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Analysis of Climatic Factors in Traditional Houses with Architectural Features of Qajar Period in Tabriz

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Abstract
Climate is one of the fundamental issues considered in the architecture of traditional houses in Iran. In the design of Iranian traditional houses all patterns are influenced by various factors, including climate as well as individual and social culture. The presence of spaces like central courtyard as well as summer and winter courtyards indicates the architects' admirable attention to sun-light across the four seasons. This article analyzes the architectural features of 6 selected houses built in the cold and mountainous area of Tabriz during the two halves of Qajar era. The results reveal that architecture of this period sought to make optimal use of sun-light by regarding the southern side as the main front, east-west stretch, spotting north in the site plan, stretching the long balcony from one side to the other side of the building. The other factor such as establishment angle and proportions in general structure are the most effected elements from climate change. Opting for a scale of 1:1 in the overall structure of the buildings proves to be the most appropriate based on the Olgyay experiment for cold mountainous areas. Building the private courtyard at an establishment angle of 10 degrees facing north-east has made it possible to optimally use the desirable winds of Tabriz.
Keywords: Cold climate, Traditional architecture, Olgyay experiment, Tabriz

1. Introduction

The technique that Iranian architects have used in house construction has taken advantage of the climate and is in harmony with climate conditions in each region. Traditional Iranian houses in vernacular architecture show that the people have been developing their homes based on climatic comfort in a variety of climatic conditions. An appreciation of the architecture of in each region and period necessitates an awareness of its subtle correspondence with its respective climate. Architecture cannot be detached from its surrounding circumstances. Therefore, based on scientific and historical indices, the author has chosen the Qajar period due to its unique architecture features, including the influence of European styles, and making the perpendicular blades in form of diagonal blades. For this purpose, seven Qajar houses in mountainous and cold climate of Tabriz were selected for this study. Cases like Qadaki house, Alavi house, Amir Nezam house, Ganjeh-i-zadeh house, Constitional house, SharbatOghli house, and Kalantari house were excluded due to their damage as well as lack of adequate and reliable documentation. It should be noted that all analyses have been done based on the floor plan. This is a retrospective study in which the research theoretical frame work was specified based on the related literature and then the distinctive features of Qajar period houses in Tabriz were analyzed regarding the establishment angle, physical characteristic of the houses, their main spaces, vertical and horizontal accesses, spatial structures, and dimensions. The key purpose of this study is to show the relationship between climate and Iranian traditional houses during Qajar period. Due to the fact that climate is one of the most important factors that impact on traditional architecture; there are several studies that focused on relation of climate and traditional buildings (Ghobadiyan 1998; Kasmaei 2003; Baghaie and Amir Khani 2009; Shahamipour 2013). Singery and Mofidi (2007) showed that relationship between climate and architecture in Tabriz. Their findings illustrated that the morphology of this area has been an important factor that effect on high air pollution. Mehdipour and Namazian (2012) showed that Yakhchal as one of the basic element structures of traditional architecture which was built in harsh climate conditions in the last decades (Ghobadian 1998). Nikpour *et al.* (2012) investigated climate conditions in cold and mountainous regions to show the strategies of traditional architecture for sustainability in residential areas. Nejad Ebrahimi *et al.* (2013) investigated impact of climate on architecture in cold and dry regions of Iran. Their findings showed that climate as a predominant parameter that verifies the orientation of buildings in different area.

2. Material and Methods

2.1. Climatic Data

Tabriz is located in north-west of Iran in $38^{\circ}4'$ N and $46^{\circ}18'$ E that is 1349 m above sea level (Figure 1). In this region, the average annual temperature; precipitation and moisture are 12°C, 321.5 mm and 58%, respectively. In addition, the location and sun radiation angles in Tabriz illustrated in Figure 2. The angle of the sun is almost vertical during summer while it is 40° to the horizon during winter. This figure shows that the south side of building and the dispersion in the northern front of the structure provide a condition for optimal use of sunlight.

