...::KENT AKADEMİSİ | URBAN ACADEMY

Volume: 16 Issue: 3 - 2023 | Cilt: 16 Sayı 3 - 2023

ARTICLE INFO | MAKALE KÜNYESİ
Research Article | Araştırma Makalesi
Submission Date | Gönderilme Tarihi: 08.01.2023
Admission Date | Kabul Tarihi: 25.03.2023

CITATION INFO | ATIF KÜNYESİ
Mutlu, E. & Yılmaz, H. (2023). Efficient Use Of Squares in Winter Cities with ENVI-met Analysis and the Effects On Thermal Comfort, *Kent Akademisi Dergisi*, *16*(3):1580-1596. https://doi.org/10.35674/kent.1231067

Efficient Use Of Squares in Winter Cities with ENVI-met Analysis and the Effects On Thermal Comfort

Kış Kentlerinde Meydanların Etkin Kullanımı ve Termal Konfora Etkilerinin ENVI-met ile Araştırılması

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ABSTRACT

With the Covid-19 epidemic, open landscape areas have become more preferred instead of indoor spaces in cities. Outdoor use is related to whether the spaces are comfortable or not. The more comfortable the outdoor spaces are in terms of thermals, the more intensive its use. Erzurum city is a winter city and is in Dsb (winters are cold and rainy, summers are dry and hot) climate class. It has a very hot and dry climate in summer due to its high altitude, and a very harsh and cold climate in winter. Havuzbaşi City Square, which is one of the most used squares in Erzurum city center, was chosen as the working area and 4 alternatives were prepared with portable landscape designs. Most of the studies are focused on a single season, and both winter (January 2017) and summer (July 2017) seasons were evaluated in this study. In this context, ENVI-met analysis was made for the current situation and 4 different scenarios for both summer and winter months. In the climate analyzes made, air temperature, relative humidity, wind speed, Mean Radiant Temperature (MRT), Predicted Mean Vote (PMV) and Physiological Equivalent Temperature (PET) indexes were evaluated for 14:00, the hottest hour of the day. As a result of the evaluations, It has been revealed that city squares should not only have hard floors, but also green areas and other landscape design elements should be included in the squares. In addition, Alternative 4, which is a collective landscape design area in the middle of the square, gave the best results, increasing the average PET value to 0,3 ℃ for January and reducing 2,8 ℃ for July. As a result, thermal comfort increases as green space and landscape design elements are used in today's city squares.

Keywords: Urban Square, Thermal Comfort, ENVI-met, Erzurum, Winter City

ÖZ

Kentlerde iç mekânlar yerine açık peyzaj alanları Covid-19 salgını ile daha çok tercih edilir olmuştur. Dış mekân kullanımı mekânların konforlu olup olamaması ile alakalıdır. Dış mekânlar termal açıdan ne kadar konforlu ise kullanımı o kadar yoğun olmaktadır. Erzurum kenti bir kış kenti olup Dsb (kışlar soğuk ve yağışlı, yazlar kurak ve sıcak) iklim sınıfında yer almaktadır. Yaz aylarında yüksek rakımından dolayı oldukça sıcak ve kurak, kış aylarında oldukça sert ve soğuk bir iklime sahiptir. Erzurum kent merkezinde en çok kullanılan meydanlardan birisi olan Havuzbaşı Kent Meydanı çalışma alanı olarak seçilmiş ve portatif peyzaj tasarımları ile 4 adet alternatif hazırlanmıştır. Yapılan çalışmaların çoğu tek mevsim odaklı olup, bu araştırmada hem kış (Ocak 2017) hem de yaz mevsimi (Temmuz 2017) değerlendirmeye alınmıştır. Bu kapsamda; mevcut durum ve 4 farklı senaryonun hem yaz hem de kış ayları için ENVI-met analizi yapılmıştır. Yapılan iklim analizlerinde hava sıcaklığı, bağıl nem, rüzgâr hızı, Yansıyan sıcaklık (MRT), Tahmini Ortalama Oy (PMV) ve Fizyolojik Eşdeğer Sıcaklık (PET) indeksleri günün en sıcak saati olan 14:00 için değerlendirmeye alınmıştır. Değerlendirmeler sonucunda; kent meydanlarında sadece sert zemin olmaması,

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Footnote: This study was produced from the thesis titled “Landscape design scenarious of havuzbaşi square in Erzurum”, numbered 434880.

meydanlarda yeşil alanların ve diğer peyzaj tasarım öğelerinin de yer alması gerektiği ortaya çıkmıştır. Ayrıca üretilen senaryolardan meydan ortasında toplu bir peyzaj tasarım alanı olan Alternatif 4 en iyi sonucu vererek; ocak ayı PET ortalamasını 0,3 ℃ arttırmış, temmuz ayı için de 2,8 ℃ ortalama PET değerini düşürmüştür. Sonuç olarak günümüz kent meydanlarında yeşil alan ve peyzaj tasarım öğeleri kullanıldıkça termal konfor artış göstermektedir.

Anahtar Kelimeler: Kent Meydanı, Termal Konfor, ENVI-met, Erzurum, Kış Kenti

1. INTRODUCTION:

Cities and their indoor and outdoor microclimates affect the thermal comfort of people (Martinelli and Matzarakis 2017). After it has been found that the outdoor thermal comfort has a strong correlation with health, studies in this field have increased (Andreou 2013). Especially the climatic environment created by urban landscape areas; It greatly affects human thermal comfort, air quality and energy efficiency (Eliasson 2000; Xiao and Yuizono 2020). This case emerges more clearly especially in settlements with extreme climate conditions. For these reasons, there have been studies related to the thermal comfort of cities in different fields. The city climate models depend on the interaction of many factors (Ali-Toudert and Mayer 2006, Tablada et al. 2009, Krüger et al. 2011, Berkovic et al. 2012; Yilmaz et al. 2015; Acero and Herranz-Pascual 2015). Some of these studies are on urban canyons (Emmanuel et al. 2007; Andreou 2013; Chatzidimitriou and Yannas 2017), the effect of the shadow areas, the effect of green space and plants (Lindberg et al. 2016; Taleghani et al. 2014; Martinelli and Matzarakis 2017; Teixeira 2021), the effect of hard flooring (Yilmaz et al. 2016), city forms (Middle et al. 2014), street and building orientations (Yilmaz et al. 2017).

