Journal of Architecture and Planning, Vol. 36 (2) , pp. 253-267, Riyadh (2024/1445H)

doi:10.33948/JAP-KSU-36-2-4

A Comparative Analysis of Traditional Turkish Courtyards in Hot-Dry and Hot-Humid Climate

Ruşen Ergün **Can Tuncay Akın**

Department of Architecture, Dicle University, Diyarbakır, Turkey.

rusen.ergun@dicle.edu.tr *ctakin@dicle.edu.tr*

(Received 18/1/2024; accepted for publication 19/3/2024.)

Abstract: Courtyards are important elements of traditional Turkish houses. In these buildings, the courtyard design, especially the geometrical form and interior features are different from each other depending on the climatic characteristics. This study aims to compare the courtyard designs in Diyarbakir (hot-dry) and Hatay (hot-humid) traditional architectures located in two different climates. While there are similarities in terms of "square planned courtyard" and "the existence of landscape" that contribute to the formation of shaded areas in the courtyards of Hatay and Diyarbakir, in terms of "orientation", "size/ratio" and "use of water element" It was found that there are significant differences. It was found that the main purpose of the Diyarbakır courtyard was to escape from the sun, create shade, and provide evaporative cooling by increasing air humidity, while the main purpose of the Hatay courtyard was to create shade and benefit from the wind. The study is a guide for the preservation of the passive design features of traditional buildings and their use in modern buildings.

Keywords: Sustainable design, Traditional Turkish courtyard, Hot-dry climate, Hot-Humid Climate, Passive cooling.

1. Introduction

The Industrial Revolution caused a rapid increase in urban orientation and urban population. This population mobility accelerated the production of standard buildings. The uncontrolled increase in building production has become one of the most important causes of energy consumption and environmental pollution. The building sector is responsible for 30% of CO2 emissions and about 40% of the energy consumed (UNEP 2020, 1; IEA 2021, 10). The sustainability of a building is achievable with its environmental sustainability principles. As traditional buildings are formed depending on climate and physical conditions, they are an important guide in ensuring building sustainability (Edwards, et all, 2006). Arguably, the courtyard is one of the most important design elements that ensure sustainability in traditional buildings. Courtyards in traditional houses contribute significantly to the sustainability of the buildings as climatic regulators such as "natural ventilation and lighting" and "sun and humidity control".

The use of the courtyard in traditional architecture; is common in different parts of the world, particularly in Asia, the Middle East, South America, and the Mediterranean (Vellinga, Oliver, and Bridge 2007; Khan, Su, and Riffat 2008; Al-Masri and Abu-Hijleh 2012). Although courtyards have been used in many parts of the world, they have evolved differently depending on the climate. Climatic characteristics also affect the working mechanisms of courtyards. In the research, it has been determined that courtyards are differentiated depending on wind, sun, and humidity. It has been stated by many researchers that the most important design criteria affecting the climatic comfort of courtyards are "shape", "direction", "height/ratio" and "natural elements" (Manioğlu and Koçlar Oral

2015; Ntefeh, Siret, and Marenne 2003; Soflaei et al. 2017; Yaşa and Ok 2014; Asimakopoulos and Santamouris 2013; Al-Hemiddi and Megren Al-Saud 2001; Khajehzadeh, Vale, and Yavari 2016; Meir, Pearlmutter, and Etzion 1995).

There are various academic studies on the climatic comfort of courtyards in many parts of the world (Rajapaksha, Nagai, and Okumiya 2003; Teshnehdel, Soflaei, and Shokouhian 2020; Meir 2000; Soflaei, Shokouhian, and Mofidi 2016; Soflaei, Shokouhian, and Mofidi Shemirani 2016; Soflaei et al. 2017; Al-Hemiddi and Megren Al-Saud 2001). However, studies comparing courtyard characteristics in different climatic regions are limited. (Khajehzadeh, Vale, and Yavari 2016; Sahebzadeh et al. 2017; Taleghani, Tenpierik, and Dobbelsteen 2012).

Sahebzadeh et al., (2017) compared the courtyard systems in the cities of Yazd and Sistan, respectively, as representatives of two different climates, "hot and dry" and "hot, dry and windy". They studied the courtyard comparisons based on the case study, depending on criteria such as "facade", "material", "roof" and "orientation". As a result of the research, they determined that although similar courtyard designs were used in the buildings in both cities, their usage patterns were different from each other. Khajehzadeh et al., (2016) compared the physical characteristics of courtyards and seasonal movements of users in Yazd (hot and dry) and Bushehr (hot and humid) two Iranian cities with different climatic characteristics. In their analysis, they found that although the courtyards appear similar, there are significant differences in design criteria such as size, shape, and ratio, which also affect the user movements. Taleghani et al. (2012) examined building courtyards in 4 different regions with "hot-arid", "snowy", "temperate" and "tropical" climates. In their analysis, they determined that there are significant differences especially in the openings on the façade and the use of natural elements. Yaşa & Ok (2014) on the other hand, analyzed the energy efficiency of courtyard shapes in traditional Turkish houses located in 3 different climate zones (hot-arid, hot-humid, and cold) with simulation programs. The main objective of the study is to evaluate the thermal performance of the courtyards of these houses with different climatic characteristics. In the study, they obtained results such as the increase in energy demand, the increase in the length of the courtyard, and extending the shadow length in the square-planned courtyards.

As a result of the extensive literature review, no study could be found apart from the one made by Yaşa & Ok (2014) on the comparison of courtyard systems in traditional Turkish houses according to climatic characteristics. The present study, it is aimed to compare the design features of traditional Turkish house courtyards in hot humid (Hatay) hot dry climates (Diyarbakır), which change according to climatic characteristics. Courtyards were compared based on a multi-criteria field study; "orientation", "shape", "size/ratio" and "natural element" design criteria. Due to the limited number of studies on traditional Turkish houses for this purpose, the current study can partially compensate for the lack of literature in this area.

2. Material

Diyarbakır (37° 91′ N, 40° 22′ E) is in the Southeastern Anatolia region of Turkey, between the Karacadağ and the Tigris River, in the area known as Mesopotamia, where the first settlements date back to the Neolithic Age and has been seen as important throughout history. (Figure 1). Until the 1950s, the city was located within a 5 km long, 6-8 meters high city wall (M Baran, Yıldırım, and Yılmaz 2011). This area where the traditional building is located is known as Suriçi.

