MICROCLIMATIC DESIGN STRATEGIES IN MARDIN VERNACULAR ARCHITECTURE

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ABSTRACT

Many of the methods used in traditional architecture have been abandoned in buildings with modern design. Most of the time, buildings that are designed without considering environmental conditions such as climatic, economic and topographic conditions, are far from being sustainable. Before the depletion of global natural resources, buildings that are suitable for the environment and climate should be taken into account in new designs by considering traditional architecture methods. Vernacular buildings, for instance, show great respect for the environment by using local materials and techniques, and by fully considering the constraints imposed by the climate. The literature review shows that most previous studies focused on urban microclimate in relation to urban scale, while only few studies focused on microclimatic design at a single building scale.

This paper presents the microclimatic strategies of vernacular architecture in Mardin. In this paper, a case study was carried out to prove the effectiveness of climatic strategies in Mardin vernacular architecture in hot-arid regions of Turkey. This article explores the characteristics of past designs with a hope to inspire the future, particularly with regard to climate responsive design which is commonly ignored in contemporary designs. Building microclimate can help create a comfortable condition for the occupants in the summer, especially in a hot and dry climate areas. This can be achieved by utilizing appropriate design strategies for building form generation and material selection in order to create or modify a building microclimate required for a comfortable living environment. Various buildings strategies that have been developed were evaluated, and positive aspects of strategies that are able to provide maximum benefit while protecting against negative environmental factors will be mentioned in this article. These strategies include climatic protection, climatic utilization, and other strategies related to local solutions. The analyses done on these strategies would create greater awareness among designers in utilizing climatic strategies in a more appropriate way in contemporary architecture. The findings of this study may contribute to the knowledge of the experts and design reviewers in developing and constructing more appropriate and sustainable buildings. This is very important as the findings may provide a better understanding in formulating the framework of vernacular structures.

Keywords: *Microclimatic design strategies, Mardin, hot-dry climate, use and protection against climate*

1. INTRODUCTION

In Mardin and similar regions where climatic conditions are challenging, both in summer and winter, people have to take into account natural phenomena and climatic data in order to survive and live in a more comfortable condition. Numerous studies have been conducted to review, classify, and comment on the climatic characteristics of vernacular architecture (Baran et al., 2011; Bouillot, 2008; Coch, 1998; Singh et al., 2010; Sözen & Gedik, 2007; and Vissilia, 2009). Cañas and Martín (2004) employed statistical methods to gather data on vernacular Spanish buildings and categorized them into different bioclimatic strategies based on their locations. By doing so, they managed to discover the most frequently used strategies that corresponded to building location and local climate. Yasa and Ok (2014) described courtyard forms that affect the thermal comfort status and energy performance in different climatic regions: hot-dry, hot-humid, and cold climates. Bekleyen et al. (2014) examined the spatial characteristics of a sample Mardin house and its thermal comfort performances. The findings reveal that the room on the lower floor is the most comfortable living space in autumn, and it turns into the warmest space in winter compared to other spaces. It has been determined that the room on the lower floor (in July) and iwan (in June) are the most comfortable living spaces in summer.

This study aimed to investigate the effects of environmental factors on the formation of houses, especially on the formation of building characteristics in Mardin vernacular architecture in order to develop evaluation criteria that are able to determine the effects of climate on building design, and environmental factors and climate-shaped comfort elements. Site parameters, settlement density, and spatial properties of the building envelope are included in the evaluation. The design criteria, i.e. keeping the streets narrow at the settlement scale, low-rise and dense building textures, building designs with inner courtyards at building scale, and passages from semi-open spaces to indoor spaces, have helped to optimize the negative effects of hot and dry climates on buildings.

2. MARDIN

Mardin, which is located in the south-eastern Anatolian region of Turkey at 36°55’ and 38°51’ north latitude and 39°56’ and 42°54’ east longitude, receives the highest degree of solar radiation (Çağlayan, 2010). (Figure 1).

Figure 1: Map of Mardin

The region comprises an influential hot-dry climate where it is hot and dry in summer, rainy in winter, and excessively hot and arid in late spring, summer and early autumn. According to meteorological data, precipitation is mostly observed in March. It was established that the highest annual temperature average is in July at 42.5ºC, while the coldest month of the year is February at -14.0ºC (Table 1). The highest humidity rate is measured in January at 76.1%. Annual shining duration in Mardin is more than 3000 hours, and in some places, the duration can come close to 3250 hours. Throughout the year, the daily sun-shining duration is between 8 and 9 hours. These challenging climatic conditions have motivated people residing in the area to create climatic protection and utilize strategies to provide user comfort in buildings.

Table 1: Extreme Maximum, Minimum and Average Temperatures Measured in Long Period (^{0}c) 1941- 2018

MARDIN	January	February	March	April	May	June	July	August	September	October	November	December	max
Maximum Temp.	19,4	19,5	27,5	33,6	35,4	40,0	42,5	42,0	39,3	35,6	26,1	24,1	42.5
Minimum Temp.	-13.4	-14.0	-11.7	-5.3	2,6	5,0	11,8	12,8	8.0	-2.5	-9.5	-11.9	-14.0
Average Temp.	3,1	4,2	8,0	13,5	19,5	25,7	30,0	29,7	25,2	18,4	10,9	5,3	16,1
Average Max. Temp.	5,7	7,3	11,6	17,3	23,9	30,5	35,0	34,7	30,0	22,8	14,4	8,0	20,1
Average Min. Temp.	0,5	1,3	4,6	9,7	15,0	20,2	24,5	24,6	20,7	14,5	8,0	2,8	12,2
Avarage duration of solar exposure (hours)	4,5	5,1	6,0	7,3	9,7	12,2	12,4	11,5	10,3	7,7	5,9	4,3	96.9
Avarage number of days Precipitation	12,0	10,6	11,5	10,3	7,3	1,5	0,5	0,2	0,7	5,1	7,6	10,8	78.1
avarage of monthly total precipation (kg/m2)	116,7	103,7	96,4	82,0	45,8	4,5	1,3	0,5	1,9	33,2	71,1	110,7	667.8
Max. Precipitation	3.2.1982	145.9 kg/m	Max. Wind	29.4.1994		143.6 km/hour		Max. Snow Height		6.3.1959	93.0 cm		

Traditional Mardin is spread along an east-west orientation, with a 20-25% incline in the south ridge of Mardin hill situated along a sloping terrain; thus, the topographic layout can be evaluated. The center of Mardin has been developed in the east-west direction due to its topography; the elevation difference between the northern and southern regions of the hill is 50-150 meters (Kaya, 2012, p.33) (Figure 2).

