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Investigating The Effect of Mesoclimate on the Physical Characteristics of Semi-Open Spaces in Vernacular Houses of Cold Climate (Case Study: Qajar-Era Houses in Ardabil and Tabriz)

[1]*Raheleh Zohouri*, [2*]*Niloufar Nikghadam*, [3] *Mansoureh Tahbaz*
[1] *Department of Architecture, ST.C., Islamic Azad University, Tehran, Iran.*
[2*] *Department of Architecture, ST.C., Islamic Azad University, Tehran, Iran.*
[3] *Department of Architecture, Shahid Beheshti University, Tehran, Iran.*

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ABSTRACT: Today, the necessity and importance of paying attention to climatic conditions in architecture as an effective factor on the environmental quality of buildings is not hidden from architects. In the country of Iran, the cold climate zone requires special attention in the climatic design of buildings due to its difficulties and considerable extent. Semi-open spaces have been a crucial element in architecture, significantly influencing the spatial arrangement of vernacular buildings in Iranian architecture. However, in contemporary housing, these spaces lack the necessary efficiency, and one of the factors contributing to this, especially in cold climates, is the failure to consider climatic conditions. Modeling climatic design solutions for these spaces in vernacular architecture and applying them in contemporary housing design will enhance the efficiency of these spaces. Intending to investigate the effect of mesoclimate on the structure of semi-open spaces in Qajar-era houses in cold climates, this article examined and compared the climatic conditions in the two cold cities of Ardabil and Tabriz. It identified the physical characteristics of semi-open spaces in the case studies and analyzed the impact of mesoclimatic conditions on the differences in the features of semi-open spaces between the two cities. This research is applied and has a qualitative nature, utilizing the grounded theory method. Comparing the physical attributes of the semi-open spaces in the vernacular houses of the two cities and matching them with the differences in climatic conditions reveals significant differences based on the influence of the mesoclimate on the physical structure of the semi-open spaces.

Keywords: *Semi-Open Space, Climate-Responsive Architecture, Cold Climate, Vernacular Architecture.*

INTRODUCTION

As a key element in the architecture of residential buildings, the semi-open space plays a crucial role in creating a seamless connection between the interior and exterior spaces. These spaces, while providing an opportunity to interact with nature, can enhance the quality of life for residents. In today's housing, these spaces often lack the necessary efficiency, and one of the factors contributing to this is the lack of attention to climatic conditions, especially in cold climates. In the previous native architecture of Iran, semi-open spaces not only served as one of the climatic elements of the building but also provided a platform for the daily activities and social interactions of the house's residents, meeting their functional needs.

By studying and analyzing traditional architecture across different regions, one can understand how architectural forms adapted to local climatic conditions (Kasmaei, 2004), offering valuable patterns for climatic design of architectural elements. Most previous studies on climate and architecture have focused on the macro scale, while less attention has been paid to the influence of climatic components at meso levels. Understanding mesoclimatic conditions and their impact on the formation of architectural elements enables the development of effective strategies to adapt architecture to environmental contexts. The research questions are:

1-What are the differences between the climatic characteristics of the cities of Ardabil and Tabriz on a medium scale?

2-What effect has the mesoclimate had on the physical structure of the semi-open spaces in the traditional houses of these two cities?

Research Objectives:

This study aims to identify the relationship between climate and the physical characteristics of semi-open spaces in

*Corresponding Author Email: *n_nikghadam@iau.ir* *ORCID: 0000-0003-0723-7396*

vernacular architecture, thereby providing a foundation for future research to propose climate-responsive design solutions for semi-open spaces by modeling and adapting these characteristics to contemporary housing. The primary objective is to investigate the influence of intermediate climatic conditions on the formation and physical structure of semi-open spaces in traditional residential buildings in cold regions.

Research Background

Nikghadam (2013) has studied and compared the patterns of semi-open spaces in traditional houses across three cities: Dezful, Bushehr, and Bandar Lengeh, and investigated the effects of central and local climate on these spaces. It concluded that, although all three studied cities are located in a hot and humid macroclimate. Still, the pattern of semi-open spaces in each city or port is in accordance with the local climate components of the same region, and these patterns differ from one another due to the variations in the middle and local climate components in these cities. One of the most comprehensive studies in the field of the effect of semi-open spaces on environmental quality in indoor spaces is an article from 2020 that comprehensively reviewed research in this field and examined the impact of balconies on environmental quality and energy consumption in residential units (Ribeiro et al., 2020). The mentioned article shows that the geometric shape, shade depth, position in the facade, and the type of balcony covering (open, glazed, shaded) are the most critical components that affect thermal performance, natural ventilation, and energy load reduction. For example, in hot and dry areas, open or shaded balconies are more beneficial, while in cold climates, glass-covered balconies with a greenhouse function help retain heat on sunny days. Babazadeh Salut et al. (2023) researched the importance of sunny courtyards in the rural houses of Shemiranat, Tehran. They concluded that the sunny courtyard, as a semi-open space on the upper floors and facing south, can provide favorable microclimatic conditions for nearby living spaces by absorbing the maximum amount of sunlight and creating a buffer against winter winds. In a study of the western regions of the country, Salem et al. (2018) characterized semi-open spaces in traditional houses in Kurdistan west and found that types with two open sides are more efficient in terms of ventilation, lighting, and social interaction. This study emphasizes the importance of climatic comfort as the dominant factor in the placement and design of these spaces.