Hatay (36° 10′ N, 36° 06′ E) is in the southernmost part of the country in the Mediterranean region of Turkey. It is located on the slopes of Habib-i Neccar Mountain in the Lower Asi valley between the Amanos Mountains and Bald Mountain, where the first settlements in the city date back to the Bronze Age (Figure 1).

Diyarbakır has a hot and dry climate. Summers are very hot and dry, winters are cool (M.G.M 2018). From the measurements made in Diyarbakır between 1929-2019, the hottest day was 46.2°C on 20 July 1937 and the coldest day was -24.2°C on 11 January 1993. When the annual temperature data of the city is examined, it is seen that the coldest month is January, and the hottest month is August. The average annual temperature is 22.5°C (M.G.M, 2020; Figure 2).

Hatay has a hot and humid climate. Hot and humid summers, cool and rainy winters (M.G.M 2018). In the measurements made between 1940 and 2019 in Hatay, the warmest month is August with an average of 27.8 °C, while the coldest month is January with an average of 8°C (Service

Figure (1). City locations

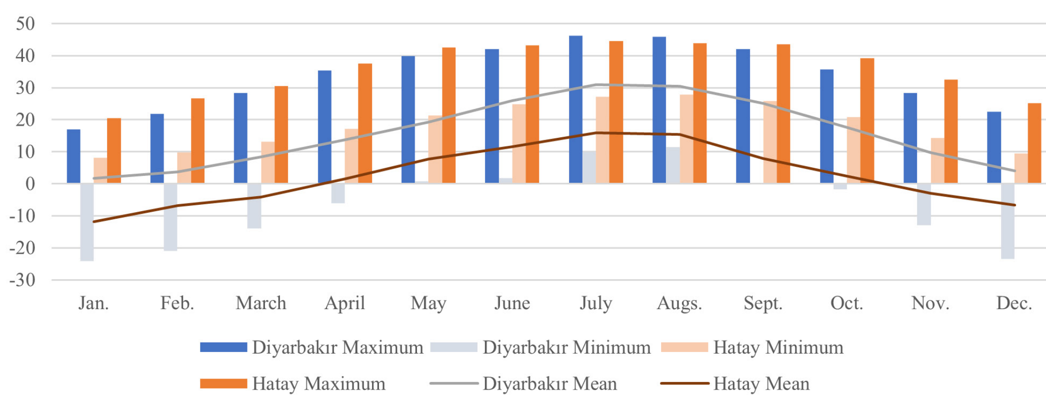


Figure (2). The average temperature of Diyarbakır and Hatay between 1929-2020 by months (Meteoblue, 2020)

2020). When the annual temperature data of the city is examined, it is seen that the months with the highest average temperature are July and August, while the lowest are January and February. (Figure 5; Meteoblue, 2020).

The prevailing wind direction in Diyarbakır is northwest the average monthly wind speed is 2.6 m/s and the wind blows hardest in July and August. Due to the dryness of the steppe vegetation of the city in summer and the rapid wind blows in these months, the number of days, when the air is dusty, is high (Meteoblue, 2020; Tuncer, 1999)

The prevailing wind direction in Hatay is southwest. The average monthly wind speed is 4.7m per second, with the strongest wind in July. The fact that wind turbines were installed in Hatay to generate electricity also proves that the wind speed is high on an annual basis (Figure 3; Meteoblue, 2020).

When Diyarbakır average precipitation amounts are examined, the rainy months are January and December with 70.7 mm and 72.3 mm respectively. The most arid months are July and August with 1.3 mm and 1 mm respectively. The annual average precipitation is at a very low level with 41.3 mm (Fig 4).

The average annual precipitation in Hatay is 96.95 mm. The rainy months are January and December with 196.9 mm and 184,1 mm respectively. The most arid months are July and August with 16 mm and 18.2 mm, respectively (Fig 4).

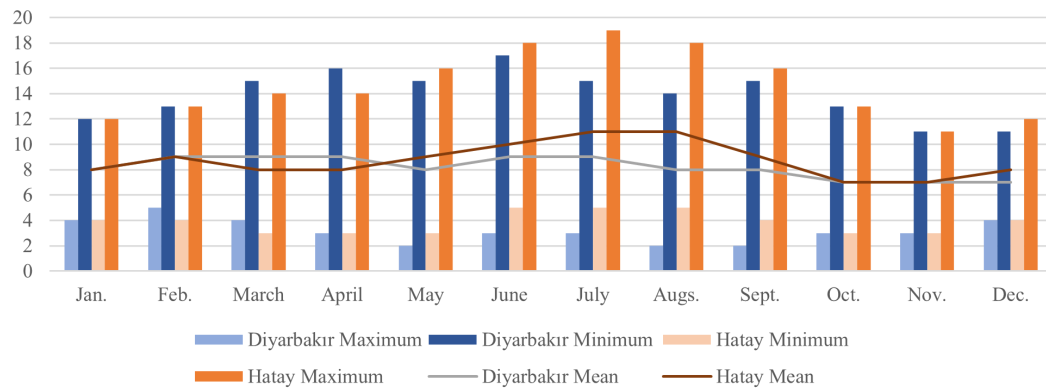


Figure (3). Average wind speed of Diyarbakır and Hatay by months (Meteoblue, 2020)

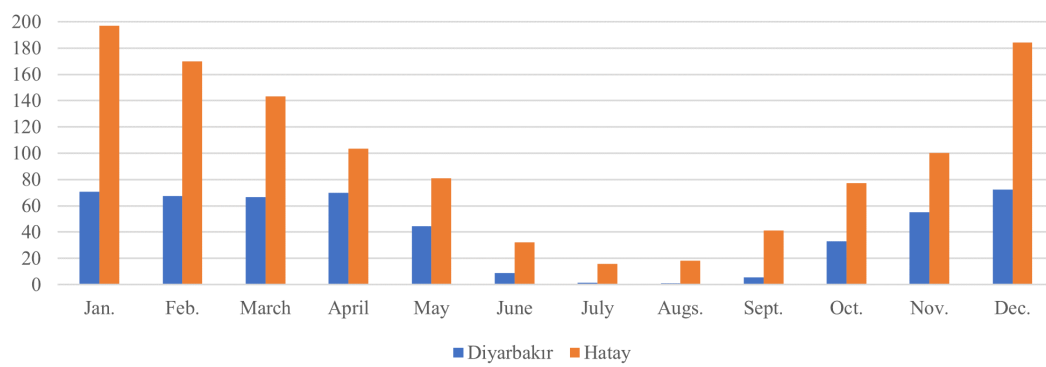


Figure (4). Diyarbakir and Hatay average precipitation by months (Meteoblue, 2020)