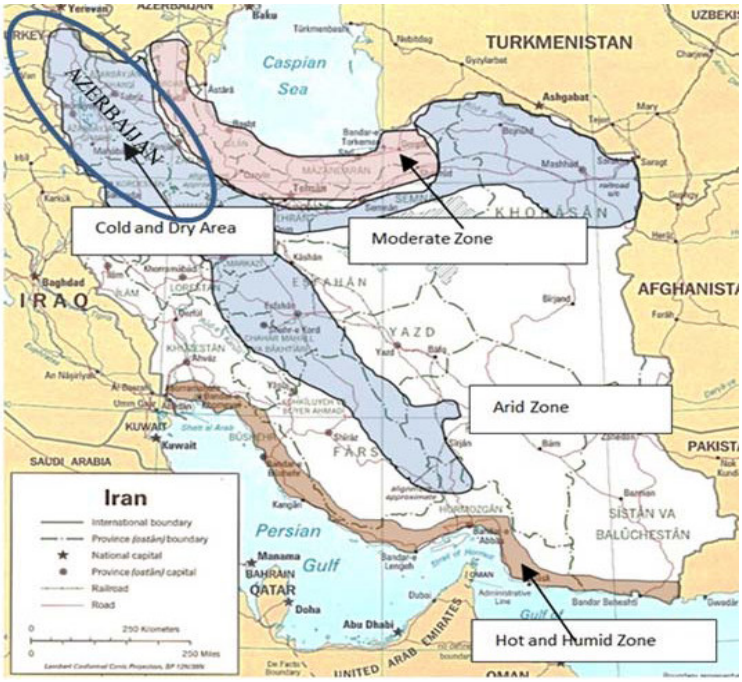

Figure 1. The study area
(Source: Nejad Ebrahimi *et al.* 2013)

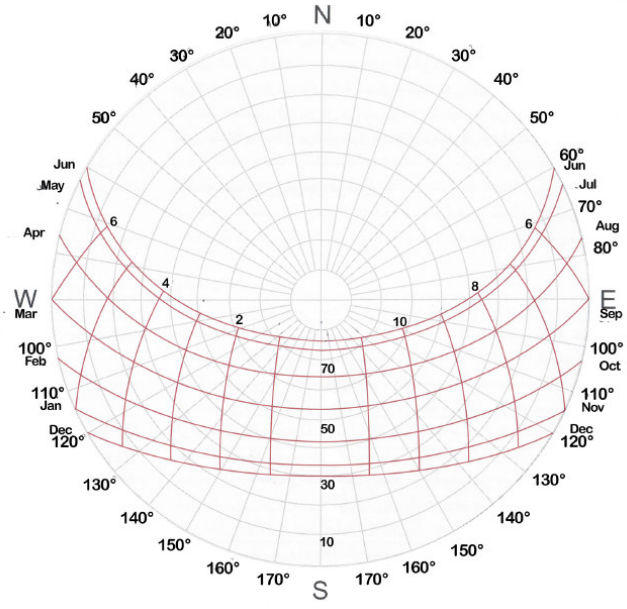

Figure 2. Location and angle of the sun in Tabriz
(Source: Kasmaei 2003)

2.2. Traditional Architecture in Cold Climate

The cold climatic conditions usually result in compact structure of the building while in conditions with intense solar radiation is compatible with east-west stretch of the building. Thus, based on the climatic condition of a region the most appropriate form of building structure can be determined for a designated area. Based on the results of Olgyay experiment (1963) conducted on the effects of environment thermal conditions in this study, the optimal form of the building in the cold climate of a mountainous location like Tabriz is presented in Figure 3.

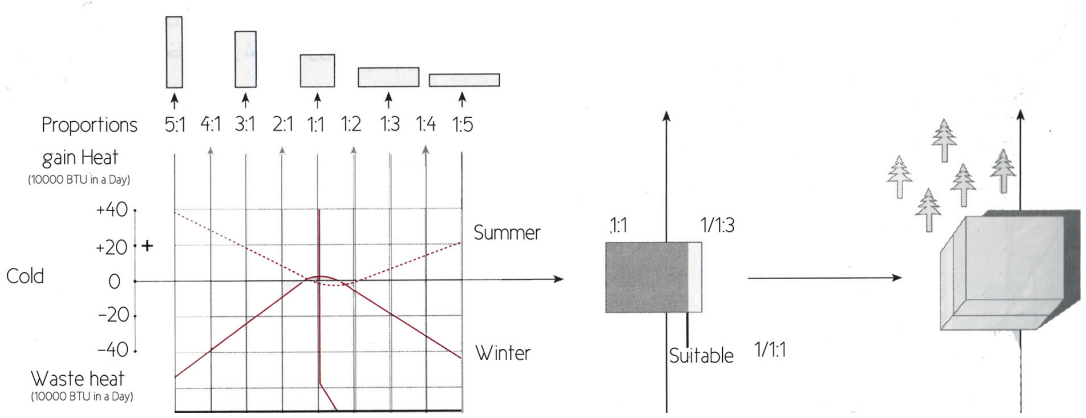

Figure 3. The optimal form of the building in cold climates of mountainous areas

Generally in cold climates and high latitudes where the weather is usually cold, the building should be in a direction that receives maximum sunlight throughout the year. On the other hand, in warmer areas and in low latitudes, the building should be in a direction that is exposed to minimum sunlight throughout the year. To determine the most suitable direction for building in different geographic widths, Olgyay studied the intensity of sunlight on vertical surfaces in different geographical directions and different seasons and times. He measured the radiated energy on the vertical surface with difference of 30 degrees around a circle and recorded in the table. According to this test, the building optimum direction in the cold climate of mountainous areas is as shown in Figure 4.