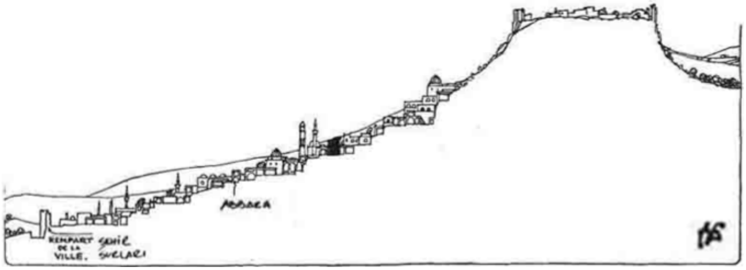

Figure 2: Mardin topography and city relation (Gabriel 1940)

The settlement shows characteristics that correspond to the criteria of an appropriate slope and orientation land selection; solar radiation gain and effects on ground temperatures; mountain and valley winds; and cold air flows, and from a climatic context, this region has an advantage of desired moist winds.

The streets in the Mardin Urban Protected Area are narrow and natural. When the settlement is on the east-west axis, stairs in the north-south direction generally connect the streets with each other in the east-west direction.

Mardin vernacular architecture

When traditional houses in Mardin or Anatolia were examined, the importance of climate and environmental data, the priority of using local materials, the location and planning of buildings i.e. the positioning of buildings, and long-term planning (thousands of years) with trials and errors, were also examined. "The main building blocks forming the frequent structure of Mardin are residences. Dwellings have benefited from this diagonal line, almost sticking to the sloping topography. Due to the Hilltop figurehead, the south-facing structures are mostly at least two stories. When the construction started on the ground floor is based on the parcel boundaries in the line parallel to the slope, it continues on the upper floors using the depth of the parcel perpendicular to the slope. Therefore, the ground floor is always one floor in the south direction. The integration of houses with land, and the failure to close each other's facades in doing so has a homogeneous effect on the whole city fabric" (Alioğlu, 2000). Mardin, has hosted different civilizations and been mentioned on UNESCO's world heritage list due to the fact that it still maintains its original architectural forms and settlement patterns; therefore, it should be evaluated from this perspective.

In Mardin, open spaces are mostly internal courtyards or terraces where the summer months are extremely hot thus, limiting outdoor and other activities in these areas. The courtyard is open to the Mesopotamian Plain, which is generally located in the southern direction. Therefore, the courtyard is generally exposed to the sun since it is located south of the building. The iwan and portico (revak) stand out as alternative venues where various activities take place. In addition, semi-open spaces, which are the transition spaces between open spaces and closed spaces, add a cooling effect to the adjacent spaces. The revak is located on the ground floor in all residences and surrounds the courtyard while iwan porticos are located on the first floor in all the buildings (Figure 3).

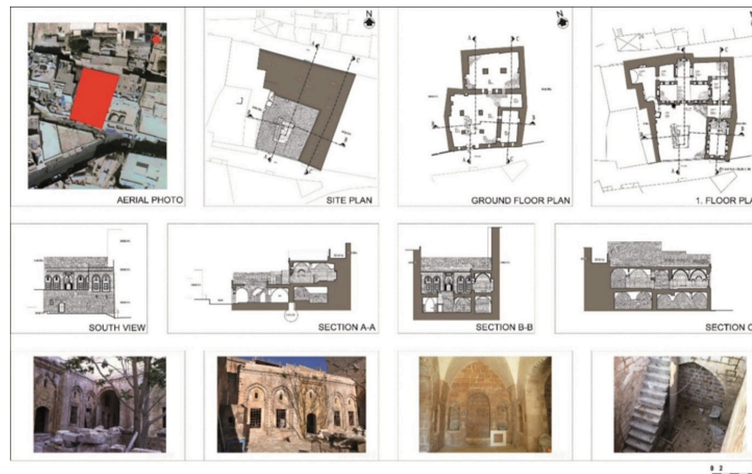

Figure 3: A typical Mardin house

3. MATERIALS AND METHODS

Vernacular housing in Mardin has adapted relatively well to the climate and adverse weather conditions. Determining the houses to be examined in the study and documenting them by photographing and interviewing local and senior citizens were performed as a technique to collect data. The selected houses were examined to investigate the diversity of climatic strategies. Generally, the buildings are well-preserved and require minor building maintenance and repairs, and they completely retain the original architectural form and spatial distribution. By choosing from highly qualified building materials, the diversity in climatic strategies expands the perspective of how these buildings struggle with climate conditions, and this help generate data for future buildings. One of the basic principles in the selection of houses for the study is the preservation of the originality of the buildings.

Restoration drawings have helped determine parts of the building that were damaged, and their original form was taken into consideration. The selected houses are not from a building island or in other words, considered to be from different parts of the urban site. Thus, the selection of a similar structure group in a particular region was prevented. The accuracy of the measurements and information is important in examining the selected houses. Therefore, measures were taken to ensure the selected residences have been included in architectural surveys, restoration projects, and possessed art history reports approved by the Cultural Heritage Protection Board (Figure 4).

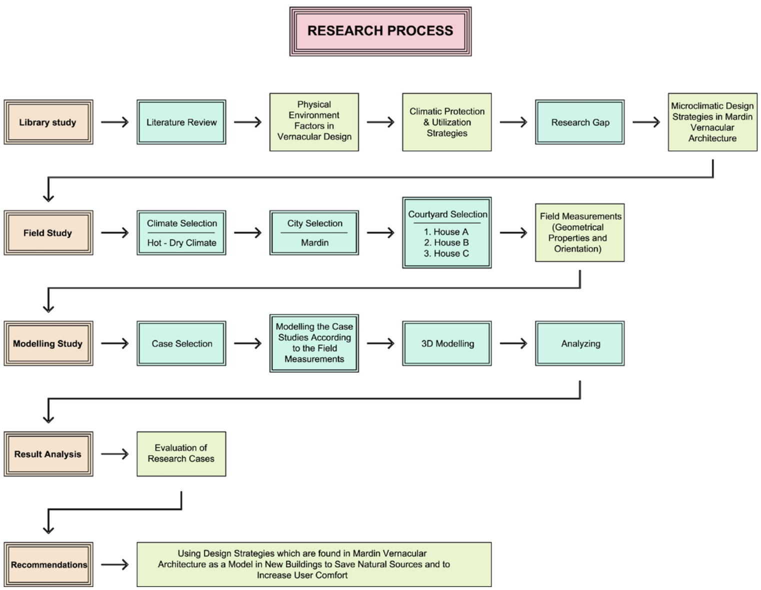

Figure 4: Research process

- Building A is oriented to the south with a 20-degree angle to the east. The building is located at an elevation of 1100-1110 m above sea level.
- Building B is oriented to the south with a 20 degree angle to the west. The building is located at 1076-1087 m above sea level.
- Building C is oriented to the south with a 4 degree angle to the west. The building is located at 1031-1043 m above sea level.

Field measurements were taken from the selected buildings and data from restoration projects and used in preparation of figures and 3-D modellings within a scale. Strategies which are similarly used in Mardin were analyzed in three different examples of vernacular architecture.