3. Traditional Diyarbakır and Hatay Buildings

Traditional Diyarbakır buildings were built around a central courtyard with 1,2,3 or 4 wings. The number of wings in the buildings varies depending on the economic status and socio-cultural characteristics of the family as well as the parcel characteristics. For the same reasons, buildings sometimes consist of only the ground floor, and sometimes they can consist of the basement, ground, and 1st floor (Tuncer 1999). Depending on the climatic directions, the units of the house are divided into summer and winter as well as spring (Baran, 2017). Non-porous basalt stones (male stone) were used on the building walls and porous basalt stones (female stones) were used on the courtyard floor. The outer wall thickness of the building can vary between 50-70 cm on average. While the number of windows is higher on the north-facing façade, which is used as a summer residence, the number of windows on the south-facing winter façade is less. Ceiling heights are high and natural ventilation and lighting are provided by using skylights. All facades of these buildings, whose only connection with the street is the courtyard door, face the courtyard. The main reasons for this situation are the climate and the sense of privacy (Figure 5; Bekleyen & Dalkiliç, 2011; Payasli Oğuz & Halifeoğlu, 2017).

The spaces of traditional Hatay houses are located around a central courtyard. The rooms, which are the main spaces of the building, are generally located on the northeast facade facing southwest, while service units such as the kitchen and WC are in the opposite direction. This situation shows that the service spaces and the main rooms are separated from each other in Hatay houses. Courtyard planning is generally the same in many houses and may differ in size depending on the sociocultural and socioeconomic status of the family. While the buildings generally consist of a ground floor or ground, 1 floor, some houses also have a cellar floor. While the building units are usually lined up on the 1,2 or 3 façades of the courtyard, the façades where the space is not positioned are separated from the exterior by a high courtyard wall (Demir 2016). While the building opens to the street with the courtyard entrance door, the openings generally face the courtyard. Although the windows can be opened to the street in the two-story sections, they are positioned quite high above eye level and in such a way that they do not see the courtyard of the neighboring house. The upper floor of the buildings was built as stone or stone filling between the wooden frame, and the ground floors were built entirely of stone. Wall thicknesses can vary between 50-70 cm. (Erdoğan, 1996; Figure 5).

As Figure 5 shows, while the two cities are similar in terms of criteria such as "wall thickness", "structure external relationship", and "courtyard use", there are differences in terms of criteria such as "courtyard orientation", "positioning of spaces" and "natural elements used".

4.Methodology

A comprehensive literature review and multi-criteria field study were carried out in the study. Within the scope of the field study, 5 courtyard buildings were selected from the cities of Diyarbakır and Hatay, which have two different climatic characteristics. All the selected buildings are registered and reflect the traditional courtyard building characteristics in their regions and are in the traditional urban texture. The buildings were chosen by the purposeful random sampling method.

Literature review: It has been extensively done on topics such as "sustainable architecture", "local architecture built according to climatic data", "Hot-humid climate and hot dry climate characteristics", "geographic locations of Hatay and Diyarbakır" and "detection of the formation of the buildings within the scope of the study according to climatic characteristics".

A multi-criteria field study was carried out according to the criteria of "the shape of the

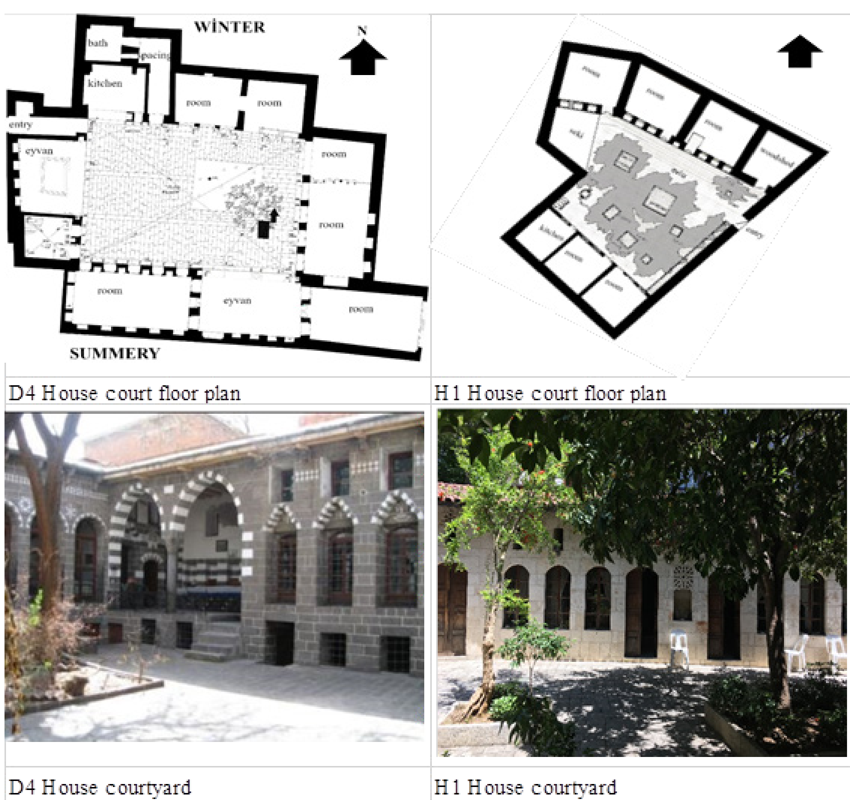


Figure (5). Diyarbakir and Hatay traditional building example H1 building plan revised from Demir, (2016), H1 house image from Ruşen Ergün's Archive, (2020) D4 house image revised by Payaslı Oğuz and Halifeoğlu, (2017). D4 house plan revised by Yıldırım et all., (2012).

