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Investigating the Climatic Structure of Vernacular Housing in the Cold Regions of Iran (The Case Study of Zanjan, Tabriz and Hamedan)

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ABSTRACT

The Iranian vernacular architecture, as a result of the interaction and compatibility between nature and architecture, has led to the formation of many types of climatic architecture. In order to study the climatic structure of vernacular housing in cold regions of Iran, the climatic features of 15 cases of vernacular housing in cities Zanjan , Tabriz and Hamedan have been analyzed. In the analysis, some notions such as the form, the orientation and the pattern of the construction, the connection with the ground, theproportion of the open, closed, and half-open spaces, and also difference performances in the sides of the courtyard, were compared in the selected samples. According to the physical properties, and as a result of the climatic analysis and the comparison, the selected samples were classified in three groups. The main issue in the present study is to investigate the physical patterns of housing in the cold regions of Iran. Investigating different types of the climatic structure of vernacular housing of the mentioned region shows that in all elements of architecture, adaptability with the environmental conditions and the climatic properties of the region, was most regarded. For instance, the orientation of the construction is in accordance with the sunlight, or the connection pattern of the open and closed spaces, the location of spaces around the courtyard, and their functions is related to the thermal requirements in different seasons of the year. The formation of different patterns of construction form and different position makes it possible to move the biological environment with the seasonal changes. The results of the analysis shows that the courtyard houses in three cities of Zanjan, Tabriz and Hamedan (of the cold climate of Iran), have similar physical patterns thathave been formed in adaptability with the climatic conditions.

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INTRODUCTION

In the present century, the researchers in the field of architecture, are trying to find the solutions for reducing the cities pollution problem arising from burning the fuels and also in order to exploit the natural energy resources more. This idea requires designing special buildings that are compatible with the favorable and unfavorable climatic conditions.

Iran is one of the few countries which possesses various climates. Hence, the vernacular architecture of Iran, as a result of the interaction and compatibility between nature and architecture, has led to the formation of many types of climatic architecture. The climatic architecture involves extensive topics, from construction form to the materials color and substance, which is considered in order to reach the appropriate architectural patterns in each climatic region. Therefore, the climatic performance of 15 cases of vernacular housing in cities Zanjan, Tabriz and Hamedan will be analyzed and the physical properties of the construction and its elements will be studied.

Determining the Region of Iranian Cold Climate:

Identifying the climatic condition of a place and analyzing the climatic requirements in case of welfare and the use of building materials, are the important prerequisites of the climatic architecture [1]. The weather in every region is composed of many different elements, and it seems almost impossible that two different places have the same weather and climates. Basically, in many parts of the world, the climate is determined by the longitude, latitude and the elevation. Being located between 25 to 40 degrees of northern latitude, Iran is in the warm area, and in case of elevation, is also a high plateau. The total area of the regions in Iran whose elevation

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is lower than 475 meters, consist a few percentage of the total area of the country [2]. Iranian plateau is located in the dry area of the world, in terms of climatic classification. However, it should be noted that the mentioned classification is a general one, and although the climate of most parts in Iran is dry and the average precipitation rate is lower than the average precipitation rate of other parts of the world, there are various climatic conditions in Iran [3].

Determining the region of the case study in the present study, is done according to the Köppen's climate classification, considering the determined purposes of the research. The reasons for selecting the Köppen's approach, was its validity and also the method of assessing on the basis of both indexes of temperature and precipitation which are the determining factors in the form of architecture. The Köppen's climate classification is based on the annual and monthly averages of the temperature and precipitation rates. Köppen has paid much attention to the vegetable life as a very effective criterion for determining the climatic boundaries, in such a way that many boundaries have been drawn according to the vegetable life type [4]. Köppen also has introduced five climate types in the global scale, on the basis of the growth of various plants. These classifications, presented by letters involve Hot-Humid/Tropical (A),Hot-Arid and Semi-arid(B), Temperate/Warm Humid (C), Cold/Snow-Forest (D), Polar (E).

In Köppen's definition of cold climate, the average temperature in the warmest month of the year is higher than 10 degrees, and in the coldest month, the temperature is lower than -3 degrees Celsius. However, in some modified versions of Köppen's classification method, the criterion for the coldest month of the year, has been regarded as zero degree Celsius; as for instance, Russell thought that zero degree is better for distinguishing the C and D climates [5].Considering the Köppen's criteria for the average temperature of the coldest and warmest month of the year, and the precipitation rate in the warm and cold seasons in the studied cities , the climatic classification of the cities is determined which can be seen in Table.1.