Urban open spaces are an important part of urban life (Mannavi and Rajasekar 2022). Green areas and plants; It is one of the most important areas affecting the quality of human life among urban open spaces (Teixeira 2021). Outdoor thermal comfort areas play a major role in the outdoor use of urban residents (Nikolopoulou and Lykoudis 2007).

In the city square and courtyards, studies typically have been made in hot climate regions (Chatzidimitriou and Yannas 2016). A better method of enhancing day and night temperatures is to raise the amount of vegetation that provides shadowing and evapotranspiration through cooling (Middel et al. 2014; Gober et al. 2012; Middel et al. 2012; Middel et al. 2012a; Shashua-Bar et al. 2009). Most of the studies and research are for hot climates; The effect of the design layers focuses on the thermal environment and pedestrian thermal feel (Tseliou et al 2022; Chatzidimitriou and Yannas 2016). In landscape researches that regulate thermal comfort for city squares; cooling effects of plants according to leaf area density (Spangenberg et al 2008), urban trees, landscape design elements (Lenzholzer 2010; Lenzholzer 2012, Xiao and Yuizono 2020), urban green infrastructure or plant cover in squares (Chatzidimitriou and Yannas 2016). Although many studies on urban squares are for the summer and warm months (Robitu et al 2006; Chatzidimitriou and Yannas 2015; Linden et al 2016; Zölch et al 2019; Acero et al 2022), they are for the winter months (Huang and Peng 2020, Chen et al. al 2015, Liu et al 2016) are also included. For this reason, it has been deemed necessary to conduct a research on urban squares in Türkiye, which are generally hard ground and where plant use is weak. In addition, the study is contrary to general research; It is planned for the city of Erzurum, which is located in the Dsb climate zone, which has the characteristics of a winter city according to Köppen Geiger climate classification.

The aim of the study; The Havuzbasi Urban Square, which is completely covered with hard floors in the present, is suggested to have designs that will changeable every season (winter, autumn, summer, spring) and bring mobility to the area. The proposed designs were evaluated in the ENVI-met program for summer and winter months, and how the microclimate of the area was affected according to the current situation. As a result, air temperature, Physiological Equivalent Temperature (PET) and Predicted Mean Vote (PMV) maps were evaluated for current situation and alternatives.

2. MATERIAL AND METHOD

2.1 Material

The urban square of Havuzbasi located in Erzurum City Center (altitude: 1850m), at the entrance to the West of the city, has been preferred as the workspace. Workspace is 7900 m^2, while 1300 m^2 is (16%) in green space. There is a vehicle road to the north and west of the square, a green area to the south, business centers to the east. The location map of the working area is given in Figure 1.

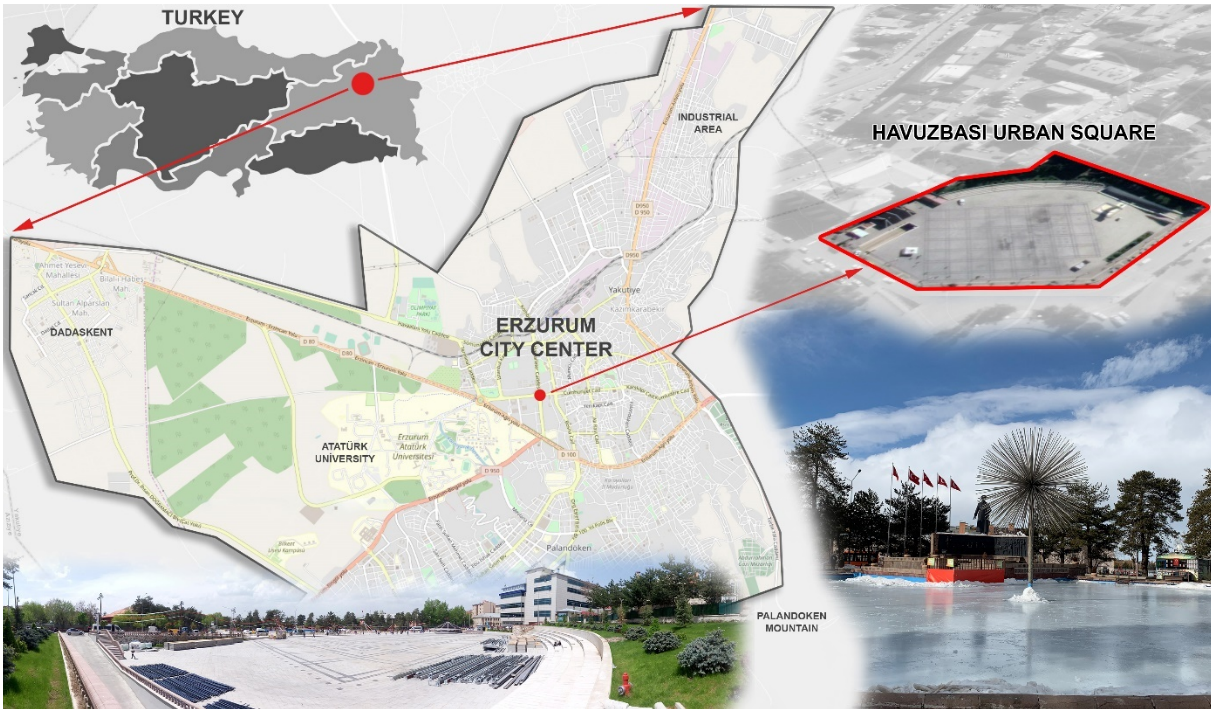

Figure 1. Location map of Havuzbasi Urban Square

2.2 Method

The current state of the study area has been considered, developing 4 different modular landscaping alternatives according to the lacking elements.