In the cold and dry climate of Iran, a study (Goshayeshi et al., 2024) using ENVI-met software has investigated the thermal performance of three different types of balconies (one side closed, two sides closed, three sides closed) in three south-facing positions (east, center, west) in four-story apartments in Mashhad. The results showed that the two-sided closed form in the central position of the facade created the highest thermal comfort range in summer, and the three-sided closed form in the western position performed better in winter. This research shows that the accurate design of the form and placement of balconies can reduce the need for mechanical heating and cooling systems. Karimzadeh et al. (2021) investigated the thermal performance of traditional verandas in the historical context of Shiraz. They showed that increasing the width of the veranda, the amount of opening towards the yard, and its height from the ground level play an important role in improving the climatic performance and increasing the thermal comfort of the residents. Raheb & Nazari (2017) identified effective indicators for the use of private semi-open spaces in a study conducted in Tehran. They showed that, in addition to dimensions and proportions, view and scenery, safety and access, as well as climatic comfort, including protection against radiation, rain, wind, and humidity, are the main factors in increasing the efficiency and acceptance of these spaces by residents. A review of previous studies reveals that no comprehensive research has been conducted on the characteristics and requirements of semi-open spaces in various climates, particularly in cold environments.

The content analysis of the previous researches shows that the orientation, depth, height, physical structure, placement position in the plan and view, access levels to the semi-open space and adjacent spaces are the components that are most influenced by the environmental conditions and play a role in the climatic efficiency of the semi-open space And in most of the researches that evaluated the efficiency of semi-open spaces or dealt with their typology and classification, they have been considered.

MATERIALS AND METHODS

Methodology and Research Processes

Two cities, Ardabil and Tabriz, were chosen for the study, both of which are located in the cold climate zone at the macro level; however, they exhibit different climatic characteristics at the meso level. For this purpose, 16 Qajar-era houses from Tabriz and Ardabil were selected. The reason for choosing the Qajar period for study is the availability of building documents and the preservation of a relatively larger number of buildings compared to previous periods. Additionally, the introduction of modern architecture and new construction technologies in later periods led to a reduction in the importance of considering environmental conditions, and the role of semi-open spaces in houses was weakened. Among the Qajar houses, samples were selected for review that had one, two, three, and even more semi-open spaces, and their information, maps, and pictures were available. These documents and information were obtained through library sources, related offices and organizations, and field visits. This research is applied and has a qualitative nature, and it was carried out using the method of foundational data theory. The research process consists of four steps as follows:

The first step is data collection, which involves reviewing the

research background, studying the theoretical foundations, and gathering information and documents from the samples. The data obtained from analyzing the content of previous research and the opinions of researchers include the physical characteristics of semi-open spaces in the local architecture of cold climates, the criteria for measuring their climatic efficiency, and knowledge of the climatic conditions of cities and their climatic goals.

Second step: Data classification, including extracting categories through content analysis and targeted data classification. At this stage, the data obtained from the studies, including climatic objectives and physical components affecting the climatic efficiency of semi-open spaces, were categorized.

The third step involves analyzing the characteristics of semi-open spaces and assessing their climatic conditions, comparing the characteristics of the samples from the two cities. Then, the characteristics of the samples were evaluated in terms of responding to each of the objectives, and the degree of compliance with the climatic needs was measured. Additionally, samples from two cities were compared, and their differences were identified.

Fourth step: conclusion, including discussion and conclusions from the findings

At this stage, the role of semi-open spaces in achieving each of the climate goals was analyzed, and the practical components were identified. At this stage, the findings from the comparison were discussed, analyzed, and matched with the climatic differences between the two cities. The relationship between them was then investigated, and the final results were obtained.

Physical Characteristics of Semi-open Space

Semi-open spaces have been a key element in traditional architecture, formed in response to environmental conditions and functional needs. In the past, semi-open spaces, in general, and porches, in particular, have been essential elements of Iranian houses. These spaces have played a role in the overall organization of the building, alongside open and closed spaces. As an independent space, they were used for various functions (Mahmoudi, 2005). In sources related to climate architecture, descriptions and analyses of the specific physical characteristics and diverse functions of these spaces are provided. The analysis of researchers' theoretical views in this field can provide a framework for identifying effective indicators in evaluating the efficiency of these spaces in the studied samples. Table 1 shows the views of researchers in this field.

By studying the research that has evaluated the climatic and functional efficiency of semi-open spaces, it is possible to identify the essential physical components, as described in Table 2. This summary suggests that the importance and influence of certain physical elements in semi-open spaces are greater in terms of their climatic efficiency, and they serve as the primary criteria for measurement in most evaluations.

The study and analysis of the background content and theoretical foundations of the research highlight the important physical components of semi-open spaces that play a crucial role in responding to climatic needs. These components include the physical structure, orientation, dimensions (including depth and height), access pattern, adjacent spaces, degree of enclosure, and level of placement with respect to the yard.

Climate Studies

Climate refers to the general trend of weather conditions in an area over a long period. It is essential to consider climatic conditions and the environmental context in architecture. The native architecture of most regions worldwide is influenced by climate, and people have consistently sought to create a suitable living environment that accommodates the facilities and climatic limitations of their local environment (Nikghadam, 2013). Climate can be studied in four scales: macroclimate, mesoclimate, local climate, and microclimate. Macroclimate encompasses a wide area, and the primary factors of the Earth determine its limits. Like the vast region called the

Table 1: Physical characteristics of semi-open spaces in cold climate vernacular architecture from the researchers' point of view

Source	Physical Characteristics
Kasmaei, 2004	Columned Iwans on the ground floor with high elevations on the front two stories of the building
Tahbaz,2013	Shallow depth, small dimensions
Shaterian,2015	Placement in front of the hall
Rezaei & Molavi, 2014	Shallow depth
Mahmoudinezhad & Hassanzadeh,2018	Shallow depth
Keynezhad & Shirazi, 2010	Shallow depth, Two types: overall, single
Esmaeili Sangari & Omrani, 2014	Two types: overall, single
Shams & Khodakarami, 2010	A rectangle with elongation perpendicular to the central axis
Babazadeh Salout et al.,2023	Overall, Iwan is on the ground floor
Valizadeh Oghani & Movahhedi, 2019	Closed on three sides and open on one side
Salem et al., 2018	Two types: overall, single