The essence of architectural bioclimatic design is to understand the local climate and utilize appropriate design strategies in generating building form and selecting materials in order to create or modify the microclimate of a building which will ensure comfortable living environments (Figure 5). Building form, solar control, and natural ventilation are the main bioclimatic design strategies in controlling building microclimate.

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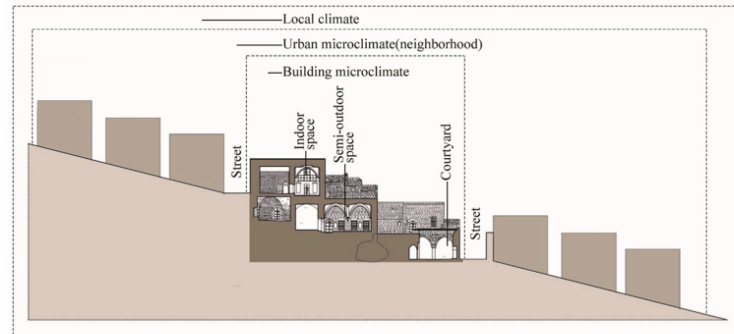

Figure 5: Local climate and building microclimate

In this paper, the authors explain the relationship between building microclimate and spatial organization which has a specific spatial configuration that makes a space suitable for the cold and intense hot seasons. Building microclimate is significantly influenced by building form, spatial organization, vegetation and landscape in the building, and construction materials. The adaptive thermal comfort model is suitable to evaluate the summer thermal comfort in building microclimate as its core assumption is that “if a change occurs such as to produce discomfort, people react in ways which tend to restore their comfort” (Nicol, 2002), and building microclimate provides this opportunity by taking all spaces (indoor, semi-outdoor, and outdoor) of a single building into account. Microclimatic modifications are examined by how the houses address environmental factors. Microclimate modification involves the best use of architectural design elements to maximize or limit sunlight, shade, and air movement. Choices are made to evaluate the aspects of microclimate housing modifications. The design of the built environment can modify the climate at different scales, especially at the microclimate scale. Various strategies developed in the vernacular architecture of Mardin were evaluated, and strategies that provide the maximum benefit of the positive aspects while at the same time protecting against the negative aspects of environmental factors were determined. These strategies include settlement, building, space, and material scale.

Climatic protection strategies, climatic utilization strategies, and other strategies were also evaluated by focusing on the orientation, use of topography, space utilization of the south facade, design of the inner courtyard, and the transport of sunlight to the lower floors.

The following steps were followed:

- Emphasis was placed on the layout and architectural design of Mardin vernacular architecture,
- Strategies used in Mardin vernacular architecture in providing climatic efficiency were determined, and
- The characteristics of Mardin vernacular architecture guiding the design of future houses were determined.

4. RESULTS OF THE RESEARCH

4.1. Protection strategies against climate

The climatic protection strategies determined from the investigated houses were examined under three main categories: rainfall protection strategies, sun protection strategies, and wind protection strategies.

4.1.1 Rainfall protection strategies

In this section, strategies for rainfall protection in Mardin traditional houses are presented; these include snow windows (snowy), gutters, floor wiping, eaves, sheltered doors and windows, sheltered main entrance doors, and sheltered semi-open spaces (Figure 6). Precipitation and humidity generally have damaging, oxidizing, and decaying effects on many building materials. Therefore, to minimize the undesirable effects of rainfall on buildings, the part of the building materials exposed to water need to be removed from the building design. Various measures have been taken for this purpose in Mardin traditional houses, and strategies have been tested to determine the effectiveness of these rainfall protection strategies. As humidity is one of the major problems associated with construction materials, rainfall protection strategies can increase the life cycle of a building.

Snow windows, floor wiping, eaves, recessed windows and doors

Rectangular shaped gaps formed on the upper parapet wall of the inner courtyard and the parapet walls of the south facade are called snow windows. Snow windows are the gaps made to remove snow accumulated on the floor during winter which could damage the building. Therefore, accumulated snow is either transferred to the ground floor from the snow windows facing the inner courtyard before being thrown into the well where water is stored, or thrown into the street from the snow window facing the southern facade. Gutters (çörten), which are formed out of local stone materials and extended outwards, help to accelerate the flow of snow and rain water accumulated on the roof to the terrace outside of the buildings. Gutters are replaced more than once in the courtyard and along the terrace facing the facades of the buildings. Floor wiping, which usually occurs on the outer surface of the upper floors of these buildings, protects the outer wall surface, which continues horizontally along the building at the same level, from the rain. As such, floor wiping prevents the formation of algae and moisture on the outer surface of the buildings and cracking and deterioration of the wall surfaces. The eaves in the buildings are the elements that project vertically from the floor beneath. Eaves, which provide protection from rainfall, extend along the street facade. The eaves in this type of residences act similarly to an umbrella on a public street façade; it protects the facade from rainfall and creates a temporary shelter for people passing through.

Window openings were observed to be constructed in a recessed manner in the vertical alignment of the outer wall surface to reduce the damaging effects of water particles on the windows. Similar measures were also taken for the doors. The main entrance door is inset further than other doors to provide protection from the rain to those waiting outside while waiting for the residents to answer the door. This measure was found on windows that may have water contact. Sheltered windows and doors are applied in all the buildings examined.

Creating protected semi-open areas or “Eyvan-Revak”

Iwans and porches are semi-open spaces that provide protection from rainfall, especially during seasons where the air temperature is high. As a result, even during rainfall, various activities can provide user comfort in these spaces.

4.1.2 Sun protection strategies

The main objective is to reduce solar radiation in summer and maximize solar radiation in winter (Soflaei et al., 2016). It has been mentioned previously that the Mardin Urban Protected Area experiences a hot and dry climate type in summer. Temperatures above 40ºC in summer have made taking serious precautions against the sun for buildings constructed in this region inevitable. The strategies determined for sun protection in Mardin traditional houses include building orientation, sheltered semi-open areas, sheltered open areas (protection from the western sun), sheltered doors and windows, sheltered main entrance doors, and the use of light colored materials (Figure 7).

Building orientation

Building orientation is an important parameter with regard to solar radiation as buildings will be exposed during the summer and winter months. In south-oriented buildings, during the winter months, the sun's rays hit the interior of the spaces horizontally, while in summer, the sun's rays hit at more of a right angle, which affects the space less.

Creating protected semi-open areas or "Eyvan-Revak"

Covered and semi-open spaces, porticoes and iwans provide protection from rain and the sun. This strategy reduces the entry of solar radiation (light and heat) into the interior of the buildings. In spring and summer, there are times when heat in shadow areas is suitable for user comfort which are usually before noon in the hot summer months and can continue all day long in the spring. During these periods, semi-open spaces act as transition spaces to host various activities due to the comfortable conditions.

