pre-determined. The green spaces cover approximately 1.9 km², with a service area of 116 km². Some of these areas have not been used as temporary shelter sites after the earthquake.

With a population of 368227, the area of Istanbul's Fatih district is approximately 15 km². The emergency shelter sites identified by DEMA are spread over an area of approximately 1.2 km². The service area of these sites covers an area of 10 km². Similarly, in some neighborhoods, there is no emergency shelter site within a 15-minute distance. The open green spaces in the study area cover an area of approximately 0.9 km², with a service area of approximately 0.7 km².

In this context, it is evident that a much more challenging process would emerge in Istanbul's Fatih district, where the population is much denser, after a major earthquake compared to the scenario in Hatay. Reaching the designated emergency shelter sites in Istanbul on foot after a major earthquake may be hindered due to population density and the lack of evacuation routes. Additionally, there is not enough open space in Fatih that the population could use as temporary shelter sites after a major earthquake.

Urban open green space systems cannot provide secure evacuation routes in either city. In this context, it has been observed that in Türkiye, temporary shelter sites and secure evacuation routes are not predetermined before disasters. The Türkiye Disaster Response Plan includes the responsibility of the operation service pre-improvement sub-service working groups to establish the infrastructure of temporary shelter and care units (TDRP, 2022). However, there is no law or regulation determining the necessity of pre-determining where these temporary shelter sites will be in cities at risk of disasters.

Worldwide documented responses to earthquakes indicate that a sufficient and consistent amount of open space surrounding buildings holds significant value during and after seismic events (Godschalk, 2003). Open space becomes a shelter and temporary home for thousands of people who must quickly adapt to new environments for days, months, or even years after an earthquake. Following a major earthquake, the open space network becomes almost a "second city," fulfilling a series of complex functions, including gathering and shelter, distribution of goods and services, re-establishment of trade, temporary residence, memorial ceremonies, and storage of dirty or hazardous materials (McGregor, 1998, Middleton, 2007). The network overflows with new meanings; its areas and components are reevaluated in terms of their capacities to support survival and recovery. However, information regarding the amount of open space per person required for evacuation or shelter is limited (Uyar & Özkan, 2023), and there is almost no research on its quality (Allan & Bryant, 2010).

In the literature, many studies focus on the risks of loss of life and property in urban centers, the structural integrity of buildings, and the effectiveness of disaster preparedness, but places where effective recovery occurs, such as open green spaces, are rarely addressed (Allan & Bryant, 2010; Masuda, 2014). Researchers emphasize the importance of planning and designing open green spaces in a disaster-sensitive manner, but even studies based on disaster sensitivity or resilience focus on specific aspects, highlighting the lack of comprehensive studies that address these standards or criteria (Şenik & Uzun, 2021).

It can be argued that many people in Hatay who have a chance of survival after an earthquake have gone through a challenging process to reach emergency shelter sites. In Istanbul, there is still an opportunity to find solutions to these problems. After the earthquake in Hatay, earthquake survivors had the opportunity to move away from the collapsed areas due to the semi-rural structure of the city. On the other hand, the Fatih district is enclosed by seas and dense urban fabric, and without precautions, there is a high probability of significant loss of life and property in the event of an earthquake. The possibility of earthquake victims encountering an environment that makes it difficult for them to adapt to life again is high. In a metropolis like Istanbul, the only option the community can rely on for shelter and evacuation in emergencies is an adequate urban open green space system. Therefore, decision-makers need to take precautions against a major earthquake in Istanbul, as expected by many researchers.

Results emphasize the need for strategic planning to integrate the urban open green space system with disaster resilience efforts. It is crucial to enhance accessibility and expand the coverage of emergency shelter sites, especially in neighborhoods with limited access. Research and planning efforts should focus on optimizing open green spaces as shelters and evacuation areas during and after disasters.

There are various initiatives to increase urban resilience against disasters and to be prepared for a potential earthquake in Istanbul. The Ministry of Interior, General Command of the Gendarmerie, Disaster and Emergency Management Authority, and district municipalities are actively involved in these efforts. Identified emergency and temporary shelter sites and scenarios have been transferred to databases using Geographic Information Systems. Necessary risk analyses (tsunami, ground conditions, etc.) have been conducted and incorporated into the study. Considering the December 2020 population data from the Turkish Statistical Institute (TSI), a neighborhood-focused disaster action plan has been prepared, and capacity analyses have been carried out. As a result of the study, temporary shelter and emergency shelter sites have been planned. According to the data from the Istanbul Metropolitan Municipality, a total of 5599 emergency shelter sites covering 4840.7 hectares have been identified in the 39 districts of Istanbul, with a per capita emergency shelter sites of 3.13 m^2 (UTBD, 2022). In addition, earthquake parks have been constructed in Istanbul since 2020. Earthquake parks with capacities of 500-700 and 5000 have been built in the Ataşehir and Topkapı districts, respectively. These parks are designed to provide short or medium-term shelter for citizens after a disaster and to support rescue efforts (Bianet, 2020). However, for these shelter sites to be effective, planning a comprehensive urban open green space system that includes evacuation routes and areas requires a nationwide approach. With this approach, the urban park system can be incorporated into the urban design process at the national, provincial, and local levels for management and distribution in emergencies.

The authors propose the development of urban green space systems in these cities by taking an example from Japan's earthquake-resistant urban green space approach. This would make access to emergency shelter sites much easier and safer. Additionally, it would be possible to create much more coordinated and appropriately scaled areas for both emergency shelter sites areas and temporary shelter sites. The urban green space system should be planned to meet post-disaster needs in the fastest and most coordinated manner possible. Therefore, the importance of the open green network system stands out more prominently as both shelter and evacuation areas. When the urban green system is appropriately planned, it not only provides a safer evacuation environment for pedestrians but also ensures interconnected refuge sites. This is crucial for the continuous flow of essential needs, even when other transportation routes are closed, providing a secure temporary shelter for earthquake survivors. Li et al. (2013) conducted a study where they explained the suitability assessment of green spaces in parks as shelter areas with three main criteria: availability (providing enough open space to accommodate an appropriate shelter population), accessibility (the shortest route to a hospital, fire station, and a safe water source), and safety (minimum distance in terms of faults, dangerous points, slope, and the width of surrounding roads) (Şenik & Uzun, 2021).

After numerous earthquakes in Türkiye and since Türkiye is an earthquake-prone region, the goal of creating disaster-resistant cities should be embraced nationwide, and detailed laws regarding its implementation should be established. Particularly in cities located in first-degree earthquake zones, while structures are being strengthened, certain decisions should also be made regarding the implementation of an earthquake-resistant approach for disaster refuge and relief urban park systems or urban open green space systems.

This study focuses on the development of green spaces as evacuation and shelter sites in the face of natural disasters, particularly earthquakes. In this context, it provides significant analyses and findings, contributing to the literature. Moreover, it emphasizes the necessity of increasing research in this field, highlighting the importance of the subject and offering a crucial roadmap for future studies. However, factors such as infrastructure conditions, topographic slope, road accessibility, and proximity to critical services, including hospitals and schools, were not analyzed due to data constraints and the defined scope of this study. Similarly, the assessment of green space quality, encompassing attributes such as capacity, design, and available facilities, was not conducted, as the requisite data were not accessible.

Addressing these limitations in future research could enable a more comprehensive understanding of the role of green spaces in disaster preparedness and contribute significantly to advancing knowledge in this domain.

5. Conclusion

Urban open green space systems are one of the most significant tools in the hands of experts to create disaster-resistant cities. Carmona (2010) emphasizes that a network of public open spaces connected by green corridors is the key to creating a sustainable environment in cities and integrating the natural environment with the built environment. Researchers even suggest that the city's open spaces have the potential to become a 'second city' by making simple contributions to complex services such as gathering, sheltering, distributing goods and services, and temporary settlement after a major disaster (Allan & Bryant 2010; Masuda, 2014; Jayakody, Amarathunga & Haigh, 2018). Many large cities that have faced earthquake disasters shape their planning approaches, accordingly, recognizing the importance of the urban open green space system as post-disaster refuge sites.

Recent studies highlight the necessity of incorporating the location, capacity, and usage strategies of post-disaster shelter sites in the hierarchical planning approaches implemented in Türkiye (Çınar, Akgün & Maral, 2018). Apart from a few studies emphasizing the importance of urban open green space systems in creating disaster-resistant cities (Şenik & Uzun, 2021), there is not enough research on this topic. By addressing this gap, this study has made a significant contribution to improving the quality of life in cities and creating earthquake-resistant cities. These results emphasize the importance of integrating urban planning, disaster preparedness, and open green space management to enhance cities' overall resilience to natural disasters. Consequently, it is crucial for the concept of urban open green spaces as a key element in creating disaster-resistant cities to receive more attention and application beyond research.

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Author Contribution and Conflict of Interest Declaration Information

The authors declare no conflict of interest.

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A Guide to the Reuse of Demountable Construction Elements and Components

Özlem EREN*

ORCID : 0000-0002-7675-6483
Mimar Sinan Fine ArtsUniversity, Faculty of Architecture, Building Technology Department, 34427, Istanbul, Türkiye.
**** e-mail**: ozlem.eren@msgsu.edu.tr*

Abstract

The fact that the demolition of buildings that have lost their function creates environmental pollution in the form of waste they produce makes it necessary to reuse the building elements. There are important points to be ensured as of the design stage for the implementation of building dismantling. One such point is to have a designer with sufficient knowledge in designing a demountable structure in which high-level building elements can be reused. In this study, a scoring system has been developed to guide the designer in the selection of materials during the design stage so that the elements and components in the subsystems of the structures that end their life cycles are highly demountable and reusable. With this system, the designer will be able to predict to what extent the building can be dismantled and the building elements can be reused depending on the selected material.

Keywords: *Reuse, demountable, building component, element.*

Sökülebilir Yapı Elemanları ve Bileşenlerinin Yeniden Kullanımına İlişkin Rehber

Öz

İşlevini yitiren yapıların yıkımlarının atık oluşturarak çevre kirliliği oluşturması yapı elemanlarının yeniden kullanımını gerekli kılmaktadır.Yapı sökümünün gerçekleştirilmesi için tasarım aşamasından itibaren yapılması gereken bazı önemli hususlar vardır. Bunların başında tasarımcının yüksek düzeyde yapı elemanlarının yeniden kullanılabildiği bir sökülebilir yapı tasarlayabilmesi için bu konuda bilgi sahibi olması gerekliliğidir. Çalışmada yaşam ömrünü dolduran yapıların alt sistemlerini oluşturan eleman ve bileşenlerin yüksek düzeyde sökülebilir ve yeniden kullanılabilecek düzeyde olabilmeleri için tasarım aşamasında tasarımcıya malzeme seçiminde yön gösterebilecek puanlama sistemi geliştirilmiştir. Bu sistem ile tasarımcı yapının seçilen malzemeye bağlı ne oranda sökülüp, yapı elemanlarının yeniden kullanılabileceğini öngörebilecektir.

Anahtar kelimeler: *Yeniden kullanım, sökülebilirlik, yapı bileşeni, elemanı.*

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1. Introduction

The advent of Industrial Revolutionbrought about mass production with new production methods, which gave rise to high availability and low-cost products. As a result, emissions to the environment, solid waste production and landfilling have increasingly led to severe impacts due to new consumer societies and staggering growth in industrial activities. Under these circumstances, consumption of natural resources, which increases with the growing world population, will become unaffordable in near future. In this scenario, it is not only the problem of environmental pollution that becomes acute, but also the problem of global resource scarcity (European Commission, 2016; Lieder & Rashid, 2016). In this respect, reuse of building elements becomes crucial in order to reduce material waste and ensure resource efficiency. According to the United Nations Environment Program (UNEP), the built environment annually accounts for 30% of global greenhouse gas emissions and consumes 40% of all energy (Durmisevic et. al, 2017, p. 275-280). The amount of waste generated from the demolition of buildings worldwide constitutes 50% of the total amount of waste. This figure represents 180 million tons of construction and demolition waste annually in Europe (Kibert & Kibert, 2008, p. 4-8; Kibert, 1994; Crowter, 2014, p. 1-9).

A report by the World Resources Institute predicts a 300% increase in energy and material use as world population and economic activity increase over the next 50 years (Saghafi & Teshnizia, 2011, p.854). For this reason, the construction industry has recently realized the need to be environmentally responsible and has turned to activities and processes that aim at reintroducing building materials and components into the production chain to minimize their negative impact on the environment. Studies on the construction of buildings and the reusability of end-of-life waste are among the leading topics of research in both academia and industry. Deconstruction is different from destruction. While the term demolition is used for the careless destruction of structures, the term deconstruction is used to describe a selective dismantling process with the aim of recycling or reusing materials or entire elements of demountable structures for a later application (Akinade et al. 2015, p. 167-175; Obi et. al., 2021, p.2-26). Reusing building elements recovered from demolished buildings is not innovation. Not only deconstruction and adaptability save the world's depleting energy and natural material resources, but also contribute to the preservation of cultural and historical values contained in different materials and buildings (Saleh & Chini, 2009, p.30—33).

A demountable building system involves the design of buildings to facilitate future replacement by partially or completely dismantling them for the recovery of systems, components, and materials (Guy & Ciarimboli, 2005, p.2-69; Aidonis et al., 2008, p.211-216). Architects and design engineers who want to include demountability in their designs should take this into consideration in the selection of building materials, components and fasteners beginning from the first stage of design (Akinadea et al, 2017, p. 9).

Wheaton (2017) states in his graduate thesis that the reuse rate of building elements will be approximately 1% in 2016, 10% in 2020, 45% in 2050, and 80% in 2100. He argues that the recycling rate will decrease from 69% in 2020 to 35% in 2050 and to 10% in 2100, leading to a reversal from recycling to reuse, and that reuse will increase due to environmental impacts (Wheaton, 2017, p. 17). Perhaps this process will be spontaneous due to the natural depletion of resources. The age of mass production created an understanding in which cheap products were replaced by new ones without repairing them, while the old ones were seen as waste. This understanding has recently been replaced by the concept of reuse repeatedly, for we have become more aware of our responsibility to the environment. When studies on the measures that the construction sector should take against carbon emissions started in late 1980s around the world, the clearest statement regarding reuse was made in Agenda 21 at the 1992 UNESCO conference in Rio, particularly with the article that cyclical processes should replace linear ones in order to create sustainable development (Durmisevic, 2003, p. 355).

When building elements cannot meet the desired needs, they become waste and harm the ecosystem. In order to create a sustainable future, the primary goal should be the reuse of all buildings before the demolition and reconstruction processes (Paduart et al., 2009, S. 1-6; McDonough & Braungart, 2003, p.10-30). If this is not possible to achieve, it is necessary to turn to a cyclical system in which building components and elements are reused, adapted, and reuse is maximized (Debacker & Manshoven, 2016, p.6; Ness, Field & Pullen, 2005, p.1-8).

Minimizing material waste and ensuring efficient use of resources will increase the value of the investor's business on the one hand, and have a positive impact on the country's economy on the other. The degree of demountability of the structural elements that make up each construction system is different from the other. In this study, research was conducted on the demountability of light steel construction systems. Although demountability of light steel structures is predictable, it should not be limited to carrier systems as increased demountability and durability in all systems, including carrier systems, building subsystems, and all other components, will improve dismantling performance. As Cai & Waldmann, (2019) stated, there is no detailed study on demountability or the reuse of disassembled components. This study aims to show that light steel structures suitable for demountability can be included in the life cycle by reusing a high percentage of their elements through systematic dismantling, and that it is a construction system with high environmental, economic and social performance. Disassembly cannot be limited to deciding on materials and connection types. Disassembly information management also requires defining the processes that involve design decisions. Since buildings designed for dismantling have dismantling plans, and the materials have barcodes, it will be possible to know how to utilize each material after dismantling. In this way, the cycle of material use will be closed, and it will be possible to design buildings that will help transition to a zero waste construction industry (Guy & Shell, 2006). The main aspects of demountable design are listed below.

The aim of this study is to ensure resource conservation by selecting materials during the building design phase, taking into account that the building elements and components can be reused after completing their functions. In this regard, a guide has been created to determine what method(s) should be followed in order to make the right choice among all materials.

1.1. Sustainability and Demountability of Structures

Disassembly is defined as the process by which some (or all) components of a building are selectively taken apart for the purpose of reuse (Durmisevic, 2003, p. 352-361; Durmisevic, 2019, p. 12-35). Design for disassembly is defined as a feature of a product design that enables the product to be disassembled at the end of its life cycle in a way that allows its components and parts to be reused, recycled, recovered for energy, or in some cases reused. Disassembly is the non-destructive separation of an assembled product into its component or components (BS 8887-2, 2009, p. 3.11; Durmisevic, 2019, p.12-35).

Demountable construction aims to construct buildings to reduce the consumption and waste of new materials during construction, renovation and demolition processes, to increase the life of the building in situ, and to create buildings that will be future building materials. Such an approach to material and building preservation will facilitate the recovery of their components for the next renovation, and therefore provide both economic and environmental benefits for builders, owners and occupants of these buildings, as well as for the communities in which they are located. To be able to produce buildings with such an understanding, the design process must develop assemblies, components, materials, construction techniques, and information and management systems that are suitable for this goal (Deller et al., 2005, p.2-69).

Demountability involves the removal of a structure by dismantling its components in the reverse order of its construction. The last thing to be installed is usually the first thing to be removed respectively. The process may include manual and mechanical tools for dismantling. The main idea is to recover as much material as possible for reuse and/or recycling. In this sense, materials that can be reused should be preferred among the materials that can be recycled (Chini & Nguyen, 2003, p. 312; Condotta & Zatta, 2021, p. 318; Lopez Ruiz et al., 2020, p. 248; Rios et al., 2015, p. 1296 – 1304).

1.2. Demountable Building Materials and Reuse

In the demountable building design, the designer should use demountable joints in the structure design, therefore the use of welding and mortar should be avoided. It is important to design the structures with simple forms, to use a large number of standard products using modular grids, and to have a small number of types and connections. When choosing materials, the aging period of the products should be taken into consideration, durable products should be selected and composite materials should not be used. Another important point is to use light materials that will facilitate disassembly (Guy & Shell, 2006). Increasing awareness among designers and customers in the reuse of building elements, and providing incentives and rewards by local governments (shortening the approval period of the project, tax reduction, etc.) will increase the tendency towards the system in the first place. Technically, in order to increase the reliability of these elements, it is necessary to have standards, quality grading of reused materials, and a warranty certificate. Stocking sufficient quantities of the same product will also increase the applicability of the products (Eren, 2021).

The materials they are produced from and their quality play an important role in the reuse or recycling of building elements. Below, reuse of building elements and materials suitable for recycling are mentioned.

The main principles for the Life Cycle are described in international standards ISO 14040 and 14044. In addition, the European construction sector has specific standards: EN 15804 which applies at product level, and EN 15978 which applies at building level (The Environmental Impact of Reuse In The Construction Sector. n.d).

Although steel has been recycled for a long time, the reuse of this material is not at the desired level for certain reasons (Vares et al., 2019, p. 750-761; Winkler, 2010, p. 92). The removability of building and structural elements and their feasibility for reuse after dismantling should be considered carefully to determine their reuse potential with other materials and systems. In this respect, steel is an important material for sustainable construction as a material that is both removable and reusable (McDonough & Braungart, 2003, p. 15). There is no specific standard test developed for reusing reclaimed steel components. As long as they are not strongly stressed (inelastic) or do not show visible signs of plastic deformation, they can be reused in structural applications (Hobbs & Hurley, 2001, p. 98-125; Thormark, 2000, p. 1-20; Fujita, 2008, p. 230). For the reuse process of steel to become widespread (disassembly, refurbishment, testing, additional handling and handling, manufacturing), its cost must be less than the price difference between new steel and scrap (Dunant et. al., 2017, p.118–131). Structural steel and steel members of light steel structures may be reused as long as they are structurally adequate for the proposed purposes. There are certain requirements to reuse structural elements, such as the number of reuse, their size and shape, and the floor height of the new building. After cleaning steel beams and girdles from paint adhering to the surface, they can be cut into the desired length and reused if they have appropriate structural features. Durmisevic (2003) stated in his study that 83% of steel products are recycled, 14% are reused, and 3% are buried in landfill (Durmisevic, 2003, p.353).

Aluminum is a material that is preferred in many areas for its low density, high corrosion resistance, high conductivity and high ductility. Aluminum extrusions and rolled sheets are typically used as purlins and cladding for light industrial buildings. Therefore, they can be reused. Aluminum extrusions are also widely used in curtain walls and window frames. The electrolysis stage required to produce aluminum from ore is extremely energy intensive. This process requires 20 times more energy than is required to melt the equivalent mass of existing aluminum. For this reason, the aluminum industry supports the recycling of aluminum material because only 5% of the energy from the initial production is required for recycling (Allwood, 2014, p.471). In the recycling of aluminum ISO 14021 standards are used (Hydro CIRCAL recycled aluminium n.d.)

In order to facilitate the reuse of brick, it is important to label the products with the company name, indicate the raw material and firing properties, and to state the place and date of production to be able to determine the bricks that can be passed on to future generations. In cases where brick qualities differ more than today, product labeling becomes an important issue (Icibaci, 2019, p. 198-202).

Currently, there are no official standards controlling the quality of reclaimed bricks and blocks. Therefore, companies that supply recycled bricks can develop ISO accreditation under ISO9002 if they establish their own quality management systems to classify bricks according to their quality, such as first quality, medium quality and below quality. This type of system will allow customers to know what to expect and might increase customer satisfaction (Hobbs & Hurley, 2001, p. 98-125).

Brick waste from demolition can be reused in two ways. Historic bricks or those with an unusual character or color can be valuable when cleared from walls for reuse in the same project or resold for other purposes. To reuse bricks, the mortar on the surface must be cleaned (Winkler, 2010, p. 1-256). However, the mortar after the Second World War was so strong that bricks would break during cleaning with mortar remaining intact (Kowalczyk et al., 2000, p. 95-140). Generally, all types of bricks can be reused, except the bricks that come out of chimneys (Thormark, 2000, p. 1-20). If lime mortar or other weak mortars are used in applications, it is easier to reuse the bricks as they are easily separated from each other. Currently, clay bricks are rarely reused for several reasons. The first reason is the lack of feasible and economical methods for cleaning bricks. Another reason is the lack of non-destructive testing methods. However, methods are constantly improving (Thormark, 2000, p. 1-20; Webster et al., 2007, p. 55-67). It is thought that this practice will become widespread in the future with the availability of easy cleaning methods to remove mortar, for clay bricks and roof tiles are building materials that can easily be removed and reused.

Although wood is a natural renewable resource and therefore has a very low environmental impact, it is widely recycled and reused. If timber is graded, a label should provide information about the strength class, species group, and origin. This information can help the architect to see that the lumber meets their specifications. Non-structural wood can also be reused in non-structural applications, but it is not subject to the strict rules mentioned above. Many wood components reclaimed from existing structures contain nails and screws that must be removed or made safe for transport before being reused or recycled. In wooden elements to be used structurally, the gaps created by the diameters of the removed nails and the decrease in the capacities of the elements should be determined (Winkler, 2010, p. 1-256). For low-income families, second-hand construction markets provide the opportunity to build their own homes. Wooden floor coverings and other wooden structural elements tend to be replaced with new ones due to user change or changes in fashion trends although these elements have been used very little and are undamaged. Reusing these elements will provide great economy to second-hand users (Kowalczyk, Kristinsson & Hendriks, 2000, p. 95-140). *Incorporating reused wood elements can also present structural challenges for architects. The structural integrity of the reused wood may be compromised, requiring careful evaluation and design adjustments. Despite several challenges (such as health concerns, or special care and maintenance demands), the aesthetic appeal and sustainability-related benefits make the reuse of wood elements a trend in architecture that is likely to continue in the years to come (*Kuzman et al., 2024, p. 2).

Increasing recycling rates of PVC pipes will increase the life cycle of PVC and reduce the amount of PVC going to landfill. PVC can be recycled six to seven times. With a product life of 100 years, this means that PVC material could potentially have a lifespan of 600 years. All recycled PVC can be used in multilayer non-pressure pipes (Construction and Demolition Waste Guide-Recycling and Re-use Across the Supply Chain, n.d.).

Glass products that are removed from buildings and expected to be reused generally include windows, doors, partition walls, etc. They are plate-shaped glass products extracted from metal. While they can be used for the same purposes, they can also be used in making mosaic floors by grinding, melting and processing.

Ceramic tiles used as wall and floor coverings are difficult to remove from surface. The adhesive mortar on the back of tiles that can be removed without breaking them is cleaned, while the broken ones can be reused by creating new patterns according to the size of the pieces. Ceramic companies such as Corian Gronala Company and Vetrazzo Company produce covering tiles from used glass and ceramic products.

Clean and dry insulation products can often be reused in projects. However, there are certain factors that might discourage the architect to reuse these products. One factor is the relatively high cost of storing insulation products for reuse. Also, old insulation products are usually thicker, and they do not function at desired levels, which might require additional insulation and increase the total cost. Still, if the original insulation materials meet the desired insulation value, their use will be economical. Insulation layers that are not damaged by moisture should be separated from those that are damaged. Since insulation materials are usually glued or nailed to the substrate, screw holes or other damage to the panels may occur during the removal process. The damaged parts of the insulation must be separated or repaired to increase their effectiveness. While carrying out these operations, it is necessary to ensure that there is no performance loss, there is no increase in costs, and there is no tendency towards new products (Winkler, 2010, p. 1-256). Thermal insulation products such as rigid Expanded Polystyrene (EPS), Polyisocyanurate (PIR), mineral wool and glass wool (in smaller quantities) are also available in used building products market. Particularly, insulation panels are often available on the used product market, and they are cheaper than their new equivalent products (Icibaci, 2019, p. 198-200). The change in the heat conduction coefficient of insulation materials over time should be determined by tests and technical information about the current situation should be given in detail. *EN 13501-1 for fire resistance, ISO 9221 for corrosion resistance, EN 29053 (ISO 9053) for air permeability, EN 29052-1 for acoustic applications, EN ISO 10140-1 for sound ınsulatıon, EN 16012 for durability, EN ISO for vapor diffusion 12572, EN 13859-1 for water tightness* (Thermal Insulatıon Products For Buildings With Radıant Heat Reflective Componenets. 2015 European Assesment Documents n.d). Products for mechanical and electrical services such as lamps, taps, boilers, elevators, fans, fixtures, radiators and plumbing are the best-selling materials in the reuse market (Icibaci, 2019, p. 98-200).

2. Material and Method

In this study, the scoring system that has been developed to measure the demountability and usability of the elements in building subsystems after dismantling consists of two stages. Firstly, the products to be used in all subsystems are listed and coded. These elements and components are scored on a Likert scale according to the criteria of durability, demountability and sustainability, with numerical data taken from the literature and in consultation with experts. During the design phase, each subsystem is scored according to the determined criteria. When the scores given to all the subsystems are added together, the demountability score of that structure is found. The designer can increase the degree of demountability of the structure by choosing different products during the design phase (Eren, 2021).

3. Findings and Discussion

3.1. Material Selections

Detachable light steel structure design should be made according to the characteristics of the building elements and the relationships established by the building subsystems (Table 1, Figure 1). In Table 2, the building subsystems that are planned to be used in the subsystems are grouped according to the basic materials. Materials of the elements and components that make up all the subsystems of light steel structures are then classified and coded (Table 4,5,6).

The values given according to the criteria in the selection of building elements and components determine the level of their reusability after the structure is dismantled.

This study is based on the principle of scoring the 5 subsystems of light steel structure separately. In the scoring tables, all components that make up the subsystems are scored according to the criteria determined in Table 3.

Table 1. Materials used in building subsystems (Original)

Roof Coverings	Wall Claddings	Floor Coverings	Water Insulation	Thermal Insulation
Terracotta Roof Covering Metal Roofing Cement Roof Coverings Bitumen Based Roof Coatings Polymer Based Roof Coverings Glass Coatings Stone coverings Wooden Roofing	**Exterior Wall Coverings** Cement Based CoatingMetal Based Coatings Polymer Based Coating Baked Clay Based Coating Stone Veneer Glass Coated Wood Veneer **Interior Wall Coverings** Gypsum Plaster + Paint Coating. Paper Coating Ceramic coating Wood Veneer	**Floor Coverings** Natural Stone Veneers Cement Based Coatings Wood and Wood Based Coatings Artificial Polymer Based Coatings Natural Polymer Based Coatings Glass Based Coatings Metal Based Coatings Carpet Coverings Stone Veneers **Ceiling Covering** Structural Coverage	Bitumen Based Products Plastic Based Products Special Waterproofing Boards Vapor Blocker-Moisture Blocker Vapor Balancer	Thermal Insulation Products of Plant and Animal Origin - Organic Insulation Mineral origin thermal insulation products Thermal insulation products of synthetic origin (synthetics)

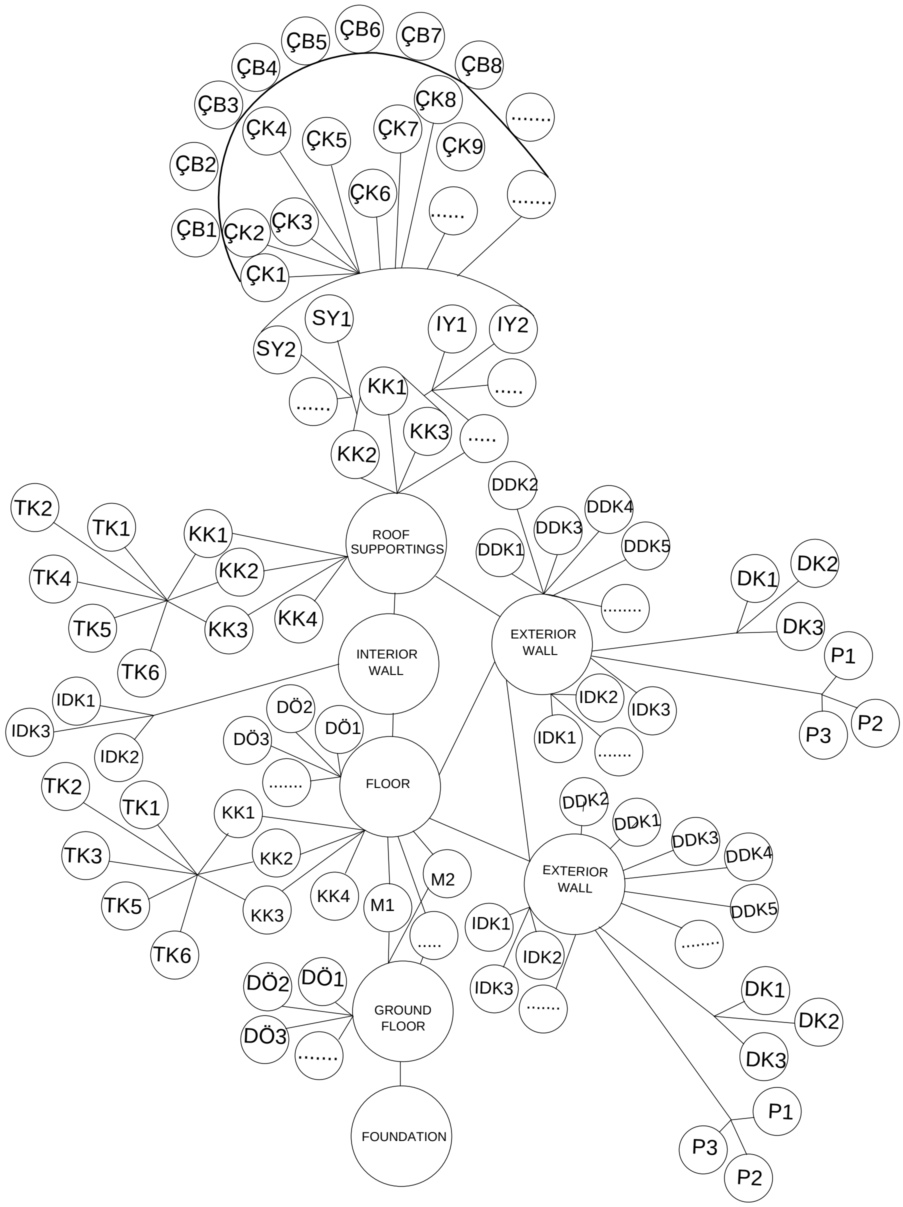


Figure 1. Relationship of detachable structural elements with the light steel carrier system (Eren, 2021)

Table 2. Demountable scoring table of light steel structure (Eren, 2021)

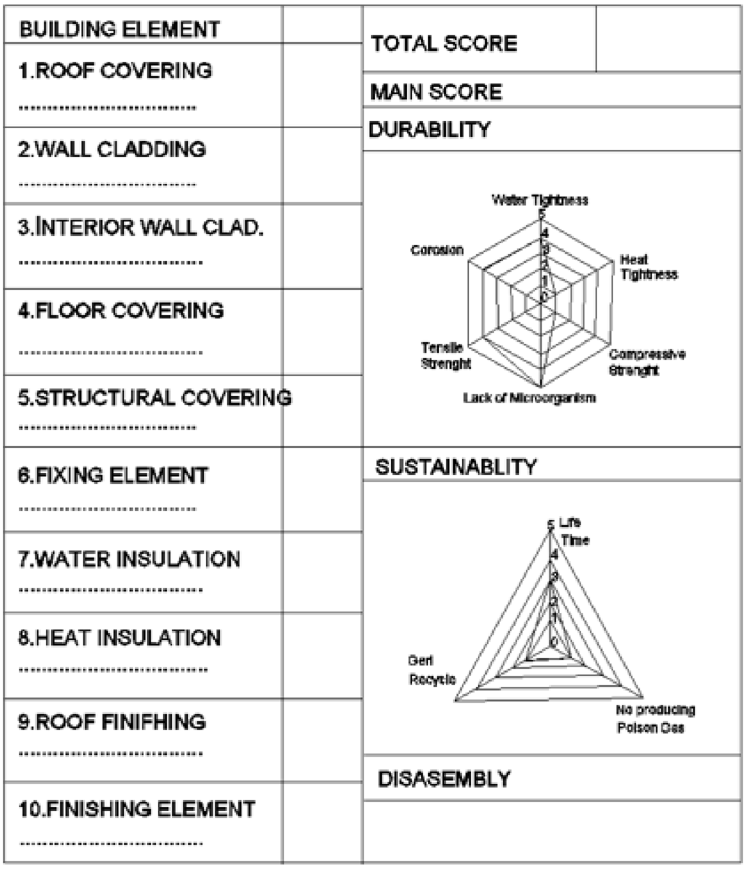


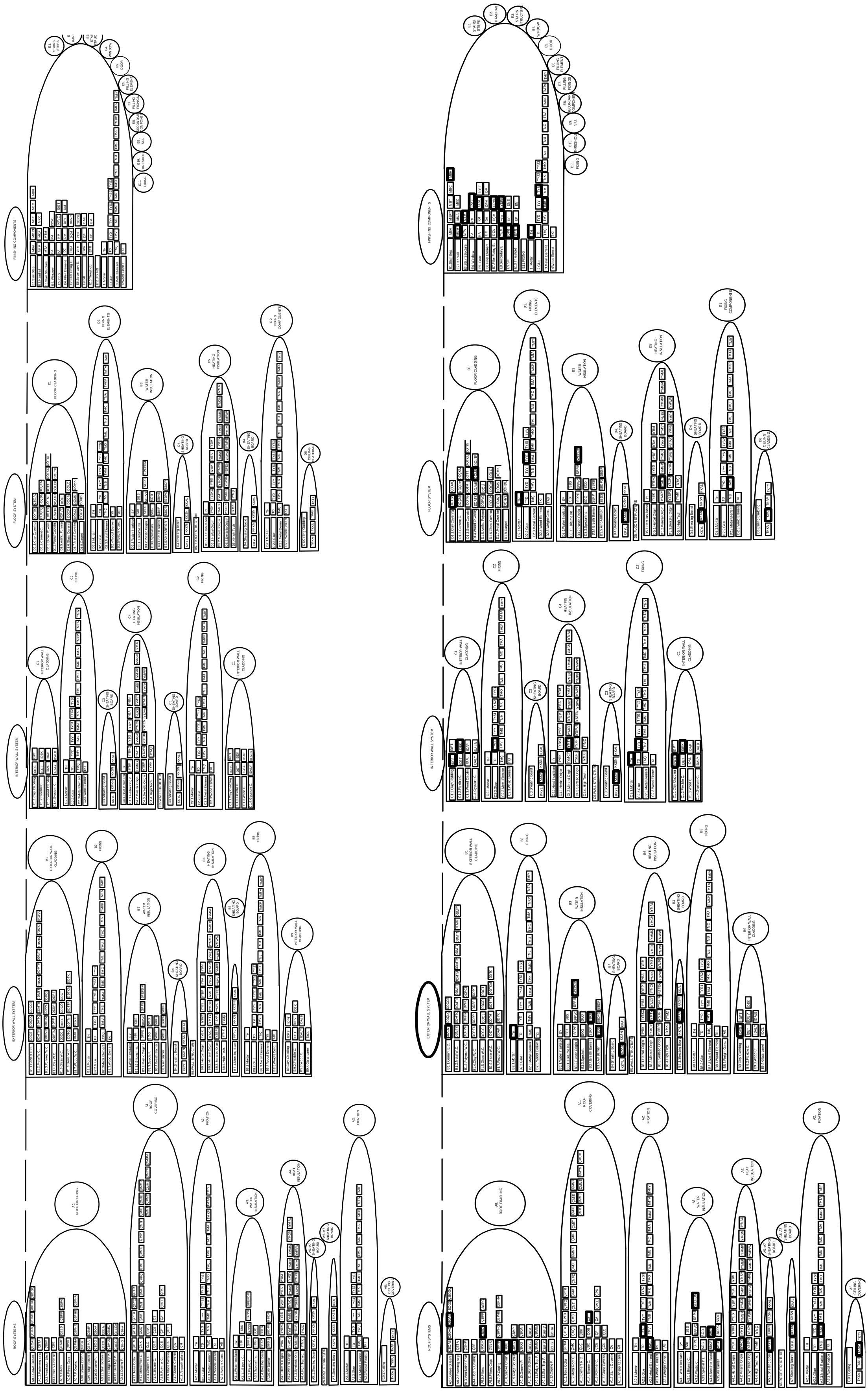
Table 3. Main and sub-criteria (Eren, 2021)

Main Criteria	Sub-criteria
Durability	Waterproofness Thermal expansion Compressive strength Tensile strength Microorganism growth Corrosion formation
Demountablity	
Sustainability	Life span Does not emit toxic gas Recyclability

Table 4. Classification of the elements and components that make up the building subsystems by coding them according to materials (Eren, 2021)

CONSTRUCTION MATERİALS	KOD
1.ROOF COVERINGS	**ÇT**
Terracotta Roof Coverings	
Marseille Tile	Ç_{PTM}
Ottoman Tile	Ç_{PTA}
Corrugated Tile	Ç_{PTD}
Roman Tile	Ç_{PTR}
Metal Roof Coverings	
Single Layer Roof Coverings	
Bullet	Ç_{MK}
Zinc	$\text{Ç}_{\text{MÇ}}$
Copper	Ç_{MB}
Titanium	Ç_{MT}
Aluminum	Ç_{MA}
Stainless Steel	$\text{Ç}_{\text{MPÇ}}$
Corten Steel	Ç_{MC}
Metal Tile	Ç_{MMK}
Insulated Metal Roof Coverings Sandwisch	
Two Sided Metal Sandwich Panel	
Polurethane Insulated Panel	Ç_{MIP}
Rockwool Insulated Panel	Ç_{MIT}
Glasswool Insulated Panel	Ç_{MIC}
EPS	Ç_{MIE}
Membran Sandwich Panels	
Sandwick Panels Made on Site	
Two sided Metal Sandwich Panels	Ç_{MYM}
Top Face Membrane Systems	$\text{Ç}_{\text{MÜM}}$
Cement Based Roof Coverings	
Fiber Cement Based Corrugated Sheet	$\text{Ç}_{\text{LÇ}}$
Concrete Tile	Ç_{BK}
Bitumen Based Toof Coverings	
Bitumen Sheets	$\text{Ç}_{\text{BÖ}}$
Corrugated Bitumen Sheets	Ç_{OB}
Asphalt Shingle	Ç_{S}
Polymer Based Roof Coverings	
Glass Fiber Reinforsed Polyester (GFR)	Ç_{CE}
PolikorbanAT (PC) Sheets	Ç_{P}
Acrylic based Roof Coverings	Ç_{A}
Polivinil Chloride (PVC) Sheets	Ç_{PKL}
Plastic Tiles	Ç_{PK}
Glass Coatings	
Glass Tile	Ç_{CK}
Laminated Glass	Ç_{LC}
Stone Veneers	
Slate	Ç_{A}
Wooden Roof Coverings	
WoodenHartama (bedavra)*	Ç_{H}
2.WALL CLADDİNGS	**DDK**
Cement Based Coating	
Plaster	$\text{DD}_{\text{ÇS}}$
Fiber Cement Board	$\text{DD}_{\text{ÇLÇ}}$
Glass Fiber Reinforced Concrete Panel	$\text{DD}_{\text{ÇCE}}$
Metal Wall Claddings	
Single Layer Claddings	
Bullet	DD_{MTK}
Zinc	$\text{DD}_{\text{MTÇ}}$
Copper	DD_{MTB}
Titanium	DD_{MTT}
Aluminum	DD_{MTA}
Stainless Steel	DD_{MTP}
Corten Steel	DD_{MTC}
Composite Claddings	
Sandwich Panels made on Site	
Polymer Based Facade Claddings	
Vinyl Polymer Facade Cladding-PVC	DD_{PVP}
PMMA-Acrylic Sheet	DD_{PPM}
PC Panel	DD_{PPC}
Glass Fiber Reinforced Polyester Sheet	DD_{PCE}
Clay Facade Claddings	
Brick	DD_{PTU}
Plaque	DD_{PP}
Ceramic Tile	DD_{SP}
Teracotta	DD_{PT}
Glass Claddings	
Glass Composite PVB	DD_{CC}
Laminated Glass	DD_{CL}
Prestressed Glass	DD_{CO}
Tempered Glass	DD_{CT}
Stone Claddings	
Granit	DD_{TG}
Marble	DD_{TM}
Travertine	DD_{TTR}
Sandstone	DD_{TKM}
Limestone	DD_{TK}
Wood Claddings	
Wood Composite	DD_{MK}
Weather boarding	DD_{MK}
3. THERMAL INSULATION	
Herbal Origin	
Hemp	IYB_{K}
Sheep Wool	IYB_{KO}
Cellulose	IYB_{S}
Cooton	IYB_{P}
Wood Wool Board	IYB_{A}
Mushroom	IYB_{M}
Mineral Origin Thermal Insulation	
Glass Wool	IYM_{CY}
Rock Wool	IYM_{TY}
Expanded Perlite	IYM_{GP}
Glass Foam	IYM_{CK}
Calcium Silicate	IYM_{KS}
Ceramic Wool	IYM_{SY}
Elastomeric Rubber	IYM_{EK}
Melamin Foam	IYM_{MK}
Expanded Vermiculite	IYM_{EK}
Wood Fiberboard	IYM_{MK}
Syntehetic Origin Thermal Insulation	
Ekspanded Polystytene Foam (EPS)	IYS_{EPS}
Ekstrude Polystytene Foam (XPS)	IYS_{XPS}
Polyurethane Foam (PUR)	IYS_{PUR}
Phenol Foal	IYS_{FEN}
Polyvinylchloride Foal (PVC)	IYS_{PVC}
Polethylene Foam (PE)	IYS_{PE}
Poloefin Foam	IYS_{PK}
Woold Wool Composite (WW)	IYS_{WW}
Advanced Technology Thermal Ins	
Aerojel	IY_{MK}
Vakum Insulated Panel	$\text{IY}_{\text{MÇ}}$
4. INTERIOR WALL CLADDINGS	**İDK**
Clay Based Claddings	
Ceramic	İD_{PS}
Teracotta	İD_{PT}
Flexible Claddings	
Textile	İD_{ET}
Vinyl	İD_{EV}
Paper	İD_{EK}
Wooden Wall Claddings	
Wood Panel	İD_{AL}
Wooden Board	İD_{AP}
Plaster Based Claddings	
Green Plasterboard	İD_{ALY}
White Plasterboard	İD_{ALB}
Glass Claddings	
Sheet Glass	İD_{CL}
5.FLOORING COVERINGS	**DK**
Terracotta	
Ceramic Tile	DÖ_{TSK}
Ceramic Mozaic	DÖ_{TSM}
Cement Based Coatings	
Concrete Screed	$\text{DÖ}_{\text{ÇBŞ}}$
Cast Mozaik	$\text{DÖ}_{\text{ÇDM}}$
Tile mozaik	$\text{DÖ}_{\text{ÇKM}}$
Stone	
Granit e	DÖ_{TG}
Marble	DÖ_{TM}
Travertine	DÖ_{TT}
Sandstone	DÖ_{TKU}
Limestone	DÖ_{TKI}
Wood	
Wood panel	DÖ_{ATK}
Parqued	DÖ_{AMP}
Laminated Panel	DÖ_{LEP}
Laminate Panel	DÖ_{LTP}
Artifcial Polyemer	
PVC Coatings	DÖ_{PVC}
Linoleum	DÖ_{LI}
Glass Coatings	
Glass Parquet	DÖ_{CP}
Glass Mozaic	DÖ_{CM}
Laminated Glass	DÖ_{LC}
Metal Coatings	
Grill Coatings	DÖ_{MIZ}
Metal Sheet	DÖ_{MS}
Metal Ceramic ve Mozaik	DÖ_{MK}
Carpet	
Artificial Fiber	DÖ_{HYL}
Natural Fiber	DÖ_{HDL}
6.CEILING COVERINGS	**TK**
Paper	TK_{KA}
Tekstile	TK_{KU}
Plasterboard	TK_{AP}
Rock Wool Panel	TK_{TY}
Metal Panel	TK_{MP}
7.STRUCTURAL COVERINGS	**KK**
OSB-particleboard	KK_{YL}
Plywood	KK_{KN}
Hatdboard	KK_{SN}
Plasterboard	KK_{AL}
8.FIXİNG ELEMENTS	**TE**
Mortar	
Natural adhesive	T_{YD}
Semi synthetic	T_{YY}
Synthetic polimer	
Termoset yapıştırıcılar	T_{YS1}
Akrilik polimerler	T_{YS2}
Termoplastik yapıştırıcılar	T_{YS3}
Vinil polimerler	T_{YS4}
Metal Fasteners	
Nail	$\text{T}_{\text{MÇ}}$
Screw	T_{MV}
Bolt	T_{MB}
Metal Clamp	T_{MM}
Bracket	T_{MK}
Omega Profile	T_{MO}
L profile	T_{ML}
U profile	T_{MU}
C profile	T_{MC}
Agraf profile	T_{MA}
Perforated Corner Profile	T_{MKP}
Ceiling Suspention Profile	T_{MTA}
Thermal Insulation Fixing Dowel	T_{MIY}
Wooden Compenet	
Frame, slat	T_{KL}
Gravity Concrete	T_{AB}
9.WATER INSULATION	**SY**
Bitumen Based Insulation	
Organic Bituminous Product	SBI
Synthetic Bituminous Product	SBS
Plastic Origin Insulatiom	
PolYethylene (PE)	SP_{PE}
Polyvinlychloride (PVC)	SP_{PVC}
Polyisobitulene (PIB)	SP_{PIB}
Synthetic Rubber- Ethylene Propylene Diene Terpolymer(EPDM)	SP_{EPDM}
Special Insulation Products	
Geotextiel-Separating Layer	SÖ_{G}
Dranage Boards	SÖ_{D}
Vapor Barier	
Polymer	SBK_{P}
Bituminous	SBK_{B}
Vapor Balance	
Bitumen Based Products	SBD_{B}
Polymer Bitumen	SBD_{PO}
Plastic Bitumen	SBD_{P}
10.ROOF FINISHING	**ÇBE**
Gutter-Groove	
Hanging Gutter	
Copper	ÇB_{OAB}
Zinc	$\text{ÇB}_{\text{OAÇ}}$
Galvanized Steel	ÇB_{OAG}
Hidden Groove	
Galvanized Steel	ÇB_{OGG}
Zinc	$\text{ÇB}_{\text{OGÇ}}$
Fixing Strip	ÇB_{TA}
Ventilation Chimney	ÇB_{HP}
Membrane Ventilation Chimney	ÇB_{MG}
Sloping Roof (Shingle) Ventilation Chimney	ÇB_{E}
Strainer	
Stteep Drop Pipe	
PVC	ÇB_{SDP}
Galvanized Sheet	ÇB_{SDG}
Parapet Outlet	
PVC	ÇB_{PP}
Galvanized Sheet	ÇB_{SPG}
Stainer Covers – Stainless Steel Sheet	ÇB_{SK}
Parapet harpuşta	
Alūminum	ÇB_{PHA}
Galvanized Steel Sheet	ÇB_{PHG}
Prekast Concrete	ÇB_{PHB}
Stone Sheet	ÇB_{PHP}
Smoke Chimney	ÇB_{DB}
Ridge Bottom Profile	
Alūminum	ÇB_{MA}
Stainless Steel	ÇB_{MP}
Gutter Edge Profile	
Galvanized Painted Profile	ÇB_{OG}
Aluminum	ÇB_{OA}
Bottom Profile	
Galvanized Painted Sheet	ÇB_{EG}
Aluminum	ÇB_{EA}
Ridge Top Profile	
Galvanized Painted Sheet	$\text{ÇB}_{\text{MÜG}}$
Aluminum	$\text{ÇB}_{\text{MÜA}}$
Top Profile	
Galvanized Painted Sheet	$\text{ÇB}_{\text{EÜG}}$
Aluminum	$\text{ÇB}_{\text{EÜA}}$
Coping Profili	
Galvanized Painted Sheet	ÇB_{HG}
Aluminum	ÇB_{HA}
11.STAIRS AND FINISHINGH COMPONENT	**ME**
Stairs by Supporting System	
Wood	MT_{A}
Metal	MT_{M}
Stair Step Covering	
Wood	MB_{A}
Ceramic	MB_{PT}
Stone	MB_{T}
Glass	MB_{C}
Carpet	MB_{H}
Railing Types	
Metal Railing	MK_{M}
Wood Railing	MK_{A}
Glass Panel Railing	MK_{C}
Window and Exterior Door Joirney Frame	
EWood	P_{A}, K_{A}
Metal-Aluminum	P_{M}, K_{M}
PVC	P_{PV}, K_{PV}
Filling Component	
Glass	D_{C}
Wood panel	D_{A}
PVC panel	D_{PV}
Metal panel	D_{M}
Fill Component Fixing	
Slat	$\text{D}_{\text{ÇA}}$
Wood	$\text{D}_{\text{ÇM}}$
Metal	$\text{D}_{\text{ÇV}}$
Nail, Screw	$\text{D}_{\text{ÇIV}}$
Secondary Components	
Hinge	YE_{M}
Door and Window Handle	YE_{K}
Blinds, Shutters	D_{PR}
Sill and Threshold Types	
Precast	E_{PR}
Stonel Panel	D_{P}, E_{P}
Metal	D_{P}, E_{M}

Table 5-6. Material selection table (Eren, 2021)



Building subsystems are scored based on the following scoring system: according to durability, sustainability, and demountability criteria (Eren, 2021).