In Alternative 1 (Green Square), green spaces and seating units are designed on the rails system that can be adapted to the field. In this alternative, the shade trees and bushes have been included.

In Alternative 2 (Unplanted Area); shaded areas are created by recommending ice sculptures and walls during the winter, and panel walls which will replace them in the summer months.

In Alternative 3 (Carpet Pattern), a design was created which can be implemented with railing systems, enhancing the aesthetic value of the square while increasing the green space. In this alternative, the percentage of green space has been increased and a carpet pattern has been created with the flowers.

In Alternative 4 (Plant Maze), it was planned to construct a plantation maze consisting of plant boxes and groups of shrubs. The design of the alternatives is given in Figure 2.

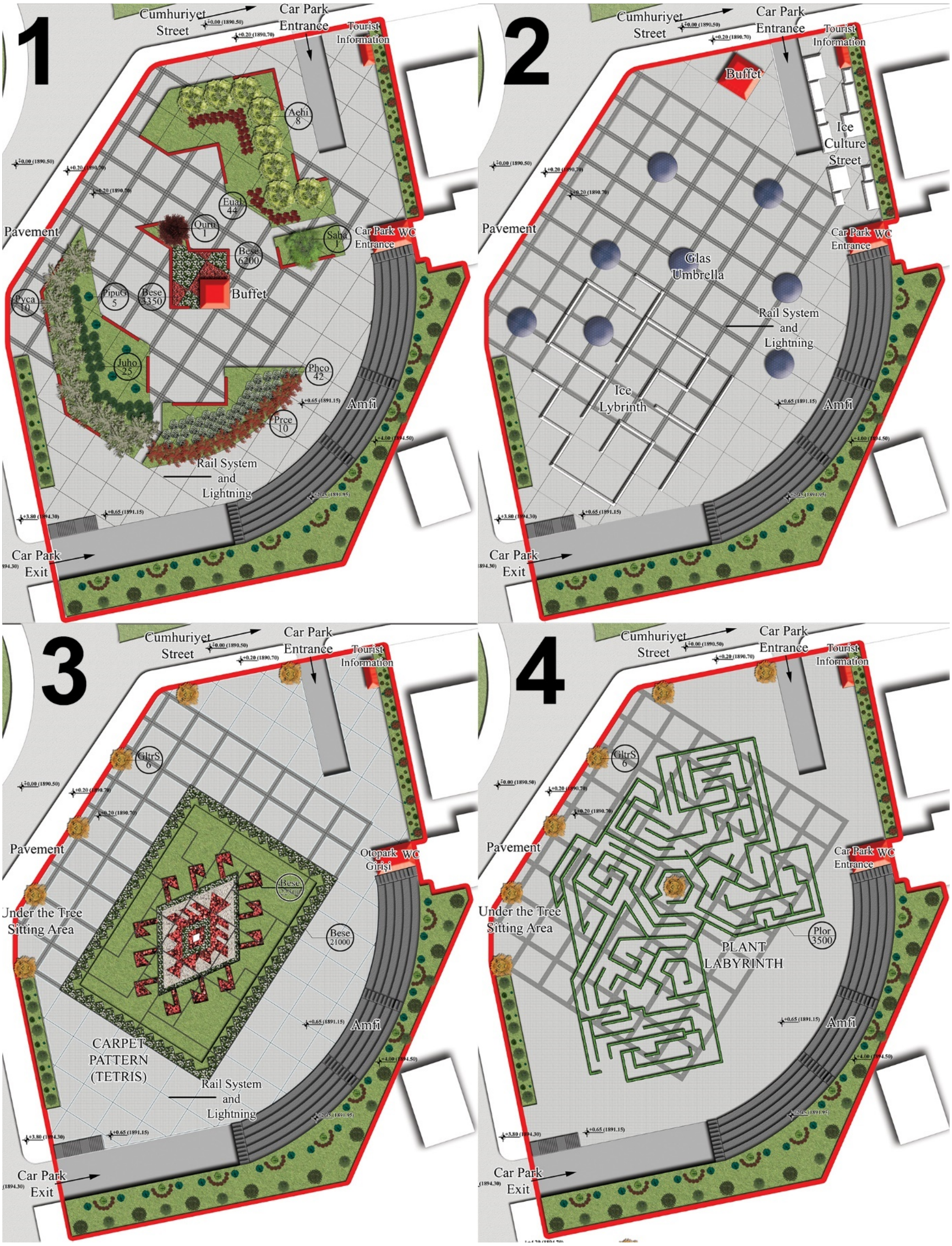

Figure 2. Alternative landscape projects for Havuzbasi Urban Square

The hourly measurements spanned for January and July in 2017. The monthly average measurements was taken and evaluations have been conducted on ENVI-met 4.3 (Bruse 2018) software. In the first stage, the current situation and 4 alternatives of the square were created in the grid system of 90 * 90 * 30 units in the software of 4.3 ENVI-met in its SPACES module. In this module, each grid has been arranged as 1m x 1m and the north direction has been rotated for -11 degrees. Detailed information on the model can be found in Table 1.

Table 1. Information about ENVI-met models

Location	Havuzbasi Urban Square		
Climate type	Mountain Ecosystem		
Simulation Period	Monthly values for January and July		
Total Simulation Duration	36 h for 1 alternative		
Spatial Resolution	1m x 1m x 1m		
Domain Size	90 m x 90 m x 30 m		
Model Rotation	-11°		
	01.2017	**07.2017**	
Basic Meteorological Input	Unshaded	Unshaded	
Wind Speed (m/s)	0,2	0,6	
Wind Direction (°)	(337,5°)	ESE (112,5°)	
Air Temperature for 24h	+	+	
Relative Humidity for 24h	+	+	
Lowest Air Temperature (°C) / h	-9,6 °C / 05:00	16,1 °C / 05:00	
Highest Air Temperature (°C) / h	-4,9 °C / 13:00	29,0 °C / 15:00	
Lowest Humidity	%71 / 13:00	%23 / 16:00	
Highest Humidity	%83 / 06:00	%58 / 06:00	
Sky Condition	Clear	Clear	
Vegetation Information of Proposal Situation			
Type	6 conifer tree	8 decidious tree	45 shrub
Vegetation Information of Alternatives			
Alternative 1	6 number conifer tree	39 decidious tree	45 shrub
Alternative 2	6 number conifer tree	8 decidious tree	45 shrub
Alternative 3	6 number conifer tree	39 decidious tree	500 flower
Alternative 4	6 conifer tree	44 decidious tree	420 shrub