Protection from the western sun by sheltered open areas

During interviews with local and experienced architects, it was mentioned that the western branches of the buildings were kept long on the top floor plans of the buildings due to the unwanted western sun. When orthographic photographs of the Mardin Urban Protected Area were examined in this research, a striking detail was observed. Generally, the "L" type or the "U" type (longer) of these western branches were observed to be protected from the western sun.

When these houses were examined in more detail, it was observed that the western branch was longer than the eastern branch. It could be seen that the area where these houses were located did not have a sufficient width in accordance with the "U" plan typology, i.e., where the neighboring wall on the western front has an existing wall, and the courtyard is protected from the western sun by the wall.

Sheltered floors, windows and main entrance doors

The examination of these houses also revealed that although the doors and windows were of different sizes, they were constructed further inward than the main plane's vertical plane based on the design decision. Therefore, the doors and windows help to prevent the negative effects of rain during the winter and summer months, and they also help to lessen the impact of sun rays on the buildings.

It was found that the main entrance door that connected the open-public space and the semi-open-private space was built further inside than other doors. The main entrance door protects against the rain, snow and cold wind in the cold season, and it also protects the entrance against direct solar rays in the hot season. In addition, it serves as a waiting area for guests after they knock on the residential doorknocker.

Use of light colored material

Buildings in the Mardin Urban Protected Area are made of beige-yellow limestone, obtained from nearby quarries. The color of this material, when removed from the furnace, is very close to light shades of yellow due to the effect of the sun, rain, and other environmental factors. Since the limestone used is light colored, it has a reflective effect towards sunlight as light color materials are often used to minimize heat absorption. As a result, it provides passive cooling for the buildings during the hot summer months.

Eaves and street structure

Eaves provide protection against sunrays during midday in summer months as they prevent sunrays from coming to the building facade, thus forming a shady area on the public street facade. Because the street structure is narrow, the shades from the building and the neighboring buildings form a canopy in the streets that are used to reach the buildings. This stands out as a sun protection strategy at the settlement scale as all are struggling with climatic conditions.

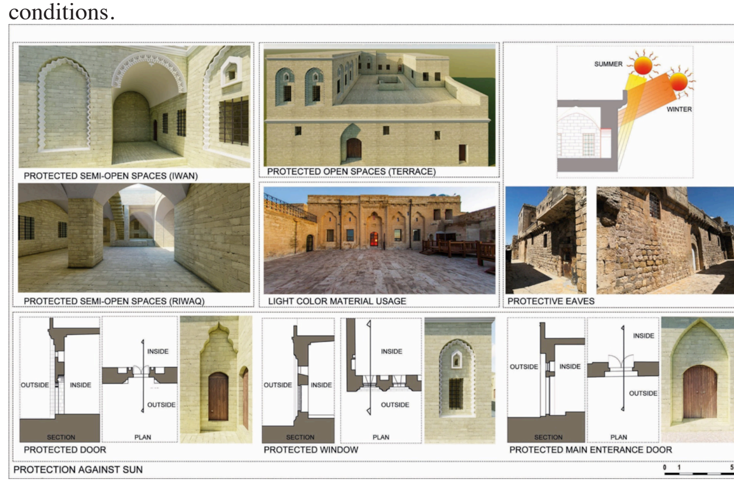

Figure 7: Strategies for protection against the sun

4.1.3 Wind protection strategies

The wind has a cooling effect on spaces. Because of this effect, winds coming from the plains to the south of the Mardin Urban Protected Area affect building structures, while winds coming from the mountains in the north are colder winds, which are expected to reduce the temperature of the structure to a minimum. Northern winds can cause significant heat losses in the structure. Therefore, wind is an important environmental factor to be controlled in buildings. In Mardin traditional houses, various wind protection measures have been taken at the settlement, building and spatial scales. The strategies determined for wind protection in Mardin traditional houses include building layout which directs the wind with the use of transition (intermediate) spaces. Thus, a severe climate impact can be controlled by the city's sloping structure, which receives a considerable amount of wind throughout the year.
Building layout and orientation

The South-Facing Hillside Settlement is located on the southern slope of the hill and is located in the Mardin Urban Protected Area. The ridge of the hill on which it is located serves as a barrier between the undesirable northern winds and the structures. In this way, the impact of the unwanted northern wind is minimized (Figure 8). The vacancy rates in the southern facade are between 8.37% and 12.0%. In all of these houses, the vacancy rate of the southern facades is too high to be compared to other facades. On the other hand, 1% of the openings remains along the northern facades. With this measure taken on the northern front, houses are protected from unwanted northern winds.

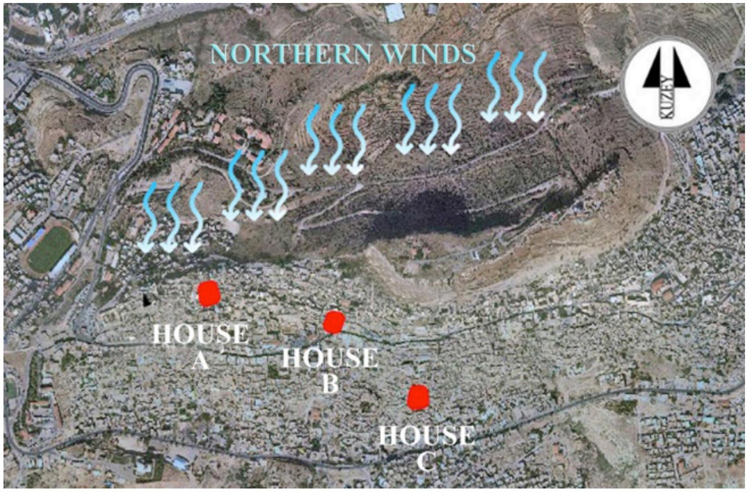

Figure 8: The hill as a barrier for undesirable wind

Use of iwan and porticoes

Eyvan and porticos (semi-open spaces) serve as transition units in housing. These spaces are located between open spaces and indoor spaces. Since semi-open spaces are less exposed to the cold effect of the wind in cold seasons compared to the open spaces, they delay the passage of cold air into closed spaces. Thus, indoor spaces are protected from the effect of the wind by the use of these semi-open spaces. The passage of closed spaces is provided from semi-open spaces (Figure 9).