Table 2: Physical components examined in previous research

Source	Physical Components
Pourahmadi & Seddighi, 2023	depth, area
Ebrahimi asl et al., 2017	depth, orientation
Nikghadam, 2013	orientation, placement level, access pattern, proportions
Saligheh & Saadatjou, 2019	depth, distribution pattern
Karimzadeh et al., 2021	depth, width, height, area in facade, height from the yard
Dehghan et al., 2022	depth, orientation, combination pattern with side spaces
Goshayeshi et al., 2024	depth, orientation, and the degree of enclosure
Izadyar et al., 2020	depth, opening dimensions
Ribeiro et al., 2020	depth, orientation, side wall
Omrani et al., 2017	depth, the degree of enclosure
Zheng et al., 2020	the presence or absence of a balcony, depth, shelter wall, and density of balconies
Eskandari et al., 2018	depth, the degree of enclosure
Mozaffari Ghadikolaei et al., 2020	wing wall depth, wing wall angle
Philokyprou et al., 2021	orientation, placement, position, and the degree of enclosure

Central Desert of Iran, which has a hot and dry climate and is separated from its northern regions by the Alborz Mountains. Mesoclimate is part of macroclimate. A macroclimate may be divided into two or more mesoclimates. The morphology of the place influences the local climate and can include a section or a block of a city. For example, areas near rivers in cities with rivers tend to be cooler than other areas of the same city. Microclimate refers to a minimal area where specific factors in a location can result in differences in climate compared to the surrounding environment, like the central courtyard in an introverted house, which has a different temperature and humidity than its surrounding environment due to shade, vegetation, water, or airflow (Nikghadam, 2012).

Cold Climate Zone

The cold climatic zones of Iran are geographically located in the high parts of the Alborz and Zagros mountain ranges. They extend along the Alborz mountain range from the north of Iran to the north of Khorasan and along the Zagros mountain range from the northwest of Iran to the west of Iran and the western parts of Isfahan province. In other parts of Iran, cold areas are visible, primarily located at the tips of individual peaks and mountains in the east or south of Iran (Tahbaz & Jalilian, 2021). Investigations conducted using 114 meteorological stations in cold regions reveal that Iran's cold regions are categorized into four distinct zones: ultra-cold, icy, cold, and relatively cold. Each of these regions is divided into three categories (sub-regions) based on humidity and greenness levels: semi-humid, semi-arid, and dry (Tahbaz & Jalilian, 2021). Cold climate subzones and the location of the studied cities in this category are shown in Figure 1.

Climatic Characteristics of the Studied Cities

Climatic Features of Ardabil City

Ardabil is located at 48:17 longitude, 15:38 latitude, and 1314 altitude above sea level in the semi-humid subzone.

Super Cold Climate Zone

In this area, the average annual temperature is typically below 10 degrees. It has mild summers. During the day, the

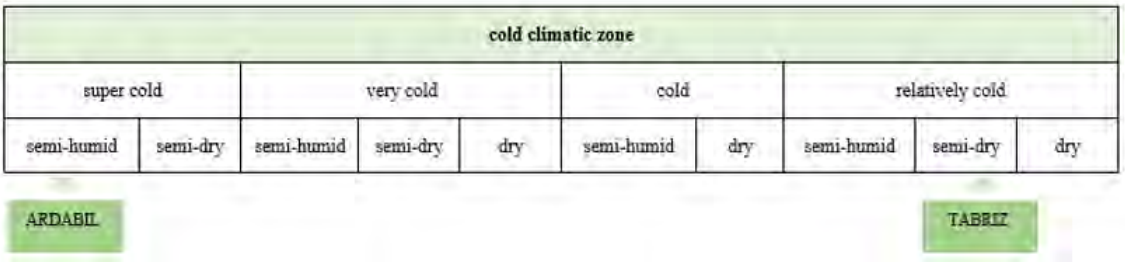


Fig. 1: Cold climate subzones

temperature reaches a maximum of 20 to 25 degrees, making it unnecessary to use cooling equipment. Summer nights are cold (10 to 15 degrees), and it is not possible to use the open space for staying overnight or sleeping. Winter days are frigid and windy, with temperatures ranging from 0 to -5 degrees. Using the warm mountain sun during these days is one of the climatic blessings and is necessary. The nights of winter were freezing, with a deadly and annoying cold, as the temperatures dropped as low as or lower than freezing.

In some cases, even temperatures as low as -20 and -30 degrees have been reported. Therefore, the protection of living beings is one of the main tasks of architecture. The period of cold and frost, with temperatures below zero degrees, in these areas lasts approximately 4 to 5 months. Due to the intense heat of the sun during these days, the phenomenon of melting and freezing also happens. In these areas, the building only requires heating, and the need for cooling is minimal; therefore, there is no need to anticipate mechanical equipment for cooling the building.

The super cold zone is divided into two semi-humid and semi-dry sub-zones, characterized by varying rainfall and humidity levels. Out of 15 meteorological stations with super cold climate characteristics, eight stations are associated with semi-humid super cold climates, and seven stations are associated with semi-dry super cold climates. The semi-humid, super cold climate zone encompasses areas such as Khalkhal, Ardabil, Sarein, Chaldaran, and Bostanabad in the Azerbaijan region, as well as Abali, Baladeh, and Firouzkouh (Pul) in the Alborz Mountains. In these areas, the amount of moisture in the air is higher (less than 10 g/kg) and the relative humidity is more than 30% (Tahbaz & Jalilian, 2021).

Figure 2 shows the annual dry temperature in Ardabil. As can be seen, the temperature in Ardabil is comfortable, ranging between 21 and 27 degrees, for approximately 10 percent of the year, from June to September. The rest of the year, the temperature is below comfortable and cold. Therefore, there is no need for cooling in Ardabil, and it is desirable to utilize the sun's heat most of the time.

The radiation angle is 29 degrees on January 1 at 12:00 p.m., which is at its highest, and 75 degrees on July 1 at 12:00 p.m. Figure 3 shows the need for sun and shade in different seasons. As is known, in most cases, to reach comfortable conditions during the year, there is a need for the sun's heat, and only in a few months of the year, from June to September, is there a need for shade in the middle of the day until evening.