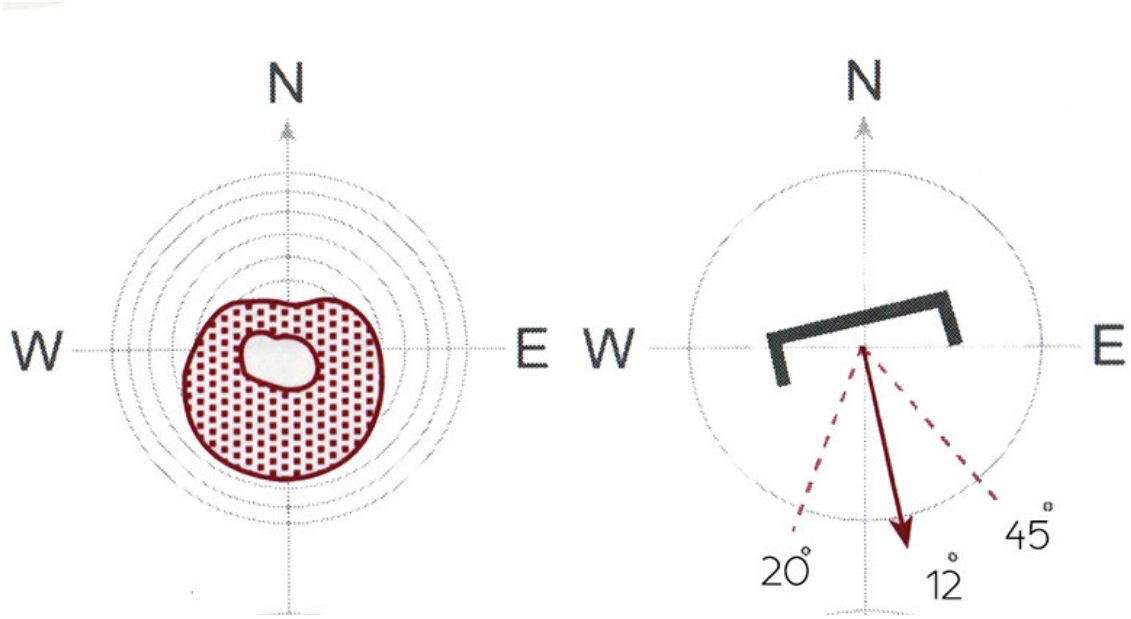

Figure 4. Building optimum direction in cold and mountainous climate of Tabriz

The wind direction is also an important factor in this region to determine the direction of structure and natural ventilation. Thus, in various stages of design, especially when deciding on the direction of a structure, particular attention should be paid to not only the climate and direction of sun-light but also the direction and speed of the wind in the area including prevailing winds. The prevailing wind is a kind of wind that has the most blowing frequency during a month. In other words, the characteristic of the prevailing wind shows the common direction of wind as well as its average speed in an area during a month. Figure 5 shows the average speed and direction of prevailing winds in Tabriz. The numerical values within the circles indicate the average wind speed in a season. The red graph shows the percentage of the winds blowing in a season while the black graph shows the result of multiplying this percentage to wind speed.