24-hour analyses were conducted on the current situation and created alternatives of the urban square in Config Wizard and ENVI-met (64 bit) modules. And lastly, the analysis results were projected on maps in Leonardo module. Analyses were conducted for 2 pm. That is because the hour in which the solid grounds and green spaces have the highest radioactivity and heat distribution is between 2 pm and 3 pm.

In the analysis of ENVI-met version 4.3 data, Predicted Mean Vote (PMV) and Physiological Equivalent Temperature (PET) outputs are also included to evaluate outdoor thermal comfort. PMV values are an analysis that determine outdoor thermal comfort (Van Craenendonck et al., 2018). To create PMV and PET values; the relative humidity (%), the air temperature (℃), the mean radiant temperature (Tmrt), the structures in the area and the topography. In addition, some preliminary coefficients (height, weight, age, metabolic rate, gender, clothing coefficient) related to the human body are included in this evaluation. After all these values are determined, PMV values are generated in the ENVI-met package program according to the methods of Fangers (1972). When PMV results were evaluated, Matzarakis et al. (1999) have determined the outdoor thermal comfort according to the range of values determined. Thermal Index ranges for PMV and PET are given in Table 2.

Table 2. Thermal Index ranges for PMV and PET (**Matzarakis and Mayer 1996**, Matzarakis et al. 1999)

PMV (°C)	*PET (°C)*	**Thermal perception**	**Grade of physiological stress**	**Color Range**
< -3,5	< 4,0 °C	Very cold	Extreme cold stress	
-3,5 / -2,5	4,0 °C / 8,0 °C	Cold	Strong cold stress	
-2,5 / -1,5	8,0 °C / 13,0 °C	Cool	Moderate cold stress	
-1,5 / -0,5	13,0 °C / 18,0 °C	Slightly cool	Slight cold stress	
-0,5 / 0,5	18,0 °C / 23,0 °C	Comfortable	No thermal stress	
0,5 / 1,5	23,0 °C / 29,0 °C	Slightly warm	Slight heat stress	
1,5 / 2,5	29,0 °C / 35,0 °C	Warm	Moderate heat stress	
2,5 / 3,5	35,0 °C / 41,0 °C	Hot	Strong heat stress	
3,5 <	41,0 °C <	Very hot	Extreme heat stress	

3. RESULTS AND DISCUSSION

3.1 Air Temperature

According to the air temperature analysis; The most positive change in summer air temperature data was in alternative 4. In alternative 4, a decrease of 2,2 °C in minimum temperature and 2,4 °C in maximum temperature was determined. An average temperature difference of 2,3 °C was determined between alternative 4 and the current situation.

In the winter months, the most positive change occurred in alternative 1 and alternative 2 landscape design. In alternative 1, the maximum temperature increased by 0,4 °C and the minimum temperature increased by 0,3 °C. In alternative 2; While the maximum temperature increased by 0,7 °C, there was no change in the minimum temperature. Although alternative 1 and alternative 2 gave the best results in winter months, it was determined that there was a positive change in all other scenarios (Table 3). Alternative 1 and alternative 2 showed the same degree of variation (0,4 °C warming) on average. Maps of the current situation and scenarios are given in Figure 3.

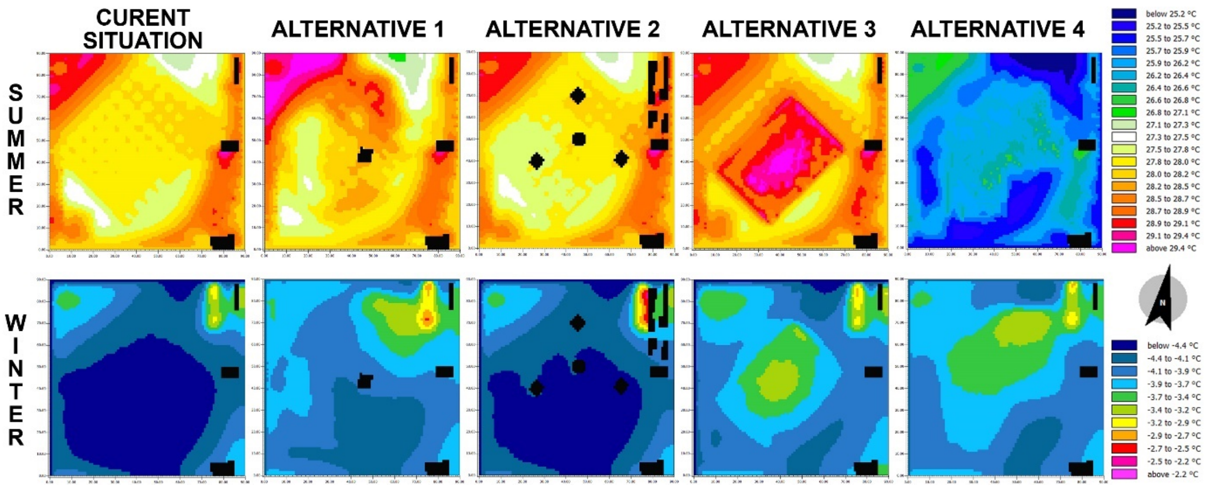

Figure 3. Air temperature (℃) distribution map of current situation and alternatives in January and July

Alternative 4 gives more positive results in summer evaluations compared to other scenarios; It is explained by the fact that the heating effect of the hard ground is reduced and it emits less heat as a result of the greater shaded areas in the plant labyrinth.