The investigation of the wind situation in Ardabil reveals that cold and unfavorable winds blow from the southwest. In contrast, calm winds blow from the east, which is favorable for natural ventilation.

Objectives of Climate Architecture in Ardabil:

According to the climatic characteristics of the semi-humid super-cold subzone and the study of the climatic conditions of Ardabil, the important goals and priorities of climatic architecture, especially related to the semi-open space in Ardabil, can be summarized as follows:

- In Ardabil, it is not possible to sleep outside the closed space at night, even in summer, and the semi-open space is used during the day.
- It is important to have a semi-open space as a buffer space and to prevent the direct connection of living spaces with the outside to reduce heat exchange.
- Most of the time of the year, the weather is cold and the air temperature is below the comfortable temperature, and there is a need for the heat of the sun. In winter, the semi-open space is used as a sunny courtyard to benefit from the radiation.

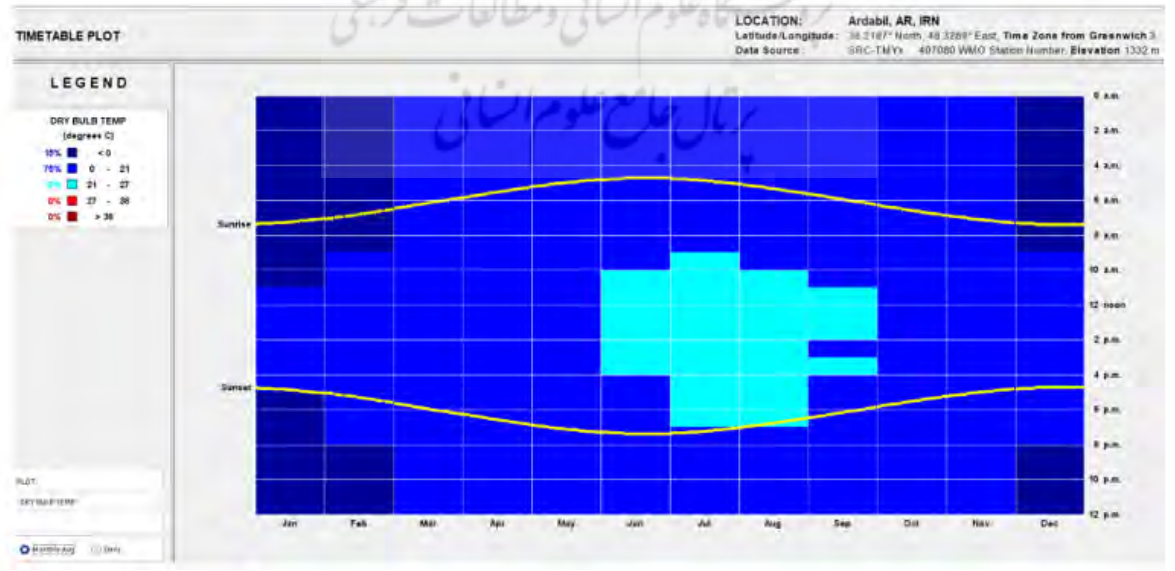


Fig. 2: The dry temperature of Ardabil throughout the year (taken from the climate consultant)

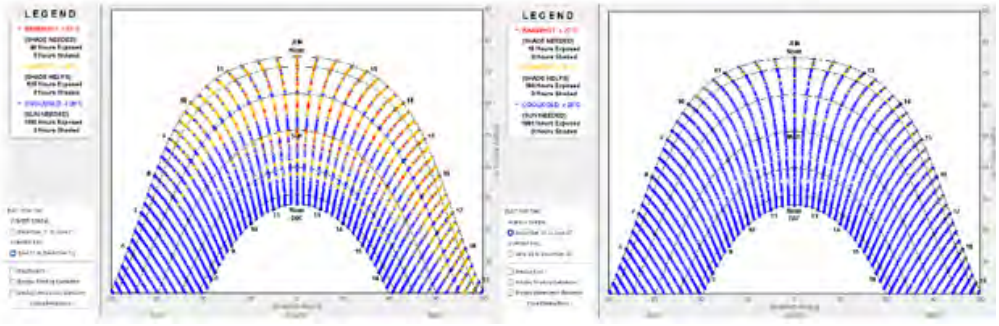


Fig. 3: The need for shade and sunshine in Ardabil (right side: winter and spring, left side: summer and autumn)

• With the moderate weather in summer and no need for a cooling system, it is enough to provide cool shade and blinds. In winter, the semi-open space is used as a sunny courtyard to benefit from the radiation.

• With the moderate weather in summer and no need for a cooling system, it is enough to provide cool shade and blinds. The semi-open space can satisfy the need for shade and benefit from airflow in the hot months, especially during the midday hours until evening.

• According to the radiation angle, the proportion of the depth and height of the semi-open space should be such that it allows the penetration of radiation into the interior space.

• Due to the effect of wind in feeling colder, the semi-open space should be protected from adverse winter wind flow.

• Due to the mild summer conditions, the role of the semi-open space in shading and benefiting from air flow is vital to provide coolness, so that there is no need for cooling equipment.

Climatic Features of Tabriz City

Tabriz is situated in a relatively cold, semi-arid subzone, with a longitude of 46°17′, latitude of 38°05 ′, and an altitude of 1,361 meters above sea level.

Relatively Cold Climate Zone

In this area, the average annual temperature is usually around 14 to 16.5 degrees. It has moderate to slightly hot summers, where the temperature in dry areas may rise to 35 degrees, forcing residents to use cooling equipment in relatively cold, dry areas during certain hours of the day. Summer nights in this area are cool (15 to 20 degrees), and it is not possible to use the open space for sleeping and spending the night. Winter days are cold and windy, with temperatures ranging from 5 to 15 degrees. Using warm mountain sun during these days is one of the climatic blessings and a necessity. Winter nights are cold, but the intensity of the cold increases as air humidity decreases. The air temperature in relatively cold, semi-arid, and dry regions usually reaches about -5 degrees. The period of cold and frost typically lasts about 3 to 4 months in relatively cold and dry areas, and less than 2 to 3 months in semi-arid and semi-humid areas. Due to the intense heat of the sun, the phenomenon of melting and freezing also occurs during these days. If the architecture of these areas allows for the use of natural ventilation, the summer heat can be tolerated without the need for mechanical cooling equipment.