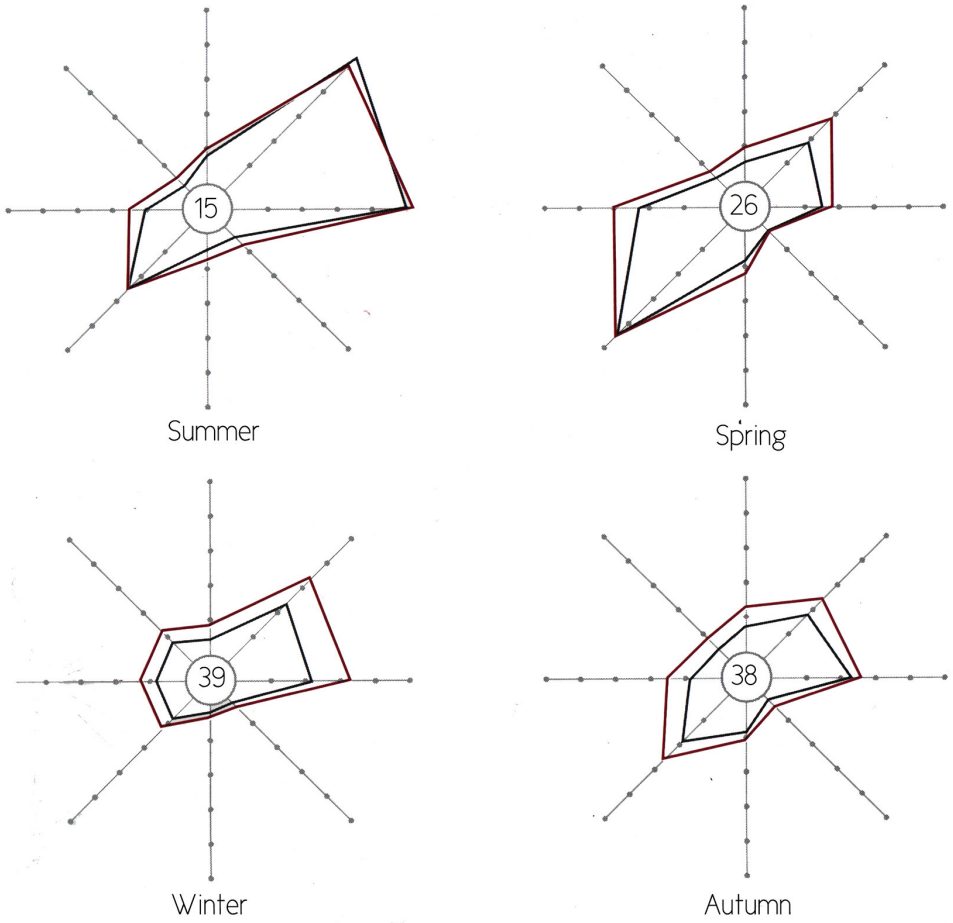

Figure 5. Mean and direction of prevailing wind velocity in Tabriz

2.3. Architecture in Qajar Era

Architecture of the Qajar period can be divided to three periods including early, mid, and late Qajar. In each of the three periods, the major fronts of the building were directed toward north that was selected due to climate condition and sun-light direction. In houses with two fronts, the reason for the south front is that it is appropriate for summer. A western front was a secondary choice for the undesirable western sun. The southerly orientation of these buildings exposed the main living spaces, including reception hall, side room, pool room and living room to favorable light of south in the different seasons. Due to the density and compactness of the city, most buildings were attached in three sides to the neighboring buildings, while their front overlooked a walkway. The position of entrance is one of the most important parts in Iranian traditional houses. During the Qajar period, the entrance and the main spaces of the houses were not directly vision because of the Islamic culture. Main areas like veranda, reception hall and pool room in most houses were located in the core. The only major areas along the sub-line were three-door rooms which were in the living room or bedroom. It was sometimes the only important area along the sub-axis. The reception hall was the main area in the structure of houses during the three periods. Although its importance in the late Qajar period was less than the previous periods, it was still considered significant. It was generally located along the building main axis on the ground floor in the northern front with a veranda in its south. The sashes windows were used for the reception hall, which were located on the south side of it.

This space is often stretched in a direction perpendicular to the main axis in order to use as much of the south light. In all the three periods, the pool room provided a cool space for resting, and storing meat and grains. The pool room had a variety of covers and often their central cover was different from the spaces in its two sides. The room had a height of one floor and there are windows on the south side of the courtyard for light and ventilation. Pool rooms were generally stretched in a perpendicular direction to the main axis to enable maximum use of light. In the houses with a public and a private courtyard, the public courtyard was placed outside the building. However, in houses with only one courtyard, the courtyard was a public courtyard. Courtyards were generally rectangular in shape which stretched from north to south parallel with the main axis of the building. Veranda was the most important area in the Qajar period houses. It played a central role in the structure if other areas. It was located parallel with the main axis of the building often to the south of the

reception hall to regulate the sun light in different seasons and to protect against rain and snow.

2.4. Climate and Traditional Houses in Tabriz

Analysis of the traditional houses of this period indicates the noticeable effect of sun-light and seasonal changes in their design. In order to find common features between climate and architecture of traditional houses in the Qajar era, six houses which were built in Tabriz from1781to1925 were selected for analysis, including:

1) Qadaki house: This building was built about 160 years ago and is related to mid-Qajar period. It has interior and exterior. Its entrance is from the main door to the vestibule which leads to the Public courtyard. The westerly side of the building has a beautiful columned veranda. The northerly side of the building has a large reception hall with sash windows which have tinted panes and open to north and south. To the south of the reception hall is located in a veranda with high columns with plaster modeling. The facade of the building has been decorated with bricks in a variety of designs. The building is used for cultural purposes today.
2) Alavi house: The house has a courtyard and the main building is located on the north and east fronts. There is a large reception hall on the ground floor. There is a pool room with stone color ceiling and a stone pool in the basement. Its façade is decorated with bricks. It belongs to the early Qajar era.
3) Amir Nezam House: The construction date of the structure is Qajar period. It consists of an exterior and an interior courtyard. The interior courtyard is in the eastern front with a brick arch. The western part has two stories. It ground floor has several nested rooms. The central building has two floors and in its south facade is located a high veranda whose central ceiling has *Santouri* and plaster decorations.
4) Gannjeh -I - Zadeh House**:** It has two eastern and western parts. The eastern part has an interior and exterior. The core of the building, which is toward south, is a reception hall with two corridors located on its both sides and side rooms located on both directions. The western part of the building has introverted architecture. The largest hall of the building is in the first floor with aspan ofover seven meters, covered with wood and wood truss.
5) Constitutional House**:** The building was built in 1868 in Qajar period in an area of more than one thousand square meters. The main front of the building is located in the north and west sides. On the first floor of this front, the north side has a terrace with side rooms opening to it. The main part of the building that is located in the northern front has two stories. In the middle of the ground floor a central space is located with color decoration. The original veranda on the south side is composed of eight columns with stone columns.
6) Sharbat Oghli House: This house is located in the old neighborhood of the Sorkhab alley with two yards, one in the north and other in the south. The northern courtyard is below the alley level. The main entrance on the northerly side of the entrance through a vestibule opens to the northern courtyard and after a few stepsto the first room. The door of the southern yard opens to an alley through a porch with a brick arch. The northern facade of the building has brick decoration and its southern side contains twelve wooden columns with chalk pillars. The eastern front of the southern yard has a brick arch.