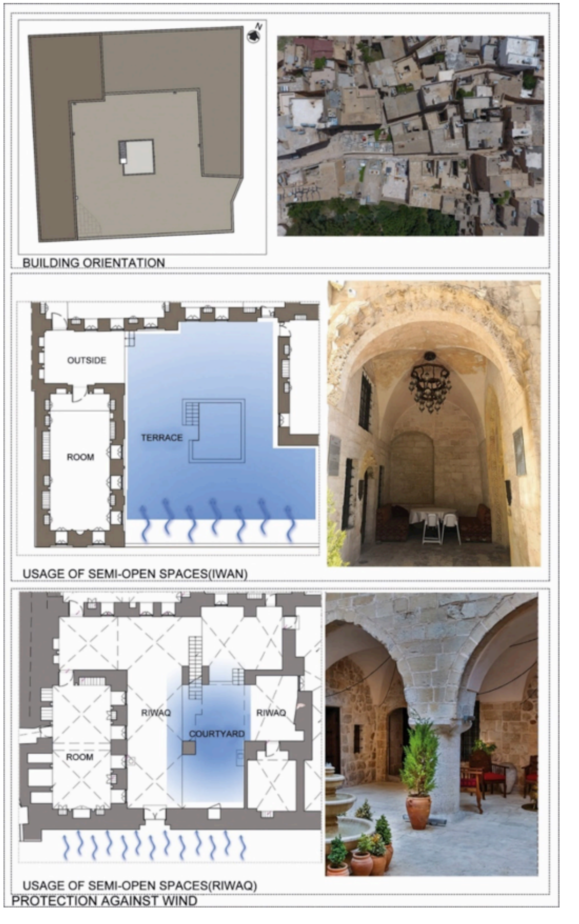

Figure 9: Protection strategies against wind

4.2 Climatic utilization strategies in investigated houses

The climatic utilization strategies identified in the three selected houses were examined under three main categories: rainfall exploitation strategies, solar exploitation strategies, and wind exploitation strategies (Figure 10).

4.2.1 Use of rainfall

Water is one of the most essential elements in hot-dry climates. As mentioned earlier, Mardin is located on the southern slope of a hill where the Urban Protected Area is located. Since it was not possible to carry water up the hillside during the period when these buildings were built, water storage became inevitable.

Storage of precipitation in water wells

In traditional Mardin residences, water is stored in wells located at the bottom of the buildings, and the water storage techniques used depend on the type of rainfall. Rainfall in the form of snow is transferred to the floor through snow windows before reaching the wells and being stored. Meanwhile, rainfall that has turned into liquid is transferred to the water wells by means of gargles, which have a water collection system and vary in size according to the amount of water they carry to protect the building from unwanted water effects. The water stored in the water wells meets the daily water requirement of the users during the four seasons.

Evaporative cooling

The temperature of the surface is reduced via evaporation. Ambient temperature and air humidity influence the rate of evaporation. Water vapor (evaporative) cooling provides quick cooling in hot-dry climates due to the hot environment and low humidity.

Interviews conducted with the elderly and local architects in all the buildings examined showed that there was at least one well in each house, and the well in each house was connected to other wells by channels. When one well was filled, the excess water was transferred to lower wells through the channels. Water stored in the wells was sprinkled on courtyards and terraces during hot days in summer, and when the water evaporated, water vapors cooled the buildings, and humidity was balanced. The temperature of the water stored in these wells was approximately between 10 and 15ºC due to the balanced soil heat during the hot summer months. The cold water used increased the efficiency of evaporative cooling.

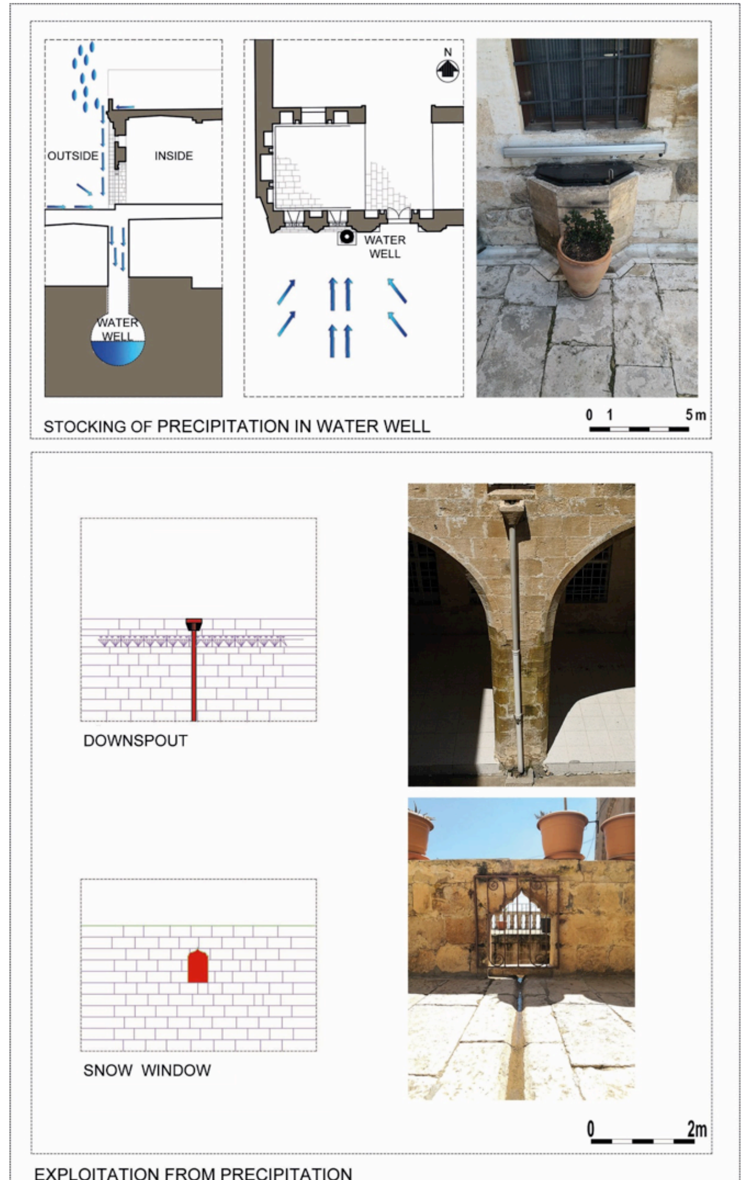

Figure 10: The use of rainfall

4.2.2. Use of solar radiation

In the Mardin Urban Protected Area, where the winter months are harsh, the sun is the most important sustainable energy source. The fact that the population of trees, which can be used as fuel, is poor and prices of coal and similar fossil resources in the Urban Protected Area and its immediate vicinity continue to increase, has heightened the importance of utilizing sustainable energy resources. Therefore, solar radiation has become the most sought-after energy source in winter.

Building orientation and layout

Located along a sloping topography, the northern facade is closed, while the southern facade is open. This makes it possible for buildings to benefit from solar radiation from sunrise to sunset. The aim of this strategy is to reduce the amount of energy employed for heating and lighting using solar radiation. (Figure 11).