Table 3. Air temperature (℃) information for current situation and alternatives

	Air Temperature					
	Summer			Winter		
	Max	Min	Mean	Max	Min	Mean
Current Situation	29,4	27,2	28,3	-3,1	-4,6	-3,9
Alternative 1 (Green Square)	29,6	27,0	28,3	-2,7	-4,3	-3,5
Alternative 2 (Unplanted Area)	29,5	27,2	28,4	-2,4	-4,6	-3,5
Alternative 3 (Carpet Pattern)	29,6	27,2	28,4	-2,9	-4,5	-3,7
Alternative 4 (Plant Maze)	27,0	25,0	26,0	-2,9	-4,3	-3,6

3.2 Relative Humidity

Considering the relative humidity, the biggest change in summer months was determined in Alternative 4. A humidity increase of 22% at the maximum value and 18.8% at the minimum value was determined. On average, there was a 20.4% increase in humidity compared to the current situation (Table 4). When the maps in Figure 4 are examined, it is seen that the increase in humidity in the summer months is quite clearly observed, while there is no change in the maps in the winter months. However, although the color change on the maps does not show this clearly, it has been determined from the data obtained that there is a decrease in the minimum value and an increase in the maximum value in the winter months.

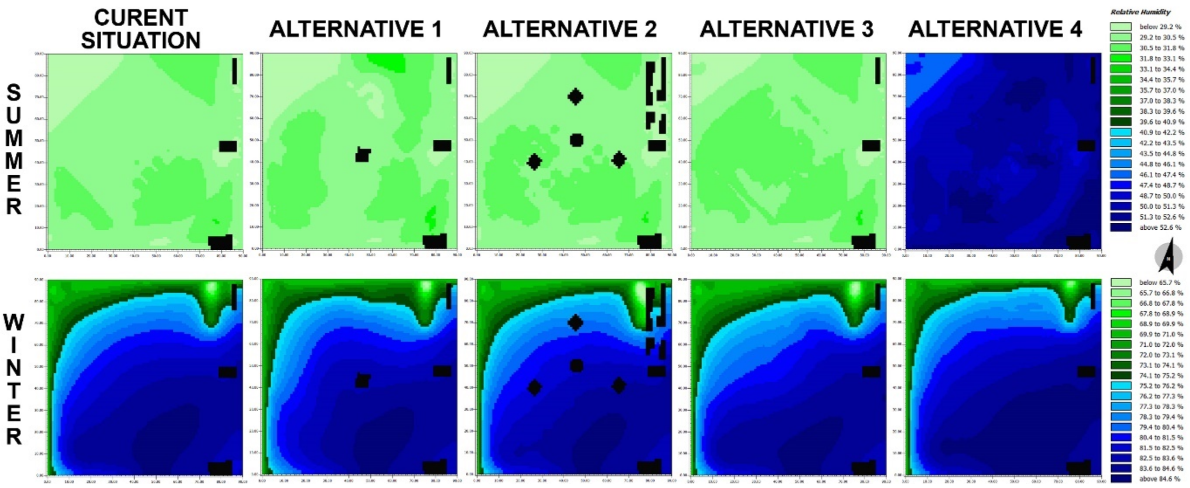

Figure 4. Relative humidity (%) distribution map of current situation and scenarios in January and July

Table 4. Relative humidity (%) information for current situation and alternatives

	Relative Humidity					
	Summer			Winter		
	Max	Min	Mean	Max	Min	Mean
Current Situation	31,9	27,9	29,9	65,5	85,1	75,3
Alternative 1 (Green Square)	32,3	27,9	30,1	85,0	64,7	74,9
Alternative 2 (Unplanted Area)	31,9	28,0	30,0	84,9	63,5	74,2
Alternative 3 (Carpet Pattern)	31,9	28,0	30,0	85,0	65,0	75,0
Alternative 4 (Plant Maze)	53,9	46,7	50,3	85,6	65,9	75,8

3.3 Wind Velocity Results

Wind speed is one of the most influential factors on outdoor thermal comfort (Lin et al 2010, Yang et al 2013). Wind: It reduces the effect of hot air in the summer months and is a very important factor in removing the polluted air layer in the cities from the city centres in the winter months. Therefore, it is an important climatic component in order to increase thermal comfort, especially in summer. In wind speed maps; In the summer data, it was determined that the minimum values in alternative 3 and alternative 4 increased by 0,1 m/s (Table 5). However, when we look at the maps of the same alternatives, it has been determined that the increase actually occurred in the outer part of the city square (Figure 5), and even in the design areas, the wind speed data decreased. The design with the lowest wind circulation in the area was determined as alternative 4.

The decrease in wind speed brought positive results for alternative 4, which gave the best results in other climatic parameters. In the study conducted in the high altitude and cold city of Trondheim, Norway, it was concluded that the removal of high-speed wind from the area increases the thermal comfort in the area (Brozovsky et al 2021). This shows parallelism with the study and explains how alternative 4 increases thermal comfort compared to other scenarios.