The relatively cold semi-dry subzone includes areas such as

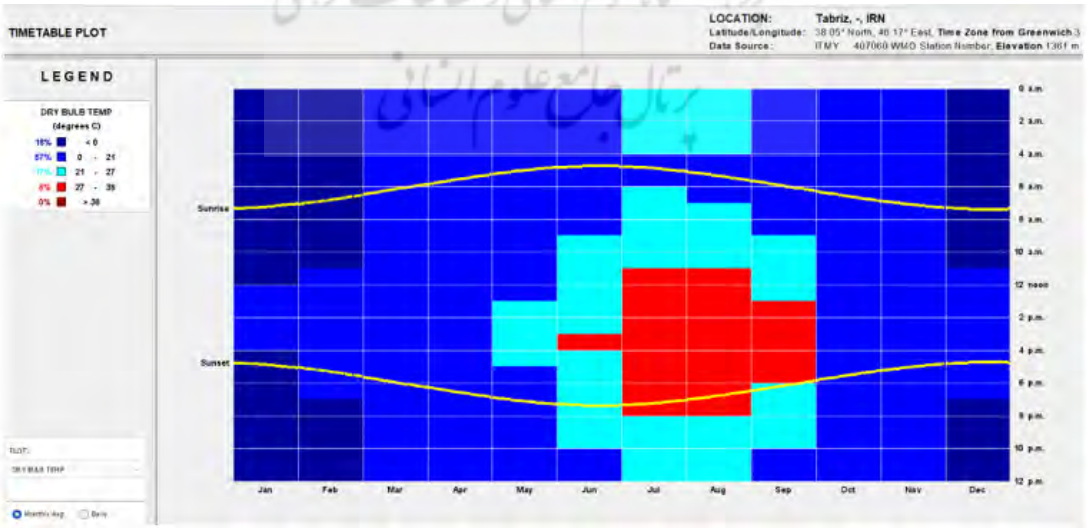


Fig. 4: The dry temperature of Tabriz throughout the year (taken from the climate consultant)

Maragheh, Tabriz, Jolfa, Marand, and Mianeh, located in the Azerbaijan region and the western highlands of Zagros, Tafresh, Golpayegan, Arak in the central province, Torbat Jam, Torbat Heydarieh, and Shahroud in the eastern highlands of Khorasan, and Sepidan and Baft in the southern highlands of the country. The amount of moisture in the air is low (less than 7 to 10 grams per kilogram), and the relative humidity is more than 10%. In two relatively cold subzones, characterized as semi-humid and semi-dry, the air temperature fluctuates minimally, with a greater difference between night and day temperatures in winter and a lesser difference in summer (Tahbaz & Jalilian, 2021).

Figure 4 shows the dry temperature of Tabriz during one year. As can be seen, the temperature in Ardabil is comfortable for 17 percent of the year, ranging between 21 and 27 degrees. In 8% of the time, the temperature rises above comfortable conditions, while for the rest of the year, it remains below comfortable conditions and is cold. Therefore, it is desirable to utilize the sun's heat most of the time. However, during June to September, there may be a need for cooling during certain hours of the day.

The radiation angle is 29 degrees on January 1 at 12:00 p.m., which is at its highest, and 75 degrees on July 1 at 12:00 p.m. Figure 5 shows the need for sun and shade in different seasons. As it is known, in most cases of the year, there is a need for the warmth of the sun to reach comfortable conditions, and there is a need for shade during many hours of the day, from June to September.

Examining the state of the winds reveals that Tabriz is generally a windy city, with winds blowing from various directions at most times of the year. Viewing the wind charts shows that the cold and unfavorable winds blow from the east, northeast, west, and southwest. In the summer season, the calm wind blows from the east and northeast, which is favorable for natural ventilation.

Objectives of Climatic Architecture in Tabriz:

According to the climatic features of the relatively cold semi-arid subzone and the study of the climatic conditions of Tabriz, the important goals and priorities of climatic architecture, especially related to the semi-open space in Tabriz, can be summarized as follows:

- In Tabriz, it is not possible to sleep outside the closed space at night, even in summer, and the semi-open space is used during the day.
- It is important to have a semi-open space as a buffer space and to prevent the direct connection of living spaces with the outside to reduce heat exchange.
- Most of the time of the year, the weather is cold and the air temperature is below the comfortable temperature, and there is a need for the heat of the sun. In winter, the semi-open space is used as a sunny courtyard to benefit from the radiation.
- Despite the slightly hot days in summer and sometimes the need for a cooling system, it is necessary to provide coolness by using shade and blinds to reduce the need for cooling equipment.
- According to the radiation angle, the proportion of the depth and height of the semi-open space should be such that it allows the penetration of radiation into the interior space in winter.
- Due to the effect of wind in feeling colder, the semi-open space should be protected from adverse winter wind flow.
- Forecasting the semi-open space in the summer so that it is entirely in the shade and benefits from the cool wind flow is very useful on hot days.