Durability Criteria include water impermeability, thermal expansion, compressive strength, tensile strength, microorganism growth and corrosion sub-criteria (Table 7, 8, 9, 10, 11).

The water permeability (%) values of the materials are calculated first in the scoring of water absorption. The water permeability values of the examined materials range from 0 to 30 and above. These values are scored on a 5-point Likert scale. According to the scoring system that has been established based on expert opinion, if the water impermeability value is 0, it will receive 5 points; between 0.1-5, it will receive 4 points; between 5-10, it will receive 3 points; between 11-29, it will receive 2 points, and if it is 30 and above, it will receive 1 point (Table 7).

Thermal expansion (cm / cmºC x10^{-6}) ***:*** It has been determined that the thermal expansion values of the materials (Arpacıoğlu, Ü., Diri C. 2009). that can be used in buildings are between 0 and 80 and above. Accordingly, it has been decided to give 5 points to products with a value between 0-10, 4 points to a value between 10.1-20, 3 points to a value between 20.1-59.9, 2 points to a value between 60-80, and 1 point to a value of 80 and above (Table 8).

Compressive Resistance **(N/mm²)*:*** Compressive strength of the used components is scored between 0 and 1200. Values of 0-49 receive 1 point, 50-199 2 points, 200-499 3 points, 500-899 4 points, and 900-1200 receive 5 points (Table 9).

Tensile Strength **(N/mm²)*:*** Tensile strength of the used components range from 0 to 800 and above. According to the 5-point Likert scale, 1 point is given to tensile strength values between 0-99, 2 points to 100-199, 3 points to 200-499, 4 points to 500-799, and 5 points are given to values of 800 and above (Table 10).

Corrosion resistance scores are given according to whether the material is metal or not, and if it is, according to its corrosion properties. For each product, the durability score is obtained by adding up the scores given to the sub-criteria under the durability criterion (Table 11). Since the evaluation of corrosion in non-metallic materials is made on a 3-point Likert scale on the Karasus Company's website, corrosion properties are evaluated according to this scale in this study, too. However, since the 5-point Likert scale has been used in this study and the materials evaluated are not limited to metal only, the three-point scale is converted into a 5-point Likert scale based on expert opinion. Accordingly, 1 (good) in Karsus's table has been converted to 5 in the evaluation table of this study; 2 (be careful) to 3 (not useful-medium), and 3 (not useable-medium) to 1. In the evaluation table of this study 5 stands for excellent and 2 for very precautionary.

Resistance to Microorganism Growth: Resistance of the components against the production of microorganisms has been scored based on expert opinion. Experts were asked to answer a set of questions with the following descriptive answers: excellent, good, average, bad, and very bad. These answers were then converted into numerical values by giving a number from 5 to 1 respectively (Table 12).

Sustainability criterion The sustainability criterion is evaluated in 3 stages according to the sub-criteria of the ***life span of the elements*** (Table 13), ***recyclability*** (Table 14) and whether they ***emit toxic gases*** (Table 15) or not. + values get the highest score of 5 points, medium +- 3 points, and - values get the lowest 1 point.

The demountability criterion has been established according to the 5-point Likert scale by taking expert opinion on the demountability levels of building elements and components.

Table 7. Water impermeability (%) (Eren, 2021)

Water absorption value	0	0.1-5	5-10	11-29	30 and above
Weighting-scoring according to 5-point Likert Scale	5	4	3	2	1

In the evaluation made on a 5-point Likert scale, 5 represents the best option and 1 represents the worst option.

Table 8. Thermal expansion (cm / cmºC x10⁻⁶) (Eren, 2021)

Thermal expansion value	0-10	10.1-20	20.1-59.9	60-80	80 and above
Weighting-scoring according to 5-point Likert Scale	5	4	3	2	1

T

Tablo 9. Compressive Strength **(N/mm²)** (Eren, 2021)

Compressive strenght value	500-1200	499-200	199-50	49-20	19-0
Weighting-scoring according to 5-point Likert Scale	5	4	3	2	1

Tablo 10. Tensile Strength **(N/mm²)** (Eren, 2021)

Tensile Strenght	0-99	100-199	200-499	500-799	800 and above
Weighting-scoring according to 5-point Likert Scale	1	2	3	4	5

Table 11. Corrosion Resistance (Eren, 2021; Corosion Durability, n.d.)

Corrosion resistance	Perfect	Good	Modarete	Bad	Worse
Weighting-scoring according to 5-point Likert Scale	5	4	3	2	1

Tablo 12. No microorganism growth (Eren, 2021)

Lack of growth of microorganisms	Perfect	Good	Modarete	Bad	Worse
Weighting-scoring according to 5-point Likert Scale	5	4	3	2	1

Table 13. Life time of elements and components (Eren, 2021)

Life span	0-9	10-29	30-49	50-99	>100 and above
Weighting-scoring according to 5-point Likert Scale	1	2	3	4	5

In the evaluation made according to 5-point Likert performance, 5 represents the best option and 1 represents the worst option

Table 14. Recyclability of elements and components (Eren, 2021)

Recycle	Excellent	Fair	Bad
Weighting-scoring according to 5-point Likert Scale	5	3	1

In the recycling of coatings, + is given for those that can be recycled, - for those that cannot be recycled, and +- for those that are partially recycled.

Tablo 15. Emit toxic gases (Eren, 2021)

No toxic gas emissions	Excellent	Fair	Bad
	5	3	1

In the recycling of coatings, + is given for those that can be recycled, - for those that cannot be recycled, and +- for those that are partially recycled.

The total demountability score of the building is obtained by scoring each system of the building, consisting of roof system, exterior wall system, flooring system and finishing elements, according to its own material. When the worst items are selected from the list of materials in Table 4, the structure's score is 870; when the best materials are selected , on the other hand, the structure recevies a maximum score of 1084. The structure can be scored in 5 categories. Scores 870 and below are considered as the worst, 871-930 as bad, 931-1000 as medium, 1001-1083 as good, and 1084 and above as very good. In order to improve the scoring of the structure, the selection of elements in each subsystem must be changed.

3.2. Implementation of the Recommended System on Roof Covering

The proposed system was applied to the roof covering of a light steel structure. After the structural covering and insulation layers etc that make up the roof system are scored in the same way, the score of the entire roof system is obtained. When the roofing shingle material is selected, it is seen that it receives a total of 26 points. Each layer forming the structure is scored in this way and the total dismantling score of the building is found. The demountability score of the structure can be increased by changing the materials (Figure 2, Table 16,17,18,19,20).

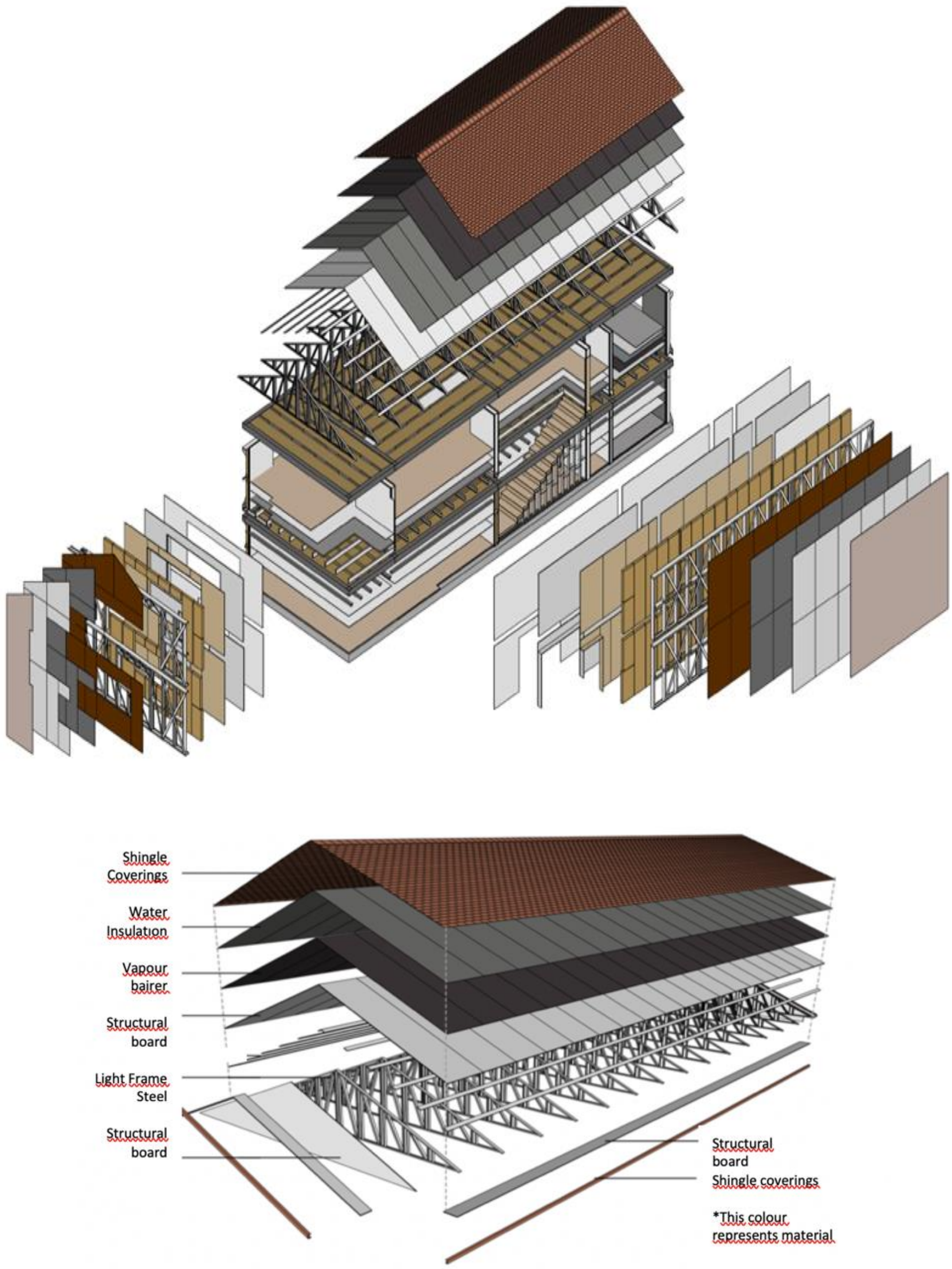


Figure 2. Separation of materials used in building subsystems into layers (Eren, 2021)

Table 16. Giving durability criterion scores of roof coverings (Anonymus, n.d.; İzo Birlik, n.d.; Cyprus Environmental Enterprises, n.d. a; Cyprus Environmental Enterprises (n.d. b); Çatı Kaplama Malzemeleri, n.d.; Almanac, n.d.; Cam Çatı Kaplamaları, (n.d.); Metal Kiremitler için Arduaz Granülleri. (n.d.); Fibercement Nedir? (n.d.); Erdem & Yatağan, 2014; Eren, 2021). Cam Elyaf Takviyeli Beton. (n.d.); Izocam Tekiz. (n.d.); Özan et al., 2017, Eren, 2021).

ROOF COVERING Main Group	Sub- Group	Code	Waterproofing %	SCORE	Coefficient Thermal Expansion cm / cm°C x10⁻⁶	SCORE	Corrosion score	Microorganism Upbringing SCORE	Compressive Strenght N/mm²	SCORE	Tensile Srenght N/mm²	SCORE	TOTAL SCORE
Clay Claddings	**Marseille Tile**	ÇPTM	10.37	3	5	5	4	4	28	2	12	1	19
	Ottoman Tile	ÇPTA	10.37	3	5	5	4	4	28	2	12	1	19
	Flat Tile	ÇPTD	10.37	3	5	5	4	4	28	2	12	1	19
	Corrugated Tile	ÇPTO	10.37	3	5	5	4	4	28	2	12	1	19
	Roman Tile	ÇPTR	10.37	3	5	5	4	4	28	2	12	1	19
Metal Wall Cladding	Lead Roofing	ÇMK	0	5	29	3	5	5	300	4	70	1	23
	Zinc Roof Coating	ÇMÇ	0	5	35	3	5	5	166	3	170	4	25
	Copper Roofing	ÇMB	0	5	16	4	5	5	350	4	230	2	25
	Titanium	ÇMT	0	5	9	5	5	5	28	2	69	1	23
	Aluminum	ÇMA	0	5	24	3	5	5	40	2	200	2	22
	Stainless Steel Galvanized S.	ÇMPÇ	0	5	12	4	5	5	515	5	860	1	25
	Metal Tile	ÇMMK	0	5	12	4	5	5	40	2	480	2	23
	Corten Steel	ÇMC	0	5	12	4	3	5	515	4	860	1	22
	Two sided metal sandwich p. – Polyurethane	ÇMİP	0	5	23	3	5	5	40	2	480	2	22
	Rockwool.	ÇMİT	0	5	23	3	5	5	40	2	480	2	22
	Glasswool	ÇMİC	0	5	23	3	5	5	40	2	480	2	22
	EPS	ÇMİE	0	5	23	3	5	5	40	2	480	2	22
	Membranlı Sandwich P. – Polyurethane	ÇMMP	0	5	23	3	5	5	40	2	480	2	22
	Rockwool.	ÇMMT	0	5	23	3	5	5	40	2	480	2	22
	Glasswool	ÇMMC	0	5	23	3	5	5	40	2	480	2	22
	EPS	ÇMME	0	5	23	3	5	5	40	2	480	2	22
	On-site bothe sides metal s.	ÇMYM	0	5	23	3	5	5	40	2	480	2	22
	Top Face Membrane S.	ÇMÜM	0	5	23	3	5	5	40	2	480	2	22
Cement Coating	Fiber Cement Based Corrugated	ÇLÇ	1-3	4	23	3	4	4	1000	5	300	2	22
	Concrete Tile	ÇBK	7	3	15	3	4	4	50	3	3	1	18
Bitumen Coating	Bituminous cover roof c.	ÇBÖ	0	5	121	1	4	5	0.35	1	800	1	21
	Corrugated bitumen roof c.	ÇOB	12	2	121	1	4	5	40	2	300	3	17
	Asphalt shingle	ÇS	1.5	4	121	1	4	5	0.30	1	600	4	19
Polymer Coating	Glass Fiber Polyester-CTP	ÇCE	0.16	4	25	3	5	5	63	3	132	2	22
	Polikorbanat -PC Based C.	ÇP	0.16	4	70	2	5	5	79.3	3	23.7	1	20
	Acrylic based roofing c.	ÇA	0.16	4	75	2	4	5	80	3	120	2	20
	Polivinil Chloride-PVC c.	ÇPKL	0.1-2	4	20	4	4	5	60	3	90	1	21
	Polyamide Plastic Tile	ÇPK	0.1-2	4	5	5	4	5	60	3	90	1	22
Glass Coating	Glass Tile	ÇCK	0	5	8	5	5	5	410	4	90	1	25
	Laminated Glass	ÇLC	0	5	8	5	5	5	1200	5	90	1	26
Stone Coating	Slate Tile	ÇA	3	4	9 l.par. 50 l.dik	3	5	5	100	3	90	1	21
Wood Coating	Wooden Hartama	ÇH	30-80	1	3.7	5	3	2	Lif∥10.000 Lif⊥300	4	130	2	17

Table 17. Scoring of sustainability criteria for roof coverings (Eren, 2021)

ROOF COVERINGS Main Group	Sub Group	Code	Life Time	SCORE	Do not emit toxic gas	SCORE	Recyclability	SCORE	Total SCORE
Clay Cladding	**Marseille Tile**	ÇPTM	150	5	+	5	+	5	15
	Ottoman Tile	ÇPTA	150	5	+	5	+	5	15
	Flat Tile	ÇPTD	150	5	+	5	+	5	15
	Corrugated Tile	ÇPTO	150	5	+	5	+	5	15
	Roman Tile	ÇPTR	150	5	+	5	+	5	15
Metal Wall Cladding	Lead Roofing	ÇMK	>100	5	+	5	+	5	15
	Zinc Roof Coating	ÇMÇ	>100	5	+	5	+	5	15
	Copper Roofing	ÇMB	70	4	+	5	+	5	14
	Titanium	ÇMT	>100	5	+	5	+	5	15
	Aluminum	ÇMA	>100	5	+	5	+	5	15
	Stainless Steel Galvanized S.	ÇMPÇ	50	3	+	5	+	5	13
	Metal Tile	ÇMMK	>100	5	+	5	+	5	15
	Corten Steel	ÇMC	>100	5	+	5	+	5	15
	Two sided metal sandwich p.	ÇMİM	70	4	_	1	+	5	10
	Membranlı Sandwich P.	ÇMMS	20	2	_	1	+-	3	6
	On-site bothe sides metal s.	ÇMYM	>50	4	+	5	+	5	14
	Top Face Membrane S.	ÇMÜM	20	2	_	1	+-	3	6
Cement Coating	Fiber Cement Based Corrugated	ÇLÇ	45	3	+	5	-	1	8
	Concrete Tile	ÇBK	100	5	+	5	+-	3	13
Bitumen Coating	Bituminous cover roof c.	ÇBÖ	35	3	_	1	-	1	5
	Corrugated bitumen roof c.	ÇOB	40	3	_	1	-	1	5
	Asphalt shingle	ÇS	25	2	_	1	-	1	4
Polymer Coating	Glass Fiber Polyester-CTP	ÇCE	35	3	_	1	+	5	9
	Polikorbanat -PC Based C.	ÇP	35	3	_	1	+	5	9
	Acrylic based roofing c.	ÇA	35	3	_	1	+	5	9
	Polivinil Chloride-PVC c.	ÇPK	35	3	_	1	+	5	9
	Polyamide Plastic Tile	ÇPK	35	3	_	1	+	5	9
Glass Coating	Glass Tile	ÇCK	>50	4	+	5	+	5	14
	Laminated Glass	ÇÖC	>50	4	+	5	+	5	14
	Slate Tile	ÇTC	>50	4	+	5	+	5	14
	Wooden Hartama	ÇLC	>50	4	+	5	+	5	14
Stone Coating	Fiber Cement Based Corrugated	ÇA	50	4	+	5	+	5	14
Wood Coating	Concrete Tile	ÇH	40	3	+	5	+	5	13

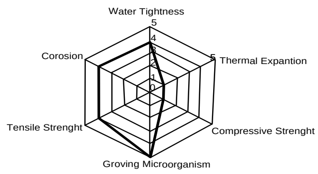
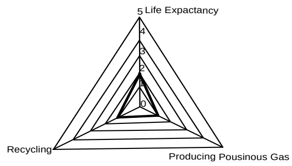
Table 18. Scoring of disassembly criteria for roof coverings (Eren, 2021)

ROOF COVERING Main Group	Sub Group	Code	Total SCORE
Clay Cladding	Marseille Tile	ÇPTM	5
	Ottoman Tile	ÇPTA	5
	Flat Tile	ÇPTD	5
	Corrugated Tile	ÇPTO	5
	Roman Tile	ÇPTR	5
Metal Wall Cladding	Lead Roofing	ÇMK	4
	Zinc Roof Coating	ÇMÇ	5
	Copper Roofing	ÇMB	5
	Titanium	ÇMT	5
	Aluminum	ÇMA	5
	Stainless Steel Galvanized S.	ÇMPÇ	5
	Metal Tile	ÇMMK	5
	Corten Steel	ÇMC	5
	Two sided metal sandwich p.	ÇMİM	5
	Membranlı Sandwich P.	ÇMMS	4
	On-site bothe sides metal s.	ÇMYM	5
	Top Face Membrane S.	ÇMÜM	3
Cement Coating	Fiber Cement Based Corrugated	ÇLÇ	4
	Concrete Tile	ÇBK	4
Bitumen Coating	Bituminous cover roof c.	ÇBÖ	3
	Corrugated bitumen roof c.	ÇOB	4
	Asphalt shingle	ÇS	3
Polymer Coating	Glass Fiber Polyester-CTP	ÇCE	5
	Polikorbanat -PC Based C.	ÇP	5
	Acrylic based roofing c.	ÇA	5
	Polivinil Chloride-PVC c.	ÇPK	5
	Polyamide Plastic Tile	ÇPK	5
Glass Coating	Glass Tile	ÇCK	5
	Laminated Glass	ÇÖC	5
	Slate Tile	ÇTC	5
	Wooden Hartama	ÇLC	5
Stone Coating	Fiber Cement Based Corrugated	ÇA	5
Wood Coating	Concrete Tile	ÇH	3

Table 19. Total score of roof coverings according to the determined criteria (Eren, 2021)

ROOF COVERINGS Main Group	Sub Group	Code	Total SCORE
Clay Cladding	Marseille Tile	ÇPTM	39
	Ottoman Tile	ÇPTA	39
	Flat Tile	ÇPTD	39
	Corrugated Tile	ÇPTO	39
	Roman Tile	ÇPTR	39
Metal Wall Cladding	Lead Roofing	ÇMK	42
	Zinc Roof Coating	ÇMÇ	45
	Copper Roofing	ÇMB	44
	Titanium	ÇMT	43
	Aluminum	ÇMA	42
	Stainless Steel Galvanized S.	ÇMPÇ	43
	Metal Tile	ÇMMK	43
	Corten Steel	ÇMC	42
	Two sided metal sandwich p.	ÇMİM	37
	Membranlı Sandwich P.	ÇMMS	32
	On-site bothe sides metal s.	ÇMYM	41
	Top Face Membrane S.	ÇMÜM	33
Cement Coating	Fiber Cement Based Corrugated	ÇLÇ	34
	Concrete Tile	ÇBK	39
Bitumen Coating	Bituminous cover roof c.	ÇBÖ	30
	Corrugated bitumen roof c.	ÇOB	31
	Asphalt shingle	ÇS	26
Polymer Coating	Glass Fiber Polyester-CTP	ÇCE	36
	Polikorbanat -PC Based C.	ÇP	36
	Acrylic based roofing c.	ÇA	32
	Polivinil Chloride-PVC c.	ÇPK	35
	Polyamide Plastic Tile	ÇPK	31
Glass Coating	Glass Tile	ÇCK	38
	Laminated Glass	ÇÖC	41
	Slate Tile	ÇTC	39
	Wooden Hartama	ÇLC	39
Stone Coating	Fiber Cement Based Corrugated	ÇA	40
Wood Coating	Concrete Tile	ÇH	38

Table 20. Demountable scoring table of light steel structure (Eren, 2021)

BUILDING COMPONENTS		TOTAL SCORE	
1.ROOF COVERING Asphalt Shingle	26	SCORING OF MAIN CRITERIA	
2.WALL CLADDING		DURABILITY	19
3.INTERIOR WALL CLAD.			
4.FLOOR COVERING			
5.STRUCTURAL COVERING			
6.FIXING TYPE		SUSTAINABLITY	4
7.WATER INSULATION			
8.HEAT INSULATION			
9.ROOF FINISHING			
10.FINISHINGS		DISASSEMBLY	3

4. Conclusion and Suggestions

The outcomes of the study are listed below (Eren, 2021).

1. Elements such as doors and windows are widely reused. This study has revealed that how the second-hand market for all building elements and components apart from these elements should be regulated is another issue that needs further investigation.
2. Changing the material selection according to the determined criteria will lead to changes in the demountability of the same structure.
3. It is crucial to have a thorough understanding of the properties of the materials used in this study, which aim to provide suggestions for the minimum waste/zero waste target in building dismantling processes, to make sure that elements produced from recyclable materials that do not contain toxic substances are used in construction, and the last layer of the building elements are more durable against weather conditions or they are not covered with synthetic substances for aesthetic reasons.
4. Economic and environmental benefits can be achieved by designing demountable structures and creating material stock for future structures. By adopting this principle, considerable amount of energy can be saved in production processes, starting from the process of obtaining materials from resources. It is important to have sufficient amount of the same elements in order to reuse them.
5. Protecting the material with coatings that can easily be separated from the surface is also important for easy cleaning of that material for further use.
6. In order to prevent waste generation by reusing building elements in the construction sector and to increase the level of reuse, certain criteria should be taken into consideration such as durability, demountability, sustainability, etc. (Eren, 2024, p. 40-56).
7. Each layer must also be classified according to their wearing time. There are also different levels of durability between the outer surface of the facade cladding and its lower layers. All technical operations must be recorded in detail including the time of the application. The same type of elements should be classified according their duration of usability: it is crucial to note whether some of them have been changed and others have been used for a longer time, which will affect the subsequent use of building elements.

In order to spread the understanding of reusability in the construction sector, courses on this subject should be designed in undergraduate education and for local governments. Government incentives should be put into effect, such as tax reductions, so that more actors in the construction sector adopt this understanding. It should be the mission of building designers to ensure that every building system is designed in a way that it will create minimum or no waste to the environment at the end of its life.

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The article was written by a single author. There are no conflicts of interest.

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Art Deco-Streamline Moderne Combination in Design: An Analysis of the Floating Space SS Normandie From the Outside to the Inside

Merve BULDAÇ [1*]

ORCID 1: 0000-0001-8390-0175
[1] *Kütahya Dumlupınar University, Faculty of Architecture, Interior Design Department, 43000, Kütahya, Türkiye.*
**** e-mail**: merve.buldac@dpu.du.tr*

Abstract

Art Deco and Streamline Moderne influenced design disciplines and enabled the production of many works during the periods they dominated. The floating space "SS Normandie Ship", which constitutes the sample of the work, can be shown as one of the important and successful examples of the combination of Art Deco and Streamline Moderne. A descriptive case study, one of the qualitative research methods, was conducted in the study. The sample of the study is analyzed from outside to inside (shell/body, spatial fiction, interior fittings, interior complementary elements, etc.) through holistic design language, aiming to emphasize the importance of both styles in design disciplines. The findings show that different design approaches can come together to create enriching and inspiring spaces in terms of offering aesthetic, functional, and innovative solutions. Therefore, the study is important in terms of making readers think about the roles of the combination of different styles in spatial fiction.

Keywords: *Art Deco, streamline moderne, ss normandie ship, interior-exterior analysis.*

Tasarımda Art Deco-Streamline Modern Birlikteliği: Dıştan İçe Yüzen Mekân SS Normandie Gemisi Üzerine Bir Analiz

Öz

Art Deco ve Streamline Modern, tasarım disiplinlerine etkilerini göstermiş, hâkim oldukları dönemlerde birçok eser üretilmesini sağlamışlardır. Çalışmanın örneklemini oluşturan yüzen mekan "SS Normandie Gemisi", Art Deco ve Streamline Modern birlikteliğine verilebilecek önemli ve başarılı örnekler arasında gösterilebilir. Çalışmada nitel araştırma yöntemlerinden betimleyici vaka çalışması yapılmıştır. Çalışmanın örneklemi dıştan içe (kabuk/gövde, mekânsal kurgu, iç mekân donatıları, iç mekân tamamlayıcı öğeleri vb.) bütüncül tasarım dili üzerinden analiz edilerek, her iki tarzın tasarım disiplinlerindeki önemine vurgu yapılması amaçlanmaktadır. Elde edilen bulgular estetik, işlevsel ve yenilikçi çözümler sunması açısından farklı tasarım yaklaşımlarının bir araya gelerek zenginleştirici ve ilham verici mekânlar oluşturabileceğini göstermektedir. Dolayısıyla çalışma, farklı tarzların birlikteliğinin mekânsal kurgudaki rolleri üzerine düşündürmesi açısından önem taşımaktadır.

Anahtar kelimeler: *Art deco, streamline modern, ss normandie gemisi, iç-dış mekân analizi.*

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1. Introduction

Many styles/movements have influenced design disciplines in the periods in which they emerged and enabled the production of works/products with different approaches. Art Deco, which was examined within the scope of the study, and Streamline Moderne, which emerged from this movement, led to the emergence of different design approaches in the period in which they were born. To reveal the exterior-to-interior spatial reading of the SS Normandie Ship, which was examined within the scope of the study and constitutes the sample of the study, with a holistic approach, it is necessary to understand both styles separately.

1.1. An Overview of Art Deco - Streamline Moderne

Art Deco emerged in France in the 1920s, at a time when the idea was intense to erase the traces of the bad days after the great destruction caused by the First World War and to bring a new order to the world. The origin of the concept of Art Deco, which means "decorative art" in Turkish, is based on the combination of the French word "art", which means art, and the adjective "deco", which means decorative (Kayaalp, 2018). It was introduced in Paris in 1925 with the "Internationale des Arts Decoratifs et Industriel Modernes" and became a movement that attracted attention all over the world, especially in the United States. It is expressed as the only decorative style with a global reach, to which world cultures can contribute, in addition to spreading to all continents of the world (Gallardo, 2022). Like many movements, Art Deco is among the movements that are the continuation of each other with the movements/styles that emerged before and after but have changed direction in some details. Art Deco can be thought of as consisting of three movements or directions: French, Anglo-Saxon, and non-European. In turn, from the interaction of these three aspects, three phases or moments of Art Deco emerge as a result of its evolution: (i) an initial phase of classical inspiration; (ii) a second phase with a strong expressionist influence and (iii) a generally wavy appearance known as Streamline Moderne. Although dates can be determined for the emergence and development of these stages, they overlap. Therefore, it can be considered a common situation to find works in which a clear transition or even a combination of two or more can be seen (Gallardo, 2022). Polatkan & Özer (2006), for Art Deco; presented an approach as follows: "It is necessary to describe an act that has no theory, is not utopian, does not turn its face entirely to the past or the future in aesthetic production, and popularizes many modern architectural rhetorics with social depth." Batur (1993) emphasizes that Art Deco is inspired by the Art Nouveau movement, but is a geometric, simple form and taste, influenced by movements such as Bauhaus and Cubism. Coates, Brooker & Stone (2011) similarly stated that Art Deco had an aesthetic approach that brought together the features of many contemporary movements such as Art Nouveau, Cubism, and Futurism. Hasol (2010) stated that "Although it emerged with the motto of form follows function, it developed more as a style of surface decoration, and angular and zigzag surface shapes gained character with ornaments." Playing an important role in interdisciplinary interaction, Art Deco projects/designs created dynamic collaborations between architects, painters, sculptors, and designers (Dewidar, 2018).

The first examples of Art Deco architecture are seen in urban/public buildings rather than residential buildings. Among these terraced and tall buildings, the Chrysler Building, Rockefeller Building, and Empire State Building, all located in New York, can be given as examples of the most iconic works of the movement. A new modern attitude and a new language were introduced with these skyscrapers that changed the skyline of the city (Figure 1.a-b-c). These buildings are important examples in the history of architecture, contributing to the recognition of the Art Deco style and revealing its most striking features (reinforced concrete, straight lines, clean rectangular shapes, terraced buildings, sharp angles, chevrons, and the use of zigzags) (Ghislini, 2021).

Figure 1. **a.** Chrysler Building, New York, USA (right) (Chrysler Building, 2024), **b.** Empire State Building, New York, USA (left) (Empire State Building, 2024), **c.** Rockefeller Building, New York, USA (bottom) (New York, Rockefeller Center, 2024)

Characterized by concepts of elegance, luxury, and modernity, Art Deco features include hard edges, rich ornamentation, geometric shapes including chevrons and ziggurats, and stylized floral and sunrise patterns (Dewidar, 2018). One of the most distinctive aspects of Art Deco architecture is the details. Doors, windows, and other architectural features often have decorative carvings or geometric patterns. Building facades are decorated with reliefs representing stylized human figures, animals, plants, or other decorative elements (Art Deco, 2024). Although some buildings used expensive handmade decorations, other buildings featured repetitive machine-made decorations inside or outside. To keep costs low, ornamental applications are generally limited to the most visible parts of building facades (Dewidar, 2018). This movement, which has a creative but short history, not only influenced the architecture of the USA but also had an impact on interiors, furniture, fashion, and art. Especially Art Deco interiors were often equipped with furniture and art objects reflecting the style of the period, creating a luxurious and sophisticated environment.

Due to the devastating financial problems that arose with the Great Depression, which was a global economic crisis that started in 1929 and lasted until the late 1930s, people's tolerance for structures, spaces, or products that were defined as ornate, intense or luxurious decreased, and designers began to adapt their creativity to their new realities. They had to find their way. In the USA, the center of the crisis, the market value of design began to be understood and formalism came to the fore in the search for something different. Streamline Moderne, which means aerodynamic, streamline, modernize in Turkish and is also called Art Modern, was born from the Art Deco style. Taking cues from movement, speed, and transportation infrastructure, a streamlined image was adopted and developed as a more accessible style influenced by the fast-paced, contemporary life of the moment (Kowalik, 2017). Therefore, the emphasis on modern luxury with the Art Deco style, where geometric forms, sharp lines, and symmetrical details are clearly emphasized, has been replaced by the interest or search for a style based on industry and more accessible/preferable for all consumer groups, namely Streamline Moderne. After the great depression, it showed itself as a style that met the needs of the period it was in and, in this sense, had a wide range of production in different business fields or disciplines. Streamline Moderne was exhibited at the World Fair held in Chicago, the third largest city in the USA, in 1933 and New York in 1939; It emerged as a style that made its name known with the view of "building tomorrow with today's tools" (Yesiralioğlu, 2021). Therefore, as the world moves into the machine age, planes, trains, and automobiles are modernizing, and all architectural and interior designs are inspired by aerodynamic aesthetics (Torres, 2020). Struggling to find a machine aesthetic that was both intellectually defensible and commercially viable, designers sought a new style that would honestly express the technological modernity of American life. However, it was thought that this style should also appeal to consumers (Meikle, 2010). In this approach, where the main theme is speed and the main line is the drop form, it is called "style paquebot", which means ocean liner style in France, due to the widespread use of the maritime theme (Ziraki, 2023). Softened corners/edges, smoothness, parallel lines, curvilinear surfaces, shiny surfaces, and the use of chrome-aluminum are among the basic design features. With this style, friction has been greatly reduced, especially in transportation, and fuel savings have been achieved (Çetin, 2020). As a mark of aesthetic style and symbol of machine-age speed, precision, and efficiency of the twentieth century, aerodynamics was embodied in the airplane as a scientific fact (Cheney & Cheney, 1936). Although transport vehicles are among its prominent examples, it has become a part of daily life as it spread all over the world. One of the most important pioneers of Streamline Moderne is product designer Raymond Loewy. Loewy expresses his view on this style as the development of the basic forms of each product or design over time towards smooth, flowing, and minimal forms that are characteristic of its era. Realizing that shell design was appreciated more than before with Streamline Moderne, Loewy began to highlight aesthetic values and benefits in many of the products it designed. Among the most important designs that support this are the Coldspot refrigerator, electric pencil sharpener, etc. (Çetin, 2020) (Figure 2.a-b).

Figure 2. a. Coldspot refrigerator (left), **b.** Electric pencil sharpener (right)(Çetin, 2020)

The Streamline Moderne movement has left a deep impact on many examples of architecture and interior architecture that are still used today. Especially the rise of transportation technologies such as automobiles, planes, ships, and trains and the speed or fast travel idea that they bring with them have revealed the reflex of the need for architects/interior designers to design spaces/areas that reflect this feeling of speed and movement. Walter Gropius also referred to Streamline Moderne by saying "We want an architecture shaped according to our world of machines, radios, and fast cars" (Hines, 2010). If structuralism brought mechanization to architecture, Streamline was turning architecture into a monument of mechanization (Andrii, 2021). Interiors, furniture, and decorative objects designed in this style took an important place in American homes of the 1930s and 1940s (Kowalik, 2017). It is considered one of the first movements to almost completely remove ornamentation from spaces and buildings and take a step towards modernist design with rounded stylish corners and horizontal lines. This approach developed for design also brought to mind requirements such as protection and stability (Meikle, 2010). The Coca-Cola Building in Los Angeles and the Ocean Drive Hotel in Miami are among the best-known examples. Both architectural structures successfully reflect the aesthetic principles of Streamline Moderne. These structures represent a design desire that is both functional and visually appealing (Forever Modern, 2024) (Figure 3.a-b). Unlike high and vertical Art Deco buildings, Streamline Moderne buildings were generally shaped as low and horizontal designs, as can be seen from the two examples given above. Horizontal lines are a defining feature of this style, supporting a sense of movement and dynamism. It is possible to see the use of horizontal lines in spaces (horizontal window strips, furniture, etc.) as well as in buildings. Large horizontal windows included in the designs play an important role, especially in maximizing natural light and providing a connection between indoor and outdoor spaces. Contrary to the color palette used in the Art Deco style, white, which symbolizes hygiene, was especially preferred along with soft colors and metallic tones (Canipe, 2018).

Figure 3. **a.** Coca-Cola Building (left)(photo from Carol M. Highsmith Archive), **b.** Ocean Drive Hotel (right) (photo from State Archives of Florida) designed in Streamline Moderne style (Forever Modern, 2024)

Influenced by the ocean liner and yacht designs of the period, Streamline Moderne frequently used marine motifs, and harsh angles were replaced by simple and aerodynamic curves. Porthole-like windows, railings resembling a ship's deck, and sea-inspired color palettes differentiated the Streamline Moderne style from other styles. Advances in material technology have further accelerated the development of this style. New materials, such as steel-reinforced concrete, have allowed designers, especially architects, to create large-scale structures with clean lines and curvilinear lines that were previously considered unattainable (What is the Streamline Moderne Style in Architecture?, 2023). These materials not only added aesthetic appeal to buildings but also reflected the modern industrial age. The Streamline Moderne effect is visible in interior design, especially in furniture, lighting, and other physical and aesthetic elements that complement the space; Furniture: Moderne's emphasis on curved forms and long horizontal lines also significantly influenced furniture design. One of the durable iconic pieces. Streamline Dining chairs produced in modern style are considered as one of the durable, iconic pieces and are known for their stylish, curved backrests and simple, elegant lines. Made from materials such as chrome and leather, these furniture blend seamlessly into contemporary dining spaces, adding timeless sophistication; Lighting: Many lighting fixtures have been produced with the Streamline Moderne approach. Pendant lights with curved, frosted glass shades and metal accents can be seen in many modern interiors. In addition to their functionality, these fixtures also served as assertive pieces that emphasized the magnificence of the period; Spatial elements: Rounded corners in wall designs or the use of horizontal bands in window frames are a homage to Streamline Moderne. These elements add a sense of sophistication and timelessness to interior designs (Streamline Moderne: Shaping Modern Interior Design with Timeless Elegance, 2023).

Within the scope of this study, aims to realize the spatial reading of the "SS Normandie Ship", which constitutes the sample of the study and is a successful synthesis of Art Deco and Streamline Moderne styles, from outside to inside (shell, spatial fiction, interior fittings, interior complementary elements, etc.).

2. Research Method

The research method used is the descriptive situation model, which is one of the qualitative research methods. The SS Normandie ship, designed and built with the Art Deco-Streamline Moderne synthesis, is taken as an example. The study was supported by visual data obtained from different sources and digital media on the ship, and the analysis aimed within the scope of the study was carried out by providing a holistic flow. The seven most iconic/main interiors serving the ship's first-class passengers are analyzed from outside to inside, starting with the hull design ((i) Grand entrance hall; (ii) Main dining hall; (iii) Theatre/cinema; (iv)) Cafe grill; (v) Deauville and Trouville suites; (vi) Smoking room; (vii) Winter garden) and readings of these spaces were made.

3. Findings and Discussion

In his novel "A Floating City" published by Jules Verne in 1871, he described the steamship Great Eastern not only as a sea vessel but also as a microcosm containing all the emotions and needs inherent in human nature. In the 1920s and 1930s, French artist Adolphe Jean-Marie Mouron attributed some meanings to the ships he drew in his poster designs; He stated that these steam-powered vehicles should be viewed as a symbol of social progress on a large scale (Yener, 2021). Before the advent of container or tanker ships, steam transatlantic passenger ships were the largest seagoing vessels. As symbols of the machine age, these ships, where speed and design met, opened up journeys leading to new adventures and dreams. At the same time, they played the leading role in luxury travel with their luxurious interior designs (Yener, 2021). The SS Normandie Ship, which constituted the sample of the study and was built for the French Line in France, is the fastest and largest passenger ship of its time with its first transatlantic voyage from Le Havre to New York Harbor in 1935 (Yesiralioğlu, 2021) (Figure 4). She completed her first voyage with great success and broke the record for the fastest transatlantic crossing, both westward and eastward (The SS Normandie – A True Monarch of The Seas, 2020).