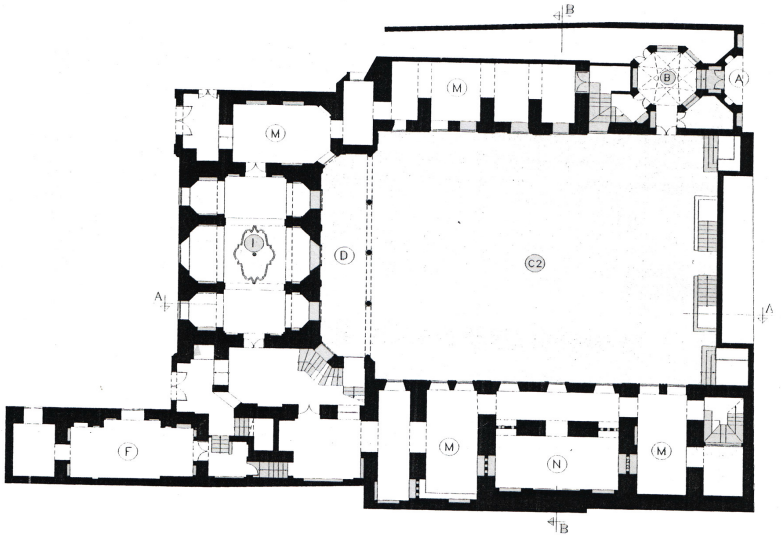

Figure 6. Plan of Qadaki House in Tabriz
(Source: Keynejad and Shirazi 2011)

Figure 7. View of Qadaki House

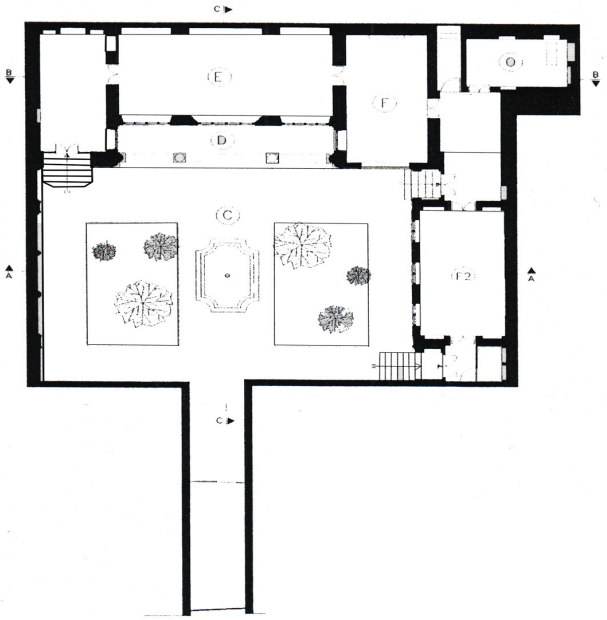

Figure 8. Plan of Alavi House
(Source: Keynejad and Shirazi 2011)