According to the data summation, the physical components of the semi-open space, which are known to be important and effective in improving climatic efficiency, can be considered as criteria for analyzing the studied samples. Additionally, the important climatic goals of the cold climate, which the semi-open space is well-suited to achieve, can serve as the basis for analyzing the efficiency and evaluating the climatic

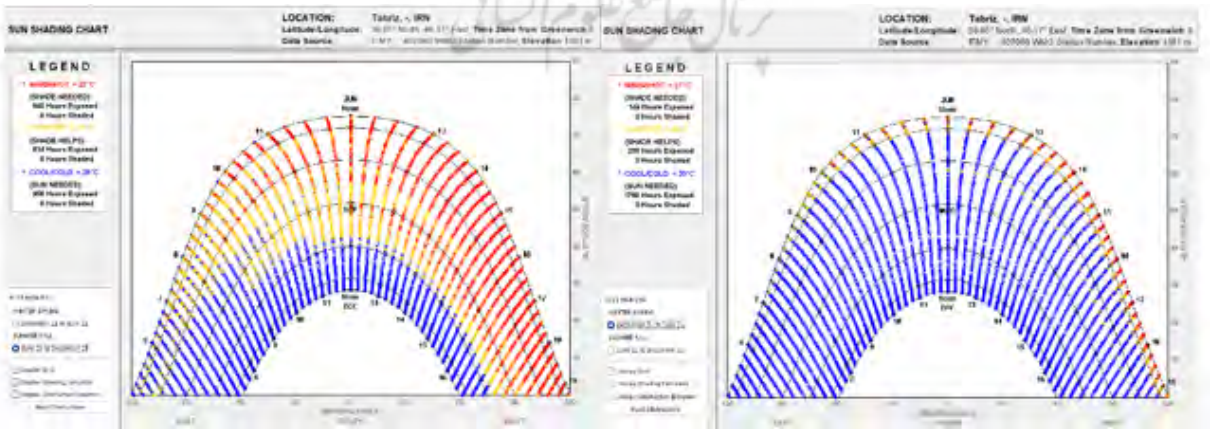


Fig. 5: The need for shade and sunshine in Tabriz (right side: winter and spring, left side: summer and autumn)

performance of the samples.

Analysis of Samples

Open, Axial, Selective Coding

In open coding, descriptive information of each semi-open space was collected. This information, which aligns with the research framework, is presented in tables, as shown in Sample Table 3, adjacent to the visual documents. In this way, the position of the semi-open spaces is specified in the plan, view, or section, and the features are provided.

Considering the important climatic goals in cold climates and analyzing the role that semi-open spaces can play in achieving each of these goals, the components affecting the realization of each goal have been identified, along with the criteria for evaluating the samples' climatic responsiveness to these goals. In this way, by identifying the physical characteristics of the samples and the climatic needs of the city, the responsiveness of each semi-open space to each of the climatic goals was measured. According to the qualitative nature of the research, it was described descriptively, with three levels: weak, medium, and good.

In axial coding, as illustrated in Table 4, the physical components were related to the climatic components, and the data related to each semi-open space were categorized in a table. Along with the climatic components, the city's climatic characteristics and trends, as well as the objectives of the climatic architecture, were also organized.

In the selective coding, components from the samples of two cities that form the physical structure of semi-open spaces and exhibit significant differences were selected for comparison, and their differences were analyzed in the next step.

RESULTS AND DISCUSSION

Physical Structure of Semi-Open Spaces in the Vernacular Houses of Ardabil City

Examination of the houses reveals that most of them have a semi-open space located directly in front of the main facade. Only one example (Islamic Parsley House) has more than one half-open space, which includes two separate half-open spaces on the same main facade of the building, facing the sun. Most of the semi-open spaces are located on the sunny front of the building (except the Vakil al-Raaya house, which has an eastern orientation and is slightly enclosed from the south side). Semi-open spaces are located approximately 3 or 4 steps above the yard level, yet they are closely connected to the yard, while maintaining a defined and independent range. Their relationship with the interior space is such that they are either on the same level as the ground floor, in which case they are adjacent to the entrance space and rooms on the ground floor. They are adjacent to the hall and its side rooms on the upper floor. Alternatively, it is possible to enter the building through several stairs. The entrance corridor, hall, and rooms are located on the same floor near the semi-open space. In these buildings, the semi-open spaces are usually not connected to the basement or pool house. Table 5 presents a summary of the climatic characteristics of the semi-open spaces in Ardabil houses.

Physical structure of semi-open spaces in the vernacular houses of Tabriz city

All the surveyed houses in Tabriz have a semi-open space in front of the main facade of the building. These spaces are located in the sunny direction of the building. Several houses have more than one (three or five) semi-open spaces, which may be located throughout the building or individually, on the same main face of the building or other aspects of the building. Most of the semi-open spaces are located on the sunny front of the building. There are two ways of positioning semi-open spaces in relation to the yard and the closed space. In the first case, the boundaries of the ground floor are placed adjacent to the yard or one step above it and are closely related to the yard, but the defined area is weaker. On the ground floor, they are typically located in the vicinity of the foyer or entrance corridor, and sometimes the pool and service spaces are also

Table 3: An example of open coding tables

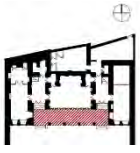
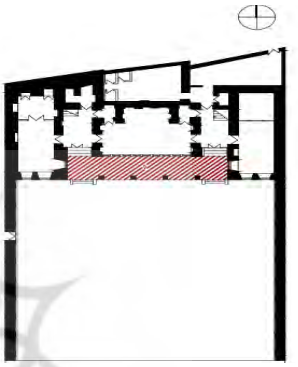
Jafari Eslami's house in Ardabil		
	Orientation: south	Spatial form: overall
	Depth: 3.25 m	Height: 7.55 m
	Level relative to the yard: 3 stairs	Area: 50.90 m2
	Enclosure: closed on three sides	
	Adjacent spaces: hall, rooms, entrance	
	Access pattern: open > semi-open > enclosed	
		

Table 4: An example of axial coding tables

Physical Characteristics of Semi-Open Space and Response to Climatic Goals							
Jafari Eslami		Climate zone: super cold	City: Ardabil	Subzone: semi-humid			
Climate conditions		Relative humidity: more than 30%	The length of the frost period: 4-5 months	winter		summer	
Angle of radiation	July: 75	Unfavorable wind direction: Southwest	Daily temperature fluctuation: low	night	day	night	day
	January: 29	Favorable wind direction: East	Need for cooling: none	Super cold	very cold	cold	moderate