Figure 4. The SS Normandie arrives in New York from her Maiden Voyage on June 3, 1935 (The SS Normandie – A True Monarch of The Seas, 2020)

The ship is also described as the latest point in construction technology and the symbol of modern culture. It has also become known as "Style Paquebot", that is, ocean liner style, in France. SS Normandie Ship has a passenger capacity of one thousand nine hundred seventy-two (1,972) and one thousand three hundred and forty-five (1,345) crew and a length of three hundred thirteen thousand fifty-eight (313.58) meters (The SS Normandie – A True Monarch of The Seas, 2020). As well as the technical features of the ship, the intertwined/synthesized Art Deco and Streamline Moderne effects on different surfaces and areas of the ship from outside to inside (shell/hull, interior, fittings, surfaces, etc.), which are discussed within the scope of the study, also play an important role in making the ship stand out for itself.

3.1. SS Normandie Shell/Hull Design Analysis

Table 1. SS Normandie Ship Imprint Information (created by the author)

Architect: Vladimir Yourkevich
Year of construction: 1931
Medicine: Ocean liner
Length: 313,58
Passenger capacity: 1.972 (848 people first class/670 people second class/454 people tourists)
Crew capacity: 1.345

Russian architect Vladimir Yourkevich was commissioned to design the ship's hull. He used a curved bow, unlike the straight vertical bow design language of other ships (Figure 5.a-b); It has created an innovative design value with a thin pear-shaped body section. The hull of this ship, whose hull construction took twenty-one months, is the largest mass ever transported on land (The SS Normandie – A True Monarch of The Seas, 2020).

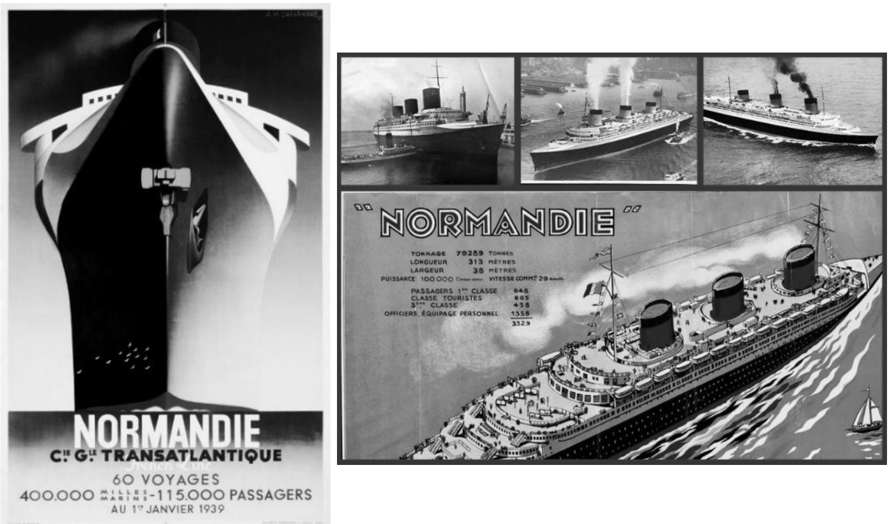


Figure 5. a. Normandie Poster, by Adolphe Jean-Marie Mouron (left)(AM Cassandre, 2010), **b.** Normandie Ship (right)(Grace, 2019)

The Streamline Moderne influence is evident in the design. Softened corners, flowing lines, and a simple design language devoid of ornamentation reveal the design principles of the style. Such a design approach also supports reducing the resistance of this floating space during movement and increasing its speed. Although the aerodynamic effects advocated by Streamline Moderne are strongly analyzed here, the presence of aesthetic concerns also draws attention. Each floor plan has a terraced structure within itself, and although this feature points to the design principle of the Art Deco style, its rounded structure supports the Streamline Moderne style (Figure 5.b). Additionally, three cylindrical ventilation chimneys, whose height gradually decreases towards the stern of the ship, complete the design. Therefore, this ship, which expresses a modern and new stance, meets both functionalities as a working principle; It also provides a balance appropriate to the contemporary and aesthetic design approach of the period.

3.2. SS Normandie Ship Interior Designs Analysis

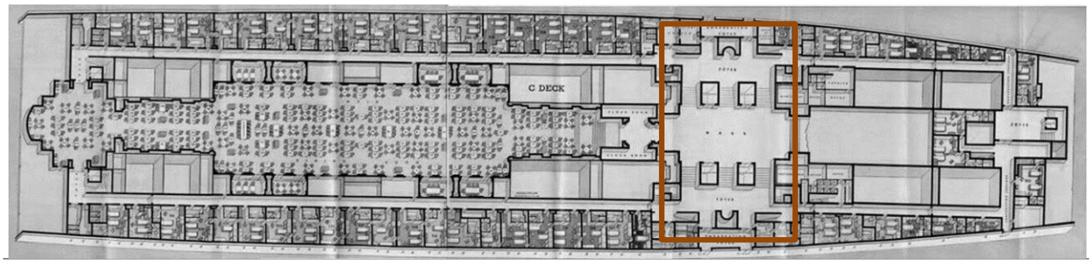
The interior designs of the ship are as important as the hull design. Luxurious interiors are designed in Art Deco and Streamline Moderne style. Major designers include Pierre Patout, Roger Henri Expert, Emile-Jacques Ruhlmann, Jules Leleu, Raymond Subes, and Rene Lalique (Moonan, 2005). In some volumes, Art Deco and Streamline Moderne effects are read separately; in others, the synthesis of these styles attracts attention. Many sculptures and murals referenced Normandy, the French province that gave its name to Normandy. Most public spaces, including the main dining room, entrance hall, suite rooms, theater, and smoking room, are available to first-class passengers for 848 people (Miller, 2017, Goran, 2016). This study discusses spaces serving first-class passengers, where Art Deco and Streamline Moderne styles are widely used. The interior layouts were analyzed formally through black and white photographs of the ship obtained from the digital environment, and the analyses were strengthened through the available color images.

(i) Grand Entrance Hall:

The main entrance hall, which provides access to the first-class main dining area, is not only a passage corridor to the spaces opened to it but also a place for guests to briefly rest, sit, socialize, etc. before moving to their suites and cabins. It is also read as a place where actions take place (Figure 6.a) (Table 2).

Table 2. SS Normandie Grand Entrance Hall Location and Plan (SS Normandie from Construction, Maiden Voyage and First Class Interiors, 2024)(created by the author)

Location: Deck C



One of the most important details that draw attention to the entrance hall is the four main elevators that provide vertical circulation, as seen in the plan in Table 2. These elevators are made of golden-colored wrought iron and leave an extremely fascinating effect. The Art Deco influence can be seen in these clad elevators, which are decorated with repeating motifs, including the motif of seashells (Figure 6.b-c). While there is a thick-lined surface design consisting of geometric forms and extending towards the center on the floor; There are light pools in oval and rectangular forms on the ceiling. This reveals an elegant synthesis of Art Deco print and Streamline Moderne.

Figure 6. **a.,b.,c.** SS Normandie Ship Grand Entrance Hall Interior Images (SS Normandie from Construction, Maiden Voyage and First Class Interiors; 2024; The SS Normandie's 80th Anniversary, 2024)

(ii) Main Dining Room:

The main dining hall, located in the large entrance hall and structured in a long and narrow corridor structure, is located in a very large square meter (Figure 7.a) (Table 3). Apart from being a place designed only for dining, it was also known as an architectural wonder.

The giant doors (6.1 m high) decorated with dense bronze medallions through which the space opens were designed by Raymond Subes. The most important spatial element of the main dining room is the fascinating Lalique glass columns (Figure 7.a-b-c) (SS Normandie from Construction, Maiden Voyage and First Class Interiors, 2024), which are the symbol of luxury and wealth represented by Normandie, shining in the light of the environment. Since natural light does not enter the living room, glass lighting elements on the ceiling (pendant lighting) and wall surfaces (vertical sconces) make a strong contribution to the space both functionally and aesthetically. These illuminations caused the ship to be called the "ship of light". Murals on the wall surfaces and occasional giant sculptures throughout the space are among the important elements that complete the space. In particular, the display of the paganist La Paix statue is in line with the hedonistic nature and reflects a luxurious lifestyle, which is the image that France wants to emphasize (La Normandie: Art Deco Afloat, 2024) (Figure 7. b).

Table 3. SS Normandie Main Dining Hall Location and Plan (SS Normandie from Construction, Maiden Voyage and First Class Interiors, 2024)(created by the author)

Location: Deck C
Hall dimensions: Length: 305 ft (93m); Width: 46 ft (14 m); Height: 28 (8.5 m) ft
Guest capacity: 700 people

In this hall, which can host 700 people at the same time, some of the tables (150) and chairs are rectangular and some have a circular seating arrangement and are placed according to the number of different people. However, the waiters' inability to move freely around the table was seen as a problem (La Normandie: Art Deco Afloat, 2024). Therefore, it is possible to say that it is a hall designed with aesthetic concerns, with functionality being secondary. The spatial organization within the hall, the colors used, the materials, and the equipment create a sense of security in the guests due to the harmony they achieve within themselves, and the absence of window openings creates the effect of protection from external factors/dangers, social diseases and lower class passengers (La Normandie: Art Deco Afloat, 2024). The forehead detail surrounding the rigid forms in the cassette ceiling design has a curved form.

Figure 7. a.,b.,c. SS Normandie Main Dining Hall Interior Images (Miller, 2017; Ryan, 2023-colored by Alejandro Art)

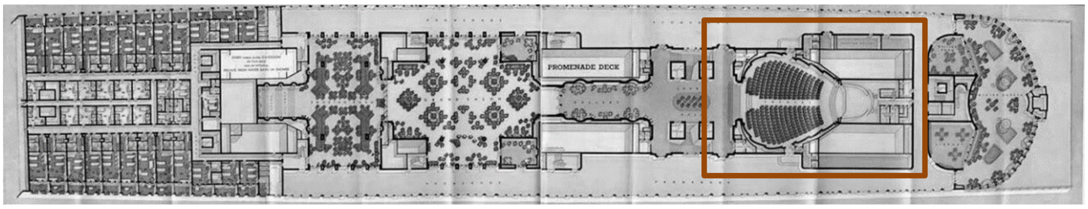
In this place, where bronze color and forged glass are generally used, the Art Deco style is dominant, but the Streamline Moderne combination can be read very clearly and distinctively in the balance of sharp forms with softened forms.

(iii) Theatre/Cinema:

Hosting some of the best performances of the period, the SS Normandie theater was a tribute to art and culture. With seating at different levels, opulent details, and state-of-the-art acoustics, it offered passengers a cultural experience that could rival the best movie theaters on land (Ryan, 2023).

Table 4. SS Normandie Ship Theater Location and Plan (SS Normandie from Construction, Maiden Voyage and First Class Interiors, 2024)(created by the author)

Location: Promenade Deck
Guest capacity: 350 people



Softened corners/edges, curvilinear lines, and plain language, which are among the main principles of Streamline Moderne, draw attention to the interior design of the theater, which is another place where the entrance hall with four elevators is felt, where the Art Deco influence is felt intensely. A holistic design has emerged with the parallel curvilinear lines on the ceiling surface and the segmented surfaces on the walls (Figure 8.a-b-c) (Table 4).

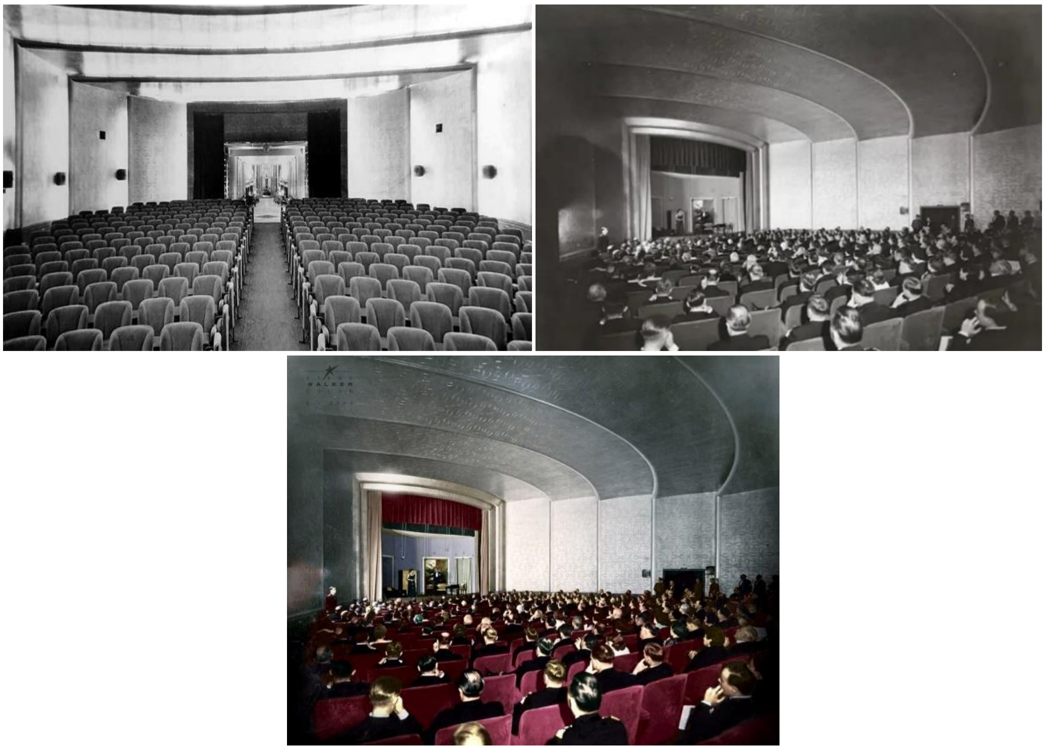


Figure 8. a., b., c. SS Normandie Ship Theater Interior Images (SS Normandie from Construction, Maiden Voyage and First Class Interiors, 2024; The SS Normandie's 80th Anniversary, 2024; Ryan, 2023 (colored by Steve Nalker, 2020))

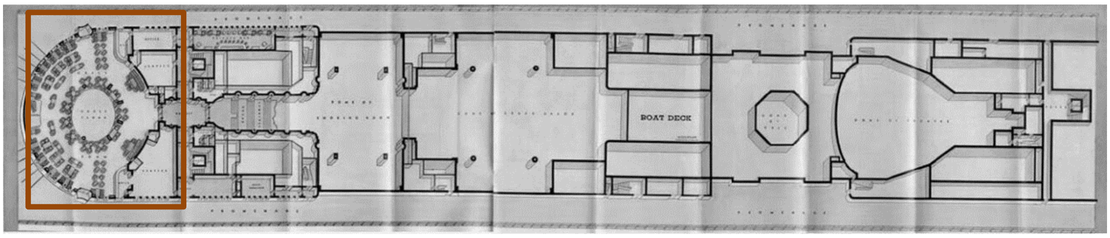
In this place, where the Streamline Moderne style generally dominates, the simple motif on the ceiling and wall panels, which does not tire the eyes, also winks at the Art Deco influence. Seating arrangement and stage design were also designed in a circular form with a sociopetal design approach to make the stage-audience relationship more effective.

(iv) Cafe Grill:

The dominance of aerodynamic forms is observed in this space, which offers guests a pleasant spatial experience with a panoramic sea view thanks to the window openings that strongly let in daylight (Table 5). The luxury and magnificence of Art Deco that the main dining room offers to its users are greatly simplified in this space.

Table 5. SS Normandie Ship Café Grill Location and Plan (SS Normandie from Construction, Maiden Voyage and First Class Interiors, 2024)(created by the author)

Location: Boat Deck



Seating arrangements are placed by the form of the space. The oval dance floor, located in the middle of the venue, is made of rosewood and oak material parquet. On the ceiling plane on the runway axis, a spiral lighting element that meets the ground form and has movement attracts attention (Figure 9. a). Other lighting elements on the ceiling plane take their place as light bands with a rectangular form. Lalique glass columns in the main dining room are among the striking lighting elements of this place. The iron profiles used on the armrests and legs of the seating elements also include softened edge/corner details without breaking away from the general design approach of the space. The plain language, simplicity, and fluid lines of the space reveal the Streamline Moderne effect (Figure 9.a-b-c).

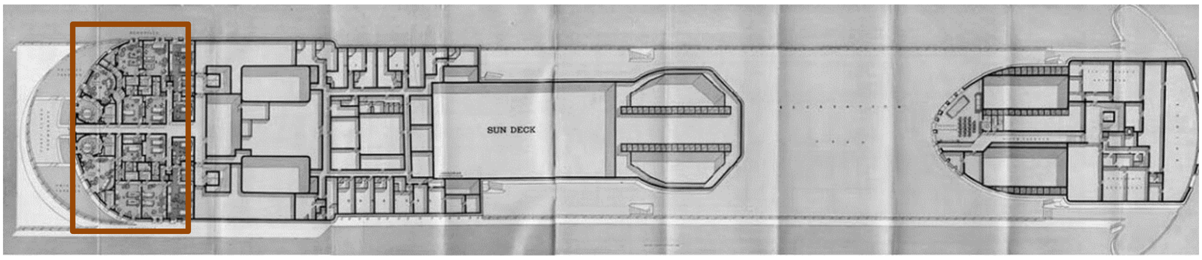
Figure 9. a.,b.,c. SS Normandie Ship Café Grill Interior Images (SS Normandie from Construction, Maiden Voyage and First Class Interiors, 2024; Ryan, 2023)

(v) Deauville and Trouville Suites:

These two grand deluxe suites, which are among the most luxurious accommodation units on the ship, include areas such as a dining room, living room, pantry, bathroom, maid's room, multiple bedrooms, and a private outdoor terrace. While the Deauville Suite is located on the port side; Trouville is located on the starboard side. Both suites are designed to offer their guests a luxurious accommodation experience (Table 6). Within the scope of the study, bedroom, and living room designs are analyzed.

Table 6. SS Normandie Suites Location and Plan (SS Normandie from Construction, Maiden Voyage and First Class Interiors, 2024)(created by the author)

Location: Sun Deck



The Art Deco influence is felt heavily in the Deauville Suite double bedroom design. The wall painting used as a bed headboard, the motifs used on the carpet and the presence of geometric lines in general, and the vertical glass sconces used as lighting elements hanging on the wall surface reflect the characteristic features of the Art Deco style. The circular aerodynamic form used on the ceiling surface and specially designed for lighting supports the movement advocated by Streamline Moderne by breaking the monotony in the space, and the synthesis of both styles can be easily observed (Figure 10. a). In the living room, a circular and fluid space setup originating from the way the ship is divided into internal volumes refers to the Streamline Moderne style, but it is possible to see soft and circular forms in some of the fittings and the carpet. However, as in the bedroom, the lighting elements used, the motif fabrics on the seating elements, and the embossed motifs on the wall surface can be read as Art Deco style (Figure 10.b).

Figure 10. a. SS Normandie Ship Deauville Suite Double Bedroom (SS Normandie from Construction, Maiden Voyage and First Class Interiors, 2024), **b.** Living Room Interior Images (The SS Normandie – A True Monarch of The Seas, 2020)

The Trouville Suite bedroom, whose design is different from the Deauville Suite, has a simpler language, unlike the Deauville Suite. While a geometric order prevails on the ceiling; There are also vertical and horizontal rectangular wall lamps on the wall surfaces. The carpet used on the floor again shows a design in which symmetrical forms meet each other (Figure 11.a). In general, the elegant elegance of Art Deco attracts attention to the place.

Figure 11. a. SS Normandie Ship Trouville Suite Double Bedroom ssmaritime.com, 2024, **b.,c.** Lounge (uncolored/colored) Interior Images (SS Normandie from Construction, Maiden Voyage and First Class Interiors, 2024; Ryan, 2023)

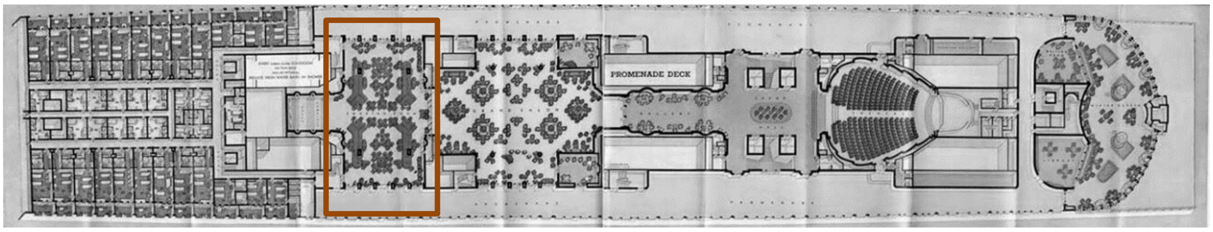
In the living room, as can be seen from the colorful image; colorful and vibrant wallpapers, ceiling surface design, patterned carpet surface, wood and leather materials used in furniture, etc. The details show the characteristic features of Art Deco (Figure 11.b-c).

(vi) Smoking Room

The Smoking Room, designed so that guests who dine or dance in the main dining hall or Café Grill can relax on comfortable, wide armchairs at the end of the evening, is located on the same deck as the cinema/theater hall and the winter garden (Table 7). It is among the places where the Art Deco style is visible.

Table 7. SS Normandie Smoking Room Location and Plan (created by the author)

Location: Promenade Deck



Wall panels depicting life in Egypt, which was a source of inspiration for Art Deco designers of the period, significantly reflect the characteristic feature of Art Deco, which stylizes ancient Greek, Egyptian, or Far Eastern motifs (Figure 12.a-b). The lacquered Coromandel panels designed by Mr Dunand depict themes of sports, fishing and hunting, horse conquest, dance, harvest, and the joy of humanity. Gold leaf lacquer wood panels have turned into an impressive design (SS Normandie from Construction, Maiden Voyage and First Class Interiors, 2024).

Figure 12. a., b. Smoking Room Interior Images (SS Normandie from Construction, Maiden Voyage and First Class Interiors, 2024, Ryan, 2023) (left image by Photo Hamon; right image by Canterbury Auction Galleries)

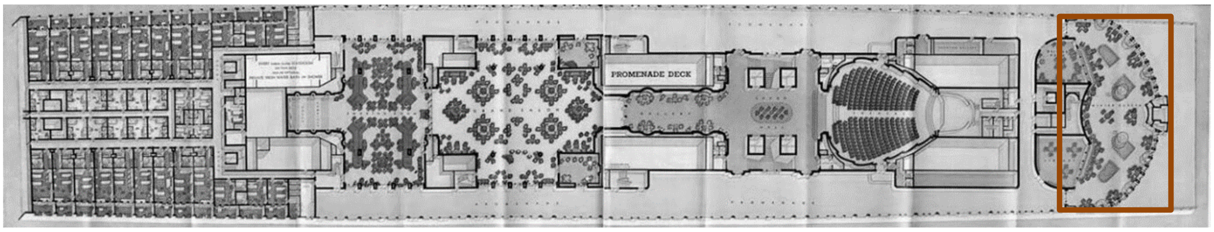
The seating elements are made of leather, which is the most commonly used material in the style, and wooden materials are used on the tables. The dominance of geometric forms and symmetry on the ceiling also reflects the distinctive features of Art Deco. While the wall panels in the space are illuminated with spotlighting elements, the lighting elements located at the center point of the circular-shaped seating arrangements are placed in vases made of slate. From here, the use of natural stone or marble material in Art Deco shows itself as an important detail.

(vii) Winter Garden

Another iconic place of the ship is the winter garden. This garden, which has an oval facade at the front of the ship, receives strong daylight through window openings on all three facades (Table 8). The ornamental pools, live plants, exotic birds, and the atmosphere of the place in the semicircular volume create the impression of a peaceful shelter in a tropical forest for the guests.

Table 8. SS Normandie Ship Winter Garden Location and Plan (created by the author)

Location: Promenade Deck



The most beautiful flowers are exhibited in parterres, pergolas, and glass-enclosed greenhouses. Two large ornate glass cages with exotic birds are located above the ornamental ponds in the middle of the garden. It can be seen that all the equipment used is placed in the space form. Elliptic, softened corners dominate the space, and the spatial organization, selected accessories, and specialized space designs for plants/birds successfully complement the fluidity of the window openings. It is observed that metal, glass, and marble are used extensively as materials. Within the framework of the data obtained from the winter garden spatial analysis, the Streamline Moderne style is read with the window openings seen as horizontal band windows in the formal sense, rounded forms, and softened corners on the ceiling/wall plane and fittings; The materials used and the stylish/flashy water elements and glass cages reflect the Art Deco style in the best way (Figure 13.a-b).

Figure 13. a., b. Winter Garden Interior Images (SS Normandie: the winter garden, 2024, CGT French Line – The Ocean Liner Normandie – 1937, 2024) (right image photo by Jardin D'Hiver)

It is clear that the ship hull/shell and seven interior layouts discussed within the scope of the study, each with a different design language, have been presented in a highly professional and holistic design language, without deviating from the characteristic features of Art Deco and Streamline Moderne, which manifests itself as its continuation. shows.

4. Conclusion and Suggestions

Art Deco and Streamline Moderne, examined within the scope of the study, were used in the design approaches of their period as two different styles that fed on each other. To make a general evaluation in the light of the data obtained within the scope of the study regarding these two styles, which differ from each other at some points (Table 9);

Table 9. An Overview of Art Deco and Streamline Moderne (Spacey, 2016) (developed by the author)

	Art Deco	**Streamline Moderne**
Type	Architectural Styles	Architectural Styles
Definition Art Deco: Art Deco is an artistic and architectural style during a period of profound social, cultural, and economic changes worldwide. Streamline Moderne: A late form of Art Deco architecture and design characterized by curving forms and long horizontal lines.		

Table 9. An Overview of Art Deco and Streamline Moderne (Spacey, 2016) (developed by the author) (continued)

Period	1920 to 1930	1930 to 1944
Characteristics		
Bold geometric shapes		Landscape orientation
Straight lines		Horizontal lines
Bright colors		Curved forms
Hard edge		Rounded edges
Rich ornaments		Subdued colors
Frequent use of lighting and mirrors		Impression of speed and movement
Elegance and Luxury		Flat roof
Analytical and industrial content		Polished meta
Planarity		Ship-like
Ancient or non-western inspiration		Machine-like
Stylized figures		Nautical themes
		Lack of ornamentation
Related Concepts	Cubism, Fovizm, Art Nouveau, Bauhaus, De Stijl	Art Deco, Ornamentation, Bauhaus

All of the characteristic features in Table 9 are observed in the design of the SS Normandie Ship, which is the sample of the study. In particular, functionality and aesthetic concern, use of materials, formal design language, and the combination of art and technology are among the most important design criteria noted in ship design. Functionality and aesthetic concern: Although functionality is important for both styles, aesthetic concern is more dominant in the Art Deco style compared to Streamline Moderne. The desire to create dense decorations and ostentatious spaces turns into the simple elegance of Art Deco in Streamline Moderne. Successful use of materials: Visual feast is provided at the highest level thanks to the generous use of glass, wood, marble, and quality fabrics. Vibrant color palettes reflect the dynamism of Art Deco in the best possible way. Form harmony: Art Deco's geometric, flat form approach and Streamline Moderne's soft, oval, and fluid structure have achieved successful unity and harmony. Although each space has a different concept within itself, they are synthesized with the unbreakable harmony of style. This indicates that design principles such as symmetry, harmony, proportion, balance, unity, and diversity have been successfully emphasized. These emphases on space, equipment, and physical elements (ceilings, walls, etc.) are not only aesthetically elegant and functionally useful; They contribute to the speed and stability of the ship. Combination of technology and art: Streamline Moderne's adaptation to technology and its feature of being the largest and fastest ocean liner of the period are combined in the best way with the artistic and craftsmanship (hand craftsmanship) success of Art Deco.

Fluid lines dominate the shell design of this floating space, which is considered from the outside to the inside, and the concepts of aerodynamics and speed advocated by Streamline Moderne are successfully emphasized, while the details referring to luxury and magnificence in the interior strongly reflect the Art Deco style. The ship is a representation of modern culture arising from the unity of technology and art. Therefore, the ship is considered a work of art and a symbol of social progress, beyond being just a marine vehicle obtained by taking advantage of all technological possibilities. Such syntheses or design approaches are also important in that they make us think about the roles of the combination or possible combinations of other different styles in spatial fiction.

Acknowledgments and Information Note

The article complied with national and international research and publication ethics. Ethics committee permission was not required in the study.

Author Contribution and Conflict of Interest Declaration Information

There is no conflict of interest in the article.

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Energy Planning and Optimization Model for Campus Buildings: A Case Study of Erciyes University

Atabek MOVLYANOV [1]*, Beyza AKYOL [2] Saltuk Buğra SELÇUKLU [3]

ORCID 1: 0000-0001-6676-5231
ORCID 2: 0000-0002-5933-5724
ORCID 3: 0000-0002-9295-3866

[1] *Erciyes University, Graduate School of Natural and Applied Sciences, Energy Systems Engineering Department, 38039, Kayseri, Türkiye.*
[2-3] *Erciyes University, Engineering Faculty, Energy Systems Engineering Department, 38039, Kayseri, Türkiye.*
**** e-mail**: atabekmovlyanov@gmail.com*

Abstract

This study addresses energy consumption and climate change challenges in university campus buildings, focusing on Erciyes University. The research develops a multi-objective optimization model using GAMS software and NEOS Server to enhance campus energy efficiency. The model evaluates various energy-saving measures and their investment costs. Findings indicate that building envelope insulation can reduce heating energy consumption by 35%, while efficient hot water systems and energy-saving technologies can achieve savings up to 75.5%. Model calculations using SCIP and LINDO solvers demonstrate high accuracy, with results differing by only 0.2%. This research provides valuable guidance for university decision-makers in implementing targeted interventions for significant primary energy savings.

Keywords: *Campus building, energy efficiency, multi-objective optimization.*

Kampüs Binaları için Enerji Planlama ve Optimizasyon Modeli: Erciyes Üniversitesi Örneği

Öz

Bu çalışma, üniversite kampüs binalarında artan enerji tüketimi ve iklim değişikliği gibi önemli sorunları, Erciyes Üniversitesi örneğinde ele almıştır. Araştırmada, GAMS yazılımı ve NEOS Server kullanılarak kampüs enerji verimliliğini artırmak için çok amaçlı bir optimizasyon modeli geliştirilmiştir. Model, çeşitli enerji tasarrufu önlemlerini ve yatırım maliyetlerini değerlendirmektedir. Bulgular, bina kabuğu yalıtımının ısıtma enerji tüketimini %35, verimli sıcak su sistemleri ve enerji tasarrufu teknolojilerinin ise tasarrufları %75,5'e kadar artırabileceğini göstermektedir. SCIP ve LINDO çözücüleri ile yapılan model hesaplamaları, %0,2'lik farkla yüksek doğruluk göstermektedir. Bu araştırma, üniversite karar vericilerine önemli enerji tasarrufları sağlayacak müdahaleler konusunda değerli bir rehber sunmaktadır.

Anahtar kelimeler: *Üniversite kampüs binaları, enerji verimliliği, çok amaçlı optimizasyon.*

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1. Introduction

The rise in primary energy consumption and climate change are critical challenges of our time. Many governments are actively pursuing policies to reduce primary energy consumption through enhanced energy efficiency (EE) and integrating renewable energy sources (RES). These strategies are crucial for addressing climate change, ensuring energy security, and promoting sustainable economic growth (Karmellos et al., 2015). The increasing population and industrial activity in Türkiye have indeed created a pressing need to harness EE and RES. The building sector's significant share of total final energy consumption underscores the need for effective policies aimed at improving energy efficiency. There are a total of 208 universities in Türkiye, each of which has multiple campus buildings (Figure 1). Universities function similarly to small towns, with their diverse populations and a wide range of activities and services. While they bring many benefits such as economic growth, cultural enrichment, and innovation they also have negative impacts on both the natural and social environments (Gültekin et al., 2024; Rüşen et al., 2018). Their efforts not only enhance their immediate environments but also contribute to global sustainability goals, making them key institutions in the transition toward a more sustainable future. Designing sustainable university campuses requires a holistic and long-term approach to process management. Universities have very dense populations of both staff and students, as well as energy-intensive structures such as buildings. It is important to create alternatives to the use of consumable resources in buildings where educational activities are carried out, to stimulate more efficient use of expended energy and materials, to prevent all types of waste, and to implement environmentally friendly building designs (Rüşen et al., 2018). In educational buildings, energy efficiency measures targeting heating, cooling, ventilation, and lighting systems have great potential to save energy, improve efficiency, and deliver environmental benefits (Ascione et al., 2017; Bellia et al., 2018; Guerrieri et al., 2019; Han et al., 2015). In the studies reviewed, insulation of building envelopes, installation of cogeneration heating systems, increasing the efficiency of lighting systems, strengthening and insulating the roof with a photovoltaic installation, replacing windows, using biomass or heat pumps in heating systems, optimizing air conditioning settings, installing heat recovery systems were identified as significant energy efficiency measures.

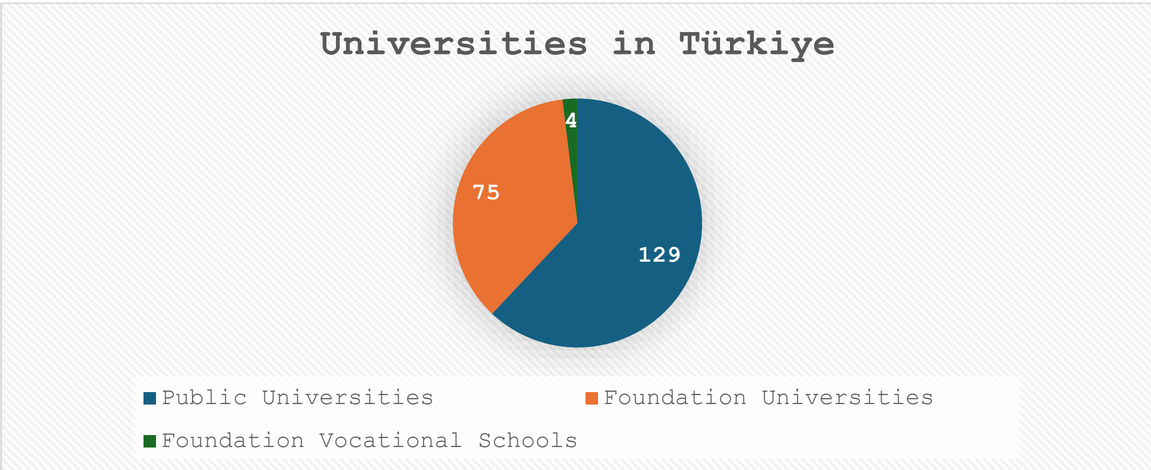

Figure 1. Number of universities in Türkiye (YÖK, 2024)

Diakaki et al. (2010) developed a multi-objective decision-making model for improving the energy efficiency of buildings. The decision criteria were focused on reducing primary energy consumption, minimizing the initial investment cost (including the cost of construction, acquisition, and installation), and lowering CO_2 emissions. The successful application of the model to a case study underscores its viability and potential for future advancements. In another study, Diakaki and Grigoroudis (2021) demonstrated the effectiveness of interactive mathematical modeling for improving energy efficiency. The paper proposes a mathematical programming approach to identify and incorporate decision-maker preferences into a decision-making model through utility assessment using the UTASTAR multi-criteria decision aid method. The study results indicate that the proposed approach effectively assists decision analysts in recommending energy measures that align closely with the decision maker's preferences, without requiring precise definitions of those preferences in advance. This flexibility allows for a more adaptive and responsive decision-making process. Karmellos et al. (2015) focused on evaluating energy efficiency measures in the residential and small commercial sectors. Their work aims to develop a methodology and a software tool to optimally prioritize these measures, enhancing decision-making and implementation strategies. A software tool has been developed using MATLAB allowing decision-makers to effectively utilize it for energy efficiency assessments. Bayata and Temiz (2017) developed a methodology and two distinct software tools using MATLAB to address multi-objective optimization problems related to building energy efficiency. The first tool, the Building Energy Consumption Calculation Program, is designed to calculate a building's annual energy consumption following Turkish standards for thermal insulation requirements. It also assesses initial investment costs and CO_2 emissions. The second tool, the Building Energy Optimization Program, is a multi-objective optimization tool that employs NSGA-II to minimize various objectives related to building energy efficiency. Hashempour et al. (2020) conducted a comprehensive literature review focusing on the energy performance optimization of existing buildings. Their analysis highlighted various strategies and technologies aimed at improving energy efficiency, addressing factors such as retrofitting, renewable energy integration, and smart building technologies. Penna et al. (2015) explored the relationship between the initial characteristics of residential buildings and the development of optimal retrofit solutions. Their research focused on achieving either maximum economic performance or minimizing energy consumption to promote nearly zero-energy building (nZEB) behavior, while also addressing thermal comfort levels. Shi and Chen (2024) introduced optimization method for building energy-saving renovations that integrates automated machine learning with the NSGA-III algorithm. Their approach aims to efficiently and accurately identify the most effective renovation schemes, contributing to enhanced energy efficiency in buildings. Vardopoulos et al. (2024) explored how smart building technologies can enhance energy efficiency and occupant comfort, demonstrating their potential to promote sustainable architectural practices. Benaddi et al. (2023) investigated the integration of innovative thermal management techniques in building design, highlighting their effectiveness in reducing energy consumption and improving indoor climate conditions. Abdou et al. (2021) analyzed the effects of renewable energy integration in building systems, demonstrating its potential to enhance energy efficiency and reduce carbon footprints in urban environments.

2. Material and Method

The optimization of energy efficiency in buildings, particularly in complex environments like university campuses, is a critical challenge. In our study, we leverage the Karmellos et al. (2015) model to target energy efficiency improvements specifically for university campus buildings. This model is renowned for its multi-objective decision optimization capabilities, which facilitate the evaluation of trade-offs between various objectives in the context of energy efficiency improvements. Multi-objective decision optimization is crucial here as it helps identify optimal solutions by evaluating a set of trade-offs in the objective function space. Their model addresses the challenge of finding the best trade-offs among multiple objectives, even when the solution space is vast and complex. We refined the Diakaki et al. (2010) model by incorporating improvements proposed by Karmellos et al. (2015) to better suit our specific application. The enhancements proposed by Karmellos et al. (2015) provide a more detailed and context-sensitive approach to energy efficiency optimization. By incorporating these improvements, our model better aligns with the unique needs of university campus buildings, offering a more precise and effective optimization solution.

In this study, we utilized the General Algebraic Modeling System (GAMS) as our modeling language to formulate the optimization problem. To solve the optimization model, we employed the NEOS Server (Czyzyk et al., 1998). Within the NEOS Server environment, we used two specific solvers for our Mixed Integer Nonlinear Programming (MINLP) model, namely, *SCIP and LINDO* solvers. The SCIP solver is well-suited for tackling complex integer programming problems with nonlinear constraints. It is known for its efficiency in solving large-scale and challenging optimization problems. The LINDO solver is specialized in handling nonlinear dynamic optimization problems, including those with mixed-integer constraints. It provides additional tools for dealing with specific types of nonlinearities in the optimization model.

2.1. Decision Variables

In the optimization model for improving energy efficiency in university campus buildings, we have identified four key decision variables. Here's a detailed breakdown of each variable and its role within the model:

Building Shells. This variable represents the selection and configuration of the building envelope components, such as doors, windows, walls, roofs, and ceilings. The building shell affects thermal insulation, energy loss, and overall energy consumption for heating and cooling. Optimizing this variable helps in enhancing energy efficiency by improving thermal performance and reducing the demand for energy-intensive climate control. In the optimization model, building shells are categorized into two distinct types: single-layer and multiple-layer constructions. Each type influences energy efficiency and cost in different ways. Single-layer construction refers to building components that consist of a single uniform material or component. This category includes doors and windows. Choices related to the type of doors can vary in terms of material, insulation properties, and energy performance. Similarly, selecting the type of windows involves considerations such as glazing options, frame materials, and insulation performance, all of which impact energy efficiency and overall building performance. Multiple-layer construction involves building components made up of two or more distinct layers of materials. This category includes walls, ceilings, and floors. The choice of composition of walls, ceilings, and floors, including materials and the number of layers, influence thermal resistance and insulation.

Building Heating and Domestic Hot Water (DHW) Systems. This variable encompasses the choice and optimization of heating systems (e.g., boilers, heat pumps) and systems for domestic hot water supply. Effective management and optimization of heating and DHW systems are crucial for minimizing energy consumption. This variable affects the operational efficiency and the energy required to maintain comfortable temperatures and provide hot water, influencing both energy use and operational costs. In optimizing building heating and Domestic Hot Water (DHW) supply systems, it's crucial to carefully categorize and select from the various system types to ensure an effective and efficient combination. (Table 1).

Table 1. Building Heating and DHW Systems Category (Authors)

	Electrical Systems	**Non-Electrical Systems**
Heating Only Systems	Utilize electric heaters or heat pumps solely for space heating	Includes systems like gas boilers or oil heaters systems for heating
Heating - DHW Systems	Use electric-powered systems for both space heating and DHW (e.g., electric boilers with integrated storage tanks)	Combine heating and DHW with non-electrical sources (e.g., gas or oil boilers with an integrated DHW tank)
DHW Only Systems	Employ electric water heaters or heat pump water heaters solely for DHW	Includes systems like gas water heaters or solar water heating systems without space heating components

Solar collector systems that use solar energy to pre-heat water or provide both heating and DHW, can also be integrated into existing systems or used as standalone solutions.

Building Lighting Systems. This variable deals with the selection and configuration of lighting systems within the building. Efficient lighting systems reduce electricity consumption and improve energy efficiency. In optimizing lighting systems, the decision variables represent the different types or categories of these systems. Each category impacts energy consumption and cost.

Electrical Appliances in Building. This variable includes the selection and usage patterns of various electrical appliances and equipment within the building, such as computers and laptops. Electrical appliances significantly contribute to the building's total energy consumption. In optimizing electrical appliances, the decision variables represent the different types or categories of these systems. Each category impacts energy consumption and cost.