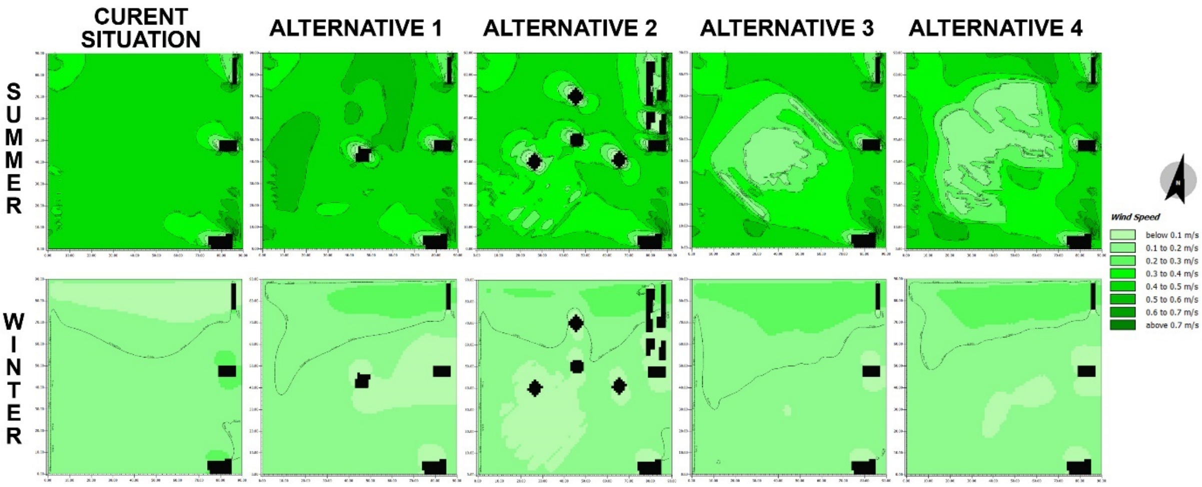

Figure 5. Wind velocity (m/s) distribution map of current situation and scenarios in January and July

Table 5. Wind velocity (m/s) information for current situation and alternatives

	Wind Velocity					
	Summer			Winter		
	Max	Min	Mean	Max	Min	Mean
Current Situation	0,8	0,0	0,4	0,2	0,0	0,1
Alternative 1 (Green Square)	0,8	0,0	0,4	0,2	0,0	0,1
Alternative 2 (Unplanted Area)	0,8	0,0	0,4	0,2	0,0	0,1
Alternative 3 (Carpet Pattern)	0,8	0,1	0,5	0,2	0,0	0,1
Alternative 4 (Plant Maze)	0,8	0,1	0,5	0,2	0,0	0,1

3.4 Mean Radiant Temperature Results

One of the physical parameters used to objectively evaluate the thermal comfort level of a space is the mean radiant temperature. Mean radiant temperature is a quantity that describes the reflected energy transfer between a human body and the environment to which the body is exposed (Lai et al. 2017). Mean radiant temperature (MRT) is one of the important parameters commonly used in thermal evaluations, as it is closely related to the human energy balance. For example, the reflectivity coefficient of a building facade affects the reflected shortwave radiation. The more the radiation is reflected, the higher the mean radiant temperature (MRT) around the building. In addition, a building or group of trees may cause a decrease in MRT by creating a shadow (Rashdi and Embi 2016, Yavaş and Yilmaz 2020; Yilmaz et al., 2021a,b,c,d). In the same place, a temperature difference of 10 °C can occur between an area exposed to direct sun and a place in the shade of plants (Andreou 2013).

As a result of the MRT evaluations made in the Havuzbaşı city square, the most positive change for the summer months was experienced in alternative 4. Alternative 4 showed a decrease of 7,9 °C at the minimum value and 8,2 °C at the maximum value compared to the current situation (Figure 6). However, there was a decrease of 8,1 °C in the average value. In studies carried out in hot climates; shaded places reduce MRT values by about 28 °C and increase thermal comfort (Acero et al 2022). Alternative 2 showed a minimum increase in summer evaluations and was the only design that progressed negatively among the alternatives (Table 6).

In the evaluations of the winter months, the alternative 4 was determined as the design with the best decline. However, this change was not as dramatic as in the summer months (Table 6).

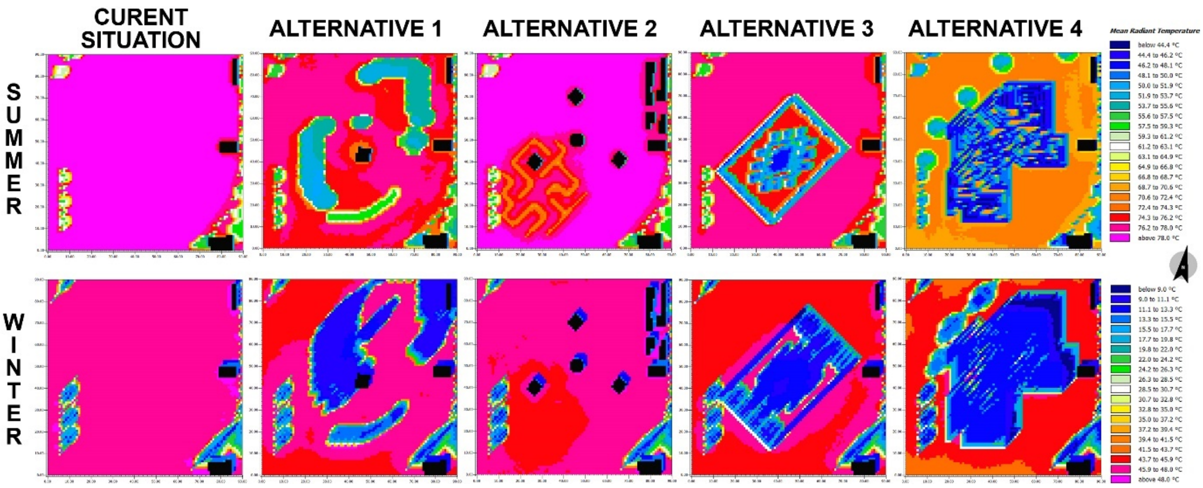

Figure 6. MRT (℃) distribution map of current situation and scenarios in January and July

Table 6. MRT (℃) information for current situation and alternatives

	Mean Radiant Temperature (MRT)					
	Summer			Winter		
	Max	Min	Mean	Max	Min	Mean
Current Situation	79,9	50,4	65,2	50,2	10,9	30,6
Alternative 1 (Green Square)	77,3	47,8	62,6	49,0	9,0	29,0
Alternative 2 (Unplanted Area)	79,4	51,3	65,4	50,2	8,9	29,6
Alternative 3 (Carpet Pattern)	77,4	46,9	62,2	48,9	8,3	28,6
Alternative 4 (Plant Maze)	71,7	42,5	57,1	48,0	6,8	27,4

3.5 Predicted Mean Vote (PMV) Results

In PMV ranges, the most comfortable values are 0 and the values closest to 0. In summer simulations, alternative 4 gave the closest value to the thermal comfortable range. The minimum PMV value decreased to 1,8 and the maximum PMV value to 3,2. Compared to the current situation, there was an average of 0,85 decrease. In addition, an improvement towards the comfortable range was detected in all alternatives in summer simulations (Table 7). As in the research, a decrease of 1,3 in the summer months and an increase of 0,3 in the winter months were detected in the areas where planting was carried out (Xiao and Yuizono 2022). These values of planting; It shows that it increases thermal comfort during day and night hours according to the design and density in the area. These results can be detected quite clearly from the colour changes in the maps in Figure 7.