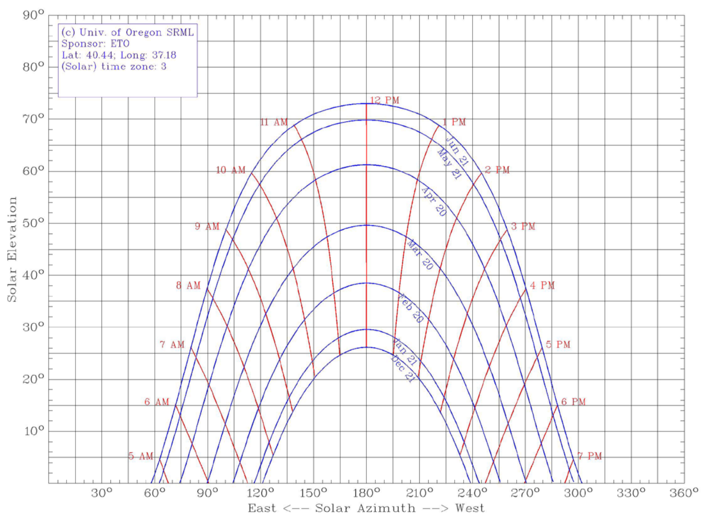

Figure 11: Solar azimuth angle for Mardin

For this purpose, the orientation and building surfaces are designed to take the sun path into account. It was observed that all of the houses were directed in the right direction to benefit from solar radiation, which was necessary in winter in the Mardin Urban Protected Area as the summer months are extremely hot, and the winter months are harsh. Therefore, any open spaces in buildings should be considered as they affect heat gain-loss of the buildings. As the gap ratio increases, heat loss will increase during the winter months. As the sun angle changes during the summer and winter months, the orientation towards the south facade provides protection from the sun in the summer and benefits from the sun in the winter. In these residences, where only the south facade is open, the floor space on the upper-floor terraces is left open so that the spaces outside the south facade could receive daylight, which has moved to the inner courtyard (located downstairs, with a daylight-flooring gap and surrounded by residential spaces). The porches and other spaces surrounding the inner courtyard were also set up to receive direct or indirect daylight. It was determined that the indoor spaces were designed around the inner courtyard and, therefore, daylight could be carried to the lower floors with this strategy (Figure 12).

Use of topography

In the Mardin Urban Protected Area, which is located on the southern slope of the hill, building elevations gradually decrease towards the south due to topographical conditions. Structures located to the south experiences a difference in elevation compared to structures gradually moving to the north, which prevents sunlight from reaching the structures. This layout can often be seen with terraces between the spaces within the structure itself, depending on the size of the building and the slope of the land. In this scenario, the roof of a space can be the terrace of an upper space.

In all the buildings examined, it was observed that due to the good use of the topographic condition of the land, both inter-building and inter-spatial planning were developed to prevent one building from influencing the sunlight received by another building. The adjacent perimeter sections of the houses show that buildings are constructed in such a way that they do not interrupt each other's direct sunlight. In this context, given the interaction of all three buildings with the surrounding buildings, it was determined that the relationship between topographic building height and building spacing was constructed correctly.

Overhead window sections

In traditional Mardin houses, overhead windows are generally smaller than other facade windows, which are located above the normal windows. Since the overhead windows are located in the upper part of the space that they are in, they have higher efficiency in receiving light and providing ventilation compared to normal windows.

It was found that the internal and external dimensions of these windows were different in all the houses examined. While the space in the outer walls was kept narrower to prevent heat loss, the space in the inner walls was wider to reach the inner parts of the space more efficiently. This expansion is observed in the right, left, and bottom parts of the cavity depending on the angle of incidence of the sun, while the upper part of the window is kept constant in both the interior and exterior walls.

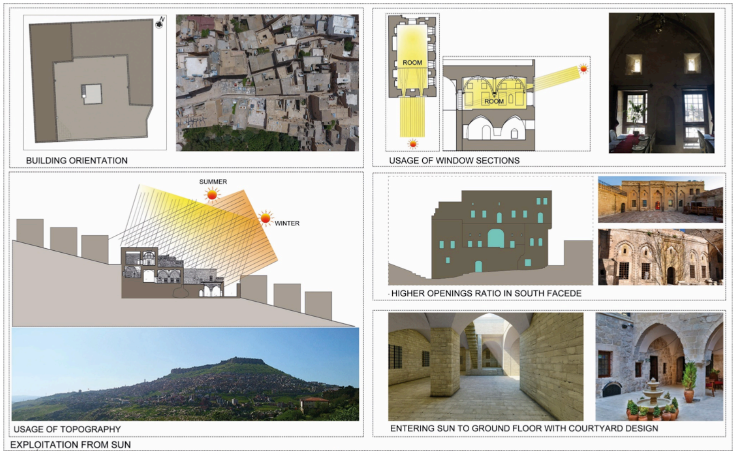

Figure 12: The use of solar radiation

4.2.3 The use of wind

In traditional Mardin houses, ventilation is provided through natural methods. Extremely hot summer months and harsh winter months have made it inevitable to develop strategies for controlling airflow in the Mardin Urban Protected Area. The strategies determined to benefit from the wind in Mardin traditional houses include building layout and orientation, use of topography, unidirectional ventilation, cross ventilation, and ventilation with overhead windows.

Building layout and orientation

The ridge of the hill where the Mardin Urban Protected Area is located acts as a barrier against the unwanted northern winds, while at the same time not obstructing air movements coming from the Mesopotamian Plain to the south. The Mardin Urban Protected Area is located in a position where it can receive the desired wind from the south. The use of wind from the south, which has a cooling effect, is achieved by directing houses to face the south (Figure 13).

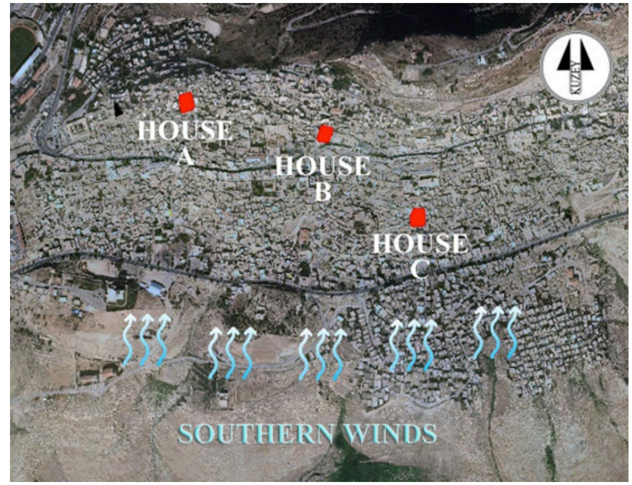

Figure 13: The desired wind from the south

It was observed from all the buildings examined that the buildings were planned in a way that they would not interfere with each other’s wind source, and this was achieved through the correct use of the topographical condition of the land. When the adjacent sections of the houses were examined separately, it was found that these buildings were designed so that they did not interrupt the southern winds coming from other neighboring buildings. In this context, it was determined that the relationship between topographic building height and building spacing was correctly constructed for the interaction with surrounding buildings.

Ventilation with overhead windows

Natural ventilation in buildings is seen as the most commonly used method to ensure airflow. Natural ventilation is provided through rectangular main window openings and skylights without mechanical components. To provide natural ventilation in the buildings, the topography of the region, the orientation of the buildings, and the use of window openings with different sizes and facing different directions are the important factors to be considered (Figure 14).