The model formulations are presented in equations A1 through A62:

Door type summation constraint:

$$x_d^{DOOR} = \begin{cases} 1, if\ door\ type\ d\ is\ selected \\ 0, else \end{cases} \tag{A1}$$

$$\sum_{d=1}^{D} x_d^{DOOR} = 1$$

d: Available number of door type, x_d^{DOOR}: Decision variable where $d = 1, \dots, D$

Window type summation constraint:

$$x_z^{WIN} = \begin{cases} 1, if\ window\ type\ z\ is\ selected \\ 0, else \end{cases} \tag{A2}$$

$$\sum_{z=1}^{Z} x_z^{WIN} = 1$$

z: Available number of window type, x_z^{WIN}: Decision variable where $z = 1, \dots, Z$

Wall structure type summation constraint:

$$x_w^{WALL} = \begin{cases} 1, if\ wall\ type\ w\ is\ selected \\ 0, else \end{cases} \tag{A3}$$

$$\sum_{w=1}^{W} x_w^{WALL} = 1$$

w: Available number of known wall layer, x_w^{WALL}: Decision variable where $w = 1, \dots, W$

Wall structures material type summation constraint:

$$x_{wp}^{mWALL} = \begin{cases} 1, if\ alternative\ material\ p \\ is\ selected\ of\ wall\ type\ w \\ 0, else \end{cases} \tag{A4}$$

$\sum_{p=1}^{P_w} x_{wp}^{mWALL} = x_w^{WALL}\ \forall\ (w = 1, \dots, W)$

p: Available number of unknown wall layer, x_{wp}^{mWALL}: Decision variable where $p = 1, \dots, P_w$

Ceiling structure type summation constraint:

$$x_r^{CEIL} = \begin{cases} 1, if\ ceil\ type\ r\ is\ selected \\ 0, else \end{cases} \tag{A5}$$

$$\sum_{r=1}^{R} x_r^{CEIL} = 1$$

r: Available number of known ceiling layer, x_r^{CEIL}: Decision variable where $r = 1, \dots, R$

Ceiling structures material type summation constraint:

$$x_{ra}^{mCEIL} = \begin{cases} 1, if\ alternative\ material\ a \\ is\ selected\ of\ ceil\ type\ r \\ 0, else \end{cases} \tag{A6}$$

$$\sum_{a=1}^{A_r} x_{ra}^{mCEIL} = x_r^{CEIL}\ \forall\ (\ r = 1, \ldots, R\ )$$

a: Available number of unknown ceiling layer, x_{ra}^{mCEIL}: Decision variable where $a = 1, \ldots, A_r$

Floor structure type summation constraint:

$$x_h^{FLO} = \begin{cases} 1, if\ floor\ type\ h\ is\ selected \\ 0, else \end{cases} \tag{A7}$$

$$\sum_{h=1}^{H} x_h^{FLO} = 1$$

h: Available number of known floor layer, x_h^{FLO}: Decision variable where $h = 1, \ldots, H$

Floor structures material type summation constraint:

$$x_{hg}^{mFLO} = \begin{cases} 1, if\ alternative\ material\ g \\ is\ selected\ of\ ceil\ type\ h \\ 0, else \end{cases} \tag{A8}$$

$$\sum_{g=1}^{G_h} x_{hg}^{mFLO} = x_h^{FLO}\ \forall\ (\ h = 1, \ldots, H\ )$$

g: Available number of unknown floor layer, x_{hg}^{mFLO}: Decision variable where $g = 1, \ldots, G_h$

Heating system summation constraint:

$$\sum_{ehsi=1}^{EHSI} \sum_{ehsj=1}^{EHSJ_{ehsi}} x_{ehsi,ehsj}^{EHS} + \sum_{nehsi=1}^{NEHSI} \sum_{nehsj=1}^{NEHSJ_{nehsi}} x_{nehsi,nehsj}^{NEHS} + \sum_{ehwsi=1}^{EHWSI} \sum_{ehwsj=1}^{EHWSJ_{ehwsi}} x_{ehwsi,ehwsj}^{EHWS} + \sum_{nehwsi=1}^{NEHWSI} \sum_{nehwsj=1}^{NEHWSJ_{nehwsi}} x_{nehwsi,nehwsj}^{NEHWS} = 1 \tag{A9}$$

$$x_{ehsi,ehsj}^{EHS} = \begin{cases} 1, if\ available\ types\ of\ electrical\ heating\ systems\ ehsj \\ of\ available\ categories\ ehsi\ is\ selected \\ 0, else \end{cases}$$

$$x_{nehsi,nehsj}^{NEHS} = \begin{cases} 1, if\ available\ types\ of\ non-electrical\ heating\ systems\ nehsj \\ of\ available\ categories\ nehsi\ is\ selected \\ 0, else \end{cases}$$

$$x_{ehwsi,ehwsj}^{EHWS} = \begin{cases} 1, if\ available\ types\ of\ electrical\ heating-DHW\ systems\ ehwsj \\ of\ available\ categories\ ehwsi\ is\ selected \\ 0, else \end{cases}$$

$$x_{nehwsi,nehwsj}^{NEHWS} = \begin{cases} 1, if\ available\ types\ of\ non-electrical\ heating-DHW\ systems\ nehwsj \\ of\ available\ categories\ nehwsi\ is\ selected \\ 0, else \end{cases}$$

$x_{ehsi,ehsj}^{EHS}$: Decision variable of available types of electrical heating systems $ehsj$ of available categories $ehsi$

$x^{NEHS}_{nehsi,nehsj}$: Decision variable of available types of non - electrical heating systems $nehsj$ of available categories $nehsi$

$x^{EHWS}_{ehwsi,ehwsj}$: Decision variable of available types of electrical heating - DHW systems $ehwsj$ of available categories $ehwsi$

$x^{NEHWS}_{nehwsi,nehwsj}$: Decision variable of available types of non - electrical heating - DHW systems $nehwsj$ of available categories $nehwsi$

DHW system summation constraint:

$$\sum_{ewsi=1}^{EWSI} \sum_{ewsj=1}^{EWSJ_{ewsi}} x^{EWS}_{ewsi,ewsj} + \sum_{newsi=1}^{NEWSI} \sum_{newsj=1}^{NEWSJ_{newsi}} x^{NEWS}_{newsi,newsj} + \sum_{ehwsi=1}^{EHWSI} \sum_{ehwsj=1}^{EHWSJ_{ehwsi}} x^{EHWS}_{ehwsi,ehwsj} + \sum_{nehwsi=1}^{NEHWSI} \sum_{nehwsj=1}^{NEHWSJ_{nehwsi}} x^{NEHWS}_{nehwsi,nehwsj} = 1 \tag{A10}$$

$$x^{EWS}_{ewsi,ewsj} = \begin{cases} 1, if\ available\ types\ of\ electrical\ DHW\ systems\ ewsj \\ of\ available\ categories\ ewsi\ is\ selected \\ 0, else \end{cases}$$

$$x^{NEWS}_{newsi,newsj} = \begin{cases} 1, if\ available\ types\ of\ non - electrical\ DHW\ systems\ newsj \\ of\ available\ categories\ newsi\ is\ selected \\ 0, else \end{cases}$$

$$x^{EHWS}_{ehwsi,ehwsj} = \begin{cases} 1, if\ available\ types\ of\ electrical\ heating - DHW\ systems\ ehwsj \\ of\ available\ categories\ ehwsi\ is\ selected \\ 0, else \end{cases}$$

$$x^{NEHWS}_{nehwsi,nehwsj} = \begin{cases} 1, if\ available\ types\ of\ non - electrical\ heating - DHW\ systems\ nehwsj \\ of\ available\ categories\ nehwsi\ is\ selected \\ 0, else \end{cases}$$

$x^{EWS}_{ewsi,ewsj}$: Decision variable of available types of electrical DHW systems $ewsj$ of available categories $ewsi$

$x^{NEWS}_{newsi,newsj}$: Decision variable of available types of non - electrical DHW systems $newsj$ of available categories $newsi$

Solar collector system summation constraint

$$\sum_{slci=1}^{SLCI} x^{SLC}_{slci} \leq 1 \tag{A11}$$

x^{SLC}_{slci}: Decision variable of available types of solar collector systems $slci = 1, \ldots, SLCI$

Building lighting systems:

$$\sum_{li=1}^{LI} x^{L}_{li} = 1 \tag{A12}$$

$$x^{L}_{li} = \begin{cases} 1, if\ lamp\ type\ li\ is\ selected \\ 0, else \end{cases}$$

x^{L}_{li}: Decision variable of available types of lamps $li = 1, \ldots, LI$

Electrical appliances in building:

$$\sum_{eaLP=1}^{EALP} x^{EA}_{eaLP} = 1 \tag{A13}$$

$$x_{eaLP}^{EA} = \begin{cases} 1, if\ laptop\ type\ eaLP\ is\ selected \\ 0, else \end{cases}$$

x_{eaLP}^{EA}: Decision variable of available types of laptops $eaLP = 1, \dots, EALP$

$$\sum_{eaPC=1}^{EAPC} x_{eaPC}^{EA} = 1 \tag{A14}$$

$$x_{eaPC}^{EA} = \begin{cases} 1, if\ computer\ type\ eaPC\ is\ selected \\ 0, else \end{cases}$$

x_{eaPC}^{EA}: Decision variable of available types of computers $eaPC = 1, \dots, EAPC$

Energy consumption (total)

$$Q_T = Q_H + Q_{DHW} + Q_L + Q_A \tag{A15}$$

Q_T: Energy consumption, annual (MJ/year)

Q_H: Energy consumption for heating systems, annual (MJ/year)

Q_{DHW}: Energy consumption for DHW systems, annual (MJ/year)

Q_L: Energy consumption for lighting systems, annual (MJ/year)

Q_A: Energy consumption for electrical appliances, annual (MJ/year)

Total annual energy consumption for heating systems

Primary energy consumption for heating (MJ/year)

$$Q_H = \frac{Q_{el}^H f^{grid}}{n_{grid}} + Q_{nel}^H \tag{A16}$$

Q_{el}^H: Power utilized by an electrical system for heating (MJ/year)

f^{grid}: Power supply from the electrical grid (%)

n_{grid}: The typical efficiency of the power supply from the grid to the building

Q_{nel}^H: Power utilized by a non-electrical system for heating (MJ/year)

The power utilized by an electrical heating and heating-DHW system

$$Q_{el}^H = Q^{HDY} SEH_{el} \tag{A17}$$

$$SEH_{el} = \sum_{ehsi=1}^{EHSI} \sum_{ehsj=1}^{EHSJ_{ehsi}} \left(\frac{x_{ehsi,ehsj}^{EHS}}{n_{ehsi,ehsj}^{EHS}} \right) + \sum_{ehwsi=1}^{EHWSI} \sum_{ehwsj=1}^{EHWSJ_{ehwsi}} \left(\frac{x_{ehwsi,ehwsj}^{EHWS}}{n_{ehwsi,ehwsj}^{EHWS}} \right) \tag{A18}$$

The energy consumed by a nonelectrical heating and heating-DHW system

$$Q_{nel}^H = Q^{HDY} SEH_{nel} \tag{A19}$$

$$SEH_{nel} = \sum_{nehsi=1}^{NEHSI} \sum_{nehsj=1}^{NEHSJ_{nehsi}} \left(\frac{x_{nehsi,nehsj}^{NEHS}}{n_{nehsi,nehsj}^{NEHS}} \right) + \sum_{nehwsi=1}^{NEHWSI} \sum_{nehwsj=1}^{NEHWSJ_{nehwsi}} \left(\frac{x_{nehwsi,nehwsj}^{NEHWS}}{n_{nehwsi,nehwsj}^{NEHWS}} \right) \tag{A20}$$

Q^{HDY}: Heating energy demand, annual (MJ/year)

SEH_{el}: The efficiency an electrical system for heating

SEH_{nel}: The efficiency a non-electrical system for heating

Heating energy demand, annual

$$Q^{HDY} = \sum_{m=1}^{12} Q_m^{HD} \tag{A21}$$

$$Q_m^{HD} = \begin{cases} HS_m F_{conv}\left(Q_{HT,m} + Q_{VEN,m} - Q_{INHG,m} - Q_{SL,m}\right) & if\ positive \\ 0, & else \end{cases} \tag{A22}$$

$$Q_{HT,m} = BLC\left(T_{IH} - T_{o,m}\right)t_m \tag{A23}$$

$$Q_{VEN,m} = \frac{\rho_{air} c_{p_{air}} ACH \ \cdot V \ \cdot \left(T_{IH} - T_{o,m}\right)t_m}{3600} \tag{A24}$$

$$Q_{INHG,m} = \left(n_{people} Q_{people,m} + Q_{eah,m}\right)t_m \tag{A25}$$

$$Q_{SL,m} = \sum_{wn=1}^{WN}\left(A_{wn}^{WIN} F_{F,wn} F_{S,wn} F_{CM,wn} t_{d,m} I_{SL,wn,m} \sum_{z=1}^{Z}(x_z^{WIN} g_z^{WIN})\right) \tag{A26}$$

Q_m^{HD}: The monthly heat demand (kWh/month)

HS_m: The monthly heating required indicating parameter (binary 0 or 1)

F_{conv}: Conversion factor (MJ/kWh)

$Q_{HT,m}$: Monthly heat loss during transmission (kWh/month)

$Q_{VEN,m}$: Monthly heat loss during ventilation (kWh/month)

$Q_{INHG,m}$: Monthly internal heat gains (kWh/month)

$Q_{SL,m}$: Monthly solar gains (kWh/month)

BLC: Load coefficient of building (W/K)

T_{IH}: Indoor temperature for the heating season (K)

$T_{o,m}$: Outdoor temperature for month *m* (K)

t_m: Month duration in hours (h/month)

ρ_{air}: Air density (kg/m^3)

$c_{p_{air}}$: Heat capacity of air (kJ/kgK)

ACH: Air changes per hour (h^{-1})

V: Interior volume of the building (m^3)

n_{people}: Occupancy count in the building

$Q_{people,m}$: Heat released per person from radiation (W/person)

$Q_{eah,m}$: Heat generated by electrical devices

A_{wn}^{WIN}: Area of window (m^2)

$F_{F,wn}$: Window frame ratio (%)

$F_{S,wn}$: Window shading adjustment factor (%)

$F_{CM,wn}$: Window adjustment factor for movable shades (%)

$t_{d,m}$: Length of the month in days (days/month)

$I_{SL,wn,m}$: Solar radiation on the window at a specific tilt and orientation (kWh/m^2/day)

g_z^{WIN}: Effective total solar energy transmittance (%) for window type z

Building load coefficient

$$BLC = \sum_{dr=1}^{DR}(A_{dr}^{DOOR} b_{dr}^{DOOR}) \sum_{d=1}^{D}(x_d^{DOOR} U_d^{DOOR}) + \sum_{wn=1}^{WN}(A_{wn}^{WIN} b_{wn}^{WIN}) \sum_{z=1}^{Z}\sum_{t=1}^{T_z}(x_{zt}^{WIN} U_{zt}^{WIN}) + \sum_{wl=1}^{WL}(A_{wl}^{WALL} b_{wl}^{WALL}) \sum_{w=1}^{W}(x_w^{WALL} U_w^{WALL}) + \sum_{ce=1}^{CE}(A_{ce}^{CEIL} b_{ce}^{CEIL}) \sum_{r=1}^{R}(x_r^{CEIL} U_r^{CEIL}) + \sum_{fl=1}^{FL}\left(A_{fl}^{FLO} b_{fl}^{FLO}\right) \sum_{h=1}^{H}(x_h^{FLO} U_h^{FLO}) \quad \text{(A27)}$$

$$U_d^{DOOR} = \left(\frac{1}{h_i} + \frac{1}{U_{value,d}} + \frac{1}{h_o}\right)^{-1} \quad \text{(A28)}$$

$$U_z^{WIN} = \left(\frac{1}{h_i} + \frac{1}{U_{value,z}} + \frac{1}{h_o}\right)^{-1} \quad \text{(A29)}$$

$$U_w^{WALL} = \left(\frac{1}{h_i} + \sum_{y=1}^{Y_w}\left(\frac{l_{w,y}^{WALL}}{kk_{w,y}^{WALL}}\right) + \sum_{p=1}^{P_w}\left(\frac{l_{w,p}^{mWALL}}{k_{w,p}^{mWALL}} x_{w,p}^{mWALL}\right) + \frac{1}{h_o}\right)^{-1} \quad \text{(A30)}$$

$$U_r^{CEIL} = \left(\frac{1}{h_i} + \sum_{f=1}^{F_r}\left(\frac{l_{r,f}^{CEIL}}{kk_{r,f}^{CEIL}}\right) + \sum_{a=1}^{A_r}\left(\frac{l_{r,a}^{mCEIL}}{k_{r,a}^{mCEIL}} x_{r,a}^{mCEIL}\right) + \frac{1}{h_o}\right)^{-1} \quad \text{(A31)}$$

$$U_h^{FLO} = \left(\frac{1}{h_i} + \sum_{e=1}^{E_h}\left(\frac{l_{h,e}^{FLO}}{kk_{h,e}^{FLO}}\right) + \sum_{g=1}^{G_h}\left(\frac{l_{h,g}^{mFLO}}{k_{h,g}^{mFLO}} x_{h,g}^{mFLO}\right) + \frac{1}{h_o}\right)^{-1} \quad \text{(A32)}$$

Primary energy usage for domestic hot water

$$Q_{DHW} = \frac{Q_{el}^{W} f^{grid}}{n_{grid}} + Q_{nel}^{W} \quad \text{(A33)}$$

Q_{el}^{W}: Energy consumed by an electrical system for DHW (MJ/year)

Q_{nel}^{W}: Energy consumed by a non-electrical system for DHW (MJ/year)

Primary energy consumption electrical DHW and heating-DHW system

$$Q_{el}^{W} = Q^{WD} SEW_{el} \quad \text{(A34)}$$

$$SEW_{el} = \sum_{ewsi=1}^{EWSI}\sum_{ewsj=1}^{EWSJ_{ewsi}}\left(\frac{x_{ewsi,ewsj}^{EWS}}{n_{ewsi,ewsj}^{EWS}}\right) + \sum_{ehwsi=1}^{EHWSI}\sum_{ehwsj=1}^{EHWSJ_{ehwsi}}\left(\frac{x_{ehwsi,ehwsj}^{EHWS}}{n_{ehwsi,ehwsj}^{EHWS}}\right) \quad \text{(A35)}$$

Primary energy consumption non-electrical DHW and heating-DHW system

$$Q_{nel}^{W} = Q^{WD} SEW_{nel} \tag{A36}$$

$$SEW_{nel} = \sum_{newsi=1}^{NEWSI} \sum_{newsj=1}^{NEWSJ_{newsi}} \left(\frac{x_{newsi,newsj}^{NEWS}}{n_{newsi,newsj}^{NEWS}} \right) + \sum_{nehwsi=1}^{NEHWSI} \sum_{nehwsj=1}^{NEHWSJ_{nehwsi}} \left(\frac{x_{nehwsi,nehwsj}^{NEHWS}}{n_{nehwsi,nehwsj}^{NEHWS}} \right) \tag{A37}$$

Q^{WD}: The total annual DHW energy demand (MJ/year)

SEH_{el}: The efficiency an electrical system for DHW

SEH_{nel}: The efficiency a non-electrical system for DHW

The total annual hot water energy demand

$$Q^{WD} = \sum_{m=1}^{12} (DQ_m^{DHW}) \tag{A38}$$

$$DQ_m^{DHW} = \begin{cases} WS_m F_{conv}\left(Q_{dhwu,m} - Q_{dSLC,m}\right), if\ Q_{dhwu,m} \geq Q_{dSLC,m} \\ 0, \qquad else \end{cases} \tag{A39}$$

$$Q_{dhwu,m} = \dot{m}_w \rho_w c_{p_w} \left(T_{DHW} - T_{DCW,m}\right) t_m \tag{A40}$$

$$Q_{dSLC,m} = F_{conv} A_{SLC} F_{S,SLC} I_{SL,SLC,m} t_d \sum_{slci=1}^{SLCI} x_{slci}^{SLC} n_{slci}^{SLC} \tag{A41}$$

WS_m: Parameter indicating whether domestic hot water is needed for month m (binary variable)

$Q_{dhwu,m}$: Average monthly demand for domestic hot water supply (MJ/month)

$\dot{m}_w$: Daily rate of hot water consumption (m^3/s)

ρ_w: The density of water (kg/m^3)

c_{p_w}: Heat capacity of water (kJ/kg K)

T_{DHW}: The base temperature set for the domestic hot water system (K)

$T_{DCW,m}$: The temperature of the cold water supply during month m (K)

$Q_{dSLC,m}$: The monthly hot water demand (MJ/month) supplied by a solar collector system

A_{SLC}: Area of the solar collector (m^2)

$F_{S,SLC}$: Adjustment factor for shading (%)

$I_{SL,SLC,m}$: Solar radiation received by a solar collector of type *slci* at a specific tilt and orientation ($kWh/m^2/day$)

n_{slci}^{SLC}: solar collector type *slci* efficiency (%)

Primary energy consumption for lighting

$$Q_L = \frac{Q_{el}^{L} f^{grid}}{n_{grid}} \tag{A42}$$

$$Q_{el}^{L} = Q^{LDY} SEL_{el} \tag{A43}$$

$$Q^{LDY} = \sum_{m=1}^{12} Q_m^{LD} \tag{A44}$$

$$Q_m^{LD} = F_{conv} t_{d,m} \sum_{l=1}^{L} \left(P_{L,l} f_{use,l}\right) \sum_{li=1}^{LI} x_{li}^{L} \tag{A45}$$

Q_{el}^{L}: Annual electrical energy consumed for lighting (MJ/year)

Q^{LDY}: Total annual demand for electricity for lighting (MJ/year)

$P_{L,l}$: Power rating of the lamp (kW)

$f_{use,l}$: Duration of device usage (h/day)

Primary energy usage for electrical appliances

$$Q_A = \frac{Q_{el}^{A} f^{grid}}{n_{grid}} \tag{A46}$$

$$Q_{el}^{A} = Q^{ADY} SEA_{el} \tag{A47}$$

$$Q^{ADY} = \sum_{m=1}^{12} Q_m^{AD} \tag{A48}$$

$$Q_m^{AD} = F_{conv} t_{d,m} \sum_{eaj=1}^{EAJ} \left(P_{A,eaj} f_{useEA,eaj} f_{load,eaj} x_{eaj}^{EA}\right) \tag{A49}$$

Q_{el}^{A}: Annual electricity usage for operating electrical appliances (MJ/year)

Q^{ADY}: Total annual electricity demand for operating electrical appliances (MJ/year)

$P_{A,eaj}$: Power rating of the electrical appliance (W)

$f_{useEA,eaj}$: Duration of device operation (h/day)

$f_{load,eaj}$: Load ratio of the device (%)

The total annual electricity demand

$$Q_{EL}^{D} = Q_{el}^{H} + Q_{el}^{W} + Q_{el}^{L} + Q_{el}^{A} \tag{A50}$$

Total initial investment cost

$$\begin{aligned} INVCOST = {} & COST_{DOR} + COST_{WIN} + COST_{WAL} + COST_{CEIL} + COST_{FLO} + COST_{HS} + COST_{WS} \\ & + COST_{HWS} + COST_{SLC} + COST_{LIGHT} + COST_{EA} \end{aligned} \tag{A51}$$

$$COST_{DOR} = \sum_{dr=1}^{DR} (A_{dr}^{DOOR}) \sum_{d=1}^{D} (x_d^{DOOR} c_d^{DOOR}) \tag{A52}$$

$$COST_{WIN} = \sum_{wn}^{WN} (A_{wn}^{WIN}) \sum_{z=1}^{Z} (x_z^{WIN} c_z^{WIN}) \tag{A53}$$

$$COST_{WAL} = \sum_{wl=1}^{WL} (A_{wl}^{WALL}) \sum_{w=1}^{W} \left(x_w^{WAL} \left(\sum_{y=1}^{Y_w} \left(CK_{w,y}^{mWALL}\right) + \sum_{p=1}^{P_w} (x_{w,p}^{mWALL} C_{w,p}^{mWALL}) \right) \right) \tag{A54}$$

$$COST_{CEIL} = \sum_{ce=1}^{CE} (A_{ce}^{CEIL}) \sum_{r=1}^{R} \left(x_r^{CEIL} \left(\sum_{f=1}^{F_r} \left(CK_{r,f}^{mCEIL}\right) + \sum_{a=1}^{A_r} (x_{r,a}^{mCEIL} C_{r,a}^{mCEIL}) \right) \right) \tag{A55}$$

$$COST_{FLO} = \sum_{fl=1}^{FL}\left(A_{fl}^{FLO}\right)\sum_{h=1}^{H}\left(x_{h}^{FLO}\left(\sum_{e=1}^{E_h}\left(CK_{h,e}^{mFLO}\right)+\sum_{g=1}^{G_h}\left(x_{h,g}^{mFLO}C_{h,g}^{mFLO}\right)\right)\right) \quad (A56)$$

$$COST_{HS} = \sum_{ehsi=1}^{EHSI}\sum_{ehsj=1}^{EHSJ_{ehsi}}\left(x_{ehsi,ehsj}^{EHS}CST_{ehsi,ehsj}^{EHS}\right) + \sum_{nehsi=1}^{NEHSI}\sum_{nehsj=1}^{NEHSJ_{nehsi}}\left(x_{nehsi,nehsj}^{NEHS}CST_{nehsi,nehsj}^{NEHS}\right) \quad (A57)$$

$$COST_{WS} = \sum_{ewsi=1}^{EWSI}\sum_{ewsj=1}^{EWSJ_{ewsi}}\left(x_{ewsi,ewsj}^{EWS}CST_{ewsi,ewsj}^{EWS}\right) + \sum_{newsi=1}^{NEWSI}\sum_{newsj=1}^{NEWSJ_{newsi}}\left(x_{newsi,newsj}^{NEWS}CST_{newsi,newsj}^{NEWS}\right) \quad (A58)$$

$$COST_{HWS} = \sum_{ehwsi=1}^{EHWSI}\sum_{ehwsj=1}^{EHWSJ_{ehwsi}}\left(x_{ehwsi,ehwsj}^{EHWS}CST_{ehwsi,ehwsj}^{EHWS}\right) + \sum_{nehwsi=1}^{NEHWSI}\sum_{nehwsj=1}^{NEHWSJ_{nehwsi}}\left(x_{nehwsi,nehwsj}^{NEHWS}CST_{nehwsi,nehwsj}^{NEHWS}\right) \quad (A59)$$

$$COST_{SLC} = \sum_{slci=1}^{SLCI}\left(x_{slci}^{SLC}CST_{slci}^{SLC}\right) \quad (A60)$$

$$COST_{LIGHT} = L\sum_{li=1}^{LI}\left(x_{li}^{L}CST_{li}^{L}\right) \quad (A61)$$

$$COST_{EA} = \sum_{eaj=1}^{EAJ}x_{eaj}^{EA}CST_{eaj}^{EA} \quad (A62)$$

A_{dr}^{DOOR}: Area of door *dr* [m^2]

A_{wn}^{WIN}: Area of window *wn* [m^2]

A_{wl}^{WALL}: Area of wall *wl* [m^2]

A_{ce}^{CEIL}: Area of ceiling *ce* [m^2]

A_{fl}^{FLO}: Area of floor *fl* [m^2]

c_{d}^{DOOR}: cost of a type *d* door [\$/m^2]

c_{z}^{WIN}: cost of a type z window [\$/m^2]

$CK_{w,y}^{mWALL}$: Total investment costs for the materials used in the known layers y of wall structure w [\$/m^2]

$C_{w,p}^{mWALL}$: Total investment costs for the materials used in the unknown layers p of wall structure w [\$/m^2]

$CK_{r,f}^{mCEIL}$: Total investment costs for the materials used in the known layers f of ceil structure r [\$/m^2]

$C_{r,a}^{mCEIL}$: Total investment costs for the materials used in the unknown layers a of ceil structure r [\$/m^2]

$CK_{h,e}^{mFLO}$: Total investment costs for the materials used in the known layers e of floor structure h [\$/m^2]

$C_{h,g}^{mFLO}$: Total investment costs for the materials used in the unknown layers g of floor structure h [\$/m^2]

$CST_{ehsi,ehsj}^{EHS}$: Total investment cost for the electrical heating system ehsj of category ehsi [\$]

$CST_{nehsi,nehsj}^{NEHS}$: Total investment cost for the non-electrical heating system nehsj of category nehsi [\$]

$CST_{ewsi,ewsj}^{EWS}$: Total investment cost for the electrical DHW system ewsj of category ewsi [\$]

$CST_{newsi,newsj}^{NEWS}$: Total investment cost for the non-electrical heating-DHW system nehwsj of category nehwsi [\$]

$CST_{ehwsi,ehwsj}^{EHWS}$: Total investment cost for the electrical heating-DHW system ehwsj of category ehwsi [\$]

$CST^{NEHWS}_{nehwsi,nehwsj}$: Total investment cost for the non-electrical heating-DHW system nehwsj of category nehwsi [$]

CST^{SLC}_{slci}: Total investment cost for the solar collector system slci [$]

CST^{L}_{li}: Total investment cost for the lamp li [$]

CST^{EA}_{eaj}: Total investment cost for the electrical appliances eaj [$]

2.2. Constraints

By structuring the constraints, we must ensure that the energy demands for heating, DHW, lighting, and appliances are adequately met while allowing for the appropriate selection and optimization of equipment. This balanced approach will lead to more effective energy management in campus buildings equations A16 through A62.

2.3. Parameters

To effectively structure an optimization model, it is essential to clearly define the parameters that will be input by the decision-maker. We can divide the parameters of our model into the Parameters Required for Energy Demand Calculations, Parameters Required for Primary Energy Consumption Calculations, and Cost Parameters for Investment Calculations. Parameters Required for Energy Demand Calculations depend on the air temperature, solar radiation and its duration, the temperature of the water used, the number of building users, and the parameters of the building envelope. Parameters Required for Primary Energy Consumption Calculations depend on the number of lamps and electrical appliances, the duration of use of lamps and electrical appliances, and their efficiency. Cost Parameters for Investment Calculations depend on the investment cost of materials and technologies given in Tables A-1 – A-9.

Table A-1. Door types (Diakaki & Grigoroudis, 2021)

Type	Thermal Transmittance (W/m^2 °C)	Cost ($\$/m^2$)
Double Wing Photocell Door (available)	3.1	0
Metal Heat Insulated Door	4	1220.43
Hollow-Core Flush Door	2.7	859.28
Solid-Core Flush Door with Single Glazing	2.1	1074.1

Table A-2. Window types (Diakaki & Grigoroudis, 2021)

Type	Thermal Transmittance (W/m^2 °C)	Effective Total Solar Energy Transmittance (%)	Cost ($\$/m^2$)
Double glazing 4-10-4, coated, air filled (available)	2.7	0.7	0
Single Typical glazing	5	0.8	44.53
Double glazing 4-20-4, uncoated, air filled	2.6	0.72	61.23
Double glazing 4-12-4, coated, argon filled	1.6	0.76	72.36

Table A-3. Wall types (Diakaki & Grigoroudis, 2021)

Material	Thickness (m)	Thermal Transmittance (W/m² °C)	Cost ($/m²)
Brick (available)	0.09	0.45	0
Coat (available)	0.01	0.51	0
Plaster (available)	0.013	0.7	0
Stonewool	0.03	0.04	24.61
Humid	0.0004	0.02	10.07
Isolation Band	0.00013	0.032	0.33
Bondeks	0.025	0.02	17.51
Eps	0.0005	0.24	2.07

Table A-4. Ceiling types (Diakaki & Grigoroudis, 2021)

Material	Thickness (m)	Thermal Transmittance (W/m² °C)	Cost ($/m²)
Concrete (available)	0.15	0.72	0
Box Profile	0.0006	0.032	3.05
Stonewool	0.012	0.04	15.07
Galvanized Carrier	0.0009	0.405	61
Green Plasterboard	0.0125	0.035	50.85
White Plasterboard	0.0125	0.03	11.92
Ekstrude	0.01	0.031	42.72

Table A-5. Floor types (Diakaki & Grigoroudis, 2021)

Material	Thickness (m)	Thermal Transmittance (W/m² °C)	Cost ($/m²)
Cement (available)	0.03	1.4	0
Slope Concrete	0.025	0.11	1
Bitumex Membrane	0.002	0.55	70.488
Roofmate Sl	0.0032	0.031	91.5
Rigid Polyurethane Foam	0.03	0.035	4.88
Stonewool	0.01	0.042	193.34

Table A-6. Heating Systems (Diakaki & Grigoroudis, 2021)

Type	Efficiency (%)	Cost ($/m²)
Electrical Resistance-based, Dry core storage boiler type 1	100	5370.49
Electrical Resistance-based, Dry core storage boiler type 2	85	4511.21
Non-electrical Oil-based, Condensing	83	5692.72
Non-electrical Oil-based, Standard oil boiler	62	5048.26
Non-electrical Natural-gas based, Condensing (available)	85	0
Non-electrical Natural-gas based, Floor mounted boiler	55	4833.44

Table A-7. Heating-DHW Systems (Diakaki & Grigoroudis, 2021)

Type	Efficiency (%)	Cost ($/m²)
Electrical Resistance-based, Electric CPSU	100	7733.51
Electrical Resistance-based, Water storage boiler	85	6229.77
Non-electrical Oil-based, Condensing combi	81	6659.41
Non-electrical Oil-based, Combi	70	6229.77
Non-electrical Natural-gas based, Condensing combi	84	7733.51
Non-electrical Natural-gas based, Combi	65	6122.36

Table A-8. DHW Systems (Diakaki & Grigoroudis, 2021)

Type	Efficiency (%)	Cost ($/m²)
Electrical Resistance-based, Electric immersion	100	1288.92
Electrical Resistance-based, Electric instantaneous at point of use	85	1074.1
Non-electrical Oil-based, Oil boiler/circulator	80	1074.1
Non-electrical Oil-based, Oil single burner	60	859.28
Non-electrical Natural-gas based, Circulator built into a gas warm air system type 1	73	912.98
Non-electrical Natural-gas based, Circulator built into a gas warm air system type 2	60	698.16

Table A-9. Solar Collector Systems (Diakaki & Grigoroudis, 2021)

Type	Efficiency (%)	Cost ($/m²)
Flat collector Type 1	90	966.69
Flat collector Type 2	80	644.46
Vacuum hear pipe CPC collector Type 1	72	837.8
Vacuum hear pipe CPC collector Type 2	67	537.05

2.4. Objective functions

To improve the energy efficiency of a campus building, it is necessary to minimize energy consumption and do so at minimal cost. For this reason, the objective functions of our study are to minimize the primary energy consumption and to minimize the investment cost as follows equations A63 and A64:

$$\min[g_1(\boldsymbol{x})] = Q_T \tag{A63}$$

$$\min[g_2(\boldsymbol{x})] = INVCOST \tag{A64}$$

Where $g_1(\boldsymbol{x})$ represents the total annual consumption of primary energy and $g_2(\boldsymbol{x})$ is the total investment cost.

The total annual consumption of primary energy in the campus building includes energy used for heating systems, domestic hot water (DHW) systems, lighting systems, and electrical appliances, providing a comprehensive overview of the building's energy use. In some cases campus buildings have cooling systems, then the calculation can be extended to include the cooling system data in the formulation. Total investment cost consists of the cost of materials for doors, windows, walls, ceilings, and floors, and the cost of purchasing and installing heating systems, hot water supply, solar collector, lighting, and electrical appliances.

2.5. Case Study

The calculations for this study were performed for the R&D Park Building of Erciyes University. The technical details of the building are presented in Table 2. The sample building comprises three blocks and is actively utilized by both academics and students. As illustrated in Figure 2, the optimization calculation is performed for a single input block.

Table 2. Technical details of the R&D Park Building of Erciyes University (Authors)

Total Volume	13,047.44 m³
Total Wall Area	1,279.407 m² (excluding windows and doors)
Total Floor Area	1,412.41 m²
Total Ceiling Area	1,412.41 m²
Windows	350 (each 0.7 m²)
Doors	1 (6.89 m²)
Occupancy	110 people

Figure 2. R&D Park Building of Erciyes University (Earth, 2024)

Details on the selection of building materials and technology are provided below. Data on existing and alternative types of doors and windows in the building can be found in equations A1 through A62. Information regarding existing and alternative materials for walls, ceilings, and floors is presented in Tables A-3 to A-5. Additionally, data on existing and alternative heating systems are included in Tables A-6 and A-7, while alternative domestic hot water (DHW) systems are detailed in Tables A-7 and A-8. Finally, information on alternative solar collector systems is available in Table A-9.

3. Findings and Discussion

The model's calculations were executed using the GAMS programming language, employing SCIP and LINDO solvers. The results from both solvers yielded very close values, differing by only 0.2%, ultimately leading the model to produce the optimal solution. The optimal results obtained are presented in Table 3 and illustrated in Figure 3. As shown in Figure 3, energy consumption declines as investment costs rise. As the building's heating system is the most efficient option available, the model did not suggest any changes. However, since the building lacks a hot water system, it is advisable to install the most efficient type of boiler for hot water.

Table 3. Data on primary energy consumption and initial investment costs (Authors)

QT (MJ/year)	INVCOST ($)	QT (MJ/year)	INVCOST ($)	QT (MJ/year)	INVCOST ($)
1240450000.00	**127544.00**	2005750000.00	87378.20	2091830000.00	36118.80
1241490000.00	120144.00	2005850000.00	86828.20	2091910000.00	34892.80
1283850000.00	115641.00	2045570000.00	53847.00	2092660000.00	32862.70
1286720000.00	108966.00	2045690000.00	52447.00	2092860000.00	28718.20
1287740000.00	103382.00	2045570000.00	53847.00	2647600000.00	23590.70
1842480000.00	97287.90	2046240000.00	51516.90	2648440000.00	20334.60
1843140000.00	94957.80	2046340000.00	50966.90	2648820000.00	14575.30
1843340000.00	94271.90	2046610000.00	46446.40	3277620000.00	11891.50
1843520000.00	89887.40	2088780000.00	43719.60	3277350000.00	9859.97
1843550000.00	88876.30	2088970000.00	41943.60	**3277520000.00**	**8934.03**

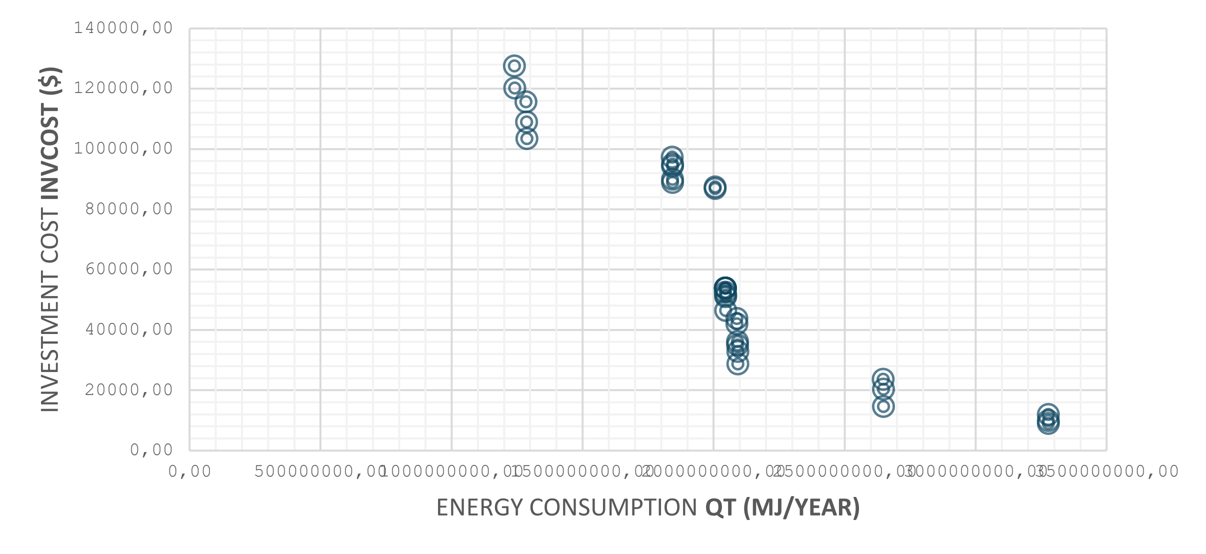

Figure 3. Chosen feasible solution values for primary energy consumption and initial investment cost (Authors)

The building's energy consumption is predominantly attributed to heating, with an annual usage of 5,044,230,000 MJ/year. Analyses indicate that a minimum investment of $8,934.03 in insulation materials could yield a 35% reduction in energy consumption per year by enhancing the thermal performance of the building envelope. Additionally, the replacement of existing insulation and heating technologies with advanced, energy-efficient alternatives is projected to incur a cost of $127,544. Implementing these upgrades is expected to achieve a significant reduction of 75.5% in the building's annual energy consumption (Figure 4).

Due to the absence of a hot water system in the building, the model identified and recommended the most cost-effective and energy-efficient technologies for implementation (Figure 5). 572 lamps currently installed have not been replaced, as they were upgraded to energy-efficient types during recent renovations. Additionally, it is recommended to replace the existing desktop computers with energy-efficient models, which would further optimize the building's overall energy consumption and efficiency (Figure 6). The selection of optimal energy-efficient measures leads to a significant reduction in energy demand, resulting in substantial primary energy savings.

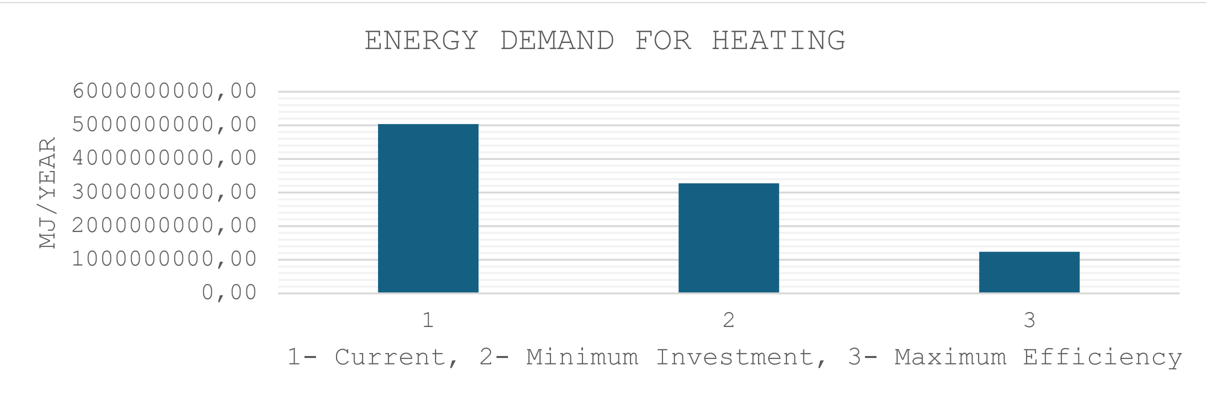

Figure 4. Annual heating energy demand before and after the retrofit (Authors)

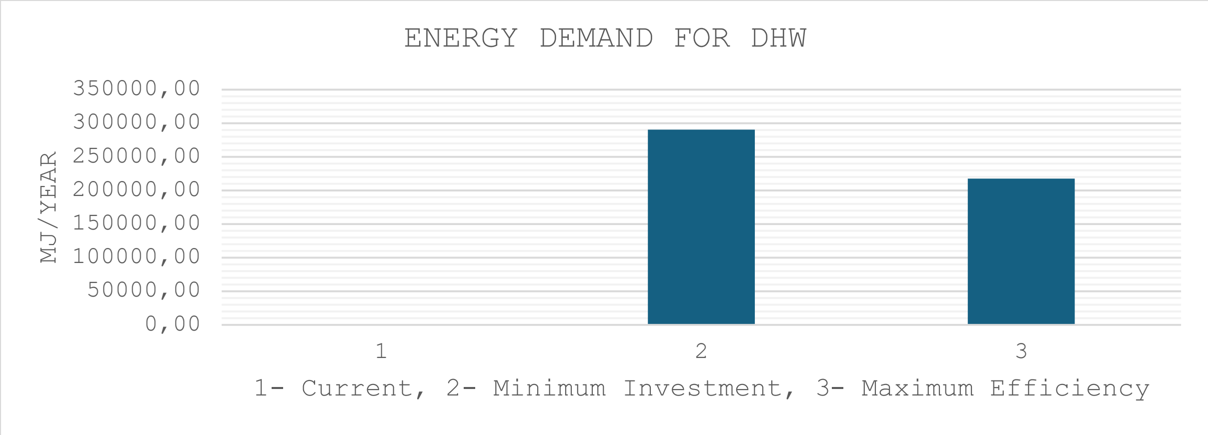

Figure 5. Annual energy demand for DHW systems before and after the retrofit (Authors)

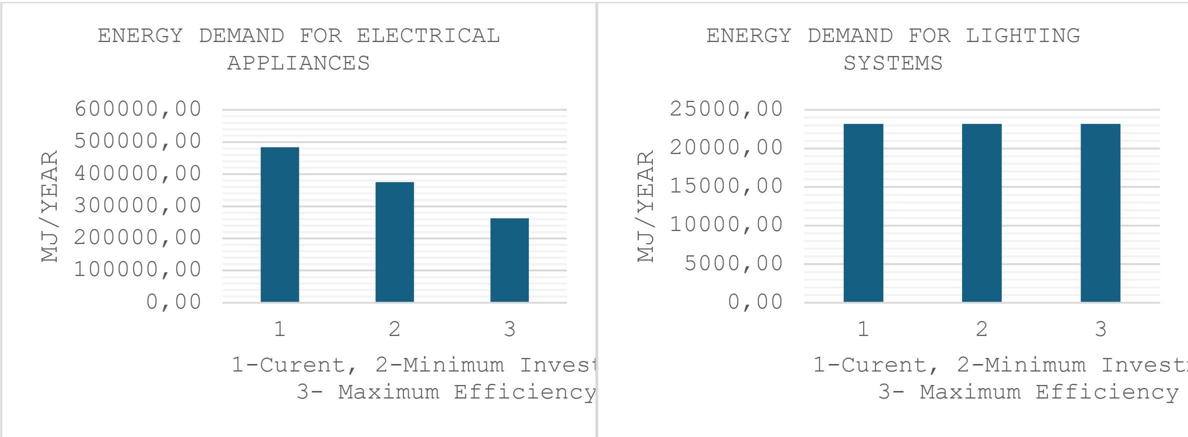

Figure 6. Annual energy demand for Electrical Appliances and Lighting Systems before and after the retrofit (Authors)

4. Conclusion and Suggestions

The scope of this article is prioritizing energy efficiency measures specifically within university campus buildings. By evaluating these measures in terms of their energy performance and initial costs, the framework aims to provide campus decision-makers with a clear strategy for implementing effective energy-saving interventions. This approach not only addresses the unique energy demands of campus facilities but also aligns with institutional sustainability goals. By optimizing energy efficiency, universities can significantly reduce operational costs, minimize their environmental impact, and create a more sustainable campus environment for students and faculty alike.

This study uses the SCIP and LINDO algorithms to address the MINLP multi-objective problem. To enhance energy efficiency on the university campus, future investigations should explore the integration of renewable energy sources, such as solar photovoltaic systems and wind turbines, into the existing energy infrastructure. This integration can reduce reliance on fossil fuels and lower greenhouse gas emissions. Additionally, further studies can examine the design and implementation of optimal parking solutions for electric vehicles, including the installation of charging stations and the allocation of space to encourage electric vehicle adoption.

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Author Contribution and Conflict of Interest Declaration Information

All authors contributed equally to the article. There is no conflict of interest.

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Symbolic Approaches in the Development Perspective of Turkish Wood Art, An Overview of Seljuk Interior Designs

Mertcan ÖZTEKİN [1*]

ORCID 1: 0000-0002-6490-4557
[1] *Yalova University, Faculty of Art and Design, Department of Interior Architecture, 77200, Yalova, Türkiye.*
**** e-mail**: mertcan.oztekin@yalova.edu.tr*

Abstract

Culture is reflected in many areas of life. Symbols are culturally significant and emotionally comprehensible representations. Culture is reflected in the spaces that meet the most basic needs of human beings and are an application area of art. In this parallelism, Turkish wood carving art has been handled within the boundary of interior design. Within the scope of qualitative research, it is seen that Turkish wood art developed during the Seljuk period and has reached the present day. The symbolic depiction of the foundation laid with the Seljuks in wood art is examined. The study aims to examine the progress of wood art in relation to interior design and its expression of cultural values. In addition, the symbolic equivalents of the values of Turkish culture in interior design are examined. The findings suggest that Turkish art is preserved and carried forward through interior design.