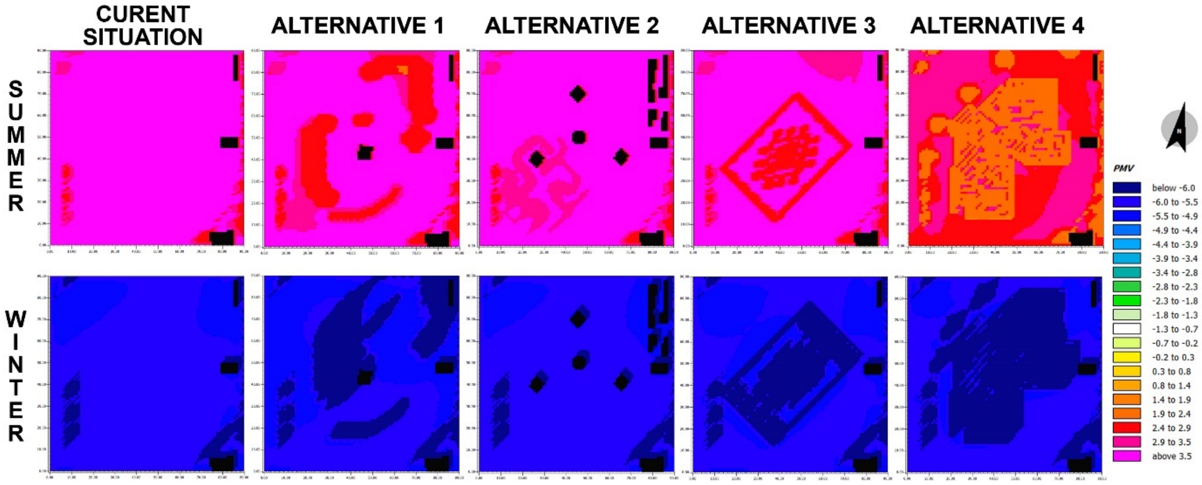

Figure 7. PMV distribution map of current situation and scenarios in January and July

In the winter months, although there was no significant change, alternative 2 experienced an average increase of 0,05. Although this increase is positive, it does not make any sense.

Table 7. PMV information for current situation and alternatives

	Predicted Mean Vote (PMV)					
	Summer			Winter		
	Max	Min	Mean	Max	Min	Mean
Current Situation	4,0	2,7	3,35	-5,2	-6,4	-5,8
Alternative 1 (Green Square)	4,0	2,4	3,2	-5,2	-6,4	-5,8
Alternative 2 (Unplanted Area)	3,9	2,5	3,2	-5,0	-6,5	-5,75
Alternative 3 (Carpet Pattern)	3,9	2,5	3,2	-5,2	-6,5	-5,85
Alternative 4 (Plant Maze)	3,2	1,8	2,5	-5,2	-6,4	-5,8

3.6 PET (℃) Results

In the summer season analysis, alternative 4 gave the best results, as in the other climatic parameters. A decrease of 0,8 °C at the maximum PET value and 4,7 °C at the minimum was detected. On average, there was a decrease of 2,7 °C compared to the current situation (Table 8). In this way, the transition from the "Very Hot" thermal class to the "Hot" thermal class was achieved in Havuzbaşı City Square (Figure 8).

In the study, the design area is gathered in the middle in alternative 4, which gives the best PET values. Similarly, in a study conducted in Mendoza Argentina, the design approaches of city squares were examined with a focus on climate, and one of the most ideal results was determined as the scenario where there is a 60% collective vegetation design in the middle of the area (Stocco et al 2021). A large part of the climate-oriented studies carried out in city squares; emphasized the need to increase large water surfaces or green areas in squares (Yu et al 2022). When the amount of green space in squares increases from 40% to 70%, PET values decrease by 1,5 °C (Yu et al 2022). This shows that alternative 4, which gives the most positive results in other climate parameters; With its design in the center of the area, providing shaded spaces and portable (removable) design, it has been determined as the most suitable design for Erzurum city Havuzbaşı Square. It has been found that in hot climates or in summer, semi-shaded places reduce the temperature by 2℃ (Acero et al 2022). Tseliou et al (2022) in Athens found a similar result to the result in Alternative 4; It improved the PET value by lowering it by 6,9 ℃ in the scenario it applied by combining water surface, grass surface and vegetation at the same time. In this way, it provided a 15% improvement.

Aboelata and Sodoudi (2020) aimed to reduce the heat island effect in a study they conducted in Cairo. In this direction, 70% grass and 50% tree scenarios reduced PET values and increased thermal performance. This shows that the intensive use of tree has a positive effect on outdoor thermal comfort. In other studies, it has been observed that the use of plants in cities has positive effects on outdoor thermal comfort. Al-Obaidi et al (2014, 2014a) determined the positive effects of the use of plants in their studies. Likewise, Ghaffarianhoseini et al (2019) found that the use of semi-enclosed and shaded plants in tropical regions increases outdoor thermal comfort. The same results have been obtained in many international studies and support the research.