The examination of the buildings showed that the windows and the doors providing air circulation to the spaces were of different forms and sizes according to the purpose of use. Overhead windows are an important alternative to ensure the outflow of dense air in these spaces during hot seasons. In all the three houses examined, overhead windows can be seen in a closed space where there are both one-way and cross ventilations. Although these overhead windows are smaller than other windows, they are able to provide effective ventilation throughout the different seasons with the use of different alternatives i.e. two different window sizes and two different elevations in which the windows are placed.

Single-side ventilation

Single-side ventilation is a form of ventilation where the windows and doors are open on the same facade. One or more openings on the same facade can be used together in this type of ventilation. The internal and external cavities of the facades where the skylights are located vary. Since the inner part of the cavity is much wider than the outer part, the inner part has a wind collector feature. The collected wind is exacerbated by the contraction of the outlet. In unidirectional ventilation, ventilation that is more active is achieved when the overhead windows are used together with other windows.

Cross ventilation

Cross ventilation is a form of ventilation created by the simultaneous opening of a door or a window in closed spaces. In this type of ventilation, the airflow enters the space through the opening on one side of the space, passes through via the space, and exits to the opening on the other side. Cross ventilation provides more active and faster ventilation than unidirectional ventilation.

Figure 14: Use of wind

4.3 Other strategies

Other strategies determined to benefit traditional Mardin houses include high thermal mass strategies which are: use of soil between the vault and flooring as an insulation material, earth cooling, and animal heat and "Abbaras" (Figure 15).

High thermal mass

In traditional Mardin houses, in addition to undertaking the task of providing protection and use in extreme temperatures, this strategy attracts attention due to its high capacity. The cross-sections of the walls, which act as carriers in the houses examined, were between 70 and 150 cm thick. The thickness of the walls provided heat delays due to the high thermal mass property of the buildings, where the thicker the mass is, the longer the time lag is. Since the building shell acted as a bridge between the external environmental conditions and the buildings, user comfort conditions inside the buildings increased due to the high insulation property of the materials used in the building shell.

Using soil between the vault and flooring as insulation material

The closed spaces were crossed with vaults, where stone was used as the main structural material. The vaults, which were built with coarse and rubble stones, were compacted with soil, and their surfaces were plastered with coarsely spread mortar. Between the flat floors that form the floor of the upper floor and the vaults covering the lower floor, earth was placed as a filling material. Soil filling material causes heat delay and serves as heat insulation. It was observed that the soil was used as filling material in all the buildings examined.

Use of earth cooling

Temperature values 2-3 m below the soil are between certain values throughout the year and undergo very small changes. These values vary between 7 and12ºC since the surface of the ground does not exceed a certain temperature range; it provides cooling under hot weather conditions and helps to warm the environment during the harsh winter months. It was observed that all of the investigated buildings were left in their natural form to benefit more from the balanced heat of the soil (the bottom of the earth) in its natural state in the closed spaces of the lowest floors of these buildings.

Use of animal heat

In Mardin traditional houses, stables are usually located on the lowest floor of the buildings. In all the three buildings, the barn is located on the ground floors of the dwellings. In addition, the warmth of the animals living in the stables results in a natural heat source. This causes an increase in the environmental temperature. It is believed that the heat increase caused by all of these factors in the stables contributes to the (horizontal and vertical) heating of the neighboring spaces in winter.

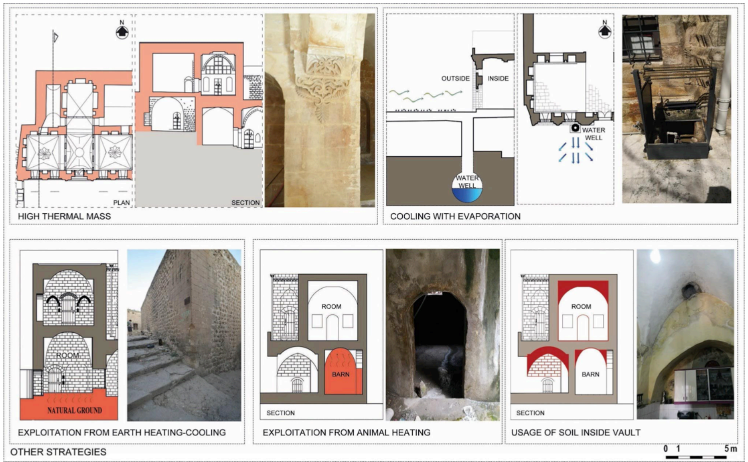

Figure 15: Other strategies

"Abbaras"

"Abbaras" are an important element that are frequently encountered in the Mardin Urban Protected Area, where the urban transition elements ensure the continuity of the streets connecting the houses from one housing area to another. "Abbaras" provide protection from rainfall and the sun, with their shaded areas formed during hot summer months. They are one of the most suitable semi-open public spaces for relaxing and cooling at noon during the summer months. In addition, "Abbaras" benefit from wind during the summer months. Other significant physical factors in the thermal performance of urban environments are wind flow and air circulation (Ricciardelli & Polimeno, 2006). Wind that enters one end of the "Abbara" flows violently and forms a wind tunnel. In the study carried out in the Mardin Urban Protected Area, it was determined that "Abbaras" were separated from each other as a plan typology. There are three different types of "Abbaras" in the urban protected area: I, L and T types. The plan typology of the "Abbaras" determines the movement of the wind through it. The wind tunnel effect varies according to the plan typology of the "Abbaras" (Figure 16.).

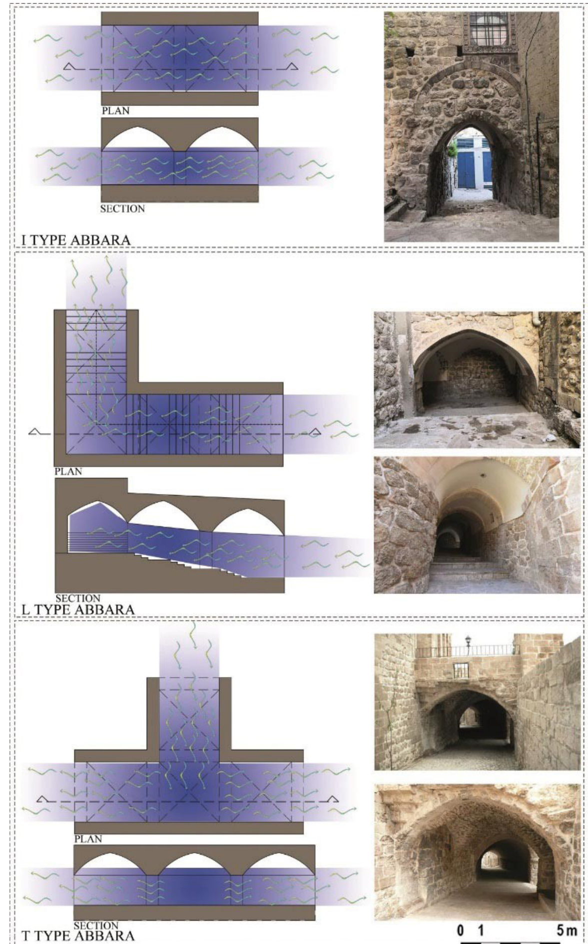

Figure 16: The typology of "Abbaras"