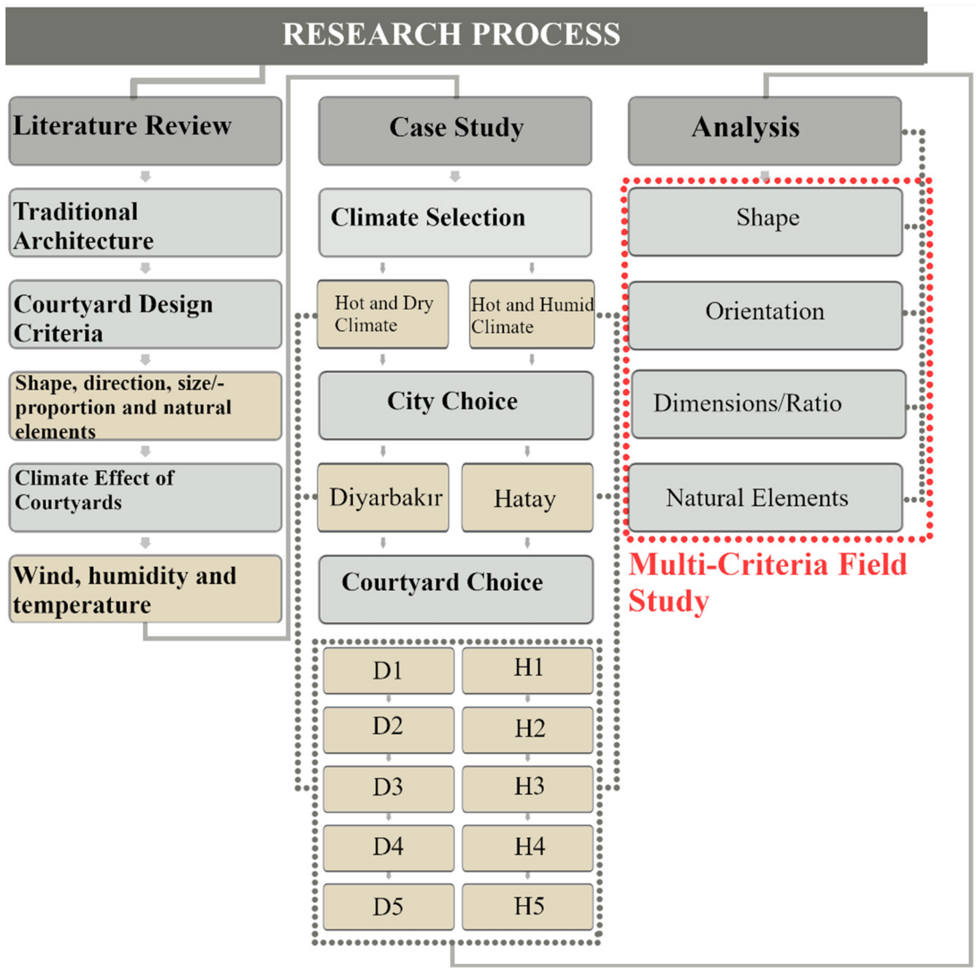


Figure (6). Research process

courtyard", "the orientation of the courtyard", "the dimensions/proportions of the facade of the courtyard" and "use of natural elements in the courtyard" (Figure 6).

Based on these data, Tables were created in which criteria such as courtyard "size", "proportion", "orientation" and "shape", "building facade measures" and "proportions", and "courtyard natural element measures" and "proportions" (water and earth) were determined. Then, the average physical property values of the selected buildings were determined to reveal an average building type in each city.

5. Results and Evaluation

Within the scope of the study, 5 buildings were taken from Diyarbakır and Hatay, which are in different climates (Figure 7). The buildings included in the scope of the study for Diyarbakır were coded as D1, D2, D3, D4, and D5, and the buildings included in the study from the traditional buildings of Hatay were coded as H1, H2, H3, H4 and H5.

5.1 The shape, orientation, and rotation angle of the buildings

In this section, the shape, orientation, and rotation angles of the 10 traditional building courtyards included in the study were examined. Essential field studies were carried out to determine the passive design criteria of the courtyard elements in the buildings of both cities. The field studies focused on criteria such as orientation, width, height, and total area of the courtyards.

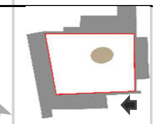
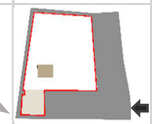
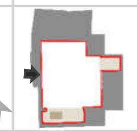
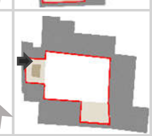
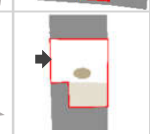
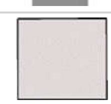
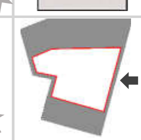
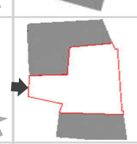
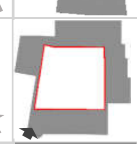
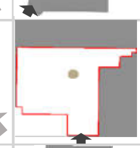
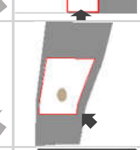
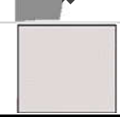
Figure (7). Hatay urban fabric and select cases b) Diyarbakır urban fabric and select

Figure (8). Spatial positioning of main rooms

When the rotation angle of Diyarbakır houses is examined, it is determined that it varies between +8 and -5 degrees and the average value of the examined buildings are approximately +5 degrees. When the rotation angle of Hatay houses is examined, it has been determined that it varies between +33 and +48 degrees and the average value of the examined buildings is approximately +42 degrees (Figure 7).

As a result of the analysis, it has been determined that the courtyards of Diyarbakır houses are generally located in the north-south direction, and the courtyards of the Hatay houses are in the southwest-northeast direction. While the orientation of Diyarbakır houses is aimed at creating a feeling of coolness by avoiding solar radiation in summer, the orientation of Hatay houses aims to benefit from the cooling effect of the prevailing wind. The fact that the main rooms (has rooms) are in the south and facing north in Diyarbakır, and in Hatay are in the northeast and face southwest, supports this situation (Figure 8).

Table (1). Dimensions and proportions of courtyards

City	Building	A_{TB} (m²)	A_{TC} (m²)	A_{TE} (m²)	E_{OA} (m)	L_{OA} (m)	H_{OA} (m)	$\frac{H_{OA}}{L_{OA}}$ (m)	$\frac{H_{OA}}{E_{OA}}$ (m)	$\frac{E_{OA}}{L_{OA}}$ (m)	$\frac{A_{TA}}{A_{TY}}$ (%)	K_O	Schematic plan
Diyarbakır	D1	738	395	343	23,7	16,8	5,63	0,34	0,24	1,41	54%	5	
	D2	219	98,9	120	9,22	10,7	6,35	0,59	0,69	0,86	45%	15	
	D3	392	195	197	12,2	14,5	5,73	0,4	0,47	0,84	50%	4	
	D4	374	131	243	12,6	9,75	4,59	0,47	0,37	1,29	35%	5	
	D5	689	312	377	15,7	18,1	8,8	0,49	0,56	0,87	45%	-5	
	Average	**482**	**226**	**256**	**14,7**	**14**	**6,22**	**0,45**	**0,42**	**1,05**	**47%**	**4,8**	
Hatay	H1	334	150	185	11,8	12,3	3,5	0,28	0,3	0,96	45%	44	
	H2	215	60,8	155	9,5	7,4	3,92	0,53	0,41	1,28	28%	33	
	H3	642	298	344	19,8	14	7,5	0,54	0,38	1,42	46%	40	
	H4	467	243	224	15	13,4	5,5	0,41	0,37	1,12	52%	42	
	H5	198	69	131	7,33	9,88	5,4	0,55	0,74	0,74	35%	48	
	Average	**372**	**164**	**208**	**12,7**	**11,4**	**5,16**	**0,45**	**0,41**	**1,11**	**44%**	**41,4**	