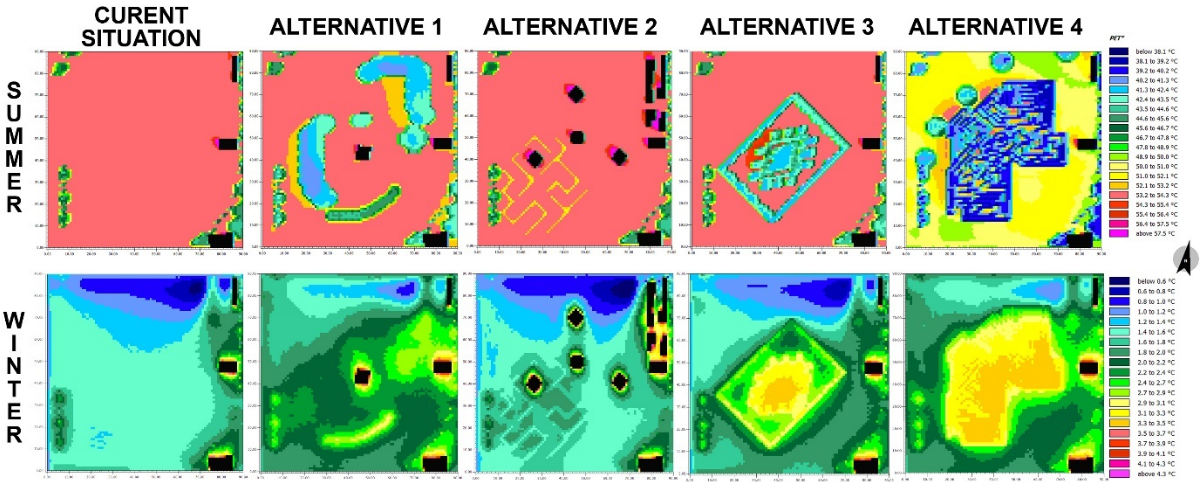

Figure 8. PET (℃) distribution map of current situation and scenarios in January and July

Table 8. PET (℃) information for current situation and alternatives

	Physiological Equivalent Temperature (PET)					
	Summer			Winter		
	Max	Min	Mean	Max	Min	Mean
Current Situation	58,2	41,7	50,0	4,0	0,5	2,2
Alternative 1 (Green Square)	57,9	40,3	49,1	4,0	0,9	2,4
Alternative 2 (Unplanted Area)	58,6	41,8	50,2	4,5	0,4	2,4
Alternative 3 (Carpet Pattern)	57,6	40,7	49,2	4,1	0,6	2,3
Alternative 4 (Plant Maze)	57,4	37,0	47,2	4,1	1,0	2,5

In the study conducted by Chatzidimitriou and Yannas (2016), in the field work done in the square and courtyards, it has been found that the shading elements decrease the PET value of the field by 5 ℃, while in alternatives with plantation, the PET value decreases by 4 ℃ in the squares and by 2,5 ℃ in the courtyards. According to these results, it has been found that it provides better external thermal comfort in the fields with hot climates. Similar results were also obtained in the study. In the Alternative 4 (Plant Maze) with the plantation labyrinth which provides shadow area on the solid ground, a cooling effect of 2,8 ℃ in average has been established for July. In the analysis for January, Alternative 4 (Plant Maze) provide a warmer environment with an increase of 0,3 ℃ for the average compared to other alternatives.

4. CONCLUSION

If an evaluation is to be made for January, there is no difference between the current situation and Alternative 1 (Green Square) for maximum air temperature. When the temperature values for January are examined, the alternatives with the best results are Alternative 2 (Unplanted Area) with 4,5 ℃. At the minimum PET value, Alternative 4 (Plant Maze) gives the best result with 1,0 ℃. If we look at both maximum and minimum values, the ideal alternative for January is the Alternative 4 (Plant Maze). The main reason is that there is a monolithic green space design consisting of a planting design in Alternative 4 (Plant Maze). The plantation in the alternative, releasing the warmth they absorb during the day at a slower rate than the solid ground, forms the ideal state for January.

In the evaluation of July, Alternative 4 gives the best air temperature result. While the minimum temperature was 25,0 ℃, the maximum temperature was determined as 27,0 ℃. Although other scenarios showed positive developments, Alternative 4 gave the best and different results. In alternative 4, an average decrease of 2,3 ℃ was determined compared to the current situation. The main factor is that the plant maze created with bushes increase the shadow area on the solid ground, decreasing the solar radiation.

This study consists of the comparison of the current status of a town square with 4 different scenarios created considering winter and summer months alike. As a result of the study, it can be seen that in the summer months, the shading elements cool down the environment to approximately 2,3 ℃, and the study done during the winter months found that the plant composition heats the environment on the average for 0,3 ℃.

According to the results of the evaluation, in Erzurum, which is a winter city, the increase of plant usage in both winter and summer season produced positive results for thermal comfort. Although there is no considerable change in the results obtained in winter months, there are considerable changes in summer months.

According to the January PET analysis for January and July; Alternative 4 was determined as the best thermal comfort design in all climate evaluations. Alternative 4 compared to the current situation; the average PET value in January increases by 0,3 ℃ and the average PET value in July decreases by 1,6 ℃.

The results of this study; This reveals the necessity of including green areas in the city squares without making hard ground, wholly or in large part. In some recent international studies, it has been concluded that city squares with completely hard floors and no shaded spaces are quite uncomfortable in terms of thermal comfort (Liu et al 2021, Acero et al 2022); supports the research. In the researches, green space structuring, landscape layers and planting structures increase comfort by 40% (Xiao and Yuizono 2022) on hot days. Especially in summer, it has been determined that too hard ground is disturbing in city squares. If design experts or local practitioners take into account the microclimate during the design stages, they can produce spaces with better thermal comfort.

Conflict of Interest: *There is no conflict of interest between the authors or any third party individuals or institutions.*

Ethics Committee Permission: *Ethics committee approval is not required for this study.*

Funding Disclosure: *No financial support was required in this study.*

Acknowledgement: *This study was produced from the thesis titled "Landscape design scenarious of havuzbaşi square in Erzurum", numbered 434880. In addition, the study was presented as an extended summary at the ICUC 1O symposium in New York USA in 2018. This article was developed from the symposium extended summary.*

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