Keywords: *Culture, Turkish arts, wood carving, Seljuk, interior design.*

Türk Ahşap Sanatı Gelişim Perspektifinde Sembolik Yaklaşımlar, Selçuklu Mekân Tasarımlarına Genel Bir Bakış

Öz

Kültür yaşamın birçok alanına yansımaktadır. Simgeler kültüre ait anlamlı ve duygusal olarak kavranabilen tasvirlerdir. İnsanoğlunun en temel ihtiyaçlarını karşılayan ve sanatında bir uygulama alanı olan mekânlara kültür yansımaktadır. Bu paralellikte Türk ahşap oyma sanatını mekân tasarımı sınırında ele alınmıştır. Nitel araştırma yöntemi kapsamında ulaşılan çıkarımlarda görülmektedir ki Türk ahşap sanatı Selçuklular döneminde gelişmiş ve günümüze kadar ulaşmaktadır. Ahşap sanatında Selçuklular ile atılan temelin sembolik olarak nasıl tasvir edildiği incelemektedir. İç mimari açıdan dönemsel perspektiflerde ahşap sanatının ilerleyişi ve kültürel değerlerin mekân tasarımdaki ifadeleri çalışmanın hedefidir. Bununla beraber Türk kültüründeki değerlerinin mekân tasarımındaki kurgulamaların sembolik karşılıkları irdelenmektedir. Bulgular, Türk sanatının iç mekân tasarımı yoluyla korunduğunu ve ileriye taşındığını göstermektedir.

Anahtar kelimeler: *Kültür, Türk sanatları, ahşap oyma, Selçuklu, iç mimarlık.*

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1. Introduction

Societies are constructed based on the common values adopted in their vital actions, which is known as culture. Culture is reflected in art, fiction, and the bond between individuals and society as a whole. Artworks based on culture provide a depiction of the values that exist in the nation, both past and future. They also create emotional and rational responses in perception. Therefore, individuals can gain valuable experiences through art (Ziss, 2009). Symbols are used to convey historical and life experiences in art, making it a communication tool with visual indicators in aesthetic compositions (Küçüköner, 2005). In Turkish culture and art, various symbols are used to create expressions.

Wood carving is one of our traditional Turkish arts. Being an agricultural product, it is permanently preferred by societies due to its natural, accessible, sustainable and economic advantages (Farrelly, 2012). Wood carving is one of our national arts, which developed in the Seljuk period after the adoption of Islam and developed in the Ottoman Empire with symbolic style revisions and professionalised infrastructure in the Ottoman Empire and after the Republic, it is one of our national arts that has come to the 21st century. The intersection of our art with this rich essence at the border of space design is the basis of the study.

Space has dimensions that meet many physiological, sociological, psychological vital needs of human beings and societies. It also aims to meet cultural, artistic and aesthetic needs. A lively atmosphere is organised in the space designed through various elements to meet the needs (Shen, 2020). Design is a social action rather than individuality. It is stated that there is a plural mobility that will take the traditional structure of my societies as a basis and transfer it to the avant-garde, that is, to the future time and interpret their own thoughts (Li, 2016). In the design of an object or a space, it gives meaning through the mediation of material, technique, form and the contexts it contains. With the formation of artistic consciousness, individuals can gain aesthetic and functional experience, and the cultural vitality can increase (Barret, 2022). Thus, the aim of the research is to address the flow of our rich cultural heritage from the past to the present in order to ensure that our cultural art is not forgotten and to achieve universal fluency. In this parallelism, the symbolic approaches of wood carving applied to various elements in space and space are aimed to be examined with the discipline of interior design in this study.

Representations in art are arrived at through analyses obtained from research. Macro and micro analyses maintain cross-relationships and even polarisations in different fields (Corner, 1995). For this reason, the cultural values of spaces, which are an application area of art, are investigated with periodical phenomena. It is seen with many inferences within the boundaries of qualitative research in the study that Mustafa Kemal Atatürk emphasises that art is a nation's freedom, originality, existence and power in life with the words of Mustafa Kemal Atatürk: "One of the life veins of a nation without art is severed" (Can & Gün, 2019). In this parallel, wood carving, which is one of the Turkish arts, should reach the original vitality of our age by preserving its cultural values. It clarifies the symbolic fictions of cultural values reflected in the design of space with wood art applications from the past to the present. With the Seljuks, who laid the professional foundation with the perspective of development, symbolic vitality in design was created. In this essence, cultural reflections in art are symbolised in spaces. The design fictions of our national artistic identity created on this basis are realised through interior design.

2. Material and Method

This study deals with the reflection of cultural values on traditional art and space design in qualitative research method. Firstly, definitions of culture, symbol and carving art are made through literature review. As a result of these definitions, connections were created with the intersection of art and space. In terms of analysing the research data, this subject, which is dealt with in depth in qualitative method, is narrowed down on the symbolic approach of cultural values. The prevalence of interior design applications is seen in terms of the functionality and accessibility of wood, one of our traditional arts. In this parallel, a historical examination of the symbolic reflections of cultural values reflected in space design is made in this study. Sampling time: The Seljuk periods are discussed due to the cultural identity formed with the acceptance of Islam, art-space practices and pioneering.

The dependent variable for inferences in historical analyses is the symbolic constructions of wood art in the applications of space design. The independent variable is the periodic phenomena that developed after the acceptance of Islam. As a result of the analyses, management policies, social structure, social and state relations shape the unity of art and space. It is seen that periodical phenomena increase religious space applications. Art is applied on the basis of belief and art is applied in space design. In the light of these data, the study findings are reached with the flow in the research structure (Figure 1).

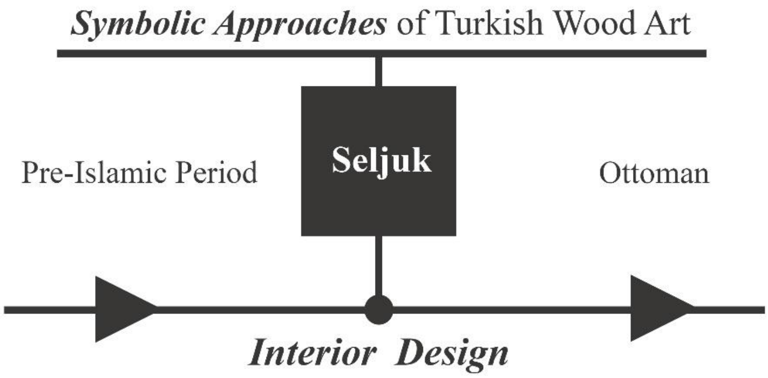

Figure 1. Research structure

Although wood art was also practised before Islam, the existence of distinctive works was established with the Seljuks. Thus, Turkish wood art has been carried out professional applications with technical methods developed by the Seljuks. The historical process in the development perspective of the wood art is examined. As a result of this examination, it is defined what the symbolic approaches reflected in the space design of the culture are and the design constructs as a result of periodical developments.

3. Findings

3.1. Wood Art and Interior Design in Turkish Culture

Common behaviours, thoughts and beliefs adopted in the society constitute culture. When we consider them as indicators, ideas, emotions, thoughts and all opinions in the society are the reflection of culture on symbols (Bayazıt, 2008). At this stage, the symbol, which is the other synonym of symbol, conveys the traditions and customs in the society that can be seen in all areas of life with cultural reflection. In the literature, symbols are defined as visuals created by people, which can be perceived sensually and have meaning (Küçüköner, 2005). When we look at the history of mankind from the past to the present, the values and attitudes of the culture have been expressed with symbols. From symbolic paintings made to communicate in caves, symbols reflecting culture are always present in various places such as hotels and shopping centres (Koca, 2012). In addition, cultural values are used symbolically in art practices. Since the ancient periods of history, art has been shaped by culture and keeps itself alive.

Art is the expression of feelings and thoughts in life through an intermediary channel. At this stage, culture defines art and gives it a unique aesthetic value. Because art can benefit both an expression and life practice with its own branches. Since the time of the first existence of mankind, its cultural structure has been reflected in the ornamental details in art approaches and has created an aesthetic form with cultural images (Akmetova, Mayorova, Makhmutova & Madina, 2016). Looking at the historical extension of art, one of its various applications has been carving.

Carving has been an important skill since the existence of mankind. It is a way that meets the needs in daily life practices and is used for various purposes. Carving is a method in which relief shapes are obtained in the depths opened on the surfaces of materials such as wood and stone (Ambrose, Harris & Stone, 2010). It is applied with alternative methods according to the structure and usage representations of different materials such as wood, stone, leather. Especially wood carving is preferred to be used in many areas due to the durable and characteristic texture of the material. In order for carving to be applied, firstly, the sub-material requirement is needed. Various application methods have been developed for wood carving from the past to the present. The tree used in the sub-floor of the art of carving can grow on its own in nature as an organic material. As there are many kinds of trees, it is processed according to the usage areas in line with the characteristics of its breed. Root, trunk and branches can be used (Asarcıklı & Keskin, 2005). One of these areas of use is the applications in space and space units. Wood has always been used in spatial arrangements due to its practical benefits in terms of accessibility, functionality and aesthetics in every period of history.

Space is a boundary formed by multiple three-dimensional planes. Plane is the name of the surfaces such as ceiling, wall or floor in design disciplines that form the space and can define it (Coates, Brooker & Stone, 2011). Spatial surfaces are an ideal space for the expression of symbols. Walls, floors, ceilings and various surfaces of the space can revive the symbolic values of wood carving art. It is also known that the space is a volume with four dimensions. Because in addition to the width, length and height that make up its structure, it is another dimension that has gained life with the vitality and emotions of the people who use it (Sözen & Tanyeli, 2011). In addition, various objects such as furniture are important elements that shape the aesthetics and functionality of the space. Because every unit in the space is included in the mentioned dimension.

Turkish wood carving art has its roots in Central Asia, the first settlements of the Turks. This art has been used for centuries as a means of reflecting the social, religious and cultural life of the Turkish society and telling their stories. Within the scope of the geography extending from Central Asia to Anatolia, Turkish communities formed a cultural structure with names such as Karahanids, Ilkhanids, Danishmendids, Ghaznavids and Seljuks. Especially the fact that Anatolia acts as a bridge in the east-west trade synthesises the rich cultures, Islamic beliefs and the transition to a settled order (Doğan, 2009). The art of wood carving developed with the need for spatial ornamentation during the transition from nomadic life to settled life.

Belief is an important dimension that shapes art. There has been an important beginning with the acceptance of Islam in the development of Turkish art. It is known that the foundations of Islamic art were laid with the conquests that existed in the period, based on the birth of the Prophet Muhammad after his death in 632. After the adoption of Islam, non-universal, regional styles were continued in the states in the period called the Early Islamic Period and later extending to the Seljuks (Hillenbrand, 2005). After the Talas victory in 751, the Turks were introduced to the Muslim faith and it was accepted in most of the societies by the 10th century. Shamanist and Manichaean beliefs were replaced by Islamic beliefs and a new belief of life was synthesised (Doğan, 2009). Abstract values in beliefs were integrated with concrete descriptions and reflected in art. In Turkish art, the lives in ancient times, difficult struggles such as wars, and expressions blended on the basis of nature and religion have been applied to metal, stone, textile, wood and many types of substrates (Özkeçeci, 2008). At this stage, with the acceptance of Islam, the Anatolian Principalities and the Seljuk State took important steps in the development of this art. With the beginning of the settled life of the Turks in Central Asia, wood applications were developed in the Seljuks. Thus, it made religious and other spaces defined in the settled order.

Cultural identity can be considered to be based on this parallelism. The Turkish identity reflected in various art practices of the Seljuks is described and it is seen that it continues with renewed fictions with the perspective of development until today. The symbolic approaches reflected in the Seljuk wood art and space design within the study boundary are examined in the other title. Thus, a general evaluation of the symbolic constructions of cultural values at the intersection of art and space is made.

3.2. Seljuk Wood Art and Interior Design

Seljuks are a community based on Kınık tribes of Oghuz Turks. On the border of the Anatolian geography we live in, two separate states, the Great Seljuk State and the Anatolian Seljuk State, are seen. The Great Seljuks ruled the regions extending from Anatolia to Central Asia between 1040-1157 (Sümer, 2009). With the disintegration of the Seljuks after the Mongol invasion, separate principalities were formed in Anatolia. The Anatolian Seljuk State, one of these formations, continued their cultural structuring in settled life (Horata, 2009). Between the years 1075 and 1308, the Anatolian Seljuk State dominated. The cultural values of the Seljuks became evident as of the establishment of the state at the beginning of the 11th century and shaped their settled lives. In this process, art, which is also a cultural expression, begins to construct itself together with belief.

The values coming from the pre-Islamic nomadic culture were blended in the Islamic settled order and works of architecture, which are indicative of fixed settlement, are seen throughout the architecture. In the Seljuks, art and architecture practices are seen in these buildings, which are used as religious, educational, cultural and social centres, called great mosques rather than palaces (Ödekan, 2011). In addition, the objects that function these spatial structures are also organised with furniture. The Seljuk Koran enclosures, rahlas, structural and spatial details of the Seljuks built in these periods were shaped on the basis of belief. The existence of a common language in art in the Islamic world between 1000 and 1220, especially during the decline period of the Seljuks, has reached its original expression. The period of decline is a dynamic period in art practices. This dynamism brought about professional developments in the fields of art in terms of technique and aesthetics. The quality of art production has shifted to a broad perspective (Hillenbrand, 2005). Thus, spatial arrangements, which are an application field of art, represent the cultural values of the period.

The art style of the Seljuks in the settled order was reflected in the interior design discipline with spatial units and elements supporting that space. Wood carving, one of these art types, is a whole with spatial elements and cultural values. Wooden carving details are seen in objects such as doors, windows, carrier columns and beams, ceilings, as well as mihrab, minbar, chest, chest, rahle, which are various surfaces of the architectural structure and space of the Seljuks and other Turkish principalities (Can & Gün, 2019). In the materials used in Turkish wood art, wood species such as oak, ebony, walnut, boxwood, linden, apple, pear, cedar and rose were generally used, and it is known that geometric compositions reflecting the cultural identity of the period were carved (Büyükçanga, 1993). When we consider these compositions in a cultural context, the settled order in the way of life and the Islamic beliefs are constructed.

When we consider the decorations of Turkish wood carving in terms of form; they can be grouped as abstract, natural, structural and documentary. In abstract weaves, triangles, geometric stars, angular shapes such as diamonds are used. In natural weaves, animal and human silhouettes were used in addition to vegetal shapes. Structural weaves include columns, column capitals, arch cornice details. In documentary weaves, they are applications that show the information about the person who had the work built or religious words are written. The symbols in vegetal weaves are palmette, rumi, lotus and acontus. There is a decrease in human figures in natural weaves after the adoption of Islam. Animals such as wolves, eagles, birds, roosters, roosters, dogs and horses were symbolised (Ödekan, 2011). The depictions mentioned in Seljuk wood arts are a cultural expression.

Table 1. Symbolic approaches in Seljuk wood art (Ödekan, 2011)

Formal Classification	Symbolic Representations
Abstract	Triangles, geometric stars, representations of Turkish Islamic beliefs reflected in baklawa patterns...
Natural	Eagle, wolf, bird, dog, horse, palm, rumi, lotus, acontus...
Structural	Geometric cultural reflections on the mass basis of column capitals, ceilings, arch details...
Documentary	Religious words, writings of belief, dates of construction, information about the person who made it...

However, it is seen that the most prominent motif used in ornamental details in Turkish arts are geometric motifs. They are compositions constructed with angles, corners and polygons that intersect each other in philosophical and religious responses. The most prominent geometric constructions with six-pointed, eight-pointed, ten and twelve-pointed star types were used in Turkish wood art (Dizel &

Özkaya, 2019). The most prominent symbol of Turkish cultural identity is the Seljuk Star. Outside our own geography, this geometric star symbol is known as the Turkestan Star in Central Asia. The eight-pointed star, one of these star types, is known to represent the existence of eight heavens in Islam and the gates of these eight heavens. Each end of the Seljuk Star, which consists of two intertwined squares, symbolises mercy, compassion, patience, truthfulness, keeping secrets, loyalty, generosity and gratitude to God (Özcan, 2019). From past to present, the Seljuk star, which is an indicator of Turkish cultural identity, is included in various design practices. As a cultural heritage, the symbols transferred from the Seljuks continue to represent our core values. In addition to the geometric forms of these stars, animal and herbal images reflecting nature depictions are constructed in Islamic belief. The courageous spirit of nomadic culture and the attitudes and spiritual values of the settled order that came with Islam symbolise Turkish cultural identity. It can be summarised that various images are used together on the basis of the integrative approach in the settled order and Islam (Table 1). In addition, massiveness and intensity in integrity represent the state and social power of the period. Thus, it can be emphasised that these symbols are reflected in the space design applications of the wooden art in the research boundary.

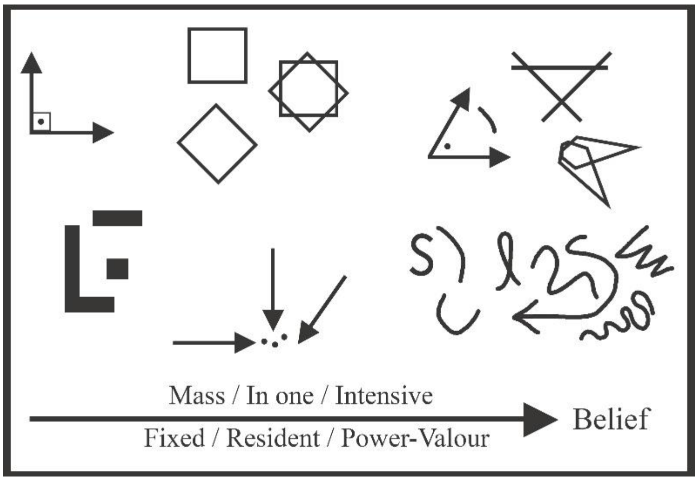

Figure 2. Seljuk Cultural Identity Symbolic Construct (by the Author)

The Seljuks' representation of Turkish heroism coming from nomadism and power in the settled order corresponds to the angled forms. In addition, curved forms are in an intertwined order reflecting this power. In the Seljuk periods, geometric shapes were generally used in large surface architectural and spatial large surface parts. Curved patterns coming from curved branches were applied on surfaces such as rahme, minbar, pulpit, lectern, balustrade plates and in areas such as additional borders on surfaces (Yücel, 1989). These formal expressions were rationalised with the techniques developed in practice during the Seljuk period. The traditional techniques generally used in Turkish wood carving art are kündekâri, carving, engraving, engraving, inlay, openwork (cage) techniques (Bozer, 1992). Wood carving techniques used in Seljuk periods vary in terms of formal features and surface criteria in application. Kundekâri, carving, engraving, engraving, cage / openwork techniques used in Seljuk wood art are seen. Through these techniques, art is applied and cultural values are symbolised.

Kündekâri technique is divided into two groups as real and imitation kündekâri due to the differences in application. In the real kündekâri technique, wooden profiles are combined with each other with protruding parts. It is a profile clamping system that occurs after various geometric patterns are embroidered on the parts without using nails and adhesive materials. Imitation kündekâri has two different applications within itself. Firstly, in the technique of hammering and embossing/carving kündekâri, after the wooden boards are brought together, the patterns are carved as kinis. Afterwards, these kiniches are formed by joining them together even with adhesive materials or nails. In the nailing and gluing kundekâri technique, minimum protrusion parts are formed. After the processed patterns, the parts are joined to each other with nails or adhesive material. In the lattice kündekâri technique, the wooden pieces brought together are formed with a frame that encloses them (Kürklü, 2011). In the minbars belonging to Konya Alaeddin Mosque (1155-56), Aksaray Ulu Mosque (12th century), Malatya Ulu Mosque (13th century), Siirt Ulu Mosque (13th century), Harput Sare Hatun (12th century), Beyşehir Eşrefoğlu (1298-99) Mosques, the minbars are made of pieces cut in polygonal and star shapes with reliefs, and they are applications in kündekâri techniques (Ödekan, 2011). As mentioned, artistic applications were realised with dynamic compositions reflecting the Turkish power in the Seljuk culture in large superficial units of the space such as the minbar (Figure 2).

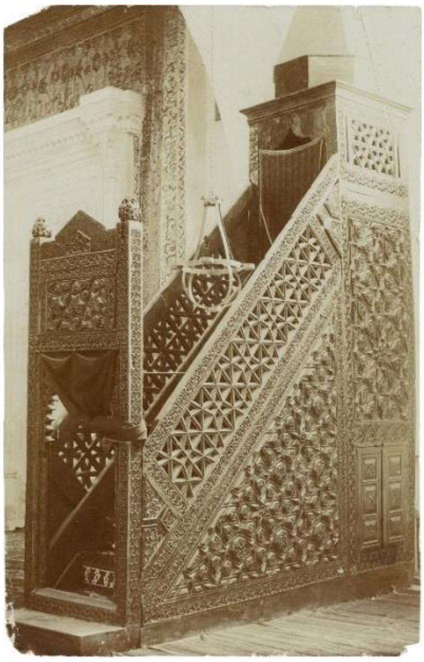

Figure 3. Minbar of Alâeddin Mosque in Konya (Salt Research, Photograph: Garabed K. Solakian, n.d.)

In the carving technique, the wooden surface is made by removing the pattern perimeter with the help of cutting tools and giving depth. As one of the important techniques applied in Seljuk periods, it has sub-application alternatives such as deep carving with flat surface, deep carving with round surface, deep carving with double-decker deep carving, curve-cut carving and grooved carving (Akınay, 2019). Ankara Alaettin Mosque pulpit (1197-98), Kayseri Ulu Mosque pulpit inscription (13th century), Akşehir Kileci Mescidi window sashes (late 13th century), Ankara Ahi Şerafettin Sanduka (1350) were made with carving techniques. In addition, Ankara Kızılbey Mosque door and Siirt Ulu Mosque pulpit are other examples (Ödekan, 2011). In these applications, both diagonal and curved patterns belonging to the Seljuks were reflected in the alternative units of the space as the cultural expression of the period. In these applications, both diagonal and curved patterns belonging to the Seljuks were reflected in the alternative units of the space as the cultural expression of the period.

In the engraving technique, depths are created by drawing patterns on wood. It can often be blended with other techniques and can be seen in a wide range of applications. In the openwork / cage technique, it is a technique in which the patterns applied on the wood material are carved around the perimeter and the patterns are shown from both sides, just like a cage, creating gaps between them (Katıldı, 2019). As a technique that requires professionalism in its application, it is usually applied on various surface elements and objects. Examples where geometric triangles and stars are applied in the lattice technique are the minbar of Beyşehir Eşrefoğlu Mosque, Çorum Ulu Mosque, and Ankara Alaettin Mosque (Ödekan, 2011). The Beyşehir Eşrefoğlu Mosque, which was completed in 1299 during the Anatolian Seljuk period, is an example of the largest religious spatial arrangement planned with the application of wood art with its richness of workmanship and intensive use of woodwork (Aslanapa, 2001). The compositions of both geometric and curved forms in this mosque are details of wood art belonging to the Seljuk period. Dynamic angular and intensely curved compositions were designed in line with the Seljuks' settled life and their belief in permanence (Figure 4, 5, 6, 7). These cultural values embroidered on religious spatial and various objects are the expression of wood art in the field of interior design.

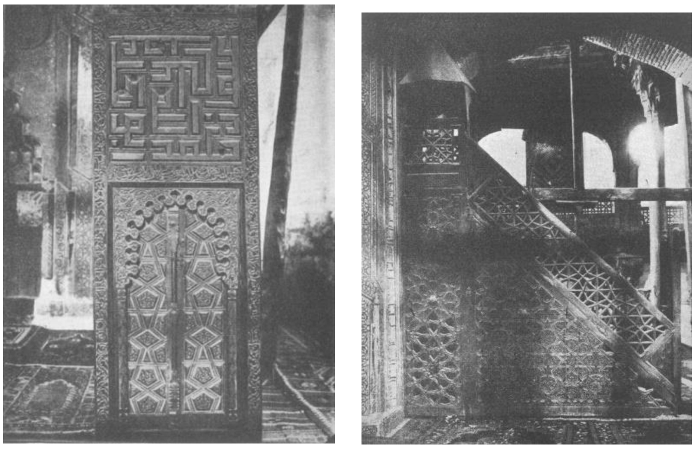

Figure 4. Minbar of Eşrefoğlu Mosque (Akyurt, 1940)

Figure 5. Beyşehir Eşrefoğlu Mosque (Tunçay & Yavuz, 2023)

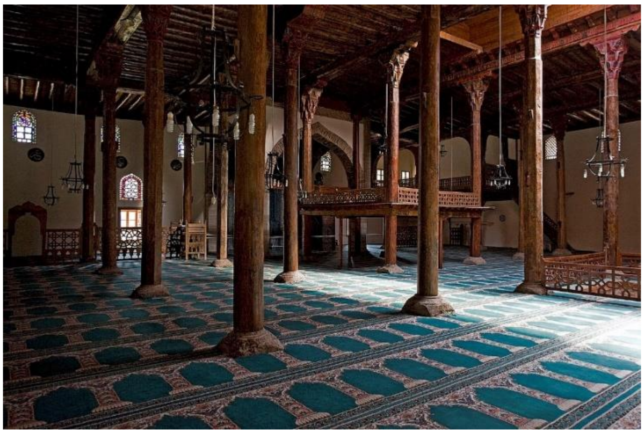

Figure 6. Beysehir Eshrefoglu Camii (Dosseman, 2019)

Apart from units such as doors, window sashes, pulpit, lectern, columns, wood was also used on ceiling surfaces. Beams, ceiling laths and boards above the beams are decorated. In addition, the details are emphasized by painting the wood carvings. In this way, a deep graded space can be created with the warmth of the wood and the depictions created by detailing with motifs in the art of carving. An example of this space is the ceiling of the Beyşehir Köşk Village Mosque (Önge, 1975). In addition to geometric forms, there are also rumi with curved branches, leafy forms, palmettes, curved and vertical kufic. The Mevlâna cist is an example of geometric, curved and written composition in these wood carving forms (Barışta, 1993). At this stage, in addition to triangles, it is seen that natural, structural and documentary patterns are composed in a complex form and dynamic, holistic density (Figure 7, 8). The aforementioned artistic practices are observed in religious spaces in line with the Seljuks' faith-based policy. In this parallelism, various elements such as minbars, which occupy space massively like the surfaces of the space, are also interior designs.

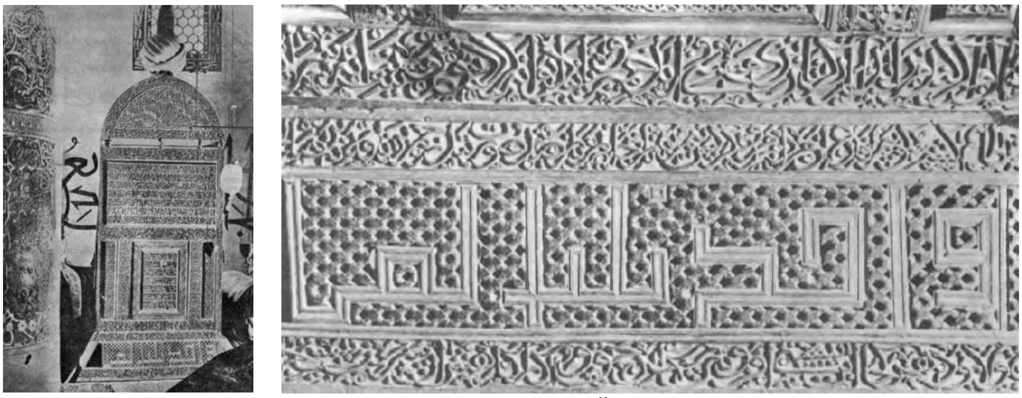

Figure 7. Mevlâna Sanduqa (Önder, 1983)

The space interface, one of the application areas of art and design, has an intergenerational communication language. It is emphasized that interiors offer rich experiences to individuals as the design of history and the history of design as the aesthetic values of the society from the past, cultural perspective has a psychological structure (Zhang, 2016). At this stage, both technological methods and traditional handcraftsmanship can be used in wood art applications reflected in space designs today. Methods may vary according to the target and design fiction in the area of use. Our cultural heritage, the foundation of which was laid in the Seljuks, is preserved and serves as an inspiration in today's applications.

Basically, the cultural symbols used in the art of wood, which became prominent with the acceptance of Islam in the Seljuk periods, can be summarized as geometric triangles, stars, squares, diamonds and curved vegetal shapes used in symmetrical compositions. In the light of this information, more geometric compositions appear on large wooden surfaces. In the units inside the large surfaces, an expression was made in curved forms. The Islamic belief of the Seljuks, the nomadic and warrior spirit coming from the past to the life practices in the settled culture, geometric angular forms, curved patterns, and compositions with more intense and strong frequent proportions have been constructed. In these compositions, an identity is expressed through abstract, natural, structural and documentary patterns. With these dynamic angles and frequent proportions, the aforementioned values of Seljuk culture are expressed in space through Turkish wood art.

4. Conclusion and Discussion

Turkish wood carving art has been applied in spatial units and various objects from past to present. In these applications, Turkish culture has been represented with its core values. Wood art was practiced on the basis of Islamic belief with its significant development during the Seljuk periods. With the establishment of the Seljuks, the art of wood carving symbolizes the heroic settled structure that depicts Islamic belief in Turkish culture. It is seen that these cultural values are reflected in the interior design arrangements, which are important representations of the settled order, with dynamic compositions. The brave spirit of nomadic culture, combined with the settled order brought by Islam, is the essence of Turkish cultural identity. It is seen in the findings of the studies that Islamic belief symbolizes documentary responses on an abstract and religious basis. The meanings of nature and living creatures are symbolized due to the relationship between nomadism and social structure. In addition, according to the structural applications, it is reflected in the responses mentioned in terms of mass. In addition to the star forms in geometric order, animal and plant motifs within the Islamic faith come to the forefront as the carrier of our cultural heritage.

In the Turkish culture of the Seljuk period, the heroism derived from nomadism and the power represented in the settled order are expressed in clearly visible forms. Furthermore, curved forms are associated with interlocking arrangements that reflect this power. The combination of different images on the basis of the established order and the unifying principles in Islam emphasizes cultural richness. Geometric shapes are frequently used, especially in architectural structures and spatial elements with large surfaces. Curved patterns derived from wavy lines are effectively applied on surfaces such as priesthoods, pulpits, pulpits, pulpits, balustrade plates and additional border areas.

In this context, it can be said that the aforementioned symbols are an important point of emphasis in the research on the role of wood art in space design. Wood carving on the border of art will exist itself with the technological advantages in material accessibility and craftsmanship. In this whole process, wood carving, one of our national arts, was developed in the Seljuks with cultural core values. This development exists permanently in our lives with periodic innovations. Our national light will be able to shine with the heritage of our cultural symbols in our art, and to remain alive for ages in this essence can be rationalized with interior design, which is one of the design areas.

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The article complies with national and international research and publication ethics. Ethics committee approval was not required for the study.

Author Contribution and Conflict of Interest Declaration Information

There is no conflict of interest.

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Creating a Model-Based Learning Environment in BIM Education through Case Studies

Semih Göksel YILDIRIM [1]*

ORCID 1: 0000 0002 7832 6575
[1] *Istanbul Gelisim University, Faculty of Engineering and Architecture, Department of Architecture, 34310, İstanbul, Türkiye.*
**** e-mail**: sgyildirim@gelisim.edu.tr*

Abstract

As demand in the construction industry continues to rise globally, universities have shown an increased interest in Building Information Modeling (BIM) education, leading to accelerated curriculum development studies. Previous research has identified several challenges associated with creating new BIM course curricula. Notably, the instructor's competence in delivering the practical components of the course and developing assignment content are significant issues. The development of case studies aims to enhance the BIM proficiency of course instructors and to generate course materials suitable for practical application. This paper outlines the design of course content for BIM curriculum development through the use of case studies. Case studies from various building programs are evaluated and compared based on their BIM maturity levels. The resulting course materials are implemented in a graduate course offered each year and assessed through student surveys. The intricate nature of BIM is explained within a model-based learning environment. By analyzing the learning environment using data gathered from student surveys, this study aims to provide insights for future improvements.

Keywords: *BIM curriculum development, BIM maturity level, model-based design, virtual construction.*

BIM Eğitiminde Model Tabanlı Öğrenme Ortamının Örnek Çalışmalar Üzerinden Oluşturulması

Öz

Dünya genelinde inşaat sektöründe artan talep üzerine üniversitelerin BIM eğitimine olan ilgisi artmış ve müfredat geliştirme çalışmaları hız kazanmıştır. Önceki çalışmalar incelendiğinde, yeni bir BIM dersi müfredatı oluşturulurken bazı zorluklar olduğu görülmüştür. Özellikle dersin uygulama kısmının yürütülmesine dair eğitmenin yetkinliği ve ödev içeriklerinin oluşturulması ana problemi oluşturmaktadır. Örnek çalışmaların geliştirilmesi ile dersin eğitmeninin BIM yetkinliğinin sağlanması ve dersin uygulama kısmında kullanılabilecek ders materyallerinin elde edilmesi amaçlanmıştır. Bu çalışmada, bir BIM müfredatının geliştirilmesi için ders içeriğinin nasıl tasarlandığı örnek çalışmalar üzerinden açıklanmaktadır. Farklı bina programlarından oluşan örnek çalışmalar BIM olgunluk seviyesi açısından değerlendirilmekte ve karşılaştırılmaktadır. Üretilen ders materyalleri, bir dönemlik bir yüksek lisans dersinde her yıl tekrar ederek uygulamaya geçirilmiş ve öğrenci anketi ile test edilmektedir. BIM' in karmaşık yapısı, üretilen model tabanlı öğrenme ortamı üzerinden anlatılmaya çalışılmıştır. Öğrenci anketi ile elde edilen bulgular üzerinden öğrenme ortamına ilişkin değerlendirme yapılarak, geleceğe yönelik projeksiyon ortaya konmaya çalışılmaktadır.

Anahtar kelimeler: *BIM müfredatı geliştirilmesi, BIM olgunluk seviyesi, model tabanlı tasarım, sanal inşaat.*

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1. Introduction

Construction productivity metrics indicate that productivity in manufacturing has nearly doubled, while in the construction sector, it has remained stagnant or declined over time (Smith & Tardiff, 2009). This stagnation has prompted the construction industry to seek more efficient business models in an increasingly competitive market. Building Information Modeling (BIM) is considered a catalyst for change, poised to reduce industry fragmentation, enhance efficiency and effectiveness, and lower the high costs associated with inadequate interoperability (Nagarajan, 2011).

BIM aims to address efficiency challenges in the construction sector. Rather than physically constructing a building, BIM focuses on creating a virtual model to identify and resolve potential design issues. BIM is an intelligent, model-based process that utilizes various computer software tools, enabling more efficient planning, design, construction, and management processes. One of the primary advantages of BIM is the early and rapid detection of design errors or conflicts. Additionally, to enhance productivity, BIM tools strongly encourage improved communication among team members and foster collaborative teamwork.

BIM is not merely a software application; it is a comprehensive business model characterized by specific workflows and supported by information technology. BIM is defined as a digital simulation that consists of three-dimensional (3D) models across various disciplines, containing detailed information about the building components. The adoption of BIM continues to grow at an accelerated pace. In the early 2000s, the term BIM was first introduced to the construction industry by a leading software company, prompting other firms to pursue involvement in this field. The BIM maturity model outlines this progression across three levels: Level 1 addresses early adoption with two-dimensional (2D) CAD drawings alongside 3D implications; Level 2 incorporates 3D drawings along with four-dimensional (4D) and five-dimensional (5D) capabilities; and Level 3 defines a six-dimensional (6D) vision for building life-cycle management (Barlish & Sullivan, 2012; Sacks et. al., 2018).

The significant increase in the use of BIM in the construction industry on an international scale over the past decade has led to a rise in academic activities focused on this subject. Public institutions are also transitioning to e-procurement processes, and the integration of BIM into these processes is currently under discussion (Pınar, 2022). Students aspire to compete in the global construction industry and secure employment upon graduation. Consequently, the development of new courses and the assessment of learning outcomes related to BIM education have been incorporated into university curricula at both the undergraduate and graduate levels. Departments are requesting BIM education from their professors to better prepare their students for competition in the construction sector after graduation. Given the increasing demand from the construction industry, BIM education is expected to enhance students' employment opportunities.

2. Literature Review

The literature review conducted at the beginning of this study examines how a BIM curriculum is developed, the strategies employed, and the challenges encountered. BIM encompasses more than just software packages or the apprehension associated with new technologies in the industry; it represents a cultural shift in the way projects are executed and managed (Barison et al., 2010; Kazaz & Ergen, 2017). The existing curricula at universities in the fields of architecture, engineering, and construction (AEC) need to be revised to incorporate BIM (Rodriguez et al., 2017).

A questionnaire-based study was conducted to assess BIM knowledge among graduate-level students at two universities, one in Brazil and the other in the USA. The study concluded that BIM needs to be better integrated into the curriculum (Arrotéia et al., 2018). Another study in the United States examined existing civil engineering curricula and conducted interviews with BIM experts in the construction industry. Based on industry expectations regarding the use of BIM and the current structure of academic programs, several strategies for curriculum development and improvement were suggested (Song et al., 2022). In addition to construction programs, both introductory and advanced BIM courses have been incorporated into the new curriculum of architecture departments (Hon & Drogemuller, 2016). Research has also been conducted on the application of BIM in design studios. For instance, parametric design, digital fabrication of buildings, and interactive technology applications are frequently explored in such studies (Baldessin et al., 2020; Uzun & Çakır, 2020; Wu & Jeng, 2012). A study conducted in Turkey proposed a three-stage model for integrating BIM education into the design studio: first, a training and learning process; second, a design process; and finally, a questionnaire survey and evaluation process (Uzun & Çakır, 2022).

2.1. Types and Levels of BIM Courses

BIM topics taught in higher education can be categorized into three primary areas: conceptual BIM knowledge, BIM software, and BIM applications (Guo et al., 2022). In undergraduate education, BIM is primarily taught at the senior level (Barison & Santos, 2011). Typically, BIM courses are defined as introductory-level courses within undergraduate programs (Lassen et al., 2018). Several studies have been conducted to explore how to integrate BIM into educational curricula and to design BIM course content for both undergraduate and postgraduate students, addressing the growing demand for BIM professionals in the industry (Kazaz & Ergen, 2017). Many programs in the AEC field are attempting to incorporate BIM content into their curricula, often replacing traditional CAD courses with introductory BIM courses (Eldin & Nawari, 2010; Huang, 2018). In architecture and civil engineering programs, BIM proficiency is categorized into introductory, intermediate, and advanced levels (Barison & Santos, 2011; Barison & Santos, 2013). When developing a new BIM course curriculum, it is essential to select one of the specified BIM competence levels and ensure that it aligns with the objectives of the chosen level (Barison & Santos, 2013). A study conducted across eleven leading universities in the United States revealed that there are three introductory courses designed to teach the concept of BIM to undergraduate students, while only one introductory course is offered to graduate students. This indicates that the primary focus of BIM education is at the graduate level. Consequently, it has been concluded that introductory courses should be incorporated into the undergraduate curriculum, while intermediate or advanced courses should be introduced and taught at the postgraduate level (Kazaz & Ergen, 2017). The goal is to improve the skills of a beginner-level BIM user at introductory level. The objective is to learn about various BIM tools and advanced techniques in 3D modeling, as well as to explore the features of families within a BIM tool at an intermediate level. The aim of the instruction is to refine certain skills of a BIM Manager at an advanced level (Barison & Santos, 2011).

Some universities have established stand-alone courses dedicated exclusively to BIM, while others have opted to provide seminars featuring industry experts. The integration of BIM at the program level, such as its inclusion in a capstone project or the creation of an individual course within the program, is also discussed and compared (Arnett & Quadrato, 2012). Many programs have implemented strategies for teaching BIM, categorizing them into four main types: stand-alone courses, cross-disciplinary courses, capstone or graduation project courses, and integration into existing courses (Abbas et al., 2016; Clevenger et al., 2010; Ghanem, 2022; Huang, 2018; Jurado et al., 2017). It is recommended to offer complementary courses in addition to independent stand-alone BIM courses to enhance students' long-term learning (Clevenger et al., 2010; Ghosh et al., 2013).

The evolution of BIM education can be conceptualized into three developing stages: (a) BIM-aware, which involves educating students about BIM and its advantages; (b) BIM-focused, which teaches students how to perform specific tasks related to the use of BIM; and (c) BIM-enabled, which emphasizes the realization of learning in a virtual BIM environment and the use of BIM as a tool for learning (Olowa et.al., 2023; Underwood et.al., 2013; Witt & Kähkönen, 2019). Research indicates that BIM-aware and BIM-focused education is generally accepted, and the effort to integrate BIM into program curricula is becoming increasingly widespread (Olowa et al., 2019). Additionally, a study conducted in Korea describes how the entire curriculum of the construction engineering department was transformed into a BIM-based education model (Lee et al., 2019).

One of the key advantages of incorporating BIM into the curriculum is its ability to facilitate collaborative learning (Witt & Kähkönen, 2019). Through BIM software, students can work together on a single project, sharing real-time updates and feedback (Ambrose, 2012). Many authors have noted that groups of more than two students from different disciplines collaborate, and this teamwork enhances the collaborative learning experience (Puolitaival & Kestle, 2018). Collaborative education involving participants from various majors is strongly recommended and even considered essential in BIM education (Ofluoglu, 2017; Macdonald, 2012).

On the other hand, online video tutorials are highly popular among students because they allow for flexible study schedules and personalized learning progress. Video-based learning (VBL) is more memorable than traditional lecture-based environments. Studies conducted on publications between 2003 and 2013 found that VBL is both effective and efficient for education (Tsai et al., 2019).

2.2. Course and Assignment Content

Starting with BIM technical content, a BIM curriculum should guide students through the acquisition of knowledge, software skills, and the application of this conceptual learning process. It must lead students to seek answers to the questions of what, why, and how. This approach encompasses the use of BIM, an understanding of case studies, and conflict resolution (Kymmell, 2008). Three skill categories defined in the learning outcomes should be targeted in each BIM application: technical skills (software tools), conceptual skills (management processes), and soft skills (teamwork). The level of detail and complexity of the subjects covered in the assignments may increase depending on the level of the BIM course (Kymmell, 2008). A comprehensive understanding of BIM and the development of problem-solving skills can be achieved by offering nD education, particularly in programming (4D), management (5D) and energy analysis (6D), in addition to 3D education (Lee et al., 2019). While the creation of a common digital model by students from various disciplines represents the primary working method of BIM, it also facilitates discipline-specific work (Károlyf et al., 2021). In a BIM working environment, group members assume different roles, such as facility manager, project manager, designer, and consultant (Lassen et al., 2018). In BIM courses conducted within architecture, civil engineering, and construction management departments, students from different disciplines often collaborate on semester projects based on 3D and 4D models within a single digital file (Charlesraj et al., 2015; Károlyf et al., 2021; Taylor et al., 2007; Tsai et al., 2019). A study conducted among postgraduate students in Nigeria examined the level of awareness and proficiency in BIM, revealing that students were more proficient in BIM 3D and more aware than proficient in BIM 4D (Maina, 2018).

2.3. Challenges of Incorporating BIM into the Curriculum

This section discusses the challenges encountered when integrating BIM into the existing curriculum and the issues surrounding BIM education. Research indicates that numerous obstacles exist in adapting BIM to the educational field (Ao et.al., 2022; Rodriguez et.al. 2017). Barriers to the integration of BIM into the curriculum include the concepts and tools of BIM, as well as the structure of the academic environment (Eldin & Nawari, 2010). One of the primary hurdles is the necessity for both faculty and students to adapt to the new software and workflows associated with BIM (Berwald, 2008).

Another significant challenge in BIM education is that most educational institutions are slow to adopt change (Eldin & Nawari, 2010). Additionally, the most common barriers to integrating BIM into the curriculum can be categorized as follows: the need for a shift in mindset regarding the process, lecturers' knowledge of the subject, lack of support for faculty, complexity of the software, availability of equipment, and time constraints (Ao et al., 2022; Huang, 2018; Olowa, 2023; Pillay et al., 2019; Witt & Kähkönen, 2019). The delivery of BIM courses necessitates additional teaching staff and the upskilling of existing academic personnel (Hon & Drogemuller, 2016). To effectively integrate BIM into academia and promote its adoption among faculty members, training opportunities should be provided by university senior management on course topics and materials (Abdirad & Dossick, 2016). Often, current faculty members lack the necessary skills to teach BIM and may not possess basic modeling competencies. To address this issue, universities often invite industry representatives or external stakeholders who are BIM experts to provide support (Lee at.al., 2019). Furthermore, inviting various BIM experts from the construction industry as guest speakers and organizing activities such as conferences, seminars, and workshops significantly enhance BIM education. The lack of continuity in the supply of BIM experts to the academic community has also created serious challenges in BIM education. In other words, even when an educational institution expresses a desire to incorporate BIM education into its curriculum, a critical issue remains: identifying qualified instructors to teach these courses (Christopher & Daniel, 2023).

3. Materials and Methods

As the methodology, a literature review on BIM education is first conducted, followed by the formulation of a problem statement to develop a BIM course curriculum based on this review. Subsequently, the aim, methodology, and scope of the research are presented. The objective is to create an original course curriculum that aligns with widely accepted standards. The success of the newly introduced curriculum is assessed through a student survey. Based on the survey results, projections for future studies are outlined. In summary, the methods employed in this study include curriculum design, the production of course materials, the definition of the necessary course environment, the scope of student assignments, and the evaluation of learning outcomes through a questionnaire.