Effective physical components in climatic efficiency	Semi-open space 1
depth	m 3.35
height	m 7.55
depth to height ratio	2.2 :1
area	m^2 50.90
orientation	south
spatial form	overall
enclosure degree	Three sides are closed, and one side is open
The difference in level with the yard	stairs 3
adjacent spaces	Entrance, hall, room
access pattern	Open > semi-open > enclosed



Climate goals	The responsiveness of the semi-open space
Absorption of sunlight in winter	●
Preventing the penetration of radiation in the summer	●
Preventing adverse wind penetration in winter	●
Optimal wind absorption in summer	○
Prevention of heat exchange	◎

situated there. On the upper floor, they are adjacent to the hall and its side rooms. In the second case, they are located on the upper floor, in the vicinity of the hall, and sometimes in its side rooms. Individual semi-open spaces are usually located upstairs and adjacent to a room. This pattern of spaces is also placed on the sunny side or other sides of the building, as well as in the shade. Table 6 presents a summary of the climatic characteristics of the semi-open spaces in Tabriz houses.

As the characteristics of the cold climate subzones and the cities located in them are presented in Table 7, the two cities studied in this research are situated in two different subzones. In this section, considering the apparent differences in the climatic characteristics of Ardabil and Tabriz, as well as the differences in the characteristics of the semi-open spaces of the two cities, the effect of the intermediate climate on the physical components of the samples from the two cities is investigated. For comparison, the differences in climatic characteristics of the two cities are summarized in Table 8.

By observing and comparing the characteristics of the samples of the two cities and their differences on the one hand, and the correspondence of the differences with the differences in their climatic conditions on the other hand, it is possible to consider several cases affected by the characteristics of the middle climate and related to it, which are:

- The existence of northern summer porches in Tabriz can be related to the temperature difference of summer days. Considering that Tabriz experiences relatively hot summers, there is a need for a semi-open space on the north side of

Table 5: Physical characteristics of the semi-open spaces of Ardabil houses

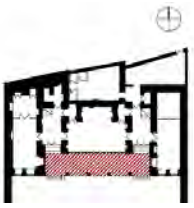
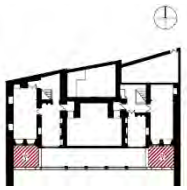
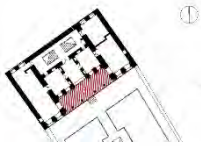
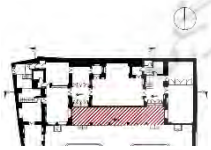
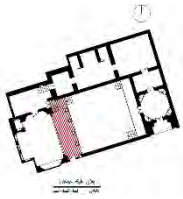
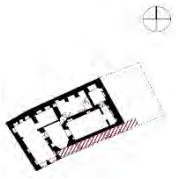
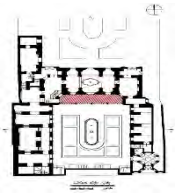
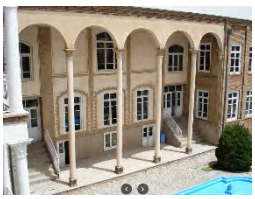
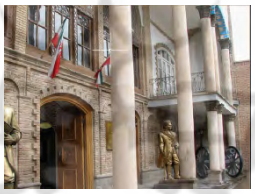
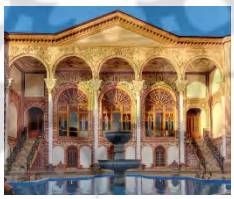
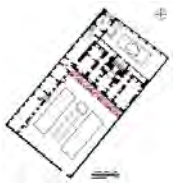
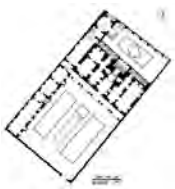
House Name	Plan	Image	Physical Characteristics
Jafari Eslami			Spatial form: overall Orientation: south Enclosure: three-sided Access pattern: open > semi-open > closed Level difference with the yard: 3 steps
			Spatial form: single Orientation: south Enclosure: two-sided Access pattern: open > closed > semi-open Level difference with the yard: 1 floor
Rezazadeh			Spatial form: overall Orientation: southeast Enclosure: three sides Access pattern: open > semi-open > closed Level difference with the yard: 4 steps
Mostafavi			Spatial form: overall Orientation: southeast Enclosure: three-sided Access pattern: open > semi-open > closed Level difference with the yard: 3 steps
Samadi			Spatial form: overall Orientation: south Enclosure: three sides Access pattern: open > semi-open > closed Level difference with the yard: 3 steps
Vakil			Spatial form: overall Orientation: east Enclosure: three-sided Access pattern: open > semi-open > closed Level difference with the yard: 4 steps
Aghazadeh			Spatial form: overall Orientation: southeast Enclosure: three sides Access pattern: open > semi-open > closed Level difference with the yard: 4 steps

Table 6: Physical characteristics of the semi-open spaces of Tabriz houses

House Name	Plan	Image	Physical Characteristics
Ghadaki			Spatial form: overall Orientation: south Enclosure: three-sided :Access pattern open > semi-open > closed Level difference with the yard: none
			Spatial form: overall Orientation: north Enclosure: three sides Access pattern: open > closed > semi-open Level difference with the yard: 1 floor
			Spatial form: single Orientation: north Enclosure: three sides Access pattern: open > closed > semi-open Level difference with the yard: 1 floor
			Spatial form: single Orientation: north Enclosure: three-sided Access pattern: open > closed > semi-open Level difference with the yard: 1 floor
Amirnezam			Spatial form: overall Orientation: southwest Enclosure: three-sided Access pattern: open > semi-open > closed Level difference with the yard: 1 floor
Alavi			Spatial form: overall Orientation: south Enclosure: three-sided :Access pattern open > semi-open > closed Level difference with the yard: none
Khatayi			Spatial form: overall Orientation: south Enclosure: three-sided Access pattern: open > semi-open > closed Level difference with the yard: none

Continiue of Table 6: Physical characteristics of the semi-open spaces of Tabriz houses