5. DISCUSSION

Microclimatic strategies used in Mardin vernacular houses at different scales include "Abbaras", streets, topography, and protection against wind based on settlement decisions at the settlement scale. At the building scale, the strategies used include building form, inner courtyards, I- and U-type plans, and spatial elements "eyvan" and "revak" while semi-open spaces, overhead windows, natural ventilation, earth cooling, evaporative cooling, and construction using natural resources are considered at the spatial scale. Some of these strategies have multiple uses in summer or winter; for example, front doors protect against the rain, snow and cold winds in the cold season, and the entrance protects against direct solar rays in the hot season.
The strategies used for protection from the western sun have allowed the courtyard to be used more effectively after noon on hot summer days in all the houses. Residences with an L plan type maintained longer shade under the western branch, while residences which have an eastern branch, i.e., no western branch, have a higher neighboring wall from the building to the west of the house which protects the building and courtyard from the western sun and provides shade. Building orientation and layout have been taken into account in extreme local climate conditions. The orientation of the building allows it to collect higher amounts of solar radiation in winter than in summer. Although the plan typologies of the houses are different, they share similar features with regard to climatic strategies since climatic strategies, knowledge, and experience that constitute the design criteria in traditional Mardin houses are gained through trials and errors formed over the years.

Evaporative cooling is a well-known and preferred method not only in Mardin and its surrounding districts, but also in the entire region. Sprinkling of water on floors by residences is of supreme significance in fostering evaporative cooling, which contributes to further thermal comfort in courtyard houses, particularly in hot-arid regions (Al-Azzawi, 1994; Beazley & Harverson, 1982; Edwards, 2005; Fathy, 1986).

The effective use of thermal mass plays a large role in many design concepts for climate-conscious sustainable buildings (Givoni, 1979; Holmes & Hacker, 2007; Slee et al. 2014). High thermal mass absorbs and stores heat during cold seasons and sunny times. It releases heat from the building when the living areas are not heated during cloudy hours or at night. In warmer seasons, the interior mass has a lower temperature than the outdoor temperature, thus providing users with a lower ambient temperature. Cooling of the internal mass can be achieved by cooling at night, typically on cool nights" (Kim, 2008 p. 35). Where is the open quotation mark?

The strategies mentioned in the houses examined have similar characteristics with each other. Buildings with a compact form experience better local climate behaviors. With thousands of years of trials and errors in Mardin traditional houses, the impact of climatic conditions on living spaces has been optimized. Traditional Mardin houses are shaped according to the climatic and topographic features of the region. The effects of cultural characteristics and natural data are felt in the spatial design and shape of the building in traditional Mardin houses. This study proves that the microclimatic strategies found in Mardin vernacular architecture are accurate (Table 2).

Table 2 : Microclimatic design strategies in Mardin

STRATEGIES		MICROCLIMATIC DESIGN STRATEGIES
PROTECTION STRATEGIES AGAINST CLIMATE	PROTECTION AGAINST RAINFALL	Snow windows
		Gutters
		Floor wiping
		Eaves
		Sheltered doors and windows, sheltered main entrance door
		Creating protected semi-open areas or "Eyvan-Revak"
	PROTECTION AGAINST SOLAR RADIATION	Building orientation
		Creating protected semi-open areas or "Eyvan-Revak"
		Creating sheltered open areas – protection from the western sun
		Sheltered doors and windows, sheltered main entrance door
		Use of light colored materials
		Eaves
		Streets and "Abbaras"
	PROTECTION AGAINST WIND	Building orientation and layout
		Use of iwan and porticos
STRATEGIES FOR USING CLIMATE	USE OF RAINFALL	Storing rain in wells
	USE OF SOLAR RADIATION	Use of iwan and porticos
		Use of topography
		Opening ratio on south facade
		Overhead window
		Inner courtyard to receive direct or indirect daylight
	USE OF WIND	Building orientation and layout
		Use of topography
		Ventilation by overhead window
		Single-side ventilation
		Cross ventilation
OTHER STRATEGIES		High thermal mass
		Using soil between the vault and flooring as insulation material
		Earth cooling
		Using animal heat
		Evaporative cooling
		Abbaras

6. CONCLUSION

The strategies mentioned in the houses examined have similar characteristics with each other. The similarities among the houses of different regions and at different heights create the impression that they are the conditioned product of common knowledge.

Although the settlements located on the slopes are generally considered as unsuitable in regions where hot and dry climates prevail, the Mardin Urban Protected Area has been able to create sustainable privileged living spaces by optimizing the impact of microclimate with a number of design decisions and measures. Creating an appropriate building microclimate in a building is important to ensure thermal comfort in summer in hot and dry climates due to the fact that building form generation has a significant influence on the microclimate of a building.

In traditional Mardin houses, particularly, the arrangement of close form types in courtyards produces shaded areas. In these courtyards, with the help of water for evaporative cooling, the floor temperatures are further minimized by natural elements and by constructing part of the house in the ground, which is always cooler than the outer ambient temperature in summer (evaporative and earth cooling). 'Eyvan' and 'revak', typical spatial elements of traditional houses, are used to create shady and cool living spaces during the day. The vernacular houses show that it is possible to create comfortable conditions for inhabitants when both the indoor climate and the whole building microclimate are taken into account.

The application of open and semi-open spaces such as courtyards, iwans, and porticoes in modernized and newly designed buildings allow users to leave indoor spaces. Water scarcity, which is one of the pertinent problems in every period, is solved by the various water storage methods in traditional Mardin houses. Water stored during periods of heavy rain is used to meet the many needs of the buildings.

In the context of conservation and utilization of natural resources, traditional Mardin houses are more sustainable. Traditional Mardin houses, which have served one generation to another for many years, have many strategies that can help generate data for newly designed houses. Currently, by using these data, the energy consumed to provide comfortable user conditions in newly designed buildings can be minimized. The vernacular architecture design practices in Mardin houses are based on a deep understanding of the climate. Therefore, further work should investigate the vernacular strategies in new and modern houses so that these new buildings can reduce their energy requirements to zero by integrating the traditional methods and modern systems.

Every day, the resources we consume and the nature we pollute harm both humans and other living things. We must place importance on nature before the harm done becomes irreversible. Further work should investigate building microclimate in new and modern houses with diverse spaces and use bioclimatic design principles to create a comfortable building microclimate in design practices.

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