3.1. Problem Statement

Some publications on course content and learning outcomes were identified, and most of the case studies were student projects presented at the end of the course (Baldessin et.al., 2020; Uzun & Çakır, 2020; Wu & Jeng, 2012). In developing the course syllabus, a sufficient number of textbooks were accessed and cited as references. Additionally, lecture notes were prepared with the assistance of these references and textbooks. However, the format and scope of the assignments for the laboratory component of the course were not clearly defined. Furthermore, the lecturer's competency in BIM posed another challenge in preparing the BIM course curriculum. It was also frequently observed that in the newly introduced BIM courses, an external consultant with industry experience was engaged to assist the lecturer in delivering the theoretical content and conducting the practical applications/laboratory work. In situations where support from professionals is not always feasible, it is crucial for the primary lecturer to possess the knowledge and experience necessary to conduct laboratory work effectively. It is strongly recommended that the lecturer assigned to the course complete BIM training prior to instruction. The literature consistently emphasizes that the development of materials suitable for the practical component of the course is a significant concern. From this perspective, the production of case studies, along with the lecturer acquiring the necessary BIM competencies, represents a primary challenge in BIM education. The hypothesis of this study is that the creation of detailed assignments and case studies will positively enhance the practical aspect of BIM education in the laboratory setting.

3.2 The Aim of the Study

The aim of this study is to describe the assignments to be completed in the laboratory component of a newly developed BIM course and to present case studies that contribute to the creation of a model-based learning environment. The term "model-based" in this context refers to the 3D, 4D, and 5D levels of BIM maturity.

3.3. The Scope of the Study

The syllabus for a graduate-level course was developed after examining various examples. Lecture notes were created by reviewing a range of textbooks, articles, and online resources. In addition to the theoretical components, there is a recognized need for materials suitable for a course structure that emphasizes practical application. Specifically, the content of assignments has been studied in detail, with research focusing on these defined assignment elements. The assignment content, categorized according to BIM maturity levels, is related to its applicability across different types of courses. In selecting case studies, a method is employed that progressively broadens the scope and complexity of design as practiced in architectural design courses within architecture departments. For instance, Architectural Design 1 begins with a project of minimal scale, while Architectural Design 8, also referred to as the Diploma Project, involves a larger-scale project. Likewise, the case studies commence with a small-scale clubhouse, gradually increasing in size and design complexity to include a habitat home, a commercial building, and ultimately culminating in a multi-storey office building.

4. Developed Graduate-Level Curriculum Content

According to the literature review, a graduate-level course is being developed, specifically designed as a BIM-focused curriculum. This newly created BIM course can be classified as a stand-alone course at the intermediate level, as it spans only one semester and includes specific assignments. The lecture notes presented herein cover BIM tools and modeling, integrated project delivery, and the construction process. These notes aim to introduce the fundamental principles of BIM solutions as a business model, promoting project-based learning through cross-disciplinary collaboration. Graduates in construction-related fields will be introduced to parametric modeling tools and cloud applications. The primary objectives include utilizing models for constructability reviews, enhancing time efficiency, and creating BIM content. The lecture notes also contribute to the development of engineering communication skills for students with backgrounds in the AEC domain. Before enrolling in this course, students should have a foundational understanding of topics such as building science and technology, practical experience, materials and methods of building construction, and design fundamentals, including orthographic drawing. If this course were offered at the undergraduate level, the content would be significantly limited, focusing solely on 3D parametric modeling.

Students in the AEC field should acquire fundamental skills in graphical drawing for building construction projects, editing 3D simulation models, creating virtually generated models, and processing all relevant data. This course promotes project-based learning through interdisciplinary collaboration. Students will learn 4D scheduling and simulation techniques essential for construction management, as well as specific BIM applications such as quantification, clash detection, and code compliance. The course covers the basic principles of BIM using Autodesk's BIM solutions. Students will be introduced to parametric modeling tools and cloud applications, enabling them to develop a foundational understanding of BIM. They will also gain familiarity with essential BIM tools. Throughout the course, students will explore the application of BIM across various disciplines and comprehend the advantages provided by the BIM process. The following is an outline of the course topics and associated readings from class textbooks or handouts: computer-aided design, building information modeling, BIM tools, integrated project delivery, parametric modeling, structural and MEP (Mechanical, Electrical, and Plumbing) modeling, clash detection, constructability and interference analysis, 4D scheduling, simulation and visualization, quantification, and estimating.

In designing the course curriculum, textbooks were initially utilized, followed by the determination of the targeted course content and activities. The course is divided into various BIM maturity levels, with course materials corresponding to these modules. Lecture notes, assignment content, presentations, and case studies are examined collectively. Given that not all modules can be addressed as homework activities within a one-semester course, two alternative approaches are proposed for the content of homework assignments, tailored to one-semester and two-semester courses (see Figure 1). The course curriculum is structured according to a BIM-focused methodology.

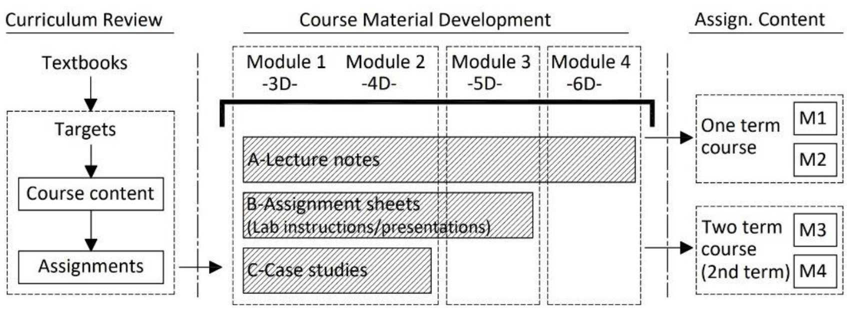


Figure 1. The workflow of course curriculum design (Yıldırım, 2018)

4.1. Targeted Assignments

BIM assignments may involve designing a new building, conducting a constructability review, and creating a virtual building model. Alternatively, students may develop a BIM model based on a project designed in another course or a building that exists on campus. In addition to individual learning in the production of the BIM model, it is beneficial to incorporate group activities into certain aspects of the work.

A cross-disciplinary work environment, the use of advanced collaboration technology, time management, and team coordination are the major challenges facing the teams. Architects, structural engineers, MEP engineers, and construction managers play a principal role in assignments mostly arising in a student BIM execution team. Working in teams of students from different disciplines to simulate the design and construction processes of a real-world project will give them an insight into the work environment they will encounter in their professional lives. In this way, they will have the opportunity to test BIM applications and develop their creative and innovative practitioners. Team communication and coordination of work are made possible by advanced collaboration technology. Through lectures and assignments, students can develop basic skills related to the activities covered in the course. In fact, it is often the case that this advanced level of exposure to technology is ahead of its industry application so that students will be more competitive and advantageous in the industry when they complete their studies. Each group should create its own collaborative platform, provide workflow on this digital platform, and work on BIM/CAD standards. How architectural and engineering problems are addressed and solved will be evaluated using the BIM model developed by the students. The assignment performance expected from students in an advanced level BIM course can be defined as follows; developing an integrated building model, constructibility reviewing, identifying conflicts of design in different disciplines, 4D work schedule and simulation, taking bill of quantities, cost calculation, and testing how to make more efficient work tracking in the construction process with cloud applications. Targeted assignments for an ideal advanced-level BIM course are presented in Table 1. Assignments are group projects comprising the entire range of topics covered in the course.

Table 1. Targeted assignments' content for BIM courses at graduate level (advanced level)

Descript.	Activity	Submission	Descript.	Activity	Submission
1- Integrat. Building Design	Families View properties Edit & modify Parametric drawing	**A**-Views in project browser **B**-3D parametric drawing	**5- 4D Simula_ tion**	Animation tool Animation script Simulation settings Single vs multiple parts	**A**-Viewpoint animation **B**-Timeliner simulation
2- Design Review	Shared parameters 4D navigation Review & mark up Adding tags	**A**-4D task ID list in "search sets" **B**-Review report	**6- Quantif_ ication**	Model takeoff Item & resource catalog Change analysis Quantity takeoff report	**A**-Item & resorce catalog **B**-Quantity takeoff report
3- Clash Detec_ tion	Clash test options Status of clashes Reviewing clash view Clash result table	**A**-Hard, clearance clashes' views **B**-Clash result report	**7- Cost Estima_ tion**	Schedule report Assemble report Online cost data Cost analysis	**A**-Schedule report **B**-Cost analysis report
4- 4D Schedul_ ing	Creating tasks Linking with "sets" Gantt chart review Exporting CSV file	**A**-Timeliner tasks and linking "sets" **B**-Exporting gantt chart as CSV file	**8_ Cloud Applica_ tion**	Navigation in cloud app Constructability review Navigation in documents Field activity report	**A**-Constructability review report **B**-Field activity report

In order to successfully complete assignments in a virtual environment, students must possess a certain level of construction knowledge. Lab assignments will begin with the formation of teams and the development of a BIM execution plan. To initiate a "BIM kick-off" at the start of the course, all team members are required to review the draft of the BIM implementation plan. The objectives of the project execution and its various phases will be discussed by the students, and collaboration on best practices is encouraged during this meeting. Centered on problem-based tasks, BIM model assignments are developed in 3D, 4D, and 5D using CAD/BIM software such as Autodesk Revit®, Autodesk Navisworks®, and cloud applications like Autodesk BIM 360 Glue®, Field®, and Docs®, as well as Microsoft Project. The instructor provides a hands-on environment for students and introduces core techniques for practicing these skills through exercises and group work. The assignments offer a task-oriented opportunity for students to enhance their abilities. Each team will select a pre-designed project, and all assignments will be applied to this case study throughout the semester. Projects must reach at least the conceptual/schematic design (SD) level to emphasize BIM execution as construction documentation (CD) rather than architectural design development. The final project requires the creation of a comprehensive BIM model of a building or house in Autodesk Revit®, which includes a complete 3D model, construction documentation, 4D scheduling and simulation, material and quantity takeoff, and cost estimation (5D). The final presentation will be based on the assignments, and team presentations will be required at the end of the semester. Student teams will present their work to the instructor and peers, facilitating an exchange of ideas.

4.2. Case Studies: Housing, Commercial, and Office Buildings

While preparing the content for the BIM course, it was determined that supporting the application phase with case studies, in addition to the theoretical components, would be beneficial. In this regard, sample studies have been developed for use in laboratory applications, which can be shared with students. The developed case studies were aligned with the targeted tasks presented in Table 1. These case studies illustrate how students should approach their assignments. It was decided that the case studies would encompass various building programs and architectural concepts. Additionally, the aim is to guide architects and engineers who are using BIM to digitally construct a building for the first time. Consequently, the course begins with a single-storey clubhouse, followed by a single-family house. After mastering 3D parametric modeling with BIM, students designed and digitally constructed a two-story commercial building. Finally, a BIM project for a mid-rise (seven-storey) office building was developed. Table 2 presents a comparison of the architectural, structural, and MEP projects, along with the BIM features of the developed case studies.

Table 2. BIM maturity levels of case studies encompassing architectural, structural, MEP, and software features

	Features	Case Studies			
		1.Club House (CS1)	**2.Habitat Home (CS2)**	**3.Commercial Build. (CS3)**	**4.Mid-rise Office (CS4)**
Architectural	Build. program	Housing	Housing	Commercial	Office
	Number of floor	1	1	2	7
	Basement	NA	NA	Yes (partially)	√
	Staircase	NA	NA	√	√
	Roof	Hip roof	Hip & valley roof	Gable & flat roof	Flat roof
	Facade	Brick veneer	Brick & precast veneer	Curtain wall & brick	Curtain wall & brick
Structur.	Structural system	NA	Framing	Framing	Framing
	Framing member	NA	Timber (LTF)	Steel (HSS)	Steel (HSS)
	Foundation	R.C.	R.C.	R.C.	R.C.
	Basement wall	NA	NA	R.C.	R.C.
MEP	Mechanical	NA	NA	NA	√
	Electrical	NA	NA	NA	√
	Plumbing	NA	NA	NA	√
BIM	2D constr. project	NA	√	√	√
	3D param. draw	√	√	√	√
	4D scheduling	NA	√	√	√
	4D simulation	NA	√	√	√
	Revit ©	√	√	√	√
	Navisworks ©	NA	√	√	√

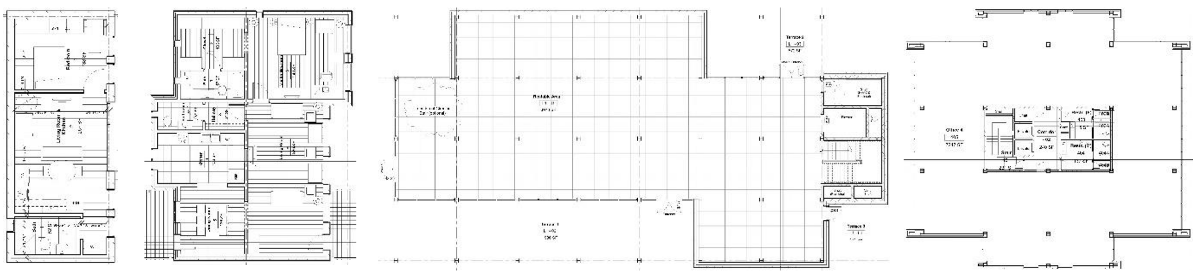
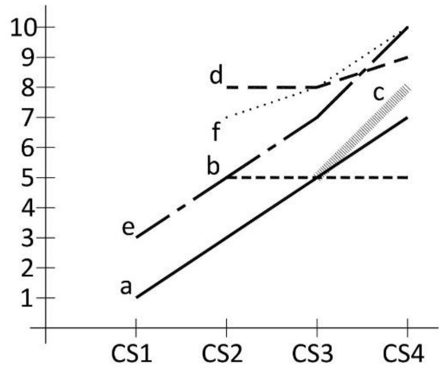


Figure 2. Architectural layouts of the case studies (from left to right: CS1, CS2, CS3, and CS4) (Yıldırım, 2018)



	Features	CS1	CS2	CS3	CS4
a)	Level of intricacy of architect. design	1	3	5	7
b)	Level of intricacy of structrural design	NA	5	5	5
c)	Level of intricacy of MEP design	NA	NA	5	8
d)	Maturity level of 4D features	NA	8	8	9
e)	Level of effort on Revit ©	3	5	7	10
f)	Level of effort on Navisworks ©	NA	7	8	10

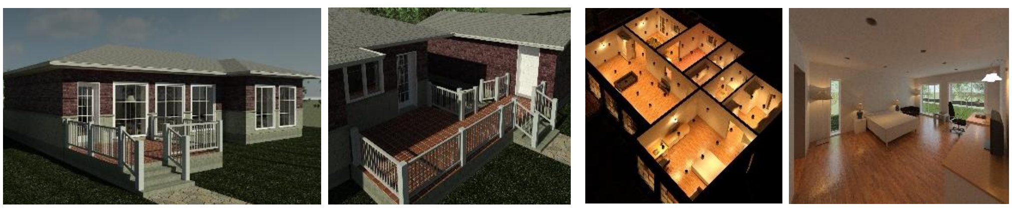
Figure 3. The difficulty level of case studies, as indicated by the author

Data on the architectural plans of the case studies are presented in Figure 2, which illustrates typical floor plans. In particular, a clear differentiation was attempted in the building program and floor usage. From case studies 1 to 4, there is an increasing utilization of square meters and the number of floors. For items a through f, a scale of 1 to 10 (with 1 indicating very easy ……. and 10 indicating very difficult) is employed as a measure of difficulty, as stated by the author in Figure 3.

4.2.1. 3D parametric modeling with architectural components

In traditional architectural project design, any modifications made by the designer necessitate the repetition of all project stages. In contrast, parametric design allows for automatic updates to the design whenever any parameter is altered. This study utilized Revit® software, a product of Autodesk, as a parametric drawing tool for the 3D modeling of buildings within a virtual environment (see Table 3).

Table 3. Parametric modeling of architectural components (Yıldırım, 2018)

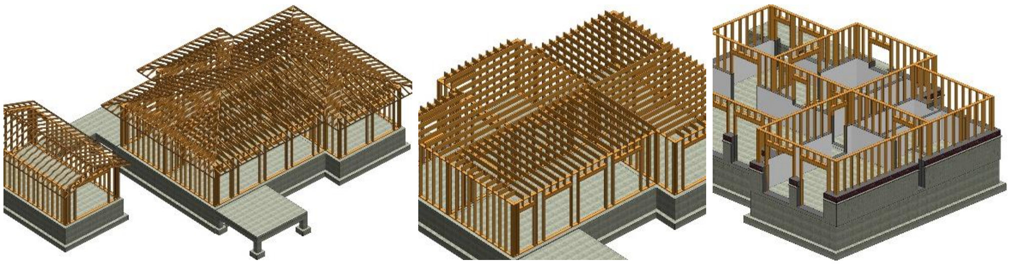
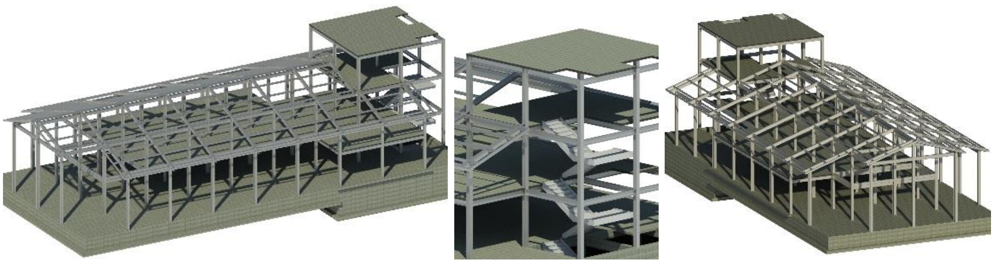
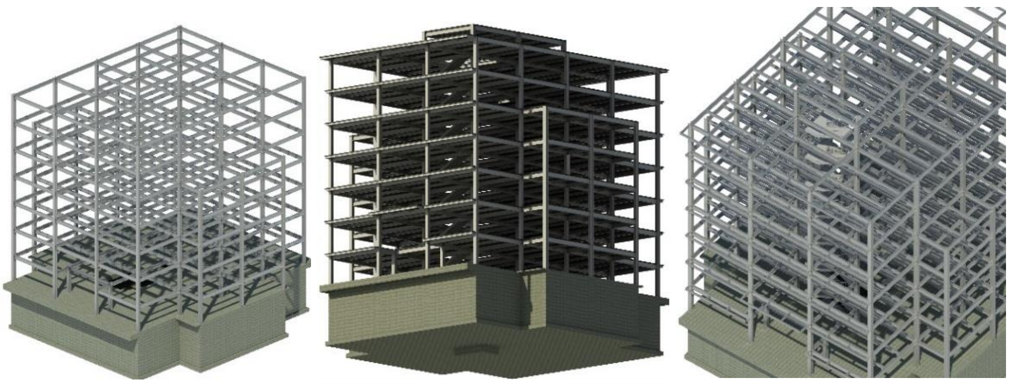
	Architectural Visuals of the Case Studies
(a) CS1 Club house;	
(b) CS2 Habitat home;	
(c) CS3 Commercial building;	
(d) CS4 Mid-rise office building	

The variables of architectural components, such as walls, floors, doors, and windows, were examined across different layers. Additionally, Navisworks® software, also developed by Autodesk, serves as a tool for 4D scheduling and simulation. To establish a foundation for the studies conducted in Autodesk Navisworks®, the architectural components in Autodesk Revit® were not utilized in a conventional manner. Some components were subdivided into parts in accordance with 4D scheduling, and corresponding 4D Task IDs were created. During the creation of these parts, both horizontal and vertical construction were considered in stages, with modifications made to align with the simulation. For instance, in CS3 and CS4, the exterior walls were not constructed as a single component extending from the ground floor to the upper floors; instead, they were created as separate walls for each floor. Similarly, in CS4, the curtain wall was not designed as a single component spanning from the bottom to the top floor, but rather was constructed separately for each floor. Additionally, in CS2, CS3, and CS4, the exterior walls were divided into layers and assigned distinct 4D Task IDs.

4.2.2. 3D parametric modeling with structural components.

Structural components in Autodesk Revit® are utilized only in CS2, CS3, and CS4, but not in CS1 (see Table 4). In all case studies, the foundation and substructure were constructed using reinforced concrete. For the superstructure, timber members were selected for CS2, while steel members were chosen for CS3 and CS4.

Table 4. Parametric modeling of structural components (Yıldırım, 2018)

	Structural Visuals of the Case Studies
(a) CS2 Habitat home;	
(b) CS3 Commercial building;	
(c) CS4 Mid-rise office building	

As is common in architectural studies, prescriptive methods were employed for component size selection, and no structural analysis was conducted. For the structural construction, which is designed to be a moment-resistant frame, further verification through structural analysis should be conducted. For the 4D simulation, a horizontal and vertical construction schedule was developed for the structural components, and groupings for 4D Task IDs were created based on this schedule. In the timber light framing structure designed in CS2, wall studs, floor joists, and roof rafters were divided into distinct parts. A similar approach was implemented for CS3 and CS4, utilizing hot-rolled steel sections (HSS). This method allows for detailed processing of the phases of work within the same item in the 4D construction schedule. Consequently, architectural and structural components are integrated into a single digital file. However, there are instances where these digital files must be uploaded separately when importing them into Autodesk Navisworks, particularly for the review and simulation of construction activities such as clash detection and object animation.

4.2.3. 3D parametric modeling with MEP systems

Parametric mechanical, electrical, and plumbing (MEP) components have been developed exclusively for CS4. System tools were utilized for the MEP system in Autodesk Revit® without conducting engineering calculations. The dimensions of component cross-sections were determined based on specific assumptions (see Figure 4).

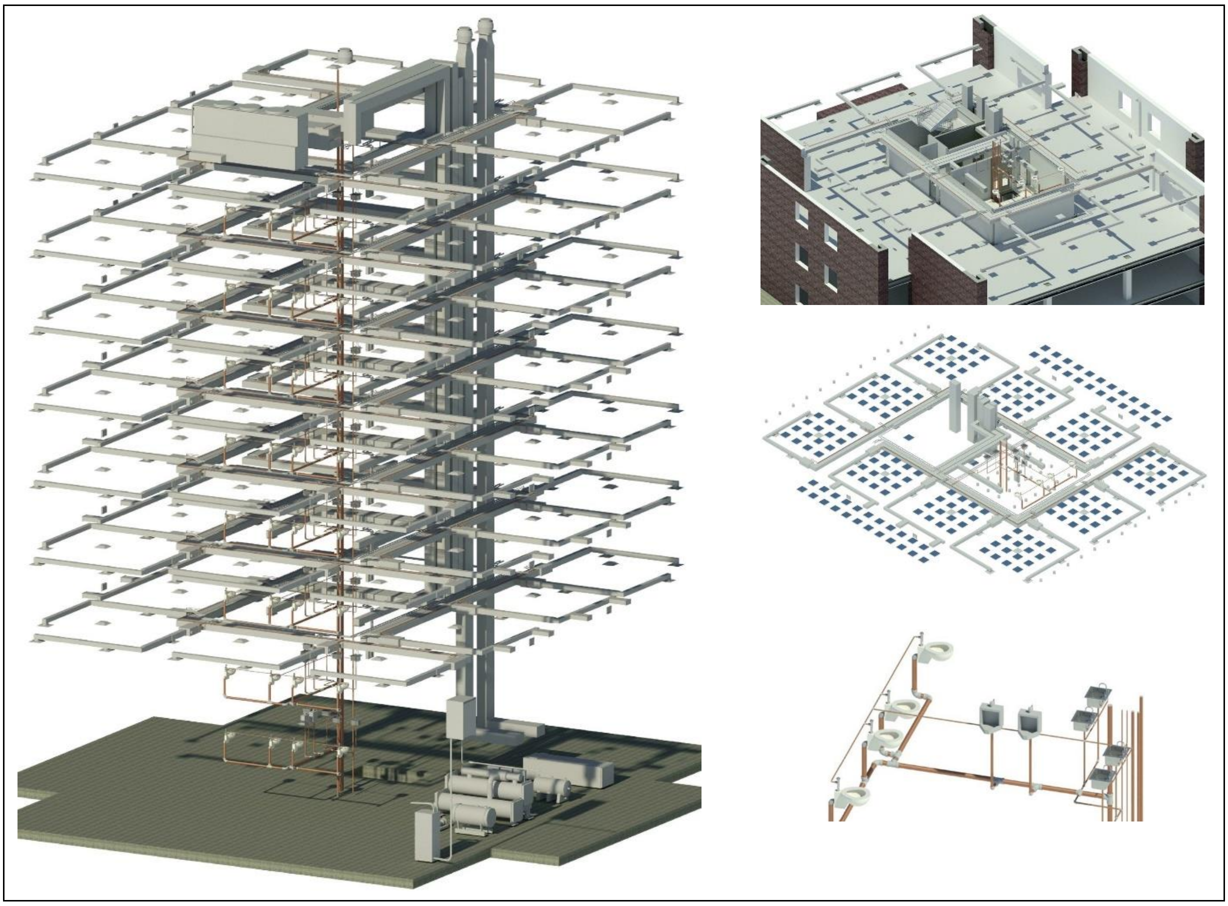


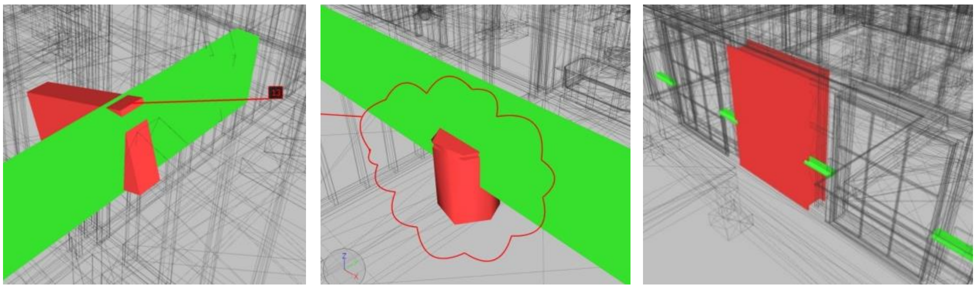
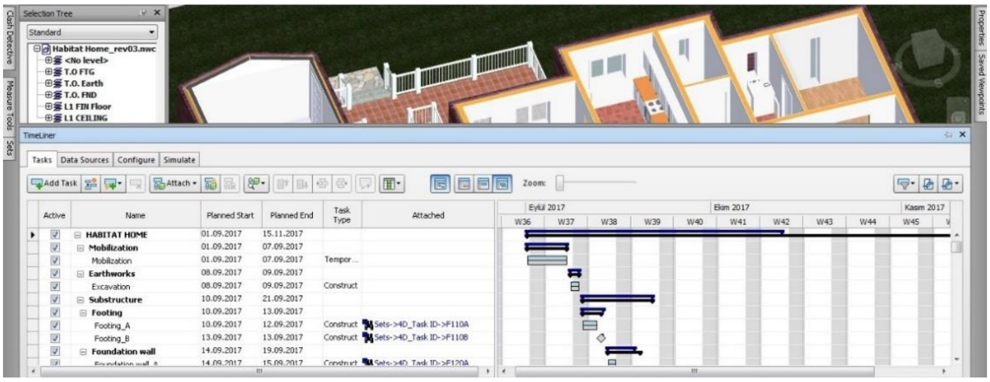
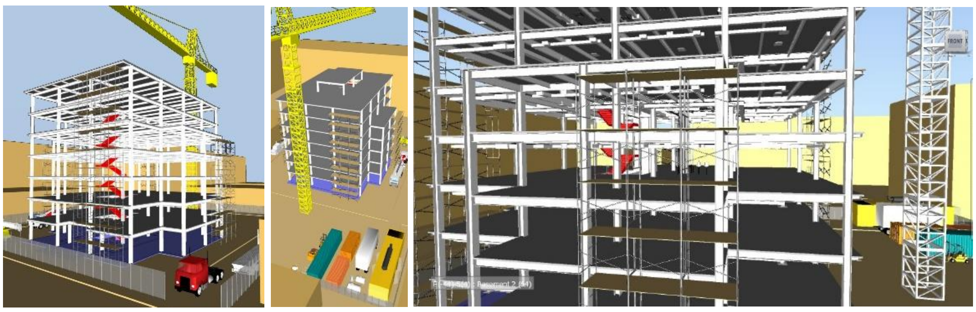
Figure 4. Parametric modeling of MEP components of the case study 4. At left; vertical and horizontal distribution of mechanical systems, at right top; ceiling and building core, at right middle; lighting fixtures integration and at right bottom; plumbing fixtures are depicted (Yıldırım, 2018)

For instance, since the height of the suspended ceiling is specified in the architectural design as 40 cm, it is anticipated that the supply and return diffuser sections/heights will be approximately 30 cm. It is also expected that an electrical cable tray can be positioned either above or below the ceiling. The electrical distribution scheme for lighting within the suspended ceiling was drafted in the plan. However, wall sockets and other electrical installations are not included in this study. The produced parametric model serves as an illustrative tool to demonstrate how various engineering disciplines can collaborate effectively. Special emphasis was placed on the suspended ceiling, as well as the plumbing solutions for restrooms, the basement, and the equipment to be installed on the roof. In addition to the general horizontal distribution of the MEP systems, the vertical distribution was also analyzed within the vertical shaft. Beyond this study, comprehensive engineering calculations and verification of all MEP systems are necessary. Furthermore, for the 4D simulation to be conducted in Autodesk Navisworks®, distinct 4D Task IDs were assigned on a floor-by-floor basis in Autodesk Revit®, thereby facilitating a simulation that aligns with the construction work schedule. Detailed procedures for performing clash detection in Autodesk Navisworks® are outlined at this stage. Subtopics such as hard clashes, clearance clashes, and time-based clashes are elucidated through the case studies presented herein.

4.2.4. 4D features of parametric modeling

The 4D features generated for CS 2, CS 3, and CS 4 are presented in Table 5. Following the production of 3D parametric models as part of the integrated building design in Assignment 1, a design review was conducted on the projects in Assignment 2. This design review aimed to create a constructability report by utilizing the "Clash Detective" tool in Autodesk Navisworks®. The tool was employed to identify hard, clearance, and time-based clashes separately for architectural, structural, and MEP components. Necessary revisions were made to the project by addressing the conflicts detected with the "Clash Detective tool. In traditional construction management, a bar diagram, commonly referred to as a Gantt chart or construction schedule, is created using software such as Microsoft Project or Excel. In the BIM described here, 4D scheduling is generated using the "Timeliner" tool integrated into Autodesk Navisworks®. The 4D Task IDs defined in Autodesk Revit® play a crucial role in this process and serve as the primary basis for 4D simulation. The communication between the "Timeliner" tool and the 3D model is facilitated by these 4D Task IDs, which are specified separately for each work item. 4D simulation can be conducted after inputting the work program into the tool. Additionally, components such as temporary equipment can be uploaded to the Navisworks® file, enhancing the 4D simulation with the "object animation" feature.

Table 5. Samples of 4D features (Yıldırım, 2018)

	4D Visuals of the Case Studies
(a) Clash detection for CS2 (hard, clearance and time-based clashes)	
(b) 4D scheduling for CS2 in Autodesk Navisworks® Timeliner tool	
(c) 4D simulation for CS4 in Autodesk Navisworks® Timeliner tool and object animation	

5. Implementation and Testing of the Developed Course Curriculum

Lecture notes and assignment content were developed using the case studies produced as part of the curriculum development process. This course material was utilized in a course titled "Building Information Modeling" (BIM) within the Master of Science in Architecture program. The course, which spanned one semester, was conducted for three hours each week. It was observed during the course that the eight targeted activities listed in Table 1 were excessive for completion within a single semester. Although all topics related to the eight assignments were covered in the theoretical portion, only the first four activities were included in the lab sessions. A survey was administered at the end of the semester to assess the effectiveness of the course materials and the learning outcomes.

5.1. Feedback from the Student Assessment

A total of eighteen questions were posed to the students, with the first five questions designed to gather information about their backgrounds. In the first year, ten students participated in the survey, while four students participated in the second year. Among the participants, 80% held a bachelor's degree in architecture in the first year, and this figure increased to 100% in the second year. The proportion of female participants was 90% in the first year and decreased to 75% in the second year. Regarding construction work experience, 40% of the participants had less than six months of experience, and 30% had between one and two years of experience in the first year. In contrast, 75% of the participants in the second year reported having less than six months of construction experience. At the beginning of the course, when the students' knowledge of Revit® was assessed, 90% indicated that they were unfamiliar with the program in the first year. However, by the second year, all participants reported having at least a basic understanding of Revit®. At the beginning of the course, an evaluation of the students' knowledge of Navisworks® revealed that all first-year students and 75% of second-year students reported being unfamiliar with the Navisworks® program. Table 6 presents the survey results for questions 6 through 18, which follow the initial five questions. The questions were categorized into three groups: the first group focused on course materials, the second group addressed homework activities, and the third group assessed student evaluations of learning outcomes. In Tables 6A, and 6Bstudents rated the importance of each item on a scale from 1 to 10, where 1 indicates unimportant and 10 indicates important in Table 6C aimed to measure students' competencies. The questions in Table 6C aimed to assess students' competencies. The average significance rating for each question is illustrated in Figure 5, which depicts the survey results.

Table 6. Student assessment for course delivery (Y1 refers to Year 1, and Y2 refers to Year 2)

A. Course Material	Rate Y1	Rate Y2	B. Activity	Rate Y1	Rate Y2	C. Learning Outcomes	Rate Y1	Rate Y2
Lecture notes	8,80	10,00	3D build. design	8,60	9,75	Competency in using Revit	8,00	9,25
Case studies	8,40	9,75	Design review	8,40	8,25	Compet. in using Navisworks	6,40	7,75
3D modeling	9,80	9,25	Clash detection	8,70	9,75	Delivery of online classes	6,50	10,00
4D modeling	8,50	8,00	4D scheduling	8,60	8,50			
			4D simulation	8,40	8,50			
			Quantification	9,20	8,33			

The course is divided into two modules. The first module focuses on assignment one: integrated building delivery and assignment two: construction review, utilizing Autodesk Revit®. The second module focuses on assignment three: 4D scheduling and assignment four: 4D simulation, employing Autodesk Navisworks®. As indicated in item c of Table 6, students report feeling more competent in Revit® than in Navisworks® by the end of the course. Based on the results of student feedback collected through surveys, it has been concluded that Assignments five through eight should be offered in a subsequent course that builds upon this one. Furthermore, there are plans to continue administering the questionnaire in the coming years to evaluate student grades and competencies and to analyze the results.

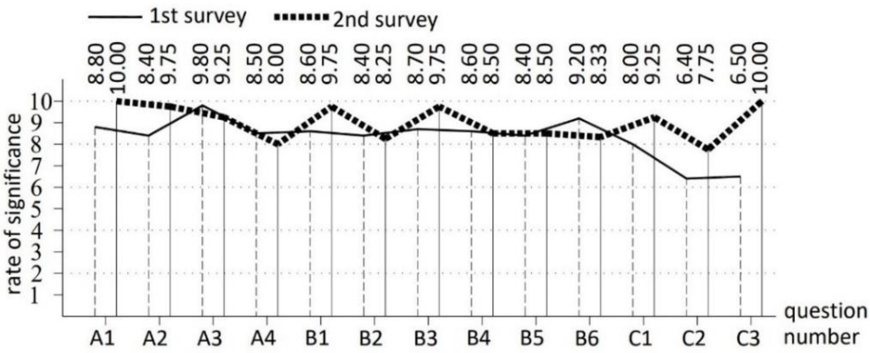


Figure 5. The average significance rating of each question reflects the results of the surveys

5.2. Evaluation of Course Materials and Findings

During the preparation of the case studies, the primary objective was to develop the content for the assignments listed in Table 1. Based on the experience gained, it has been determined that the eight assignments in Table 1, which are derived from previously prepared case studies and course materials, can be incorporated into the BIM course over two semesters. However, since this is a one-semester elective course, it was decided to limit the suggested assignments and provide students with appropriate alternatives. It is recommended that these eight assignments be categorized into three groups based on students' desired areas of improvement and their prior knowledge of Autodesk Revit® (see Table 7). All students will complete the activities in Module 1, after which they can choose one of the remaining modules. This approach allows students to select the content of the course for their lab work or homework assignments. Students will have the option to complete these assignments individually or in groups, with a strong encouragement for group collaboration.

Table 7. Grouping assignments according to BIM maturity levels, as adapted from Table 1 (intermediate level)

Module 1 - 3D		Module 2 - 4D		Module 3 - 5D	
A1.	Integrated build. design	A3.	Clash detection	A6.	Quantification
A2.	Design review	A4.	4D scheduling	A7.	Cost estimate
		A5.	4D simulation	A8.	Cloud application

In terms of 5D features, the quantification in assignment 6 and the cost estimation in assignment 7 have seen very limited progress. Lecture notes on utilizing the "Quantification" tool in Autodesk Navisworks® have been prepared; however, no case studies have been developed. Currently, only the tool in Autodesk Revit® is employed for quantification in CS2, CS3, and CS4. Overall, there is a need to further develop the 5D features of case studies in Autodesk Navisworks®.

In the current study, although the course content was designed for students from various disciplines, a multidisciplinary approach could not be implemented each term because the majority of students in the Master of Architecture program are architects. Consequently, a reluctance was observed among architecture students regarding certain assignment topics. It would have been beneficial to include team members such as civil engineers and/or mechanical engineers in the working group.

At the beginning of this study, Revit® courses were offered at the undergraduate level during the pandemic, and video recordings of these online classes were made available to students through the university's web portal. During this process, it became evident that the student satisfaction reported in previous research was being realized in practice. However, since the focus of this paper was on face-to-face instruction, no video recordings were shared with the students. For a course that includes such an in-depth lecture on software learning, students frequently expressed that having access to a video recording, as was provided during the pandemic, would be beneficial.

According to the survey results, it was observed that by the end of the BIM education program, students demonstrated greater competence in BIM 3D compared to BIM 4D. Furthermore, to address the knowledge gap of the instructor, it is essential that the instructor completes BIM training and attains proficiency while preparing the BIM course curriculum. Consequently, the development of case studies was a crucial activity for the instructor to comprehend the intricate structure of BIM. From the outset, it was planned that the exercises conducted during the learning process would be incorporated into the assignments ultimately shared with the students. This aspect can be highlighted as the most significant topic of discussion and the primary objective achieved by this study. In other words, we can observe how the case studies produced through a model-based learning process have been integrated into the course curriculum.

6. Conclusion and Suggestions

Initially, the goal was to create an advanced-level course comprising eight assignments and accompanying lecture notes; thus, course materials were prepared accordingly. However, due to the constraints of a one-semester class and the extensive content of the assignments, a stand-alone, intermediate-level BIM-focused course was ultimately developed. In designing the BIM course curriculum, it was anticipated that, in addition to the theoretical components, a practical application or assignment section would also be included. Regarding the homework section, if the projects do not originate from the course instructor, there are potential copyright issues associated with selecting and sharing sample projects with students. Furthermore, obtaining external professional support to facilitate the practical aspects of the course is not always feasible. To address these challenges and ensure that both the theoretical and practical components of the course are effectively delivered by the instructor, case studies have been developed as part of this study. The case studies produced range in complexity from levels 1 to 4, with an increasing BIM maturity level. Various building programs and floor heights were utilized, and architectural, structural, and MEP components were generated parametrically.

In preparation for 4D scheduling and simulation using Navisworks®, 4D task IDs have been assigned to components in Autodesk Revit®. Additionally, the "parts" tool in Revit® was utilized to stage the work schedule. This distinction sets 4D drawings apart from standard 3D drawings in Autodesk Revit®. The structural and MEP components produced were selected based on indicative prescriptive codes, and each component must be individually verified through calculations. These calculations fall outside the scope of this study and should be assessed separately. For case studies two through four, 4D simulations were conducted in Navisworks®, which significantly aided in illustrating the construction phasing during the course. Of the eight assignments planned, only the first four were applicable to the laboratory component of the one-semester course, while the remaining four were discussed solely in theoretical terms.

According to the results of the survey, which evaluated course materials, the learning environment, and student outcomes, students provided generally positive feedback. The data obtained from the questionnaire, it was evident that students held favorable opinions about the course. The questionnaire results presented in Figure 5 comprise thirteen items, with an increase observed in eight of these items in the second year. Notably, the responses regarding course materials and assignments (Figures 5a and 5b) all scored above 8 out of 10. In the second year, the lecture notes and the online delivery of the course received perfect scores from the students. Conversely, students' interest in case studies was rated at 8.40 points in year one and increased to 9.75 points in year two. By the end of the course, students' Revit® competency score was 9.25, surpassing the Navisworks® competency score of 7.75. Analyzing the responses to the questions about Navisworks® in section C reveals that students' interest in Navisworks® was limited. The delivery of the online course received full points in the second year because the recorded lectures can be uploaded to the university's web system.

Consequently, it is recommended that the eight assignments be divided into three groups, allowing students to select one of these assignment packages based on their undergraduate education and research interests. This approach will ensure that only interested students choose the Navisworks® assignments, as survey results from the first two years indicate limited student interest in this area. Students with diverse backgrounds, in addition to architecture, such as civil engineering and mechanical engineering, will contribute significantly to the formation of diverse teams for the term project. It is anticipated that a more effective educational environment will be fostered in classroom studies through teams composed of individuals from various professional disciplines. In the future, the goal is to establish such teamwork, and there is a need to evaluate the outcomes of the learning environment created here. As long as the course is offered annually, the assessment of learning outcomes will continue.

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The article was written by a single author. There is no conflicts of interest.

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Revitalizing Ruins: Adaptive Reuse of Yamanlar Sanatorium as a Contemporary Summer Camp by Experiential Education in Interior Architecture

Deniz AVCI [1*], Gözde ÖZDER ÇAKIR [2]

ORCID 1: 0000-0003-1157-5654
ORCID 2: 0000-0002-6785-1788
[1] *Izmir University of Economics, Faculty of Fine Arts and Design, Interior Architecture and Environmental Design, 35330, Izmir, Türkiye.*
[2] *Izmir Institute of Technology, The Graduate School, PhD Program in Architecture, 35430, Izmir,Türkiye.*
*** e-mail**: *denizavci.hist.arch@gmail.com*

Abstract

This article evaluates module-based experiential education through the case of a junior-year interior architecture studio project for the adaptive reuse of the historical Yamanlar Sanatorium Complex in Izmir, Turkey. The project aimed to transform this example of Turkey's 20th century Modern Movement healthcare heritage into a summer camp for university students who were affected by the 2023 earthquake. The project drew attention to social problems like the increase in contagious diseases due to uncontrolled migration during the Syria's civil war and the housing crisis following the earthquake. The project's holistic design approach was examined through four connected modules: (1) context to concept, (2) concept to form, (3) form to detail, and (4) architectural model production (implementation). Design students as selected clients also encouraged participatory design. The project outputs fell into three categories: modular, rectangular forms influenced by the sanatorium building; forms inspired by nature; and sculptural forms with period influences.

Keywords: *Interior architecture, experiential education, adaptive reuse, modern movement sanatoria, Türkiye.*

Harabeleri Canlandırmak: İç Mimarlıkta Deneyimsel Eğitimle Yamanlar Sanatoryumu'nun Çağdaş Bir Yaz Kampı Olarak Yeniden İşlevlendirilmesi

Öz

Bu makalede, üçüncü sınıf iç mimarlık stüdyosunda gerçekleştirilen İzmir'deki tarihi Yamanlar sanatoryum kompleksinin yeniden kullanım projesi, modül tabanlı deneyimsel eğitimi değerlendirmek için incelenmiştir. Proje, Türkiye'nin 20. yüzyıl Modern Hareket sağlık mirasının, 2023'te meydana gelen depremden etkilenen tasarım alanlarında eğitim gören üniversite öğrencileri için bir yaz kampı olarak dönüştürülmesini hedefleyerek, Suriye savaşından sonra kontrolsüz göç nedeniyle Türkiye'de tüberküloz gibi hastalıkların artmasına ve barınamama gibi sosyal sorunlara dikkat çekmiştir. Dört bağlantılı modülle bütüncül bir tasarım yaklaşımı incelenmiştir: (1) bağlamdan konsepte, (2) konseptten forma, (3) formdan detaya ve (4) mimari maket üretimi (uygulama). Tasarım öğrencilerine yönelik tasarım, katılımcı işbirliklerini de teşvik etmiştir. Projeleri çıktıları, sanatoryum binasından etkilenen modüler, dikdörtgen formlar; doğadan ilham alan, çevreye uyumlu ancak yapıyla çatışan formlar; dönemsel etkilerine sahip heykelsi formlar olarak kategorize edilmiştir.

Anahtar kelimeler: *İç mimarlık, deneyimsel eğitim, yeniden işlevlendirme, Modern Hareket sanatoryumları, Türkiye.*

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1. Introduction

Within the objectives of a third-year studio in interior architecture and environmental design education at Izmir University of Economics (IUE), the semester project for Fall 2023-24 was determined as the historic Yamanlar camp and sanatorium complex in the *Karşıyaka* district of Turkey's third largest city, Izmir, located on the Aegean coast of Anatolia. As an example of republican 20th century modern heritage, the complex was to be converted into a summer camp for university students affected by the disastrous earthquake in southeastern Turkey on February 6, 2023. This earthquake devastated the nation, with thousands deceased and thousands unemployed and left homeless. To address the issue of the post-earthquake housing crisis, the studio aimed to convert an abandoned historic building that incorporated a similar contextual use in the past as a camping or accommodation site for tuberculosis patients.

The project aimed to increase social awareness regarding three main points: (1) the housing crisis facing the masses after the earthquake; (2) the housing crisis facing students, especially in major cities, due to high rents for dormitories or rented accommodation (a social issue even before the earthquake) (Anonymous, 2023; Cengiz, 2024); (3) the risk of demolishing a neglected historic building and exemplar of cultural heritage without regard for its history and importance. The project drew attention to the fact that the students' accommodation crisis is a social problem that requires the provision of free housing while a historic building could be reused rather than face neglect, decay and eventual demolition. Another social layer was the recent rise in contagious diseases in Turkey, including tuberculosis, due to the increasing number of immigrants entering Turkey since the civil war erupted in Syria. Given these issues, the project aimed to respond to the broader social, cultural, and political contexts of contemporary Turkey and create awareness that design is concerned with cultural, sociological, psychological, and political issues as well as medical, physical, and environmental ones (Bremner & Rodgers, 2013, p.4).