A_{TB}, Total building area; A_{TC}, Total courtyard area; A_{TE}, Total enclosed area
E_{OA}, Courtyard average width; L_{OA}, Courtyard average length; H_{OA}, Courtyard average hight

The average total building area of Diyarbakır and Hatay houses are 482m² and 372m², respectively, and it has been determined that there is a significant difference between the area sizes. However, when the ratio of the courtyard area to the building area is examined, it is seen that there is no significant difference between Diyarbakır (47%) and Hatay houses (44%). The fact that the courtyard dimensions are close to the total closed area dimensions indicates that the courtyard system is considered important as a climatic regulator in both cities. It was determined that the courtyards of Diyarbakir traditional houses were in the form of a rectangular shape, close to a square, with a ratio of 1/1.01, extending in the east-west direction of 14.7 m and the north-south direction of 14 m. It has been determined that the courtyards of Hatay traditional houses are rectangular, close to a square, with a ratio of 1/1.11, extending in the direction of 12.7 m southwest, northeast, and 11.4 m southeast and northwest. (Table 1; Figure 10). Yaşa & Ok (2014) determined that the most ideal shape for a courtyard to be protected from the sun in summer and to provide heat gain in winter is a square. The fact that both Diyarbakir and Hatay are in the hot climate zone shows that this shaping of the courtyards provides optimum climatic comfort in both cities.

The average courtyard height of Diyarbakır houses is 6.22m, which is deeper than the courtyards of Hatay houses with an average height of 5.16m. In Diyarbakır, which has a warmer climate compared to Hatay, the greater depth of the traditional courtyards may indicate that the need for shaded areas is higher. The fact that Yaşa & Ok (2014) found in their studies that increasing the depth of the courtyard increases the shadow length in hot-arid and hot-humid climates while increasing the height decreases the shadow length, which supports this situation. The determinations made about the orientation of the buildings of both cities, providing climatic comfort by turning to the wind in Hatay and avoiding the sun in Diyarbakır supports the idea that the shaded area has more importance in Diyarbakır buildings.

5.2 Size and proportion of façades

When the average length of the façades in which the housing is in Diyarbakır houses with courtyards is examined, it has been determined that the longest façade is the south façade (directing to the north) with 17.58 m. In addition, it is seen that the highest façade is the south façade (directing to the north) with 7.2 m. Accordingly, the fact that the south façade (directing to the north) has the most area shows that it is the most used façade in traditional houses (Table 2).

The aim here is to increase the shadow length of the facade, which faces north on hot summer days, by avoiding the sun, and to experience the climatic comfort at the optimum level by turning its face to the north winds. Baran et al. (2011) stated that the south façade was used as a summer residence by the locals. Tuncer (1999) stated in his study that the comfort in hot summer days is preferred over cold winter days in Diyarbakır and that the main rooms in the houses are on the south façade. These studies support our findings.

It has been determined that the longest façade in Hatay traditional buildings included in the study is the northeastern façade, oriented to the southwest, which constitutes 44% of the total façade length. In addition, it has been determined that the facade with the highest façade is the northeast facade, which constitutes 29% of the total facade height (Table 3)

These results show that the most used façade in Hatay courtyard houses throughout the year is

Table (2). Average dimensions of Diyarbakir traditional building facades

Diyarbakır	H_K (m)	H_G (m)	H_D (m)	H_B (m)	E_K (m)	E_G (m)	E_D (m)	E_B (m)	H_K/H_{TA} (%)	H_G/H_{TA} (%)	H_D/H_{TA} (%)	H_B/H_{TA} (%)	E_K/E_{TA} (%)	E_G/E_{TA} (%)	E_D/E_{TA} (%)	E_B/E_{TA} (%)
D1	5,45	6,1	5,9	5,08	17,7	19,3	22,7	10,5	24%	27%	26%	23%	25%	27%	32%	15%
D2	6,2	7,14	5,2	6,87	0	16,3	15,3	0	24%	28%	20%	27%	0%	52%	48%	0%
D3	6,7	8,4	5,5	3,17	11,4	13,6	16,2	7,97	28%	35%	23%	13%	23%	28%	33%	16%
D4	6,8	4,68	4,65	6,8	14,1	21	9,48	8,34	30%	20%	20%	30%	27%	40%	18%	16%
D5	8,9	9,7	8,3	8,3	18,8	17,7	0	0	25%	28%	24%	24%	51%	49%	0%	0%
Average	6,8	**7,2**	5,9	6,0	12,4	**17,6**	12,7	5,4	26%	**28%**	23%	23%	26%	**37%**	26%	11%

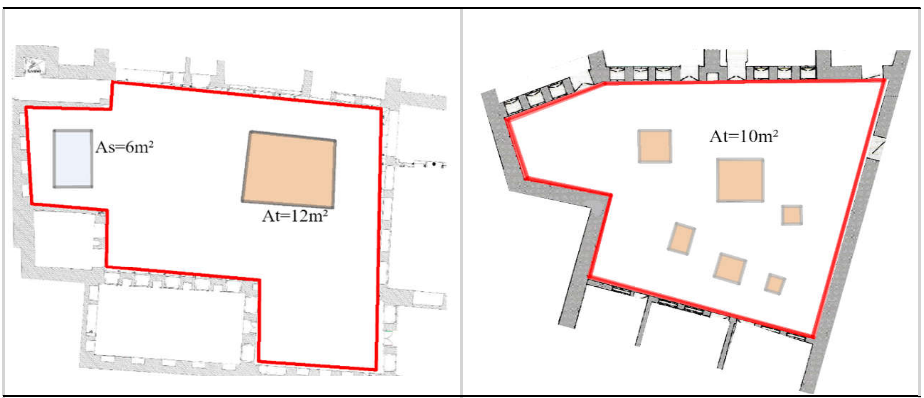
Table (3). Average dimensions of Hatay traditional building facades