Figure 9. View of Alavi Hous

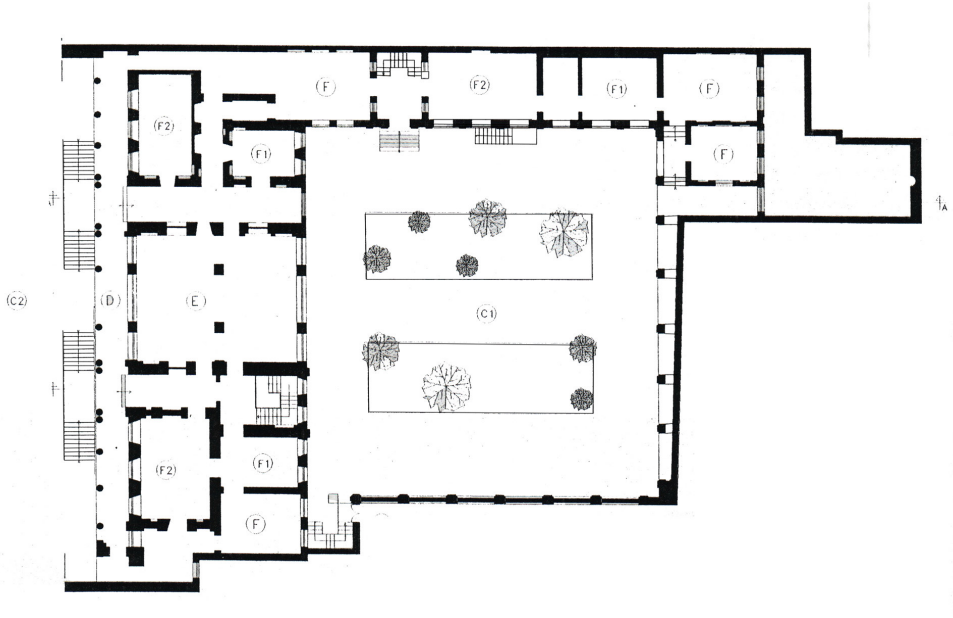

Figure 10. Plan of Tabriz Amir Nezam House

Figure 11. View of Amir Nezam House

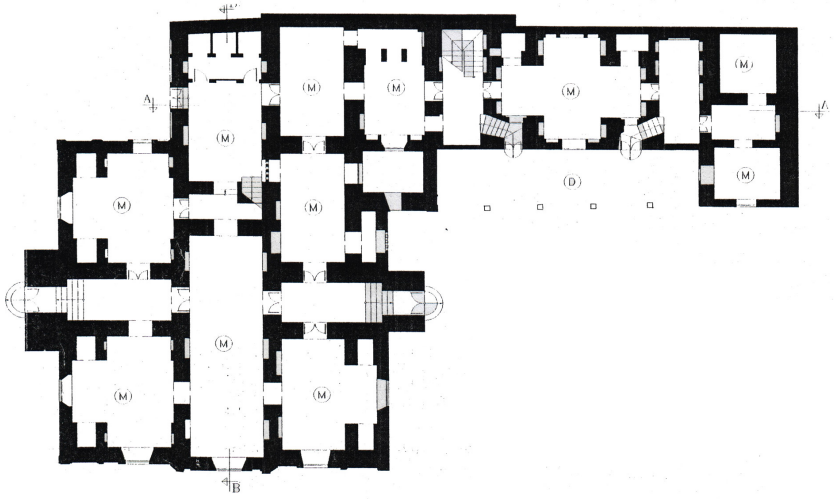

Figure 12. Plan of Tabriz Gannjeh -I – Zadeh House

Figure 13. View of Gannjeh -I – Zadeh House

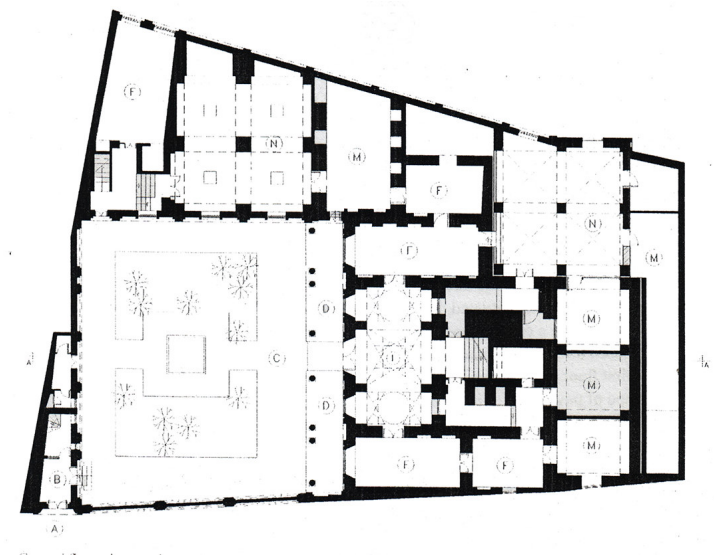

Figure 14. Plan of Tabriz Constitutional House

Figure 15. View of Constitutional House

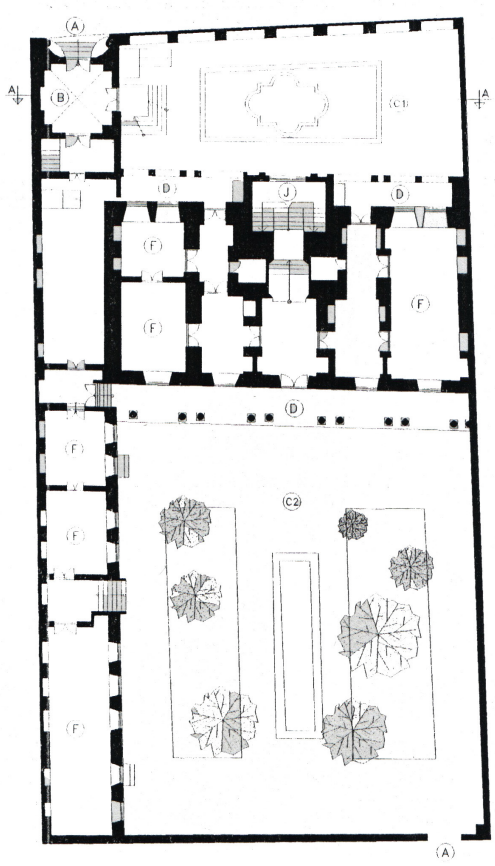

Figure 16. Floor plan of Tabriz Sharbat Oghli House

Figure 17. View of Sharbat Oghli House

3. Results and Discussions

In order to investigate the architectural features of traditional houses of Qajar period in Tabriz 6 homogenous houses were chosen from two different halves of the period. The samples were investigated by analyzing the houses in reference to their physical characteristics, main spaces, access, spatial structure, dimensions and measurements, as shown in the following tables. Table 1 indicates the dimensions, main spaces measurements, as well as minimum and maximum area of the rooms. Table 2 shows the physical characteristics of spaces including their establishment angle, shape of the ground floor, spotting the building and connection profile settings such as main space stretching, interior access, and main front. In the final table, the properties of the main spaces such as reception hall, veranda, and courtyard have been presented.

Table 1. The dimension, measurements, minimum and maximum area of rooms in different houses in the study area

House Factors	House 1	House 2	House 3	House 4	House 5	House 6
Reception -hall dimension(meter)	16.2*11.2	20*10	16.6*13.3	16.6*11.6	18.3*11.36	10*7.33
pool room dimension	16.2*1.2	20*10	16.6*13.3	16.6*11.6	18.3*11.36	11*7
Veranda dimension	21*4.5	20*5	56.6*4	30.6*7	50*5	52*4
Room minimum area	20.66	98	33	46	54.78	33.73
Room maximum area	112.5	105	77	174	324	132.67
private Courtyard dimension	32.5*25	-	38.3*38.3	46*33.3	50*30	40*15
Public courtyard dimension	-	50*26.6	-	-	-	50*41.66

Based on the dimensions shown in Table 1 and considering the dimension of the veranda, it can be stated that it has a stretching length and width dimensions. Based on the map, the location of the veranda in all houses is at the main front of the Building towards the southern side. Being behind prevailing and favorable winds and due to the spatial connection between the veranda and yard, the verandas make wind circulation between the yard and the veranda possible. The first space after veranda is reception hall with sash windows. In Tabriz