Interior design can often have negative connotations, such as being concerned with mere decoration. Especially when compared to architecture, it is often considered that the field lacks a social dimension. Due to these misconceptions, it could remain a self-contained practice (Chu, 2003, p.38). Hence, the studio course examined in the present study engages with a larger social dimension. As Salmon & Gritzer (1992, p.79–80) emphasize, "the physical environment can have a significant impact on social life, whether such an impact is intended or not. It is thus incumbent upon designers to realize that the space they design will have human consequences, and that professional responsibility includes anticipating these consequences." Design reflects the attitudes, customs, beliefs of its users; thus, "physical, social, and cultural contexts" are inherent in its emergence (Lawson, 2014; Zande, 2010, p.249). The technical skills of an interior architect remain insufficient if they ignore their obligations to the broader social context. Hence, design education should prioritize the integration of methodologies dealing with the relationship "between culture and social organization," "the processes of social conflict and social change" (Salmon & Gritzer, 1992, p.79–80), and consider specific populations, such as economically disadvantaged youth, disaster victims, hospital patients, prisoners, or the elderly.

The contemporary design approach should involve sharing knowledge between users and designers (Chu, 2003, p.46) while another important pedagogical component is understanding the nature of multidisciplinary and interdisciplinary nature of design. Design is fluid with evolving patterns. These "traverse, transcend and transfigure disciplinary and conceptual boundaries" (Bremner & Rodgers, 2013, p.8). Interior design education has thus realized the importance of collaboration between related design professions (Nubani et. al., 2018, p.218). Consequently, for the project assessed in the present study, the design question defined the user profile as "university students who major in the design field." The students specified the design field for their projects (e.g., design students from the fields of industrial design, visual communications design, interior architecture, architecture, photography, or music). There is strong evidence that participatory design models in (interior) architecture studios can enhance students' project development via social connections and collaborations (Nubani et al., 2018, p.219; Tokman & Yamacli, 2007). Hence, the studio course required students to place themselves on both sides of the design negotiation as designer and user.

The students were encouraged to communicate with their friends from other design fields while developing their projects for their selected user profile.

1.1. Tuberculosis and Sanatorium Architecture in Early Republican Türkiye and the Yamanlar Sanatorium Complex

A sanatorium is a type of healthcare facility that offers strict hygienic-dietatic-therapeutic treatment to enable tuberculosis patients to convalesce. The expansion of these facilities from the late 19th to the early 20th century was known as the "sanatorium movement" while the hygienic design principles they incorporated triggered the Modern Movement in 20th-century architecture (Campbell, 2005; Colomina, 2019; Overy, 2007). Although Turkey lacks the canonical examples of European counterparts like the Paimio Sanatorium by Aino and Alvar Aalto or the Zonnestraal Sanatorium by Jan Duiker Bernard Bijvoet and Jan Gerko Wiebenga, there were many examples of "standard" sanatoriums, which were *state-of-the-art* if not "iconic" as defined by Del Curto (2013).

The young republican state invested in fighting tuberculosis as part of its modernization agenda, which saw the health of the nation as an important branch in its development (İlikan Rasimoğlu, 2018; Yıldırım & Gürgan, 2012). Accordingly, the Turkish Republic invested in constructing state-of-the-art facilities based on the universal examples of Modern Movement sanatoria, i.e. block-type rectangular prisms formed of a modular repetition of rooms and balconies while avoiding historicism (Avcı & Değirmencioğlu, 2024). Heybeliada Sanatorium, Turkey's first state sanatorium, which was inaugurated in 1924, and its block-type state-of-the-art Block B structure built in 1945 and designed by architect Rebii Gorbon, became a model for Turkish sanatoria (Avci-Hosanli & Degirmencioglu, 2024; Yüzer, 2020).

During the early republican period, Izmir became the first center in the struggle against tuberculosis, with Turkey's first tuberculosis association established there in 1923 (Avci-Hosanli, 2023, p.678; Ülgen, 1947). The Yamanlar sanatorium complex in Izmir is unique in Turkey's sanatorium typology (Avci-Hosanli, 2023). The camp area (Figure 1), designated and inaugurated at the request of Atatürk, the founder of the Turkish state (Yavuz, 2017), was later expanded into a sanatorium complex, with the block-type sanatorium structure, designed by architect Arif Kınay, being constructed in the 1950s (Karabağ Aydeniz & Erdoğmuş Manav, 2015).

The camp, which covered 42 hectares and was situated 732 meters above sea level on Yamanlar Mountain in Karşıyaka, was inaugurated on June 10, 1932, by the Ministry of Forestry (Karabağ Aydeniz & Erdoğmuş Manav, 2015): In 1944, the area was registered to Izmir Tuberculosis Association. During the 1950s, the complex included a sanatorium building, two aeriums, 13 single accommodation units, and an administrative building, dining hall, casino, swimming pool, volleyball and tennis courts, and a field for up to 80 tents (Figure 1). The sanatorium structure (hereinafter "accommodation building") is a rectangular prism of 40x14 meters (Figure 2). Southwest of this is the dining hall (hereinafter "multipurpose hall"), dated to 1945, while the casino building is to the south (Figure 3). The latter two are single-story reinforced concrete structures with stone cladding. The accommodation building is a block-type rectangular prism of three floors with a basement floor. It is longitudinally extended with the main and longer south- and north-facing facades formed of modular, repetitive spaces. This modularity is reflected on the façade in that the rooms face the balconies on the south side while the room doors open onto a corridor on the north side. The second structure is a one-story open-plan ancillary structure.

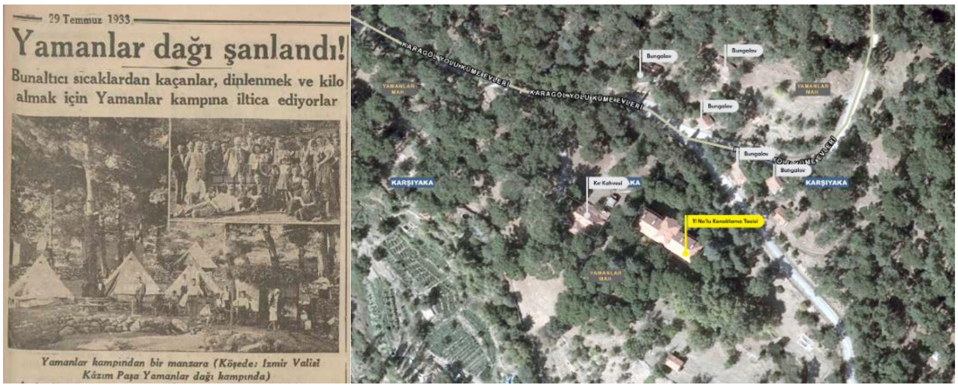

Figure 1. Left: Article reporting the annual inauguration of the Yamanlar camp (Doğanoğlu, 1933). Right: Aerial photo of Yamanlar sanatorium complex (Uslu, 2023a)

Figure 2. Accommodation building (Avci & Özder Çakır, 2023a)

Figure 3. Multipurpose hall (Avci & Özder Çakır, 2023a)

The complex was transferred to the Directorate of Provincial Regional Forestry in 2002 and then to Karşıyaka Municipality in 2011. Today, the complex is a heritage at risk. In 2017, the Yamanlar camp in ruins was noticed by the public (Yavuz, 2017). In 2021, Izmir City Council offered to renovate the complex, but this was rejected by the Ministry of Forestry (Anonymous, 2021a) due to insufficient technical specifications. The municipality pleaded for support (Anonymous, 2021b) before *Grand Plaza Hotel* proposed a project (Güçtekin, 2022) in collaboration with *Mert Uslu Mimarlık* [Architecture] (Uslu, 2023b) (Avci-Hosanli, 2023, p.684). According to Uslu (2023b), the project plans to demolish the complex's buildings because they are not earthquake proof and replace them with replicas. However, this approach is concerning regarding the conservation of Turkey's cultural heritage. Hence, given that Yamanlar sanatorium complex is an architectural, medico-social, and cultural heritage at risk, the interior architecture studio course aimed to focus on its adaptive reuse.

1.1. Using the Yamanlar Sanatorium Complex as a Case for Interior Architecture Education

During the Interior Architecture and Environmental Design's four-year undergraduate program at IUE, students take interior architecture studios in sophomore, junior, and senior years. Studio courses are held twice a week for a total of eight hours for discussions, critiques, and presentations. These studios work on adaptive reuse, public interiors, residential interiors, and a senior-year thesis project focuses on AI and VR technologies.

Valuable research has been conducted on design education, mostly regarding educational methods, and focused on freshman, sophomore, and senior year interior architecture courses (Demirkan & Afacan, 2012; Erdman et al., 2002; Harwood, 2008; Hasirci et al., 2022). However, the junior year, though a very important step, has often been overlooked. Accordingly, the present study focused on IUE's junior-year interior architecture studio course, which contextualizes adaptive reuse in its design question with an understanding of a broader social context. By adaptive reuse, the course refers to a conservation proposal to update the use of, or find a new use for, an old site or historic building. In the studios, the students are expected to demonstrate their understanding of design elements like "space, line, mass, shape and texture" and design principles like "scale, proportion, balance, rhythm, emphasis, harmony and variety" (Hasio & Crane, 2014, p.38). The students are further expected to demonstrate critical thinking skills by establishing relationships between the built environment and human behaviors as well as by showing awareness of cultural and social issues, including the history of the site, building, or complex, and the social context that incorporates key social issues in contemporary Turkey, particularly earthquake risks, the spread of contagious diseases, and the housing crisis.

According to the project's scenario, the state owned the entire complex and converted this facility into a summer youth camp for university students specializing in design. The scenario imagined that the camp opens annually on June 1st and closes on September 1st, and is active throughout the summer months, as it was used from the early republican years until the 1970s (Anonymous, 1935, 1939; Doğanoğlu, 1933). The project's main goal was to design a camping resort for university students enabling specific activities to encourage the student users' participation and integration.

The design question asked for the adaptive reuse at the historical site of two structures and a central courtyard framed by them on its northern and western sides. The three key parts of the building program were (a) the block-type accommodation building; (b) the one-storey ancillary structure (multipurpose hall); and (c) transitionary structures in the courtyard between (a) and (b). The project required the incorporation of the buildings' immediate surroundings and the courtyard, the buildings' interior and exterior relations, circulation into and around the buildings, and a properly functioning layout inclusive of conceptual and functional decisions. The courtyard was included as an intermediary element that should expand the interior spaces through conceptual, functional, and aesthetic continuity with the design of the new transitionary structures to serve as places for public and semi-public gatherings, and private seclusion areas.

Because the accommodation building was considered as an example of cultural and architectural heritage, the students could not alter the facades, roof, or openings. The existing walls were approached with a similar sensitivity, though certain basement and ground floor walls were removed by the instructors to enable spatial experimentation. Optionally, the walls of the bathroom spaces could be removed. Other than these alterations, the students could not alter the accommodation building's walls or columns (Figure 2). However, the multipurpose hall could be approached simply as a shell or open space for free spatial play (Figure 3).

While a representative list of expected functions was specified, the students were also asked to elaborate on and modify this program according to their own concepts and scenarios. The project aimed to promote a variety of activities. Regarding the accommodation building, the half-basement floor and ground floor were to be used as the entrance and public venues, including reception and security, a lounge, small library and reading hall, a small café-bar and kitchenette with storage, administrative offices for four people (manager, accountant, public relations, and secretary), and public restrooms. For the accommodation building's upper floors, based on the modularity of the rooms and balconies, the design had to include two four-person rooms, two three-person rooms, and 12 two-person rooms, all with private bathrooms. Additionally, two one-person rooms were to be reserved for the workshop instructors.

Regarding the multipurpose hall, the students had to incorporate a dining hall, conference hall, and workshops with their own storage, a kitchen space with its own storage, and public restrooms. The students were free to experiment with this space without the partition walls through a multi-functional approach.

Finally, the students were asked to reimage the courtyard with structures of their own design. The goal here was to encourage them, as interior architecture students, to experiment with structural systems. The courtyard was defined as a "transitionary space" while the structures were "transitionary structures". The students were free to determine the exact nature of these structures: as mountable and demountable, using suspension or inflatable architecture, and/or any other structural systems of their own choice. The only requirement was that they should be spatially functional and create defined gathering areas, open-air workshop areas, and individual resting areas.

The design outcomes were expected to display universal design principles, accommodating the needs of all people (children, elderly, people with a cognitive impairment, etc.) (Levine, 2003; Zande, 2010, p.252). Additionally, there should be spatial efficiency that incorporated the integrity of the volumes and their functions with flowing interior and exterior circulation and flexibility for transformations, or upgrades. The design question drew on a holistic approach, starting from a larger scale of 1:200, including the landscape, before moving down to a smaller scale of 1:10. The aim was to create a conceptual idea first before maintaining this through the different scales.

The process of generating relevant design solutions includes specific steps. The constituent parts of this project were as follows: research; spatial, formal, geometric, and contextual analyses of the built environment; formation of the program with area requirements; generation of concept-level design ideas; translation and implementation of the concept into spatial planning and design solutions; overall materials selection; focus study on specific areas regarding materials, textures, textiles, lighting, etc.; detailing in 1:20 and 1:10 scales.

The students also had to consider the exterior-interior connections, landscaping, and expressions of the facades. After establishing proper circulation, spatial connections, public and private areas according to the needs, and the volumetric control of the space; the students had to consider lighting (both daylit and artificial), surface materials (including acoustics), furniture, textures, textiles, and colors. Finally, they had to consider infrastructural factors, such as HVAC and plumbing systems (Hasirci et al., 2022, p.659), although detailed productions were not required.

2. Materials and Method

The semester-long studio course was divided into four modules based on evidence that students tend to show greater clarity in their creative processes if specific tasks are limited to certain periods. Each module required successful completion of the previous module. The four modules are discussed in later sections as follows: Context to Concept (Section 3.1); Concept to Form (Section 3.2); Form to Furniture (Section 3.3); and From Ruins to Architectural Models (Section 3.4). The first three modules were all closely interlinked, thereby requiring a holistic approach from the students throughout, based on the concept they established in the first module. Though still linked to previous ones, the final module was more independent. In this module, the students prepared an architectural model based on their previous decisions. This model-making process often revealed potential problems regarding spatial, physical, and/or structural control of space. Solutions or adaptations could then be quickly incorporated before finalizing the model. In this final phase, the students had to provide a representative demonstration of materials and textures to enable assessment of their design's overall ambiance. Following an assessment of the students' projects in Section 3, the final section of the article (Section 4) discusses and evaluates the lessons learnt from this experimentation with modules/charrettes in an interior architecture studio course.

Two modules were conducted as charrettes, where the students experienced coming together with professionals. A *charrette* (Sanoff, 2005) is a workshop or a working session enabling an exchange of ideas between designer students and professionals (Nubani et al. 2018, p.220). As also pointed out by Nubani et al. (2018, p.227), design charrettes enhance students' understanding of buildings, social issues, and, most importantly, clients' needs. Charrettes also enhance collaboration across design fields. Hence, incorporating a charrette component in the interior design studio aimed to gain the following benefits (Nubani et al., 2018, p.232–233): increasing collaboration with different designers and stakeholders, greater understanding of complex issues in real-life scenarios, and exposure to users' needs and problems. The IUE studio course incorporated two charrettes: a site visit with architect Mert Uslu during the first module and a model-making workshop with architect Ekin Güven during the final module.

The four modules covered the weekly based curriculum. For instance, the first module,"Context to Concept," focused on conceptual development, programming, research, and site analysis in weeks 1 and 2. The second module, "Concept to Form," covered spatial planning, functional layout, vertical connections/relations in weeks 3-6 before the first review in week 6. The third module, "Form to Furniture," focused on structural details, selection of materials and furniture, and the development of custom details during weeks 7-10 before the second review in week 10. The final module, "From Ruins to Architectural Models," focused on improving the designs by experimenting with the architectural models in weeks 11-13 before the final presentation/exhibition.

As part of their research, the students learned about student accommodation complexes from around the world, and studied designers' chairs, using their designated chair in their projects (see Section 3.3). The camp and dormitory examples included MIT Baker House Dormitory by Alvar Aalto; Camp Lakota, California, by Perkins & Will; Casa dell'Accademia, Mendrisio, by Könz-Molo; the Indian Institute of Management dormitories, Ahmedabad, by Louis Kahn; the Olympic Village Munich by Heinle, Wischer Und Partner; Peabody Terrace, Harvard, by Josep Luís Sert; and the Apartment Building Gasometer B by Coop Himmelb(l)au.

In the first charrette for site analysis, the students met the conservation architect Mert Uslu, and filmed a short documentary at the site after their discussions. Working in pairs, the students collected information by analyzing the landscape, structures, building interiors, spatial layout, use of materials, finishes, and observable infrastructure, such as lighting systems. The documentaries incorporated research on (1) the historical background; (2) architectural and spatial analysis (mass, shape, size, volume, and relationship to the surroundings); (3) a thorough analysis of an interior space of their own choice (including analysis of color, light and shadow, materials, and textures); and (4) an analysis of a detail from their own selection (e.g., tile, doorknob, joint) (Figures 4 and 5). For the following assignment (i.e., the development of concept), they had to select four keywords from the four parts of their documentary film. The aim was to improve their concepts based on these keywords and enable them to contextualize the characteristics of the historic buildings and site into their concepts.

The studio course was attended by 24 students. The course's outcomes are discussed below in terms of six successful projects that understood and met the course requirements by successfully converting a historic modern healthcare heritage into a contemporary camp for university design students affected by recent earthquakes.

This research article is thus based on the experiential education method that was adopted in the junior year interior design project/studio course. The article provides a critical analysis and evaluation of the students' projects, performance, work process, and progress by supporting the "charettes/modules" model with relevant literature. The process revealed that each module had to be adapted during the semester in accordance with the students' performance, necessitating considerable attention and adaptation to the students' requirements. The completed projects, as intended from the beginning of the semester and as a result of the experiential adaptation of the modules, demonstrated the holistic character of the interior architecture profession (to students), encompassing the contextual, conceptual, formal, and furniture-related aspects. The architectural models, as a concluding phase, enabled students to implement corrections to potential issues that might have been inadvertently overlooked during the design process. The projects thus demonstrated the efficacy and limitations of the experiential education approach, whereby tailored charrettes/modules were employed in the junior-year interior architecture project/studio course.

3. Findings and Discussion

This section presents and discusses the four course modules and two charrettes within these modules via the successful student projects: (1) *Tet+mation*, (2) *Pix-fash*, (3) *Layer+reflection*, (4) *Spirarchimedean*, (5) *Metamorphosis*, and (6) *Fashinnovation*.

The inspirations from concept development directly affected the outcomes (Table 1). Concepts inspired by the block-type sanatorium building resulted in modular, repetitive, rectangular forms, which harmonized with the building (Figure 4). Concepts inspired by nature resulted in forms in harmony with the landscape, though in opposition to the forms of the building. Hence, they were challenging for the students (Figure 5). Concepts inspired by the 1950s (when the accommodation building was constructed) resulted in designs that were more decorative than architectural. Among these one prevailed and resulted in forms that challenged the building and became more sculptural (and thus was included here). Several projects pushed the limits of this classification, with two achieving forms that could fall under two, even three categories (marked * and ** in Table 1). The following subsections elaborate these projects.

Figure 4. Details from the decaying block-type sanatorium structure that inspired students. Left: Period-style cement tiles in the circulation corridor on the northern side. Right: Brick masonry revealed by a decaying balcony wall on the southern façade (Avci & Özder Çakır, 2023a)

Figure 5. Inspirational details captured by the students during the site analysis. Left: Fireplace on the upper terrace floor of the sanatorium building. Middle: Yellow, teal, and white cement tile found detached from the structures. Right: Illustrating harmony between teal and red mosaic tile from the bathroom spaces of the rooms and leaves from nature (Avci & Özder Çakır, 2023a)

Table 1. Development of the projects: Concept inspiration to forms

Concept inspiration Forms	Inspired by the block-type sanatorium building	Inspired by nature	Inspired by the period of the sanatorium (the 1950s) and the new function
In harmony with the block-type sanatorium building	*Tet+mation* *Pix+fash* *Layer & reflection***	*Layer & reflection***	
In harmony with the landscape & in opposition to the forms of the building		*Spirarchimedean* *Metamorphosis*	*Fashinnovation**
Framed by the shell of the building (furnishing and fitting design)		*Layer & reflection***	*Fashinnovation**

3.1. Context to Concept

Regarding the development of the concept, students' approaches can be categorized into four main groups:

Concept inspired by the building

Designers have a responsibility to understand their creative contributions as part of a larger cultural context (Bremner & Rodgers, 2013, p.4; Friedman, 1994). The projects assessed in this subsection were able to adapt traditional and original elements and motifs and integrate them into the design. As Chu (2003, p.43) also explains, "by becoming familiar with the forms, styles, and techniques from the past, students could assimilate their essence and be able to transform it into something of their own." In the projects analyzed here, this inspiration of the building's characteristics evolved into something entirely new without breaking from originality and tradition.

Tet+mation was inspired by the modular and rectangular forms of the building, which provided a modular space for arcade game designers. Inspired by an arcade game from the 1980s, their concept developed from "dynamic" and "colorful" "frames". Combining the transformation of the building and the tetris game, they named their project by combining "tetris (form) + transformation (function)" (Figure 6). *Pix-Fash* presented a modular and dynamic fashion design concept using the geometric shapes and patterns of pixel art, which became popular in the early 20th century. Based on the keywords of "dynamic", "frame", "transition", and "tones of color", the project name combined "pix (form) + fashion (function)" (Figure 6). The aim was to create a functional, modular, and creative environment for fashion design students. Characterized by geometric shapes and patterns, the historic references were achieved with a level of sophistication as different furnishings and fittings were used together in subtle variations.

Figure 6. Concept boards of the Tet+mation (left) and Pix-fash (right) projects (IAED, 2023)

Layer+reflection revealed a combination of layers and reflections that created a complex and intriguing aesthetics (Figure 7). Inspired both by nature and the building's forms, the project's keywords were "transparency", "calmness", "layers of nature", "layers of building", "linearity", "mirror", and "shadow". The design proposal mostly focused on the term "layer" and aimed to empower interior architecture students in the inspiring environment offered by the layers and contrasts between nature and the historical site/building, such as natural versus artificial and organic versus geometric.

Figure 7. Concept boards of the Layer+reflection (left) and Fashinnovation (right) projects (IAED, 2023)

Concept inspired from nature

Spirarchimedean was inspired by keywords “repetitive,” “nature”, and “organic”, which resulted in the form of the Archimedes spiral (Figure 8). These words found a reflection in the spiral form of the ammonites and the balanced distribution of its nodes. The dark ambiance suited the needs of these graphic design and photography students. Notably, the project’s circular form directly contrasted with the building’s inherent linearity. Similarly, *Metamorphosis*, inspired by the process of a caterpillar turning into a butterfly, drew on the keywords “energetic”, “colors of nature”, “organic”, and “natural light” (Figure 8), and was influenced by death-life-rebirth cycles in nature. This transformation proposal was also functional in enabling the landscape designers “to explore themselves, undergo transformations, and realize their potentials” and “to explore their creativity, learn new skills, and gain self-confidence.” These definitions were appropriate for a camp.

Figure 8. Concept boards of the Spirachimedean (left) and Metamorphosis (right) projects (IAED, 2023)

Period inspiration: Concept from the 1950s

The third category included projects directly inspired both by the new function and the period of the accommodation building’s construction. The students aspired to design their new interiors with a period-reference to the 1950s. *Fashinnovation* [fashion (function) + innovation (alteration+purpose)] was designed for a fashion studio (Figure 7). Hence, its forms imitated the main component of fashion design: textiles. However, to contextualize the building’s history, the design also aimed at reviving 1950s’ fashion, characterized by stripes and polka dots, with the innovation of the new contemporary technologies and amenities. The keywords were “fashion”, “renovation”, “light colors”, “repetition”, and “mosaic density”. The building’s original 1950s’ features, i.e., the mosaics and cement tiles, were to be preserved. The spirit of the period was captured with light colors, repetitive motifs, and mosaic density in a combination of modern and nostalgic.

3.2. Concept to Form

In the process of turning concept into form, three main approaches with their branching strategies emerged. These can be categorized as (1) in harmony with the forms of the building (rectangularity, modularity, repetition); (2) in harmony with nature and in opposition to the forms of the building (undulating curves, spirals, shells); and (3) framed by the shell of the building (furnishings and fitting design). Each project is assessed under the same project names as before. The project definitions are described in the following order: the accommodation building, the multipurpose building, and the transitionary structures connecting the buildings. This is because the students considered the accommodation building as the core/root and their designs developed from there.

In harmony with the forms of the building

Tet+mation used tetris forms to shape the forms of the built-in furniture and as surface engravings that spread from the walls to the ceilings in the accommodation building's public spaces (Figures 9 & 10). The spatial adaptation of these forms could be achieved in "private" spaces, such as the bedrooms on the upper floors. Each room acted as a single tetris module in that each room was painted, furnished, and decorated in a single color. These colors also coded for the number of users per room. The project used lines as prevailing elements to define the connections between the *tetris* modules. These lines had the function of defining the circulation paths, especially in the accommodation building; i.e., paths directing users to their rooms. This linearity was also utilized to emphasize the structure's rectilinearity.

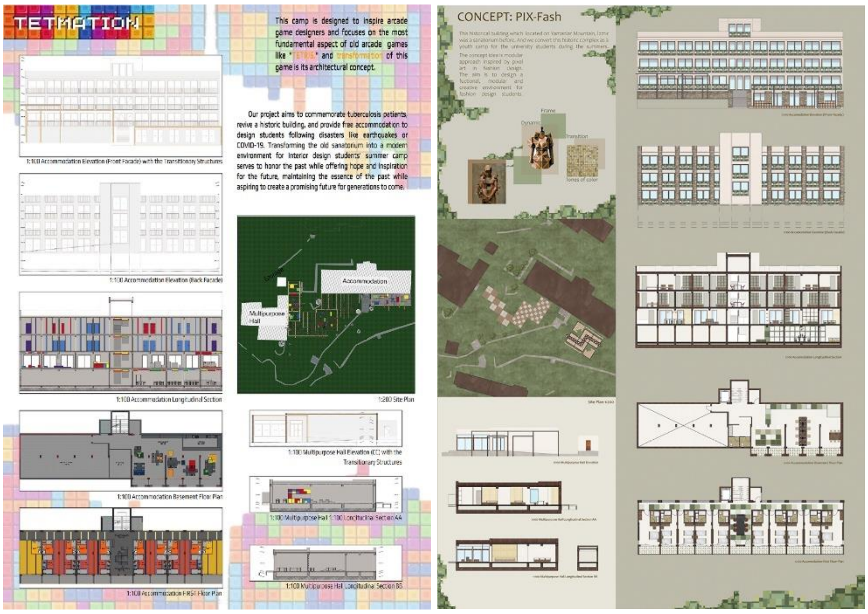

Figure 9. 1:200 site plan and 1:100 plans and facades of the Tet+mation (left) and Pix-fash (right) projects (IAED, 2023)

Figure 10. 1:50 Plans, materials board, and 3D visuals of the Tet+mation project (IAED, 2023)

While the project established a consistency with the *tetris* game and its modules, the students adopted a different approach for the multipurpose building and the transitionary structures. The accommodation building was more orderly, whereas the socialization centers of multipurpose hall and transitionary structures were left chaotic. The sanatorium structure's disciplinary nature referred to the sanatoria's disciplinary regimen in the history of tuberculosis treatment.

With multipurpose hall and transitionary structures, the *tetris* modules are dismantled and left free to hover in space (glimpses of De Stijl). In the transitionary structures, the lines of the disintegrated *tetris* modules become even more random: lines became timber struts to form the skeletal system of the structure and colorful planes (leftovers of the *tetris* colors) became the canopy. In the multipurpose hall, this approach changed once again. The struts gained color whereas the planes (the walls, the floor, the ceiling) were left in shades of white and gray. These transitions established a planned transition from order to chaos, from private to public, from calm to exciting. This approach was also in harmony with the forms of the buildings in terms of moving from the orderly rectilinear structure formed of modules to the disorderly multipurpose hall with its dynamic mass.

The *Pix-Fash* project aimed at continuing the repetitive, modular, and orderly forms of the accommodation building because these also coincided with the micro modules of the pixels (Figures 9 & 11). The color palette of teals, greens, and browns was inspired by the colors of the original cement flooring tiles in the patients' rooms and bathrooms as well as the paint colors for the window, door frames, and built-in cupboards (Figure 4). This was a well-received appreciation of the building's history referring to both the forms and the materials.

The merging of the pixel idea with the building's repetitive modularity was also implemented spatially because the spaces began to act as cubes of different sizes. Hence, the room as a cube became the spatial translation of the pixel. The sizes of the cubes were decided according to the function of the defined spaces. On the upper floors, each bedroom acted as a cube/pixel individually; in the transitionary structures, the cubes defined the passage and runway with its own seating as a structure of multiple cubes within a larger one (Figure 11).

Figure 11. 1:50 Plans, materials board, and 3D visuals of the Pix-fash project (IAED, 2023)

In harmony with nature and in opposition to the building's forms

The photography and film students in the *Spirarchimedean* project drew on the spiral form and dark ambiance of the ammonite fossil (Figures 12 & 13). Three fossils were placed in the three required sections: the accommodation building, multipurpose hall, and transitionary structure. The fossils were in three different phases: one was disintegrated to fit the rectilinearity of the building; one was merged with the multipurpose hall to act as a single piece; and one was decaying but still compact as the transitionary structure in a nod to the site and its "dilapidated" buildings (Jackson, 1980; Yablon, 2010).

Figure 12. 1:200 site plan and 1:100 plans and facades of the Spirarchimedean (left) and Metamorphosis (right) projects (IAED, 2023)

Figure 13. 1:50 Plans, materials board, and 3D visuals of the Spirarchimedean project (IAED, 2023)

For the public areas of the accommodation building, the fossil was disintegrated into sections, with each one adapted to the structure's rectilinearity. This disintegration naturally formed an inner and outer shell side. In the design of the public areas, these two sides defined the furnishing and flooring materials; the outer shell was represented by lighter timber parquet flooring, whereas the inner shell was represented by darker gray carpet/linoleum flooring. The inner shell areas designated the more introverted use of the public space, i.e., semi-private seclusion areas within the public spaces. This darkness in the basement floor supported the purpose of the cinema and photography ateliers. The shells became the focal elements in the bedrooms as study and gathering spaces for the occupants. Imagining the gathering as intimate, a similar inner shell/outer shell approach was applied using a black core (black carpeting) within a timber parquet flooring.

Another ammonite shell was integrated into the multipurpose building, or rather vice versa, the multipurpose building was integrated into the shell. Merged, the nature of the fossil was blurred between the new design and the old building. The timber parquet flooring (outer shell) signified the dining, entertainment, and socialization areas, while the black linoleum flooring (inner shell) signified the study, workshop, and conference areas. An open-air gathering area was defined beneath the massive ammonite's skeleton. Finally, the transitionary structure was also imagined as a single spiral fossil, slowly decaying though preserving its form (unlike the disintegrated one in the accommodation building).

The *Metamorphosis* project aligned the phases of the butterfly's life, from caterpillar to chrysalis (pod) to winged insect (butterfly), with specific functional requirements (Figures 12 & 14). For instance, the caterpillar phase was correlated with consumption; thus, caterpillar forms were utilized in gastronomic spaces. Similarly, in the accommodation building, the caterpillar defined the public areas, i.e., the gastronomic spaces, offices, workshops, library, study area, etc. The curvilinearity of the caterpillar was skillfully harmonized with the rectilinearity of the accommodation building. For the chrysalis (pod) phase, the selection of the bedrooms were evident as the pods answered to resting and seclusion within the rooms. Within the multipurpose building, as a place of consumption, the caterpillar forms, which created a path from the accommodation building, were used once again. For the winged insect phase, the socialization aspect of the transitionary structure was represented as an abstracted butterfly form, specifically a tensile fabric structure stretching over the caterpillar-shaped paths in the courtyard.

Figure 14. 1:50 Plans, materials board, and 3D visuals of the Metamorphosis project (IAED, 2023)

Framed by the shell of the building (furnishing and fitting design)

In line with its 1950s' period approach, *Fashinnovation* adopted the abstraction of textiles as a sculptural ceiling element in the accommodation building's circulation spaces and proposed a large canopy in the form of a cemented textile as the transitionary structure in the courtyard, recalling Sedat Hakkı Eldem's flying carpet in the Istanbul Hilton Hotel (Avcı Hosanlı, 2023). Although it might appear challenging to adapt these forms to the historic building, they were integrated into the interiors as sculptures while the transitionary structure remained independent (Figures 15 & 16). The project further used mid-20th-century polka dot and stripe fashion patterns, converted into the main forms of the project by transforming them into built-in furniture in addition to the flowing forms of fabric. Having been initially intended as a secondary approach after the polka dots and stripes, the petrified textiles ultimately became the primary element.

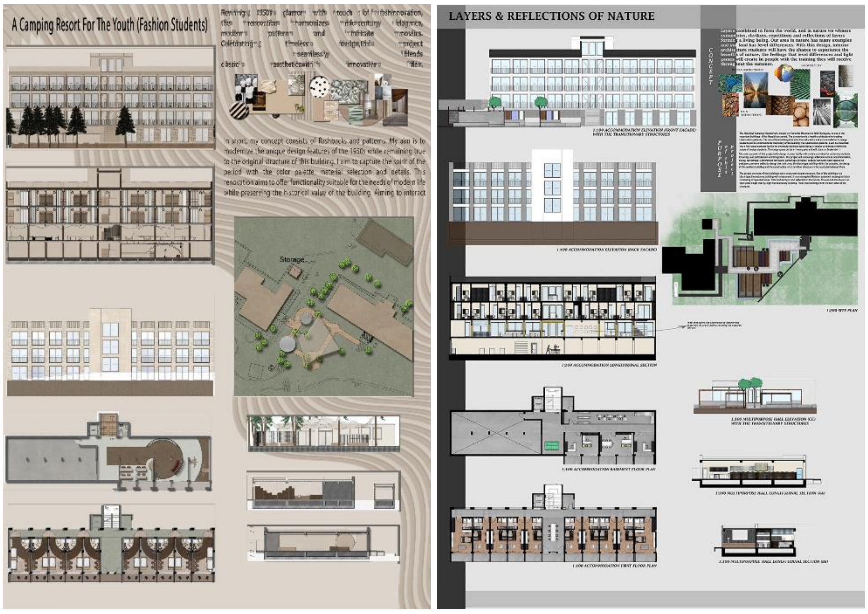

Figure 15. 1:200 site plan and 1:100 plans and facades of the Fashinnovation (left) and Layer+reflection (right) projects (IAED, 2023)

Figure 16. 1:50 Plans, materials board, and 3D visuals of the Fashinnovation project (IAED, 2023)

For instance, in the public areas of the accommodation building, the stripes were expected to provide an apparent linearity parallel to the building. However, these lines were intersected by massive polka dot shapes to indicate important spatial functions, such as the dining and workshop areas. The emphasis on linearity continued to the upper floors, especially in the corridors, with a dominant sculptural ribbon abstraction petrified in the cement that served as a ceiling structure with hidden lighting. In the multipurpose hall, this linearity was replaced by the polka dots to define different functions: the amphitheater, dining area, and the entrance hall. This approach was most successful in the courtyard, where the polka dots acted as openings in the textile-inspired canopy for the site's trees. In the transitionary area under the canopy, the stripes became paths while the polka dots became gathering and seclusion areas.

Although the *Layer+reflection* is categorized as being "in harmony with the forms of the building", its inspiration comes from reflections in nature, so the project falls into more than one category (Figures 15, 16 & 17). The repetitive reflections result in forms with in-depth effects, with transparent and reflective surfaces used to reflect nature into the interiors. Reflective surfaces formed in-depth frames and boundaries, which also referenced the building's modularity and repetitiveness.

Figure 17. 1:50 Plans, materials board, and 3D visuals of the Layer+reflection project (IAED, 2023)

The framed and boundaried structures extended to the courtyard and became modular transitionary structures, variously defining public gathering places, seclusion areas, and circulation paths between the accommodation and multipurpose buildings. Reflections were established between these frames via a Miesian shallow pool (referencing the Barcelona Pavilion). The transitionary structures lay perpendicular to the accommodation building, shadowing the layers of the modular balconies. The idea of reflection was dominant, especially in certain details. For instance, the bar area was designed with cubic glass bricks, while mirrors were used on the walls of the public areas with views of the forest. The framed tunnel on the ground floor, which was the main circulation route between the public spaces, was painted yellow to reference the sun's rays infiltrating the interiors through the repetitive slits of the buildings' original windows and openings as a nod to the Paimio Sanatorium's canary yellow corridors (Cartwright, 2023). The aim was to create "an environment of calmness" by "the sunrays infiltrating in". Nature was not only integrated through reflections; it was also achieved through the prevalent use of timber, especially in the bedrooms, with beds designed as cubic timber huts, referencing the idea of camping in nature, to form secondary layers within the room's frame.

3.3. Form to Furniture

To demonstrate how designing furniture is an essential part of the design process, the students were asked to implement designers' chairs in their projects. The instructors selected 22 famous architectural designers and their chairs, which were then randomly distributed among the students by drawing lots. At this point, the students had almost completed their designs, so they had to adapt the given chair for a space of their choice while the instructors anticipated and welcomed contrasting concepts, colors, and materials. The examples included chairs by Ludwig Mies Van Der Rohe, Gerrit Rietveld, Frank Gehry, Gaetano Pesce, Oscar Niemeyer, Daniel Libeskind, Waro Kishi, Julien De Smedt, Zaha Hadid, Piero Lissoni, Kazuyo Sejima, Frank Lloyd Wright, Eero Saarinen, Le Corbusier, Lina Bo Bardi, Marcel Breuer, Peter Zumthor, Mario Botta, Santiago Calatrava, Doriana and Massimiliano Fuksas, Mario Bellini, Alvar Aalto.

The students' responses to the assignment were evaluated in terms of three criteria: (1) getting to know the architect and their design approaches; (2) understanding the chair's design as an important component of a holistic design approach; (3) understanding the design connection/relationship between the chair and the building. The assignment thus demonstrated the influence of architectural design on smaller scale elements like furniture and objects in a *gesamkunstwerk*, a-total-work-of-art approach. This exploration continued with an in-depth analysis of the use of materials, textiles, textures, colors, and joints. Finally, the students integrated the chairs into the project by selecting a space for them and justifying their selection via sketches, 3D renders, or models. The inclusion of the designers' chairs enabled a greater comprehension of the connections between architectural design and its constituent elements. Furthermore, because of the random selection process, the students had to integrate a chair that could be either in harmony with or in contrast to their overall design concept, as discussed below.

Assigned designer's chair in harmony with the concept

Tet+mation presented an interesting case of balancing design synergy with functional relevance. Characterized by its modular nature and adherence to a strict grid system, the project seemed to find a perfect fit with the 184 Eve Chair, originally designed by Lissoni & Partners. Moreover, the chair's modular design fitted naturally with the project's overall grid-based structure. Having initially proposed using the chair for the project's office space, the students later realized the limitations of this in that the chair's design, intended for short-term use, would not provide the necessary ergonomic support for long office hours. Thus, they eventually placed the chairs in the multi-purpose hall's cafeteria and workshop area, which harmonized with the dynamic, multifunctional hall (Figure 18).

Figure 18. 184 Eve Chair by Lissoni & Partners in Tet+mation project (left) and Wiggle Chair by Frank Gehry in the Fashinnovation project (right) (IAED, 2023)

Fashinnovation was assigned Frank Gehry's iconic Wiggle Chair, which prioritizes ergonomics and aesthetics in the wavy form of its design. Regarding functionality, although visually stimulating in an office space, the students recognized that the chair would be uncomfortable as a desk chair (Figure 18), which required a re-evaluation of the chair's placement. The students determined that the balconies accessed from the rooms would provide a more suitable place for the Wiggle Chair (Figure 16). This new position preserved the chair's artistic value while removing it from an environment where its ergonomic deficiencies could hinder productivity.

Assigned designer's chair in contrast with the concept

The *Layer+reflection* project's students explored the relationship between dynamism and the rigidity of their strict line and grid system. This contrast required furniture that could complements both aspects. However, except for its reflective surface, Zaha Hadid's Z Chair, with its sharp angles, sculptural form, and bold curves, which convey a sense of movement and fluidity, contrasted with the project's approach. The students placed the chair in the lounge spaces, designed for informal meetings and conversations, which demonstrated an understanding of how furniture can bridge the gap between seemingly diametrically opposed design concepts. The Z Chair's unique form encouraged a dialogue between the structured grid system while harmonizing with the reflections (Figure 19).

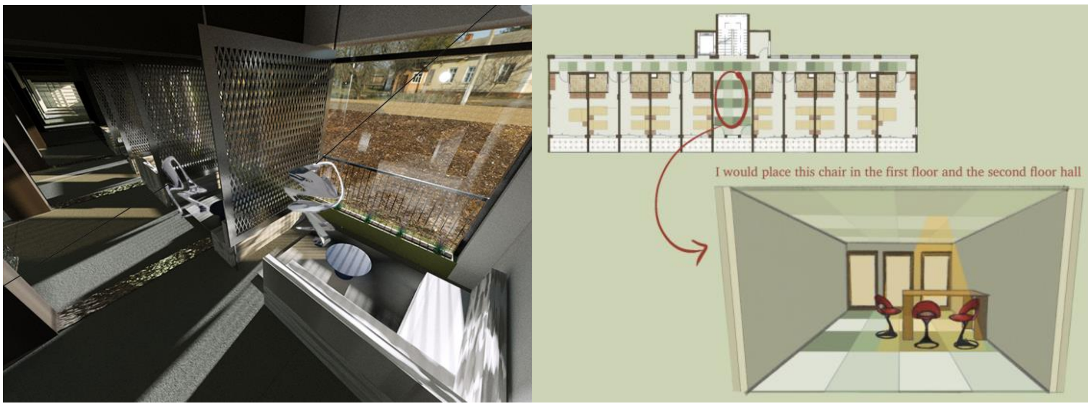

Figure 19. Z Chair by Zaha Hadid in the Layer+reflection project (left) and Tabourettli Theatre Chair by Santiago Calatrava in the PIX-Fash project (right) (IAED, 2023)

PIX-Fash was given the Tabourettli Theatre Chair, designed by Santiago Calatrava, known for his expertise in organic forms and use of biomimicry. Consequently, the chair was in complete opposition to the project's highly stringent grid system. The students placed the chair in the communal areas between the rooms, which meant that as the users ascended the staircase, the vibrant red color of the Tabourettli Theatre Chair stood out in a highly conspicuous location against the project's green backdrop, thereby creating a visually striking focal point (Figure 19).

Maria Botta's rectilinear Seconda Chair was matched with two projects, *Metamorphosis* and *Spirarchimedean*, which both adopted curvilinear approaches. In response to this challenge, the students placed the chairs within computer rooms and library spaces to hide this contrast (Figure 20).

Figure 20. Seconda Chair by Maria Botta in the Spirarchimedean (left) and Metamorphosis (right) projects (IAED, 2023)

The students' journeys highlighted the importance of considering both form and function when selecting design elements and furniture for environments. While experimenting with forms can spark creative inspiration, ensuring practical usability remains paramount in certain spaces. The students demonstrated a thorough consideration of user needs while recognizing that the intended purpose of the environment determines optimal functionality and user experience.

3.4. From Ruins to Architectural Models

Architectural model making is essential pedagogically. Furthermore, architectural models are an important part of architectural history in enabling communication by different stakeholders, such as professionals, the state, designers, and the public (Altan, 2020; Degirmencioglu & Avci-Hosanli, 2022; Derviş, 2020). For model making, technology can both be a blessing and a threat. In particular, various interior architects' responsibilities and skills, such as drawings, drafting, and architectural model making, are diminishing (Chu, 2003, p.43–44). Another problem is that copying a computer-generated design can threaten interior architects' creativity. Thus, another aim of this studio was for the students to experience crafting within their profession and experience the way that the design process continues and evolves while making architectural models.

Although the students were able to understand the selection of materials and construction detail-solving, they struggled to imagine these in real life scenarios (Hasirci et al., 2022). To help overcome this, they were asked to make two architectural models: one was at 1:50 scale for the accommodation building, the other was at 1:20 scale for the 3-person bedrooms. Both models had to demonstrate selection of materials, colors, and textures. This proved extremely beneficial for understanding how structure and materials interacted, and helped the students to more easily communicate their ideas and designs. The students were asked to conduct a thorough selection of materials for fitting, furnishing, and built-in furniture. Their approaches fell into two groups: (1) uniformity established by the use of few materials (e.g., *Spirarchimedean* and *Metamorphosis*); (2) selection of many materials for variety (e.g., *Layer+reflection*).

During the final weeks of the semester, a two-week workshop was conducted with architect Ekin Güven on making architectural models of the projects. The aim was to create a physical environment in which the students could grasp the challenges of implementing concept and design, and experience structures and forms beyond a virtual screen. Through their architectural models, the students had to demonstrate their use of materials, colors, fabrics and textures, and fittings and furnishings. The aim was to guide students to see if their designs were actually significantly impactful, and determine if their alterations and additions would harm the historic buildings in any way. Making the models also helped the students to control the three-dimensional space and prevent their design from becoming merely two-dimensional through furniture and fitting selection. This aligned the projects with the essence of interior architecture education, namely developing sculptural, structural, and enveloping control of the space.