Hatay	H_{KDA} (m)	H_{GB} (m)	H_{GD} (m)	H_{KB} (m)	E_{KD} (m)	E_{GB} (m)	E_{GD} (m)	E_{KB} (m)	H_{KD}/H_T (%)	H_{GB}/H_T (%)	H_{GD}/H_T (%)	E_{KB}/E_T (%)	E_{KD}/E_T (%)	E_{GB}/E_T (%)	E_{GD}/E_T (%)	E_{KB}/E_T (%)
H1	4,8	6,5	4,0	3,5	20,2	11,2	0,0	0,00	25%	35%	21%	19%	64%	36%	0%	0%
H2	4,0	3,8	3,5	4,5	9,7	5,1	0,0	0,00	25%	24%	22%	29%	65%	35%	0%	0%
H3	9,3	4,2	8,5	9,2	15,7	22,5	13,8	9,5	30%	13%	27%	30%	26%	37%	22%	15%
H4	8,9	4,5	5,0	3,5	21,8	0,0	14,0	0,00	41%	21%	23%	16%	61%	0%	39%	0%
H5	5,0	5,2	6,4	5,1	11,1	7,5	1,4	15,3	23%	24%	30%	24%	31%	21%	4%	43%
Average	**6,4**	4,8	5,5	5,2	**15,7**	9,3	5,8	5,0	**29%**	22%	25%	24%	**44%**	26%	16%	14%

the northeastern façade facing southwest. This situation supports that the wind is an important factor in the formation of Hatay traditional houses.

5.3 Courtyard natural elements

Natural elements have an important effect on the regulation of environmental thermal conditions. Landscape areas, earth, and water are among the most important of these elements (Al-Masri and Abu-Hijleh 2012). Plants which are one of the most important elements of landscape areas used in the courtyards of traditional houses in hot and dry climates; increase the humidity of the air, generally create shade in the ground and building in summer, also when they shed their leaves in winter and allow heat to enter, they heat the courtyard and therefore the spaces for providing climatic comfort. While water is an important moisture and cooling element



D4, Pool, earth, landscape area | H1;earth, landscape area

As, Total water area; At, Total earth and landscape area

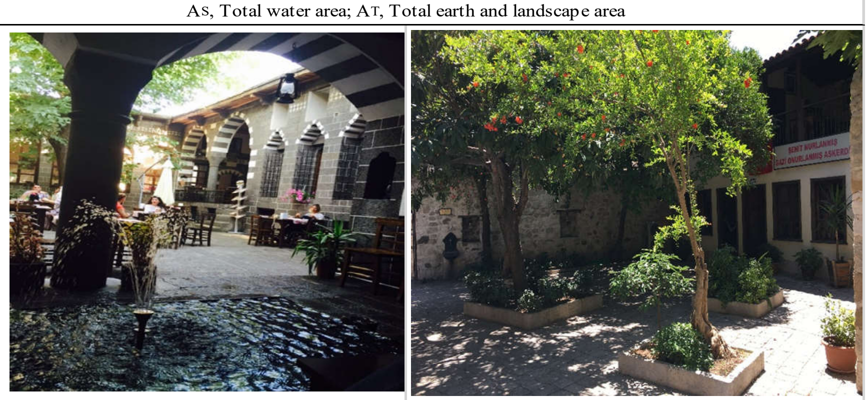


Figure (9). An example of measuring natural elements. Image of house number D4 from Ruşen Ergün Archive, (2020), H1 house image from Ruşen Ergün's Archive, (2020), H1 house image from Mekiye, K.'s Archive

Table (4). Dimensions of natural elements in courtyards

City	Building	A_{TA} m²	N_H m²	N_T m²	A_H m²	A_T m²	A_S/A_{TA} (%)	A_T/A_{TA} (%)
Diyarbakır	D1	395	2	3	25	56	6,3%	14,2%
	D2	98,9	1	2	5	15	5,1%	15,2%
	D3	195	1	3	0,6	6	0,3%	3,1%
	D4	131	1	1	6	12	4,6%	9,2%
	D5	312	1	1	2,8	13	0,9%	4,2%
	Average	226,412		2	7,88	20,4	3%	9%
Hatay	H1	150	0	8	0	10	0,0%	6,7%
	H2	60,8	0	1	0	1,2	0,0%	2,0%
	H3	298	0	4	0	4	0,0%	1,3%
	H4	243	1	4	9	55	3,7%	22,6%
	H5	69	1	2	3,75	4	5,4%	5,8%
	Average	195,6104		3,8	2,55	14,84	2%	8%

ATA, Total courtyard area; NH, total number of pools; NT, Total number of landscape areas; AH, Total water area; AT, total earth area

in hot and arid climates (evaporative cooling), the earth acts as an important element in providing cooling (earth cooling) by showing insulating properties in hot weather (Soflaei, Shokouhian, & Mofidi, 2016; Soflaei, Shokouhian, & Mofidi Shemirani, 2016).

A field study and literature review were conducted in the courtyards of traditional houses in Diyarbakır and Hatay considering the effect of natural elements such as earth, tree, and pool areas on housing comfort, (Figure 9; Table 4).

In the examinations made, it was determined that there was at least 1 pool in all Diyarbakır houses included in the study. Baran et al. (2011) showing pools as a natural element of Diyarbakır courtyards in their study supports this ratio. It can be said that these pools provide climatic comfort by increasing the humidity (evaporative cooling) of Diyarbakır's arid climate. The fact that Şerefhanoğlu Sözen & Gedík (2007) shows the pools as the main air coolers of the courtyard support this situation. Considering the use of female stone in the courtyard floors of Diyarbakır houses to provide water accumulation in the pores and to create a feeling of coolness like the pool system, the importance of water in these structures for climatic comfort becomes evident.

It was determined that only 2 of the examined Hatay houses had pools. The fact that water is not used as a climate regulator in Hatay houses due to the high humidity in Hatay throughout the year. It can be evaluated that in the houses where there is a pool, it is not as a regulator of humidity, but giving visualization to the courtyard.

Contrary to the pool, which is a water element, it has been determined that there are land areas, landscape areas, and landscape areas in all the houses in both Diyarbakır and Hatay included in the study. This can be explained by the fact that both cities are in a hot climate zone and the houses are exposed to high sun rays, especially in summer. It can be said that in the traditional buildings of both cities, it is used to benefit from the sun's absorbing effect on the soil and the shade-making effect of the trees.