House Name	Plan	Image	Physical Characteristics
Ghanjei zadeh			Spatial form: overall Orientation: southwest Enclosure: three-sided Access pattern: open > semi-open > closed Level difference with the yard: none
Mashroote			Spatial form: overall Orientation: southeast Enclosure: three-sided Access pattern: open > semi-open > closed Level difference with the yard: none
			Spatial form: single Orientation: southeast Enclosure: two-sided Access pattern: open > closed > semi-open Level difference with the yard: 1 floor
Sorkhei			Spatial form: overall Orientation: southwest Enclosure: three-sided Access pattern: open > semi-open > closed Level difference with the yard: none
Maboodi			Spatial form: overall Orientation: southeast Enclosure: three-sided Access pattern: open > semi-open > closed Level difference with the yard: none
Sharbat oghli			Spatial form: overall Orientation: southwest Enclosure: three-sided Access pattern: open > semi-open > closed Level difference with the yard: none
			Spatial form: single Orientation: northeast Enclosure: three sides Access pattern: open > semi-open > closed Level difference with the yard: none

Continiue of Table 6: Physical characteristics of the semi-open spaces of Tabriz houses

House Name	Plan	Image	Physical Characteristics
Heydar zaeh			Spatial form: overall Orientation: southeast Enclosure: three-sided Access pattern: open > closed > semi-open Level difference with the yard: 1 floor
			Spatial form: overall Orientation: northwest Enclosure: three sides Access pattern: open > closed > semi-open Level difference with the yard: 1 floor

Table 7: Effective differences of the middle climate in Ardabil and Tabriz

Climatic Components		Ardabil	Tabriz
latitude		degree 38	degree 38
The main subzone		Super cold	relatively cold
Sub sub-zone		Semi-humid	Semi-dry
winter weather	day	Frigid + cold wind	cold
	night	Super cold	cold
summer weather	day	moderate	warm
	night	cold	cool
Times with comfortable conditions in the year		14%	17%
Times with temperatures higher than comfort conditions		1%	10%
Need for cooling equipment		none	Sometimes it may be needed
Prevailing wind direction	desirable	East	East, Northeast, West, Southwest
	undesirable	Southwest	East, Northeast
The length of the frost period		months 4-5	Less than 2-3 months

the building that is entirely shaded and can benefit from the favorable summer winds. Examples of summer semi-open spaces are shown in Figure 6.

- Semi-open spaces in Ardabil often have a level difference of about 3 or 4 steps with the yard and have an independent and separate area from the yard. In Tabriz, they are often located on the ground floor, adjacent to the yard, and do not have a completely separate area. This difference can be related to the longer ice age in Ardabil. With this method, the area of the semi-open space will be protected from the spread of snow and frost, and it will last a long time.

- Several samples from Tabriz are adjacent to the area of Hozkhaneh, and this feature is not present in any of the samples from Ardabil. This case can also be related to hotter summers and the need for a summer place. Figure 7 shows the proximity of the semi-open space to the Hozkhaneh in the Alavi house in Tabriz.

CONCLUSION

By comparing the physical structure of the semi-open spaces in the native houses of Ardabil and Tabriz and matching them with the climatic goals for summer and winter, it can be said that the primary purpose of using semi-open spaces in the houses of Ardabil and Tabriz was to benefit from the radiation in winter. However, in the houses of Tabriz, with slightly hotter summers, there is a greater need for semi-open summer spaces than in Ardabil. Some examples are more suitable for summer use and benefit from the shade and calm summer wind. Usually, summer semi-open spaces are not the only semi-open

Table 8: Comparison of climatic characteristics of Ardabil and Tabriz

Ardabil	Tabriz
The number of houses under study: ..... 6 The number of houses with a semi-open space..... 5 The number of houses with more than one semi-open space: ..1 The total number of studied samples: 8	The number of houses under study: ..... 10 The number of houses with a semi-open space……..... 6 The number of houses with more than one semi-open space:…….4 The total number of studied samples: 19
Five houses under investigation have a semi-open space on the south front or near it, and the semi-open space of another house is located in the east direction.	All 10 surveyed houses have an entire semi-open space on the sunny front, and if available, their other semi-open spaces are located on the same front or other fronts.
Most of the verandas have 3 or 4 steps and a level difference with the courtyard. At the same time, they are closely connected to the courtyard; yet they also have an independent and separate area.	Of the open semi-open spaces, eight examples are ground floor with (or with one level difference from the floor) the yard and do not have an independent and separate area from it. Four examples have a level difference with the yard and have little connection with it, and they also have no access.
In the investigated houses, most of the semi-open spaces are located above the yard level with a difference of 3 or 4 steps, and none of the samples are adjacent to the pool area or the basement.	In most of the investigated houses, where the semi-open space is located on the ground floor of the yard, there is no basement. The main living spaces are located at a higher level, and the pond house and service spaces are situated on the ground floor. In 6 cases, the semi-open space is adjacent to the pond house, and in 5 cases, they have access and connection to it.
None of the samples has a north orientation without receiving radiation during the day.	Three of the investigated samples have a north orientation and do not receive radiation. There are two samples with a northwest orientation, one northeast, and one eastern sample, which have low radiation and are more efficient as semi-open summer spaces in the hot season.

Fig. 6: Examples of semi-open summer spaces (from the right: Qhadaki, Heydarzadeh, and Sharbat-Oghli houses)

Fig. 7: The proximity of the semi-open space to the pond in the Alavi house

spaces of buildings, and in addition, there is also a semi-open space suitable for winter.

This comparison and its results demonstrate the impact of the middle climate on the characteristics of the semi-open spaces in the two cities of Ardabil and Tabriz. Examining the differences in physical characteristics between the samples of Ardabil and Tabriz reveals that the components of the mesoclimate have an impact on the physical structure and, consequently, the way semi-open spaces are utilized.

AUTHOR CONTRIBUTIONS

All authors contributed equally to this work.

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CONFLICT OF INTERESt

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy, have been completely witnessed by the authors.

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