The students adoped two approaches to making their models: (1) constructing them layer by layer with each floor acting separately but forming the overall structure when joined together (Figure 21); (2) constructing the building's shell first, i.e., the exterior walls, before placing each floor within it, separately from the shell (Figure 23).

The process of building the architectural models revealed certain findings. For example, *Tet+mation* successfully impelemented the spatial application of the tetris modules in the rooms, although only by altering the surface due to the rooms' modularity (Figure 21). However, this approach needed a new perspective for the public areas of the ground and basement floors since the space had lost its modular nature. Here, the students added furniture scale modules. However, while constructing the model, the students realized that this remained a two-dimensional approach to design. They therefore altered the ground-floor ceiling by adding a suspended ceiling and lighting design, which complemented the furniture from above (Figure 21).

Figure 21. 1:50 architectural models of the accommodation building and transitionary structures of the Tet+mation project (Avci & Özder Çakır, 2023b; IAED, 2023).

The *Pix-fash* project students demonstrated two important approaches in constructing their model. First, the use of the original cement tiles in the balconies and the mosaic tiles in the balconies commemorated the building's history as a cultural heritage. However, working with the cubic models demonstrated challenges in that the floor-to-ceiling modularity risked becoming merely two-dimensional. The students therefore altered the transitionary structure to avoid this. Used as a runway for presenting the fashion student users' work, the seats were shaped by smaller cubes within larger ones at the corners of the structures in a three-dimensional approach (Figures 11 & 22). Through this alteration to the runway, the project became one of the few able to offer the transitionary structures as more than just a canopy.

Figure 22. 1:50 architectural model of the transitionary structure of the Pix-fash project (Avci & Özder Çakır, 2023b; IAED, 2023).

Layer+reflection's model-making phase was incredibly successful and led to a realization and thus a final alteration. More specifically, the students recognized that their use of nature-based colors and materials meant that their final design lacked dynamism and color (Figure 23). They therefore painted the large frames in the main circulation and lounge area of the accommodation floor yellow, which reflected the sun and the canary yellow of the corridors of the Paimio Sanatorium. This was a welcome reference to the architectural history of tuberculosis treatments while enlivening the overall design. The model was crafted skillfully down to the smallest detail: materials were shown in the model with the bar counter formed of luminescent glass-bricks and the timber amphitheater for various organizations (Figure 24).

Figure 23. 1:50 architectural model of the accommodation building (ground floor) of the Layer+reflection project (Avci & Özder Çakır, 2023b; IAED, 2023)

Figure 24. Detailed views (left and second left) from the 1:50 architectural model of the Layer+reflection project, showing public spaces of conference hall and gastronomic spaces. Detailed views (right and second right) from the 1:50 architectural model of the Spirarchimedean project, showing the ground floor public spaces (Avci & Özder Çakır, 2023b; IAED, 2023)

The architectural model of the *Spirarchimedean* project communicated the effective structural/sculptural control of space (Figure 25). While making their model, the students realized that the inner partition walls needed greater variety to prevent monotony. This variety would also reference the decomposition of the ammonite shell. The model-making process also helped the students to finalize three forms of partition walls (Figure 25): (1) colored vertical timber struts with visual permeability; (2) horizontal timber elements with visual permeability; and (3) solid, black-painted partition walls to separate and isolate. As expected, these color selections through the model created dense, dark spaces. However, the need for more color after the reveal led the students to add the burgundy color of the transitionary structure. In detailing the interiors, the students skillfully demonstrated the nature of the inner and outer shell references through the gathering areas, which were crafted with the smallest details of the fabrics, textures, cushions, and indoor plants. The finished model confirmed that the students' selection of a limited number of materials effectively created a holistic ambiance within the interiors (Figure 25).

Figure 25. 1:50 architectural model of the accommodation building and the transitionary structure of the Spirarchimedean project. Views of basement and ground floors with a focus on the public spaces (Avci & Özder Çakır, 2023b; IAED, 2023)

The *Metamorphosis* project's model-making process provided similar findings (Figure 26) in that the use of limited materials created a holistic consistency in the overall space. However, the completed model revealed that the partition walls of metallic wire mesh, which formed the curves of the caterpillar, needed more color. Thus, the students added yellow hues to the wire mesh (another reference to the Paimio sanatorium). The students' use of greens and yellows against white surfaces provided another reference to hygienic environments, and thus a nod to the nature of a healthcare building. Before the model-making workshop, the students had been struggling with the transitionary structure in that they had taken the butterfly concept too literally so that, in the 3D computer visualizations, the transitionary structure ended in forms similar to a butterfly. The students were then advised to play with a fabric, and experiment with tension and suspension structures during model making. Consequently, their final design choice evolved into the anticipated abstracted butterfly form.

Figure 26. 1:50 architectural model of the accommodation building and the transitionary structure of the Metamorphosis project. Views of basement and ground floors with a focus on the public spaces (Avci & Özder Çakır, 2023b; IAED, 2023)

The *Fashinnovation* project's students produced a model in which the flow of the fabric in the circulation areas, such as the decorative ceiling and its hidden lighting, had a prominent sculptural effect on the interiors (Figure 27). The students had previously imagined the fabrics purely as décor. However, the architectural model demonstrated the real effect of textile abstraction and revealed its dominant sculptural control of space, which made the stripes and polka dots ineffective as built-in furniture. The model also revealed a dominant control of the courtyard space with the transitionary structure: the cement abstraction of a flowing fabric amongst the existing trees became truly a unique element (Figure 27).

Figure 27. 1:50 architectural model of the accommodation building and the transitionary structure of Fashinnovation project. Detailed views of the transitionary structure with courtyard canopy (left) and ground-floor ceiling detail (right) (Avci & Özder Çakır, 2023b; IAED, 2023)

4. Conclusion and Suggestions

As the course instructors, this studio helped us assess the students' approaches to an architectural and medico-social heritage. The studio had three pedagogical aims: (1) establishing a concept that could reference both form and function; (2) implementation and maintenance of this concept in all interior layers and scales; and (3) designing at a variety of scales (from 1:200 to 1:10, 1:5, and 1:1) from the structural/sculptural aspects to fittings/furnishings to material selection, and involvement in furniture design or selection. The students were guided to develop a holistic understanding of design by recognizing their responsibility for the design of details like handrails, doorknobs, and sinks. While most projects achieved the first two aims, there was still room for growth regarding the third.

The approaches categorized and discussed in Section 3 helped the students question whether the chosen historic building was suitable for designs that were in line with its forms or whether bolder, aesthetically challenging designs would attract more users and thereby be more effective in keeping the building in use and prolonging its life as cultural heritage.

Pedagogically, the students learned to understand the limitations of the historic building and site. They found that the existing walls and modular division of spaces were challenging, even though the instructors allowed the students to ignore the partition walls in the basement and ground floor, while the upper-floor bedrooms required modular division anyway. Furthermore, although the bathroom spaces and their walls were removed, the students did not challenge themselves by changing the existing bathrooms' locations.

The students also struggled continually with not being able to create gallery spaces or alter the sizes and shapes of the openings because they wanted to work with larger masses. On the other hand, they were given more freedom in designing the multipurpose hall and transitionary structures in the courtyard. One pedagogical limitation was that the task conserved the historic building's existing staircase. Consequently, the students were not challenged with designing a sculptural staircase, as would normally be required in an interior architecture studio course.

One of the most beneficial aspects of this project was the transitionary structures. The interior architecture students proved to be very talented in working with different structural systems and structural compositions, which answered the requirements of connections (between the two buildings), and offering private, semi-private and public areas within or beneath the canopy-like structures/designs.

Regarding spatial programming, there are several inferences to note. Although the project consisted of three main venues (accommodation building, multipurpose hall building, and courtyard with transitionary structures), the students considered the ground floor of the accommodation building as the most important space and gave most of their energy towards designing this floor. The repetitive modular nature of the rooms helped them. However, found the two- and three-person bedrooms challenging. In addition, despite being discouraged from doing so, they approached the four-person bedrooms as a symmetrical repetition of the two-person bedrooms.

Overall, this article analyzed the module-based approach in interior architecture education. The course's aim of encouraging the students to develop a holistic design approach was implemented through four interconnected experiential modules. These modules focused, respectively, on developing the concept, implementing it in form, solving detailing challenges, and making architectural models as a tool for communication and experimentation. Another beneficial aspect was the incorporation of two charrettes, one during site analysis and the other during the model-making process. These charrettes allowed the students to discuss their projects with professionals to understand the collaborative nature of the design field and establish relations for their future careers.

Moreover, the selection of the project's site and building was not random; rather, it aimed to address the broader social context of contemporary Turkey, addressing its accommodation crisis after the recent earthquake and the increase in contagious diseases in the country due to uncontrolled immigration during the Syria's civil war. Another layer of the design question was to understand the multidisciplinary nature of design; hence, various kinds of design students were selected as the projects' clients. This helped to convey the collaborative nature of the profession in that the students were brought together with other designers in the charrettes and encouraged to contact and discuss their projects with their designer friends as their selected clients.

As an overall evaluation, one of the challenges for the instructors was that the students did not voluntarily research the history of tuberculosis generally or in Turkey, or the history of Izmir's Yamanlar camp/sanatorium. Indeed, none of the projects offered healthcare services in their program.

Nevertheless, the results of design process demonstrated that the students were able to successfully and easily follow a module-based pedagogical structure and translated their concept inspirations into forms and details without disconnections.

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Author Contribution and Conflict of Interest Declaration Information

1st Author %60, 2nd Author %40 contributed to the article. There is no conflict of interest.

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Analysis of Professional Awareness, Anxiety, Expectation and Career Planning Levels of University Students Who are Taking Landscape Education

Esra ÖZHANCI [1*] Ahmet KOÇ [2]
ORCID 1: 0000-0003-2789-6380, **ORCID 2:** 0000-0001-6932-6680
[1]*Nevşehir Hacı Bektaş Veli University, Faculty of Engineering and Architecture, Department of Landscape Architecture, Nevşehir, Türkiye.*
[2]*Dicle Üniversity, Diyarbakir Technical Sciences Vocational School, Landscape and Ornamental Plants, Diyarbakır, Türkiye.*
***e-mail:** eozhanci@nevsehir.edu.tr

Abstract

This study aims to assess the professional awareness and career planning of undergraduate and associate degree students in two cities with landscape education infrastructure. The study comprised 69 undergraduate and 48 associate degree students from Dicle and Nevşehir Hacı Bektaş Veli Universities during the 2023-2024 academic year, with a survey administered to 117 students through face-to-face interviews. The study results were derived utilizing the T-test, ANOVA test, and Games-Howell test with the IBM SPSS STATISTICS 22.0 software modules. The results were assessed in tables, revealing the choices of undergraduate and associate degree students together with their future aspirations aligned with these interests. Consequently, disparities were identified between the choices of undergraduate and associate degree students regarding employment in their respective fields, pursuing advanced education, enrolling in alternative programs, and seeking employment outside their current disciplines. Differences emerged between undergraduate and associate degree students' professional commitments and future concerns. Primary factors affecting these differences included education content and duration, gender, academic level, and socioeconomic status.

Keywords: Landscape architecture, undergraduate and associate degree students, professional awareness, career planning.

Peyzaj Eğitimi Alan Üniversite Öğrencilerinin Mesleki Farkındalık, Kaygı, Beklenti ve Kariyer Planlama Düzeylerinin Analizi

Öz

Bu çalışmanın amacı peyzaj eğitimi altyapısına sahip iki şehirdeki lisans ve ön lisans öğrencilerinin mesleki farkındalıklarını ve kariyer planlamalarını değerlendirmektir. Çalışmada, 2023-2024 eğitim öğretim yılında Dicle ve Nevşehir Hacı Bektaş Veli Üniversitelerinde eğitimini sürdüren 69 lisans ve 48 ön lisans öğrencisi çalışmanın evrenini oluşturmuş olup, 117 öğrenciyle yüz yüze görüşme yöntemiyle anket çalışması yürütülmüştür. Çalışma sonuçları IBM SPSS STATISTICS 22.0 program modülleri kullanılarak T testi, Anova testi ve Games-Howell testi kullanılarak elde edilmiştir. Sonuçlar tablolar halinde değerlendirilerek lisans ve ön lisans öğrencilerinin tercihleri ve bu tercihler doğrultusunda gelecek planları belirlenmiştir. Buna göre lisans ve ön lisans öğrencilerinin tercihleri arasında iş bulma, bir üst programdan eğitimine devam etmek, farklı bir program daha okuma, kendi programları dışında iş bulma gibi farklılıklar bulunmuştur. Lisans ve ön lisans öğrencilerinin mesleki bağlılıkları ve gelecek endişeleri arasında farklılıklar ortaya çıkmıştır. Bu farklılıkları etkileyen birincil faktörler arasında eğitim içeriği ve süresi, cinsiyet, akademik seviye ve sosyoekonomik statü yer almıştır.

Anahtar Kelimeler: Peyzaj mimarlığı, lisans ve önlisans öğrencisi, mesleki farkındalık, kariyer planlama.

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1. Introductıon

Anxiety influences an individual's career aspirations and job expectations, while occupational awareness is crucial for making informed decisions to achieve these goals, taking into account one's abilities, interests, and the demands of various professions. The vocational decision-making process is influenced by individuals' career aspirations and expectations, which are affected by their worries and their understanding of their interests and competencies. Anxiety can adversely affect decision-making processes, however it can also serve as a motivating factor at optimal levels. Research indicates that individuals have professional hesitation during the career choosing process due to an inability to recognize their own strengths and interests, which subsequently elevates their anxiety levels (Özen & Zorlu, 2024). Career decision-making, particularly during high school and university, demonstrates that vocational awareness and expectation levels are essential in this process (Gönüllüoğlu & Çakmak, 2022). Inadequate occupational knowledge may hinder individuals' ability to make informed decisions, thus resulting in career anxiety. Moreover, the literature often underscores that counseling services can positively influence individuals' decision-making in profession selection (Gerçek, 2018). A significant correlation exists between vocational anxiety and schooling. Education enhances individuals' occupational awareness and equips them with the requisite knowledge, skills, and tools to attain their future job objectives (Blustein et al., 2016).

The 'Sumerians' gradually laid the foundations of education with the emergence of writing in 3200 BC. Education is the primary means for achieving a higher standard of living individually and for the development and progress of a society through learning and teaching through interaction with knowledge. Education is also the way to establish and develop a political and social system that is democratic and compatible with human rights (Özyılmaz, 2013). Education has important power in terms of its individual, social, economic, and political functions. Education systems shape societies according to their cultures and the behaviors they are expected to have (Sarıbaş & Babadağ, 2015).

In addition, it is one of the important elements of education and the education system to comply with new paradigms in the fields of science, technology, and art and to raise individuals who are open to innovations, researchers, inquisitive, and tolerant (Sarıbaş & Babadağ, 2015). A country's economic development closely correlates with the knowledge and skills of its society. This situation necessitates the education of experienced and qualified individuals in every professional field in accordance with today's requirements. The existence of academic institutions at the appropriate level is very important for individuals who choose the profession to have the necessary knowledge to contribute to the health, economic, and social development of society in line with their fields (Hızel & Kumbasar, 2000).

Countries now derive their power not only from their populations, but also from their qualified, well-equipped, educated, and innovative human resources. In the second half of the 20th century, due to the development of technology and infrastructure, the need for qualified, well-equipped, educated, specialized experts in their field and those who developed themselves in parallel with technology increased.

In our nation, we begin with vocational high schools, followed by vocational colleges, and conclude with institutions offering undergraduate education. Vocational colleges are university-affiliated institutions that provide two-year joint degree education in various branches. In vocational colleges, education and training last four semesters; on the one hand, theoretical knowledge is given to students; on the other hand, practical vocational practice training is also provided (Gökdoğan & Sarıgöz, 2012, Ulus et al., 2015, Günay & Özer, 2016).

Similarly, higher education institutions providing undergraduate education are higher education institutions that cover at least eight semesters (4 years) of programs based on secondary education. Formal, open, and external education is provided at the undergraduate level (ÖSYM, 2024). In our country, landscape architecture education at the undergraduate level started in 1971, the name of the department changed to 'Landscape Architecture' after 1977, and the title of 'Landscape Architect' has been given to graduates since 1990 (Gül et al., 2011). After 1990, in order to ensure coordination between contractors and landscape architects, technicians were started to be trained in the landscape and ornamental plants program at the associate degree level in vocational colleges (Karakuş et al., 2014).

The aim of this study is to strengthen the necessary infrastructure of the institutions providing landscape education by evaluating the awareness of the profession and the future thoughts of the students studying in the programs with landscape infrastructure at the undergraduate and associate degree levels.

2. Material and Method

The material of the study consists of 2nd, 3rd, and 4th year students studying at Nevşehir Hacı Bektaş Veli University Faculty of Engineering-Architecture Department of Landscape Architecture and 1st and 2nd year students studying at Diyarbakır Vocational School of Technical Sciences Landscape and Ornamental Plants Programme in the 2023-2024 academic year. Opened in 2010 within the Faculty of Engineering-Architecture, the Department of Landscape Architecture started undergraduate education in 2017. The Landscape and Ornamental Plants Programme started its education and training activities as the 'Landscape and Ornamental Plants Breeding Programme' under the Park and Horticulture Department of Dicle University Diyarbakır Vocational School in the 2008–2009 academic year.

Within the scope of the study, a face-to-face survey based on simple random sampling method was applied to a total of 69 students studying and attending the Department of Landscape Architecture at Nevşehir Hacı Bektaş Veli University, Faculty of Engineering and Architecture, and 48 students studying at Dicle University, Diyarbakır Technical Sciences Vocational School, Landscape and Ornamental Plants Program. It was aimed to analyze the professional awareness, anxiety, expectation and career planning levels of the students through detailed questions directed to them. In the preparation of the student surveys that form the basis of the study, the relevant literature was used (Ateş, 2020; Çevik & Öneren 2019; Gerçek 2018; Gönüllüoğlu & Çakmak 2022; Karadeniz & Özkan 2021), and then original questions were prepared based on the points aimed at providing the expected benefit from this study.

After the demographic characteristics of the participants were determined based on the asked options, a 5-point Likert scale (Strongly disagree, Disagree, Undecided, Agree, Strongly agree) was used in the section where the professional awareness, anxiety, expectation and career planning levels were questioned (Likert, 1932). Undergraduate students were asked 5 questions about demographic characteristics, 5 questions about professional commitment, perspective on courses and education, and 17 questions about career planning, economic expectations and concerns. Associate degree students were asked 5 questions about demographic characteristics, 6 questions about professional commitment, perspective on courses and education, and 19 questions about career planning, economic expectations and concerns.

In the survey study, first-year students were not included in the undergraduate group due to the content of the study and the number of active students in both groups was taken into account. The total student sample size was calculated separately for undergraduate and associate degrees using the formula below to determine the sample size (Baş, 2006). In order to represent the target audience determined in the study (N=84, N=55), the student sample size was calculated as 69 students for undergraduate and 48 students for associate degree with a 95% confidence level and 5% margin of error.

For undergraduate;
N: Universe size (84 active students)
Z: Reliability level (95% reliability = 1.96)
P: Probability of the event occurring (0.5)
Q: Probability of the event not occurring (0.5)
D: Acceptable margin of error (5% margin of error = 0.05)
n: Sample number

$$n = \frac{Z^2 xNxPxQ}{(N-1)xD^2 + Z^2 xPxQ} = 69$$

For associate degree;
N: Universe size (**55** active students)
Z: Reliability level (95% reliability = 1.96)
P: Probability of the event occurring (0.5)
Q: Probability of the event not occurring (0.5)
D: Acceptable margin of error (5% margin of error = 0.05)
n: Sample number

$$n = \frac{Z^2 xNxPxQ}{(N-1)xD^2 + Z^2 xPxQ} = 48$$

The IBM SPSS STATISTICS 22.0 package program was used for statistical analyses. With the Kolmogorov-Smirnov test, it was determined whether the variables were normally distributed, and parametric tests were applied since the data obtained were normally distributed (Tabachnick & Fidell, 2013). The answers to the questions were given in the form of percentage distribution tables, and the T-test and one-way analysis of variance (Anova test) were used to determine whether there was a significant difference between the data. In cases where a difference was determined, the Games-Howell test was applied to reveal between which groups the difference occurred.

3. Research Fındıngs

3.1. Statistical Distributions of Participants with a Bachelor's Degree

Table 1 shows the personal characteristics of the participant students. The monthly family income of 42% of the undergraduate students was between 17.003 and 35.000 TL; 47.8% were senior students; 84.1% of them were female; 53.6% of them were living in a state dormitory; 84.1% of them were not working in any job outside the school; and 8.7% of them were working in a workplace unrelated to their own work.

Table 1. Personal Characteristics of the Participants (Landscape Architecture / Undergraduate)

Demographic Factors	Participants	Total(Frequency)	Total(%)
Classroom	2nd class	27	39,1
	3rd class	9	13,0
	4th grade	33	47,8
Gender	Male	11	15,9
	Woman	58	84,1
Family monthly income range	5.000-17.002 TL	12	17,4
	17.003- 35.000 TL	29	42,0
	35.001-44.000 TL	6	8,7
	44.001-72.000 TL	16	23,2
	72.001-150.000 TL	6	8,7
Place of residence during university education	State dormitory	37	53,6
	Apart	15	21,7
	Home	17	24,6
Part-time employment in any job outside the school	Yes, I've been working in a company	3	4,3
	Yeah, I've been working at a job that's not related to my work.	6	8,7
	Yes, I draw from home	1	1,4
	No, I do not work in any job	58	84,1
	Other	1	1,4

While the majority of the participating undergraduate students stated that they chose the Department of Landscape Architecture consciously, knowing the educational and working conditions (72.4%), similarly, the majority stated that they were happy to study Landscape Architecture (75.3%) and that they liked the profession of Landscape Architecture (87.0%) (Table 2).

Table 2. Distribution of evaluations regarding professional commitment

	Answers				
Evaluations	**Strongly Disagree (%)**	**Disagree (%)**	**Undecided (%)**	**Agree (%)**	**Strongly Agree (%)**
I chose the Department of Landscape Architecture consciously, knowing the education and working conditions.	1,4	13,0	13,0	39,1	33,3
I am happy to study Landscape Architecture.	2,9	5,8	15,9	42,0	33,3
I love the profession of Landscape Architecture.	2,9	1,4	8,7	46,4	40,6

While the participants stated that the courses they took were especially important in terms of preparing them for working life (88.4%), similarly, the majority stated that the faculty members of the department provided the necessary support in terms of professional development (75.3%) (Table 3).

Table 3. Distribution of evaluations regarding the perspective on course and teaching staff

	Answers				
Evaluations	**Strongly Disagree (%)**	**Disagree (%)**	**Undecided (%)**	**Agree (%)**	**Strongly Agree (%)**
I care about the courses I take, especially in terms of the aspects that will prepare me for working life.	2,9	0,0	8,7	37,7	50,7
Department lecturers provide the necessary support for my self-development.	1,4	5,8	17,4	47,8	27,5

While the majority of the participants stated that finding a job after graduation is important (92.7%), similarly, the majority stated that they have decided which landscape architecture practice area they will work in after graduation (68.1%). In addition, while the majority of the students were undecided about whether they had difficulty finding a job after graduation (53.6%), the answers'my job after graduation is not ready' (42.0%) or 'uncertain' (30.4%) also gained weight (Table 4).

The students were undecided about starting their own business after graduation (55.1%), undecided about working abroad after graduation (47.8%), and the majority did not think of working in another profession after graduation (60.8%). The majority of the students stated that they could work in a city separate from their families after graduation (75.3%) (Table 4).

Table 4. Distribution of evaluations regarding career planning after graduation

	Answers				
Evaluations	**Strongly Disagree (%)**	**Disagree (%)**	**Undecided (%)**	**Agree (%)**	**Strongly Agree (%)**
I care about finding a job after graduation.	2,9	1,4	2,9	13,0	79,7
I have decided which landscape architecture application area I will work in after graduation.	5,8	4,3	21,7	24,6	43,5
I will not have difficulty finding a job after graduation.	1,4	5,8	53,6	26,1	13,0
After graduation, my job is ready.	13,0	29,0	30,4	17,4	10,1
I will start my own business after graduation.	7,2	14,5	55,1	11,6	11,6
I plan to work abroad after graduation.	7,2	18,8	47,8	17,4	8,7
I plan to work in another profession after graduation.	30,4	30,4	29,0	8,7	1,4
After graduation, I can work in a city away from my family.	10,1	2,9	11,6	47,8	27,5

While the majority of the participants were undecided about whether the income they would earn from the place where they would work as a landscape architect would be able to support themselves (50,7%), the answer ‘I can make a living’ (40.6%) took second place in this issue. In addition, students were undecided and negative about whether landscape architecture is an ideal profession in terms of finding a job in Turkey (49.3%, 31.8%). According to the participants, it is easy to find a job for a landscape architect who has developed himself or herself (65.2%) (Table 5).

Table 5. Distribution of evaluations regarding socio-economic expectations after graduation

	Answers				
Evaluations	**Strongly Disagree (%)**	**Disagree (%)**	**Undecided (%)**	**Agree (%)**	**Strongly Agree (%)**
The income I will earn from where I work as a landscape architect will support me.	5,8	2,9	50,7	31,9	8,7
Landscape architecture in Turkey is an ideal profession in terms of finding a job.	13,0	18,8	49,3	14,6	4,3
It is easy to find a job for a self-developed landscape architect.	1,4	4,3	29,0	31,9	33,3

It was revealed that the majority of the participant students were afraid of not finding a job (68.0%), did not feel professionally inadequate (56.5%), and did not prefer to study in another department because they would have difficulty finding a job (66.6%). Participant students stated that they were not afraid of business life because they were not social (79.7%) (Table 6).

Table 6. Distribution of evaluations regarding individual concern and professional characteristics

	Answers				
Evaluations	**Strongly Disagree (%)**	**Disagree (%)**	**Undecided (%)**	**Agree (%)**	**Strongly Agree (%)**
I am afraid of not finding a job.	8,7	15,9	17,4	34,8	23,2
I feel professionally inadequate.	18,8	37,7	17,4	18,8	7,2
It would be better for me to study in another department because I would have difficulty finding a job.	30,4	36,2	18,8	8,7	5,8
Business life scares me because I am not a very social person.	46,4	33,3	10,1	5,8	4,3

In addition, it was determined that the majority did not plan to study in another department when they finished school (55.1%) and they were not currently studying in another department with open or distance education (86.9%) (Table 7).

Table 7. Distribution of evaluations regarding career plans outside school

	Answers				
Evaluations	**Strongly Disagree (%)**	**Disagree (%)**	**Undecided (%)**	**Agree (%)**	**Strongly Agree (%)**
I am thinking of studying in another department when I finish school.	23,2	31,9	26,1	7,2	11,6
I am currently studying in another department with open or distance education.	53,6	33,3	0,0	4,3	8,7

3.2. Statistical Distributions of Participants with Associate Degrees

Table 8 shows the personal characteristics of the participant students. While the monthly family income of 37.5% of the undergraduate students was between 5.000 and 17.002 TL; 52.1% of them were 2nd class students; 54.2% were male;75.0% of them stayed at home; 64.6% of them did not work in any job outside the school; and 18.8% of them worked in the public sector.

Table 8. Personal characteristics of the participants (landscape and ornamental plants programme / associate degree)

Demographic Factors	Participants	Total(Frequency)	Total(%)
Classroom	1st class	23	47,9
	2nd class	25	52,1
Gender	Male	26	54,2
	Woman	22	45,8
Family monthly income range	5.000-17.002 TL	18	37,5
	17.003–35.000 TL	12	25,0
	35.001-44.000 TL	10	20,8
	44.001-72.000 TL	5	10,4
	72.001-150.000 TL	3	6,3
Place of residence during university education	State dormitory	9	18,8
	Apart	3	6,3
	Home	36	75,0

Part-time employment in any job outside the school is an option.	Yes, I've been working for a company.	4	8,3
	Indeed, I've been working at a job unrelated to my field of expertise.	4	8,3
	No, I do not work in any job.	31	64,6
	Other	9	18,8

Participating associate degree students did not show a predominant tendency in terms of whether they consciously preferred the Landscape and Ornamental Plants Program, knowing the education and working conditions, and close answers were received. In addition, the majority stated that they were happy to study landscape technician (58.4%) and that they liked the profession of landscape technician (64.6%) (Table 9).

Table 9. Distribution of evaluations regarding professional commitment

	Answers				
Evaluations	**Strongly Disagree (%)**	**Disagree (%)**	**Undecided (%)**	**Agree (%)**	**Strongly Agree (%)**
I chose the Landscape and Ornamental Plants Program consciously, knowing the education and working conditions.	20,8	18,8	12,5	22,9	25,0
I am happy to study landscape technology.	8,3	6,3	27,1	29,2	29,2
I love the profession of landscape technician.	8,3	6,3	20,8	31,3	33,3

While the participants stated that the courses they took were especially important in terms of preparing them for working life (77.1%), 56.2% stated that the program faculty members provided the necessary support in terms of professional development. In addition, 79.1% of the students think that the technical drawing courses will be useful in practical work in the future (Table 10).

Table 10. Distribution of evaluations regarding the perspective on course and teaching staff

	Answers				
Evaluations	**Strongly Disagree (%)**	**Disagree (%)**	**Undecided (%)**	**Agree (%)**	**Strongly Agree (%)**
I care about the courses I take, especially in terms of the aspects that will prepare me for working life.	12,5	6,3	4,2	37,5	39,6
I think that technical drawing courses will be useful for practical work in the future.	4,2	4,2	12,5	20,8	58,3
Program lecturers provide the necessary support for me to improve myself.	6,3	20,8	16,7	35,4	20,8

While the participants stated that finding a job after graduation was important to a large extent (66.7%), there was no dominant tendency to decide which field of practice to work in after graduation. In addition, 39.6% of respondents were undecided about whether they would have difficulty finding a job after graduation, and the responses "my job after graduation is not ready" (39.6%) and "uncertain" (35.4%) also gained weight in Table 11.

37.5% of the students were undecided about starting their own business after graduation, while 35.4% expressed a negative opinion. We determined that they were undecided and negative (60.8%) about working abroad after graduation, with no predominant tendency to pursue another profession. Table 11 revealed that the students had negative and undecided feelings (64.6%) about working in a city far from their family after graduation.

Table 11. Distribution of Evaluations Regarding Career Planning After Graduation

	Answers				
Evaluations	**Strongly Disagree (%)**	**Disagree (%)**	**Undecided (%)**	**Agree (%)**	**Strongly Agree (%)**
I care about finding a job after graduation.	14,6	8,3	10,4	25,0	41,7
I have decided which landscape architecture application area I will work in after graduation.	10,4	8,3	35,4	22,9	22,9
I will not have difficulty finding a job after graduation.	14,6	16,7	39,6	16,7	12,5
After graduation, my job is ready.	20,8	18,8	35,4	10,4	14,6
I will start my own business after graduation.	12,5	22,9	37,5	12,5	14,6
I plan to work abroad after graduation.	25,0	25,0	20,8	8,3	20,8
I plan to work in another profession after graduation.	8,3	14,6	41,7	18,8	16,7
After graduation, I can work in a city away from my family.	25,0	20,8	18,8	12,5	22,9

While the participants were partially positive about whether the income they will earn from the place where they will work as a landscape technician will be able to support themselves (43,8%), the ‘I am undecided’ response (31,3%) took second place in this issue. In addition, students expressed a positive opinion about whether landscape technician is an ideal profession in terms of finding a job in Turkey (41.7%). According to 50.1% of the participants, it is easy to find a job for a landscape technician who has developed himself or herself (Table 12).

Table 12. Distribution of evaluations regarding socio-economic expectations after graduation

	Answers				
Evaluations	**Strongly Disagree (%)**	**Disagree (%)**	**Undecided (%)**	**Agree (%)**	**Strongly Agree (%)**
The income I will earn from where I work as a landscape technician will support me.	14,6	10,4	31,3	14,6	29,2
Landscape technician in Turkey is an ideal profession.	18,8	10,4	29,2	22,9	18,8
It is easy to find a job for a self-improved landscape technician.	2,1	25,0	22,9	31,3	18,8

The study revealed that 64.6 percent of the participating students were afraid of not finding a job, 37.5% felt professionally inadequate, and 45.8% were undecided about the idea of studying in a different department due to the difficulty of finding employment. In addition, the participant students stated that they were not afraid of business life (50.1%) because they were not social people (Table 13).

Table 13. Distribution of evaluations regarding individual concern and professional characteristics

	Answers				
Evaluations	**Strongly Disagree (%)**	**Disagree (%)**	**Undecided (%)**	**Agree (%)**	**Strongly Agree (%)**
I am afraid of not finding a job.	10,4	4,2	20,8	31,3	33,3
I feel professionally inadequate.	10,4	22,9	29,2	22,9	14,6
It would be better for me to study in another department because I would have difficulty finding a job.	14,6	14,6	45,8	12,5	12,5
Business life scares me because I am not a very social person.	18,8	31,3	29,2	14,6	6,3

In addition, while 37.5% of the participants were undecided about studying in another department after finishing school, it was determined that they are not currently studying in another department with open or distance education (66.6%) (Table 14).

Table 14. Distribution of evaluations regarding career plans outside school

	Answers				
Evaluations	**Strongly Disagree (%)**	**Disagree (%)**	**Undecided (%)**	**Agree (%)**	**Strongly Agree (%)**
I am thinking of studying in another department when I finish school.	12,5	22,9	37,5	16,7	10,4
I am currently pursuing an open or distance education degree in another department.	33,3	33,3	0,0	22,9	10,4

While the students were positive (47.9%) or undecided (27.1%) about taking the Vertical Transfer Examination after the associate degree, the undecided (35.4%) and positive opinions (35.4%) were similar in their desire to study in the Department of Landscape Architecture after the Vertical Transfer Examination (Table 15).

Table 15. Distribution of evaluations regarding the vertical transfer examination

	Answer				
Evaluations	**Strongly Disagree (%)**	**Disagree (%)**	**Undecided (%)**	**Agree (%)**	**Strongly Agree (%)**
I'm considering taking the vertical transfer exam after completing my associate degree.	12,5	12,5	27,1	25,0	22,9
After the vertical transfer exam, I'd like to study landscape architecture.	18,8	10,4	35,4	12,5	22,9

3.3. T-test and One-Way Analysis of Variance (Anova Test)

T-test and One-Way Variance Analysis (Anova Test) were used to determine whether there was a significant difference between the answers given to the questions and individual characteristics, and significant results are given in this section. Table 16 shows statistically significant t-test results regarding answers and gender differences for undergraduate students.

Table 16. t-test Results regarding answers and gender differentiation for undergraduate students

			N	M	df	Sd	t	p
1	Gender	Female	58	3,81	67	1,206	-2,474	,016
		Male	11	4,73		,467		
2	Gender	Female	58	3,28	67	,768	-3,935	,000
		Male	11	4,27		,786		
3	Gender	Female	58	2,60	67	1,075	-3,990	,000
		Male	11	4,00		1,000		
4	Gender	Female	58	2,86	67	,868	-4,094	,000
		Male	11	4,09		1,136		
5	Gender	Female	58	3,24	67	,885	-2,315	,024
		Male	11	3,91		,831		
6	Gender	Female	58	2,71	67	1,060	-1,459	,014
		Male	11	3,18		,405		
7	Gender	Female	58	3,79	67	,969	-2,454	,006
		Male	11	4,55		,688		
8	Gender	Female	58	3,66	67	1,222	2,822	,006
		Male	11	2,55		1,036		
9	Gender	Female	58	2,03	67	1,123	2,752	,009
		Male	11	1,09		,302		

In line with the T-test results between gender factors and undergraduate student evaluations,

1. In terms of deciding which landscape architecture practice area to work in after graduation, males' scores (mean = 4,73, SD = 0,467) are higher than females' scores (mean = 3,81, SD = 1,206) (t (68) = 2,474, p<0,05).
2. The scores of males (mean = 4,27, SD = 0,786) were higher than those of females (mean = 3,28, SD = 0,768) in terms of thinking that they would not have difficulty finding a job after graduation (t (68) = 3,935, p<0,05).
3. Males (mean = 4,00, SD = 1,000), who stated that their job is ready after graduation, scored higher than females (mean = 2,60, SD = 1,075) (t (68) = 3,990, p<0,05).
4. Men who stated that they would start their own business after graduation had higher scores than women (mean = 2,86, SD = 0,868) (t (68) = 4,094, p<0,05).
5. The scores of men who think that they will be able to live on the income they will earn from the place where they will work as a landscape architect (mean = 3,91, SD = 0,831) are higher than those of women (mean = 3,24, SD = 0,885) (t (68) = 2,315, p<0,05).
6. The scores of men (mean = 3,18, SD = 0,405) who stated that landscape architecture is an ideal profession in terms of finding a job in Turkey were higher than those of women (mean = 2,71, SD = 1,06) (t (68) = 1,459, p<0,05).
7. Men (mean=4,55, SD=0,688) who think it is easy to find a job for a self-developed landscape architect have higher scores than women (mean=3,79, SD=0,769) (t(68)=-2,454, p<0,05).
8. Women who think they are afraid of not finding a job (mean = 3,66, SD = 1,222) have higher scores than men (mean = 2,55, SD = 1,036) (t (68) = 2,822, p<0,05).
9. The scores of women (mean = 2,03, SD = 1,123), who think that work life scares me because I am not a very social person, are higher than those of men (mean = 1,09, SD = 0,302) (t (68) = 2,752, p<0,05).

Table 17 shows the statistically significant One-Way Variance Analysis (Anova Test) results for undergraduate students regarding the responses and the differences in terms of the class factor.

Table 17. Anova Test results for undergraduate students regarding the responses and the differentiation in terms of the class factor

ANOVA						
		Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
1	Between Groups	16,614	2	7,565	7,190	,001
	Within Groups	76,256	66	60,377		
	Total	92,870	68			
2	Between Groups	11,140	2	5,570	6,495	,003
	Within Groups	56,599	66	,858		
	Total	67,739	68			
3	Between Groups	7,565	2	3,782	4,135	,020
	Within Groups	60,377	66	,915		
		67,942	68			

According to the findings of the analysis of variance and Games-Howell test between the class factor and undergraduate students' evaluations,

1. 4th graders are more decisive than 2nd graders in deciding which landscape architecture practice area they will work in after graduation [$F(2-66)=7,190$, $p<0.05$].
2. The 2nd graders were more negative than the upper grades about landscape architecture being an ideal profession in terms of finding a job in Turkey [$F(2-66)=6,495$, $p<0.05$].
3. It was found that 4th graders were happier than 2nd graders [$F(2-66)=4,135$, $p<0.05$] because they studied landscape architecture.

Table 18 shows the statistically significant One-Way Variance Analysis (Anova Test) results regarding the responses and income factor differences for undergraduate students.

Table 18. Anova test results regarding the responses and income factor differentiation for undergraduate students

ANOVA						
		Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
1	Between Groups	14,984	4	3,746	3,038	,023
	Within Groups	78,929	64	1,233		
	Total	93,913	68			
2	Between Groups	9,500	4	2,375	2,610	,044
	Within Groups	58,239	64	,910		
	Total	67,739	68			
3	Between Groups	11,437	4	2,859	2,628	,042
	Within Groups	69,636	64	1,088		
		81,072	68			

In line with the results of variance analysis and the Games-Howell test between the income factor and evaluations for undergraduate students,

1. Among the two income groups that constitute the majority, the 17003-35000 TL income group is more hopeless about having a job after graduation than the 44001-72000 TL income group [$F(2-66)=3,038$, $p<0.05$].

2. The 17003-35000 TL income group was more negative than the 44001-72000 TL income group about landscape architecture being an ideal profession in terms of finding a job in Turkey [F(2-66)=2,610, p<0.05].
3. It was revealed that those who think that business life scares me because I am not a very social person are more in the 17003-35000 TL income group than those in the 72001-150000 TL income group [F(2-66)=2,628, p<0.05].

Table 19 shows the statistically significant t-test results for associate degree students regarding responses and gender differences.

Table 19. t-test Results for associate degree students regarding responses and gender differentiation

		N	M	df	Sd	t	p
Gender	Female	26	3,04	47	1,216	-0,962	,011
	Male	22	3,91		1,065		

In line with the T-test results between gender factors and evaluations for associate degree students,

- It was found that the scores of males (mean = 3,91, SD = 0,467) who thought that the lecturers provided the necessary support for me to improve myself were higher (t (47) = -0,962, p<0,05) than females (mean = 3,04, SD = 1,216).

4. Discussion and Conclusion

We can say that individual ideals, economic conditions, role models, and coincidence influence career choices in our country, particularly in undergraduate and associate degree programs (Tuncer, 2011). Professional prestige and high income play a significant role in choosing a profession. Unconsciously chosen professions and individuals continuing their education in positions they do not want cause the emergence of unhappy people (Karadeniz & Özkan 2021). In other words, while the individual is successful, productive, and happy in the field he or she chooses as a profession in line with his or her abilities, interests, and wishes, he or she becomes unsuccessful, inefficient, and unhappy when he or she makes a random choice without considering his or her interests and abilities (Sarıkaya & Khorshid, 2009). This situation causes a decrease in quality. In this study, the majority of both the participant undergraduate students and associate degree students stated that they chose their department or program consciously, knowing the education and working conditions, and that they were happy to study and loved their profession. Since love of profession is one of the basic building blocks of education, it facilitates the transfer of knowledge, especially in education and training, and increases its quality (Kayadibi, 2002).

In assessing this study for professional awareness and commitment, 72.4% of undergraduate students deliberately selected the landscape architecture department. This indicates that their professional awareness is elevated. 87% of undergraduate students indicated that they liked their profession is a significant element that enhances dedication to school and work determination. The rate of deliberate selection among associate degree students is diminished, and the replies are more uniformly distributed. This indicates that the selection of profession at the associate degree level may be influenced more by economic factors and chance circumstances. Nonetheless 64.6% of associate degree students stated that they loved their profession. While vocational awareness and dedication are more pronounced among undergraduate students, the passion and devotion of associate degree students towards their career are also significant. This disparity may be linked to the extended and more comprehensive nature of undergraduate education (Blustein et al., 2016; Sarıbaş & Babadağ, 2015).

Regarding career preparation, 92.7% of undergraduate students deem it essential to get employment post-graduation. 68.1% have determined their prospective career field post-graduation. Nevertheless, the majority indicated that their post-graduation employment prospects were either unprepared or ambiguous. Although the majority of students do not want to pursue a different profession (60.8%), the uncertainty over employment abroad (47.8%) is significant. The percentage of associate degree students who deem job acquisition crucial is lower (66.7%), however this still a substantial majority. The level of uncertainty regarding professional objectives post-graduation is elevated at 39.6%. There are an increasing number of adverse reactions to working overseas or seeking a job in a different field. The specificity of career planning goals among undergraduate students may stem from the detailed and comprehensive character of their education. The ambiguity experienced by associate degree students can be ascribed to inadequate knowledge and a deficiency of direction resulting from short-term education (Türkoğlu & Acar, 2019). Regarding economic expectations and apprehensions, the perception that landscape architecture is not an optimal profession for job acquisition in Turkey is prominent (31.8%). Nonetheless, 65.2% of students believe that self-improving landscape architects can easily secure employment. 68% of students express apprehension regarding job acquisition. Students an associate Degree: A more favorable perspective indicated that the landscape technician profession is more advantageous for employment opportunities in Turkey (41.7%). Fifty percent of respondents believe that self-developed technicians can easily secure employment. The apprehension over job acquisition has reached a notable level of 64.6% among associate degree students. Both groups express apprehension over employment; however, students with associate degrees appear to exhibit greater optimism toward economic issues. This is elucidated by the reality that associate degree programs are pragmatic and directly respond to job market demands (Yenilmez & Akman, 2023; Çevik & Öneren, 2019).

As for gender-related differences, male undergraduate students provided more favorable comments than their female counterparts about post-graduation employment, entrepreneurship, and the perception of landscape architecture as an optimal profession. Male associate degree students assessed the help received from their instructors more favorably than female students. Gender disparities indicate that male students have a more optimistic outlook regarding economic prospects and self-assurance. Women’s heightened caution and anxiety may stem from societal expectations and possible gender discrimination in the business. Socioeconomic status and income levels directly influence students' perceptions of their careers and future aspirations. Students in advanced grades or with elevated income levels may perceive an increase in opportunities (Işık & Bahat, 2021; Ateş, 2020; Çinko et al., 2017).

Fourth-year undergraduate students appear to exhibit greater professional commitment and optimism over post-graduation prospects compared to second-year students. This indicates that professional awareness and motivation escalate with the length of education. Students from the high-income bracket assessed the profession more favorably and appeared more optimistic about securing employment post-graduation. The curriculum of educational programs significantly influences students' dedication to their career and their self-assurance in securing employment. Applied and vocational education appears to be particularly effective for associate degree students (Korkmaz & Kılci, 2024; Korkmaz, 2023). Undergraduate education programs are crucial for strengthening students' professional knowledge and competencies. The majority of students believe that the courses adequately prepare them for professional life. Survey results indicated that associate degree students consider technical courses and instructor support essential for their professional development. Consequently, disparities emerge between the professional dedication and future concerns of undergraduate and associate degree students. The primary factors influencing these disparities include educational content and duration, gender, academic level, and socioeconomic status. Enhancing vocational advising and support programs can alleviate students' worries and better equip them for the work market.

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The article complies with national and international research and publication ethics. Ethics Committee approval in the study, Ethics Committee of the University of Dıcle dated 24.05.2024 and with the decision no:14.

Author Contribution and Conflict of Interest Declaration Information

All authors contributed equally to the article. There is no conflict of interest

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