It can be said that the use of natural elements such as water, soil, and trees in the courtyards of both cities is used not only for climatic comfort but also because it provides visual comfort. The fact that Tuncer (1999) stated in his study on Diyarbakır houses and Demir (2016) on Hatay houses that these natural elements provide visual comfort in courtyards supports this argument.

6. Conclusion

In the study, the physical structure characteristics of the traditional Turkish house courtyards in two different climatic regions were compared. Although the courtyards seem like each other, it has been determined that there are significant differences in terms of physical properties.

In the results of working:

- In both cities, a rectangular courtyard shape close to a square was used to increase the shaded area and the use of trees as a landscape element was close to each other,
- Although the depth of the courtyard in both cities is more than 5 meters, the average depth of the courtyard in Diyarbakır reaches 9 meters in some places, especially to be protected from the summer sun.
- In Diyarbakır houses, the courtyards extend in the north-south direction to avoid the

sun and the main rooms face north, in Hatay houses the courtyards extend in the southwest-northeast direction with an average angle of 42° with the north, and the rooms with similar functions face southwest, which is the prevailing wind direction.,

- Considering the ratio of courtyard-closed area in both cities, importance is given to the use of courtyards as a climatic comfort provider,
- To increase humidity and the feeling of coolness (evaporative cooling) in Diyarbakır, which has a hot and dry climate, analyzes and evaluations can be made that the use of water elements in the courtyard is much more important than Hatay, which is in a humid climate region.

The design criteria determined in the study, although it is not possible to imitate them exactly in modern buildings, is thought to be an important guide for their use in sustainable building designs and to raise awareness in the preservation traditional houses.

7.References

Al-Hemiddi, Nasser A., and Khalid A. Megren Al-Saud. 2001. "The Effect of a Ventilated Interior Courtyard on the Thermal Performance of a House in a Hot-Arid Region." Renewable Energy 24: 581–95. https://doi.org/10.1016/S0960-1481(01)00045-3.

Al-Masri, Nada, and Bassam Abu-Hijleh. 2012. "Courtyard Housing in Midrise Buildings: An Environmental Assessment in Hot-Arid Climate." Renewable and Sustainable Energy Reviews 16 (4): 1892–98. https://doi.org/10.1016/j.rser.2012.01.008.

Asimakopoulos, D., and Matheos Santamouris. 2013. "Passive Cooling of Buildings." In Passive Cooling of Buildings, 2nd ed., 56–83. London. https://doi.org/10.4324/9781315073668.

Baran, M, M. Yıldırım, and A. Ylmaz. 2011. "Evaluation of Ecological Design Strategies in Traditional Houses in Diyarbakir, Turkey." Journal of Cleaner Production 19 (6–7): 609–19. https://doi.org/10.1016/j.jclepro.2010.11.001.

Baran, Mine. 2017. "Eski Diyarbakır Evleri İklim İlişkisi." Dicle Üniversitesi Mühendislik Dergisi 8 (2): 423–30.

Bekleyen, Ayhan, and Neslihan Dalkiliç. 2011. "The Influence of Climate and Privacy on Indigenous Courtyard Houses in Diyarbakır, Turkey." Scientific Research and Essays 6 (4): 908–22. https://doi.org/10.5897/SRE10.958.

Demir, Ataman. 2016. Çağlar İçinde Antakya. Hatay: Dafne Kitap.

Edwards, Brian; Sibley, Magda; Hakmi, Mohammad; Land, Peter, ed. 2006. Courtyard Housing Past, Present & Future. USA: Taylor & Francis.

Erdoğan, Elmas. 1996. "A Comparative Research on The Features and Planning Principles of Anatolian Patios." Ankara University. https://dspace.ankara.edu.tr/xmlui/handle/20.500.12575/35087.

Khajehzadeh, Iman, Brenda Vale, and Fatemeh Yavari. 2016. "A Comparison of the Traditional Use of Court Houses in Two Cities." International Journal of Sustainable Built Environment 5: 470–83. https://doi.org/10.1016/j.ijsbe.2016.05.010.

Khan, Naghman, Yuehong Su, and Saffa B. Riffat. 2008. "A Review on Wind Driven Ventilation Techniques." Energy and Buildings 40 (8): 1586–1604. https://doi.org/10.1016/j.enbuild.2008.02.015.

M.G.M. 2018. "Köppen-Trewartha İklim Sınıflandırmasına Göre Türkiye İklimi." Ankara. https://www.mgm.gov.tr/FILES/iklim/iklim_siniflandirmalari/Köppen-Trewatha.pdf.

Manioğlu, G., and G. Koçlar Oral. 2015. "Effect of Courtyard Shape Factor on Heating and Cooling Energy Loads in Hot-Dry Climatic Zone." In 6th International Building Physics Conference, 78:2100–2105. https://doi.org/10.1016/j.egypro.2015.11.250.

Meir, Isaac A. 2000. "Courtyard Microclimate: A Hot Arid Region Case Study." In Architecture City Environment, Proceedings of the 17th PLEA International Conference, 218–22. https://www.academia.edu/8465760/Courtyard_microclimate_a_hot_arid_ region_case_study.

Meir, Isaac A., David Pearlmutter, and Yair Etzion. 1995. “On the Microclimatic Behavior of Two Semi-Enclosed Attached Courtyards in a Hot Dry Region.” Building and Environment 30 (4): 563–72.

Meteoblue. 2020. “Simulated Historical Climate & Weather Data for Diyarbakır.” Average Temperatures and Precipitation. 2020. https://www.meteoblue.com/en/weather/historyclimate/climatemodelled/diyarbakır_turkey_316541.

Ntefeh, Roula, Daniel Siret, and Christian Marenne. 2003. “The Internal Courtyard of Mixed Use Buildings, a Device of Thermal and Luminous Comfort.” In 20th Conference on Passive and Low Energy Architecture, 1–6. Santiago. https://halshs.archives-ouvertes.fr/halshs-02472416/document.

Payasli Oğuz, Gülin, and Fatma Meral Halifeoğlu. 2017. “Protection Problems of Construction Techniques and Materials on Traditional Houses of Diyarbakır.” Dicle Üniversitesi Mühendislik Dergisi 8 (2): 345–57.