climate the sun shines almost vertically in summer, but in winter the sun shines at an angle of approximately 40 degrees to the horizon. The veranda as the first area located after the yard provides a safe space for reception hall against the annoying summer sun-light while allowing desirable winter sunlight to the reception hall. In all cases, the pool room is located under the reception hall whose dimensions are equal with those of the pool room. The coolness of the pool room has two important functions; first by providing a place for storing food items throughout the year; and second for cooling down the reception hall floor. Minimum area of rooms is approximately between 20 and 98 square meters and most of the rooms have been built with their back facing the annoying western light or facing north. The maximum area of rooms is approximately 77 to 324 square meters. Most of these spaces face south to let in the favorable light and winds blown from north-east and let out from the south-west, providing a suitable temperature for residents. Therefore, it is easily possible to utilize sunlight, radiation angle, favorable and prevailing winds and the seasonal change by planning the spaces

appropriately.

Table 2. The physical characteristics of different houses in the study area

House Factors	House 1	House 2	House 3	House 4	House 5	House 6
Interior access	Room-reception hall-room	Room-reception hall-room	Room-reception hall-room	Room-reception hall-room	Room-reception hall-room Room-open terrace-room	Room-reception hall-room
Main front	South	South	South	South	South-east	South-west
Main space stretching	West-east	West-east	West-east	West-east	West-east	West-east
Building spotting	North-west-east	North-east	South-west	east-west	East-west	West-east
Establishment angle	8	29	-5	60	-43	30
Shape of ground floor						

According to the information provided by Table 2, the ground floor of the building has L shape with the empty spaces filled by the inside and outside yards. According to Table1, and Olgyay's findings, the best ratio of buildings length and width in cold and mountainous climate is 1:1, which is the case for these houses. Interior access shows the importance of reception hall in traditional houses. Reception hall is the space designed most concordantly with the climate. According to this table, the main front is the southern front. Based on the issues discussed previously, the southern front with an east-west stretch is the most effective front for houses in cold and mountainous climate, taking advantage of the sun-light.