Rajapaksha, I., H. Nagai, and M. Okumiya. 2003. “A Ventilated Courtyard as a Passive Cooling Strategy in the Warm Humid Tropics.” Renewable Energy 28 (11): 1755–78. https://doi.org/10.1016/S0960-1481(03)00012-0.

Sahebzadeh, Sadra, Abolfazl Heidari, Hamed Kamelnia, and Abolfazl Baghbani. 2017. “Sustainability Features of Iran’s Vernacular Architecture: A Comparative Study between the Architecture of Hot-Arid and Hot-Arid-Windy Regions.” Sustainability (Switzerland) 9 (5). https://doi.org/10.3390/su9050749.

Şerefhanoğlu Sözen, Müjgan, and Gülay Zorer Gedík. 2007. “Evaluation of Traditional Architecture in Terms of Building Physics: Old Diyarbakír Houses.” Building and Environment 42 (4): 1810–16. https://doi.org/10.1016/j.buildenv.2006.01.019.

Service, Turkısh State Meteorological. 2020. “Hatay Climate Data.” Cities & Holiday Resorts. 2020. https://www.mgm.gov.tr/veridegerlendirme/il-ve-ilceler-istatistik.aspx?m=HATAY.

Soflaei, Farzaneh, Mehdi Shokouhian, Hossein Abraveshdar, and Ali Alipour. 2017. “The Impact of Courtyard Design Variants on Shading Performance in Hot- Arid Climates of Iran.” Energy and Buildings 143 (May): 71–83. https://doi.org/10.1016/j.enbuild.2017.03.027.

Soflaei, Farzaneh, Mehdi Shokouhian, and Seyed Majid Mofidi Shemirani. 2016. “Investigation of Iranian Traditional Courtyard as Passive Cooling Strategy (a Field Study on BS Climate).” International Journal of Sustainable Built Environment 5 (1): 99–113. https://doi.org/10.1016/j.ijsbe.2015.12.001.

Soflaei, Farzaneh, Mehdi Shokouhian, and Shemirani Seyed Majid Mofidi. 2016. “Traditional Iranian Courtyards as Microclimate Modifiers by Considering Orientation, Dimensions, and Proportions.” Frontiers of Architectural Research 5: 225–38. https://doi.org/http://dx.doi.org/10.1016/j.foar.2016.02.002.

Taleghani, Mohammad, Martin Tenpierik, and Van Den Dobbelsteen. 2012. “Environmental Impact of Courtyards a Review and Comparison of Residential Courtyard Buildings in Different Climates.” Journal of Green Building 7 (2): 113–36. https://doi.org/https://doi.org/10.3992/jgb.7.2.113.

Teshnehdel, Saeid, Farzaneh Soflaei, and Mehdi Shokouhian. 2020. “Assessment of Solar Shading Performance of Courtyard Houses in Desert Climate of Kashan, Iran.” Architectural Engineering and Design Management 16 (6): 473–92. https://doi.org/10.1080/17452007.2020.1758025.

Tuncer, Orhan Cezmi. 1999. Diyarbakır Evleri. Diyarbakır: Diyarbakır Büyükşehir Belediyesi.

Turkısh State Meteorological Service. 2020. “Diyarbakır Climate Data.” Cities & Holiday Resorts. 2020. https://www.mgm.gov.tr/veridegerlendirme/il-ve-ilceler-istatistik.aspx?m=DIYARBAKIR.

Vellinga, Marcel, Paul Oliver, and Alexander Bridge. 2007. Atlas of Vernacular Architecture of the World. New York: Routledge Taylor and Francis Group. https://doi.org/10.1108/09504120810914655.

Yaşa, Enes, and Vildan Ok. 2014. "Evaluation of the Effects of Courtyard Building Shapes on Solar Heat Gains and Energy Efficiency According to Different Climatic Regions." Energy and Buildings 73: 192–99. https://doi.org/10.1016/j.enbuild.2013.12.042.

Yıldırım, M., Dalkılıç, N., Halifeoğlu, F.M., Dağtekin, E., Payaslı Oğuz, G., (2012). Rölöve teknikleri dersi öğrenci çalışmaları (Surveying techniques course student studies), TMMOB Mimarlar Odası Diyarbakır Şubesi Yayınları.

IEA. 2021. "Buildings: A Source of Enormous Untapped Efficiency Potential." 2021. https://www.iea.org/topics/buildings.

UNEP. 2020. "Guidelines on Green Houses of Worship." https://www.unep.org/resources/publication/guidelines-green-houses-worship.

doi:10.33948/JAP-KSU-36-2-4

تحليل مقارن للأفنية التقليدية في تركيا في المناخ الحار الجاف والحار الرطب

روشين أرجون **جان تونجاي اكين**

قسم الهندسة المعمارية، جامعة دجلة، ديار بكر، تركيا.

rusen.ergun@dicle.edu.tr *ctakin@dicle.edu.tr*

قدم للنشر في ٦/ ٧/ ١٤٤٥ هـ ؛ وقبل للنشر في ٩/ ٩/ ١٤٤٥ هـ.

ملخص البحث. تعد الأفنية عناصر مهمة في المنازل التركية التقليدية. وفي هذه المباني، يختلف تصميم الفناء، وخاصة الشكل الهندسي والسمات الداخلية، عن بعضها البعض أخرى حسب خصائص المناخ. وتهدف هذه الدراسة إلى مقارنة تصميمات الفناء في العمارة التقليدية في ديار بكر (حارة جافة) وهاتاي (حارة رطبة) الموجودة في مناخين مختلفين. وفي حين أن هناك أوجه تشابه من حيث «الفناء المخطط المربع» و»وجود مناظر طبيعية» تساهم في تكوين مناطق مظللة في ساحات هاتاي وديار بكر، من حيث «الاتجاه» و»الحجم/ النسبة» و»استخدام» عنصر الماء» فقد وجد أن هناك أهمية كبيرة اختلافات. وقد وجد أن الغرض الرئيسي من فناء ديار بكر هو الهروب من الشمس وخلق الظل وتوفير التبريد التبخيري عن طريق زيادة رطوبة الهواء، بينما كان الغرض الرئيسي من فناء هاتاي هو خلق الظل والاستفادة من الرياح. وتعد الدراسة بمثابة دليل للحفاظ على السمات التصميمية السلبية للمباني التقليدية واستخدامها في المباني الحديثة.

الكلمات المفتاحية: التصميم المستدام، الفناء التركي التقليدي، المناخ الحار الجاف، المناخ الحار الرطب، التبريد السلبي.