Table 3. The length and width of the reception hall, veranda and yard

House Factors	House 1	House 2	House 3	House 4	House 5	House 6
veranda proportions	5:1	10:1	10:1	5:1	-	4:1
courtyard proportions	3:2	3:1	5:3	4:3	1:1	-
reception –hall proportions	3:2	4:3	3:2	3:2	6:5	2:1

By investigating the ratio of the length and width of the reception hall, veranda and yard as the three important areas affecting the climate and architecture, as shown in Table 3, it can be argued that the stretches of veranda area is fully climate-oriented, while the yard proportions are almost close to1:1, which is in line with Olgyay's views about proportions of the buildings in cold and mountainous climates.

4. Conclusion

Climate, topography, geography and socio-cultural factors are most important factors that impact of design of traditional houses in previous decades. The following conclusions can be made based on the results of analysis and investigation of climatic factors in Tabriz traditional houses during Qajar era:

1) In the traditional architecture of this period, optimal use of sunlight has been sought by placing the southern front as the main front, stretching east - west of building, spotting north in the plan site, stretching the veranda, putting rooms with minimum area behind to cover the annoying light of west.
2) The designers of these houses have taken advantage of the favorable wind of Tabriz, by selecting a 10-degree establishment angle to the north-east, building a private courtyard, and spatial selection in the plan structure.
3) Adjacency of the reception hall to the pool room, which was placed under the reception hall, is another indicator of precise attention to the climatic and seasonal changes to maximize the convenience of the residents.
4) Choice proportions of 1:1 in general structure of the buildings also indicates optimal proportions for houses in cold and mountainous, based on Olgyay's experiments.

References

Baghaie, P., & Amir Khani, A. (2009). Investigate transformation of proportions ruling on arcades of Tabriz Bazzar in Qajar period, *Fine Art Magazine*, No.37.

Ghobadiyan, V. (1998). *Climatic analysis of the traditional Iranian buildings*. Tehran. Tehran University

Publications.

Hosseini, B. & ZandKarimi, A. (2012). *A breif survey on the principles of Iranian Islamic Architecture*. 2nd International Conference, Mukogawa Women's Univ., Nishinomiya, Japan

Kasmaei, M. (2003). *Climate and architecture.* Isfahan: Khak Publication.

Keynejad, M.A., & Shirazi M.R. (2010). *Historical houses of Tabriz*. Vol. 1. Tabriz, Iran: Tabriz Islamic Art University Press.

Mehdipour, A., & Namazian, A. (2012). *Yakhchal; Climate Responsive Persian Traditional Architecture*. 2nd International Conference on Environment Science and Biotechnology. Vol. 48. Singapore.

Nejad Ebrahimi, A., Pour Rahimian, F., & Sahraei Loron, M. (2013). Impacts of Climate on Genesis of Vernacular Architecture of Different Parts of Iran: Case Study of Cold and Dry Azerbaijan – Iran. *Alam Cipta* 6 (1): 69-82.

Nikpour, M., Kazemian, F., & Bahmani, N. (2012). Architectural Strategies in Cold Regions to Create Sustainability in Residential Spaces. *International Journal of Modern Engineering Research (IJMER)* 2(1)160-164.

Olgyay, V. (1963). Design with climate, bioclimatic approach and architectural.

Pakravan, G. & Mohammadpour, F. (2013). *A study of principle of climatic designing of Iranian houses(cold & dry, warm & dry, mild& humid)* .national conferences of Structure, Civil and Architecture. Islamic Azad university of Chaloos.

Pirniya, M. (2009). *Familiarity with Iran Islamic architecture*. Sorush-E-Danesh publication, Tehran.

Pirniya, M. (2010). *Style of Iranian architecture*. Sorush-E-Danesh publication, Tehran.

Sattary, H. & Godaie, A. (2011). Analysis schemes used in the Tabriz market arcades. *Study city Journal*. Vol. 4.

Shahamipour, A. (2013). The role of climate in shaping Iranian markets proportions Comparison of Tabriz and Isfahan Bazzar. *Life Science Journal* 10(5s): 633-637.

Singery. M., & Mofidi. S. M. (2007). *Climatic responsive architecture of Tabriz.* 2nd PALENC Conference and 28th AIVC Conference on Building Low Energy Cooling and Advanced Ventilation Technologies in the 21st Century, September 2007, Crete island, Greece.

Tavassoli, M. (2002). *Urban structure and architecture in the hot arid Zone of Iran*. Payam Publication.

Utaberta,N., & Sharifi,N. (2012). The Experience of Iranian Architecture in Direction of Urban Passages and Forming of Urban Structures to Increase Climatic Comfort. *World Academy of Science, Engineering and Technology journal*, 637-641.

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