Table 1: The Climatic Classification Resulting from Köppen's Classification Method [6].

City	Average of annually temperature in c.	Average of coldest month temperature in c.	Average of warmest month temperature in c.	Months with mean temperatures above 10 °c	Annually total of precipitation in mm.	Total of precipitation in winter months in mm.	Precipitation in driest winter month in mm.	Precipitation in wettest winter month in mm.	Total of precipitation in summer months in mm.	Precipitation in driest summer month in mm.	Precipitation in wettest summer month in mm.	Microclimate
Zanjan	11	-2.5	23.3	7	313.1	189.7	21.7	48.1	123.4	3.7	56.5	Dfa
Tabriz	12.5	-1.7	26.0	7	288.9	160.1	21.9	40.6	128.8	3.2	52.7	Dfa
Hamedan	11	-3.2	24.4	7	332.7	234.0	17.1	55.4	98.7	0.9	54.3	Dsa

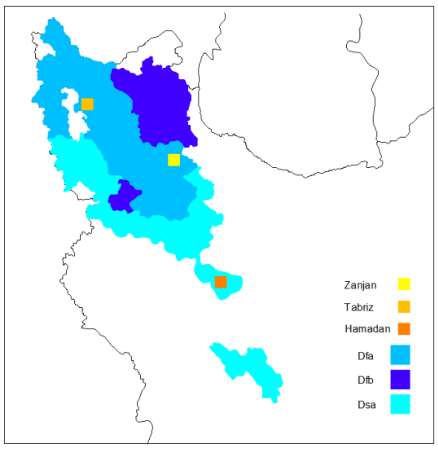

Fig. 1: Zoning the Microclimates of Cold Region of Iran [6].

Determining the Criteria for Climatic Analysis:

The archetype of a courtyard house, has been considered for presenting the inactive system for providing the heat inside the building, and it has been adapted to the microclimatic and weather changes. The courtyard house, acts as a temperature regulator and also as an open space through a building, as the courtyard is a designing element which has been widely used in the vernacular buildings in the Mediterranean, the Middle

East, and tropical areas [7]. The geometry of the building, the yard, the orientation, the construction texture density, and the availability of the wind can provided effective architectural functions by changing the microclimate of the courtyard. In terms of climatic designing, the plan of a house with a courtyard, allows that larger areas of the internal inactive space, benefit from the natural ventilation and the daylight [7]. The house with a courtyard pattern acts differently in cold and warm climates. In the cold climates, this pattern is used for allowing the sunlight into the house. Hence, the rooms can have large windows for receiving the southern light, without losing the privacy [7]. The central courtyard is one of the ancient patterns in the Iranian architecture which organizes the architectural space and it provides the quality of the natural environment [8]. Planning any of the solid and void spaces such as the courtyard, the confined spaces, the porch, the room in different orientations and the underground, is related to the certain hours in day or night, in cold and warm seasons , and one can change his/her life space according to the changes in the area. Moreover, all the traditional buildings in Iran, in both cases of architecture and construction, have been designed in such a way that the most possible use of the sunlight in the winter and the most possible benefit from the shadows in the summer are guaranteed, so that the natural ventilation is made possible and the peace and well-being of the residents are insured. The houses with courtyard with features like thick walls, porches, and undergrounds, are the obvious examples of understanding the natural environment conditions [9]. However, all the features mentioned are affected by the environmental circumstances and vary from one region to the other. In other words, housing as one of the important elements of vernacular architecture, has different physical patterns, observing the principle of adaptability with various climates. These features and differences can be supposed as the variables and criteria for the climatic analysis, in the vernacular houses of the cities and in different microclimates of the studied region. The criteria is determined considering the common physical features in the samples and also according to the effectiveness of the environmental conditions. The analysis criteria, have been selected considering the research purposes – which is the typology of the climatic housing in the cold areas of Iran- that are mostly either quantitative or their results are expressed quantitatively. The quantitative data makes it possible to use computer software in analyzing the results;thus, a more realistic zoning is presented. Also, the selection of the criteria has been done according to the common elements of the samples and on the basis of investigating their changes. In the first phase, 10 criteria are considered the physical structure of the housing, and after doing the analysis, these criteria becomes 30 indexes in the final assessment as follows:

- Building Form (BF):This criterion, investigates the pattern of building location in relation to the courtyard. Various forms involve the courtyard with the building mass on one side (BF1), courtyard with building mass in the two facing sides (BF2), courtyard with the building mass in the two adjacent sides (BF3), courtyard with the building mass in three sides (BF4), and courtyard with building mass in four sides (BF5).
- Building Orientation (BO):This criterion, assesses the orientation of the courtyard in relation to the geographical orientations which can be either north-south or east-west.
- Building Mass Location in Courtyard (BL):Here, the location of building mass is studied affected by the orientation of the courtyard in various instances. The building mass may be located in one of the north, south, east or west of the courtyard.
- Courtyard Dimensions Proportion (L: W):This criterion, compares the ratios of the length and width of the courtyard in various samples.
- Ratio of Building Mass Area to Courtyard Area (BA: CA): this criterion, studies the ration of the occupied area by the building and the area of the courtyard; in other words, it considers the ratio of the solid and void spaces.
- Ratio of Building Mass Area in one Side to Total Building Mass Area (BA: TBA): Considering the fact that the orientation of various parts of the building mass in relation to the courtyard, has direct impact on the environmental conditions of the building, and it can determine its performance type and also seasonal function, this criterion evaluates the building mass area and the ratio among different parts. Thus, the details of this criterion involve the ratio of the building mass area in each side to the total building mass area.
- Ratio of Courtyard Facade Area in one Side to Total Courtyard Facades Area (FA: TFA):This criterion, considers the ratio among the areas of different facades of the courtyard, which involves the façade area of each side of the courtyard to the total courtyard facades area.
- Ratio of Opening Area to Facade Area (OA: FA):The criterion investigates the ratio of the opening area to façade area in each side of the courtyard. The opening areas involve all the doors and the windows.
- Functions around Courtyard Proportion (FCP):The spaces around the courtyard involve the residential, service and communicational performance. Considering the climatic function, the ratio of the performances in different aspects of the courtyard is compared by this criterion. The details of the criterion involve the ratio of the residential performance area to the total area and the ratio of the service performance area to the total area, and ratio of the communicational performance area to the total area in each side of the courtyard.
- Building Mass Connection to Earth (BMCE):The area of the lowest floor of the building may be in the level of courtyard level (CL), above the courtyard level (ACL), or below than the courtyard level (BCL). In each of these states, the hierarchy of accessibility is different which is investigated in this criterion.

Data Analysis:

Noting the fact that the vernacular houses of each region has the most climatic and environmental adaptability, a number of vernacular houses with courtyard would be investigated in terms of the construction history, the traditional materials, and the use of the climatic architecture solutions. The other criterion in selecting the samples, is the determination of the boundary of the construction and its elements. Therefore, the houses that do not have definite boundary and components or their dimension or elements cannot be measured are removed from the samples. In this regard, the selected buildings involve the houses of As'adi, Dabbagh-ha, Davoodi, Eslami and Jamali from Zanjan, Alavi, Behnam, Lalehi-ha, Qadaki and Savojbolaghi-ha from Tabriz, and also the houses of Ahmadi, Moghaddasi, Samadian, Seifi and Zarrabi from Hamedan. The selected houses are investigated considering the physical features and are analyzed according to the determined criteria.

The purpose of this analysis, is to classify the houses in case of climate in the studied region. One of the main results of the climatic studies is the classification of the case studies. The data classification, also makes it possible to compare the groups according to the samples features and the analysis criteria. Hence, the results of the analysis of the climatic criterion in the houses of the cold region of Iran, is classified in different groups. In the samples classification, the similarity of the qualitative and quantitative indexes and also the distance of the quantitative indexes should be taken into consideration. In this regard, in the classification of the selected samples of the vernacular housing of the cold region of Iran, three types are determined considering the physical characteristics. The results of the classification show that the samples of Zanjan city are distributed in each of the three groups. Although the samples of Tabriz are placed in group 2 and 3, and the samples of Hamedan are distributed in group 1 and 2. Table.2 shows the classification of the selected samples of the mentioned cities in three groups.

Table 2: The Classification of Selected Samples in Three Groups.

City	Group 1	Group 2	Group 3
Zanjan	As'adi House Jamali House	Dabbagh-ha House Eslami House	Davoodi House
Tabriz		Alavi House Behnam House Lalehi-ha House Savojbolaghi-ha House	Qadaki House
Hamedan	Ahmadi House Seifi House	Moghaddasi House Samadian House Zarrabi House	

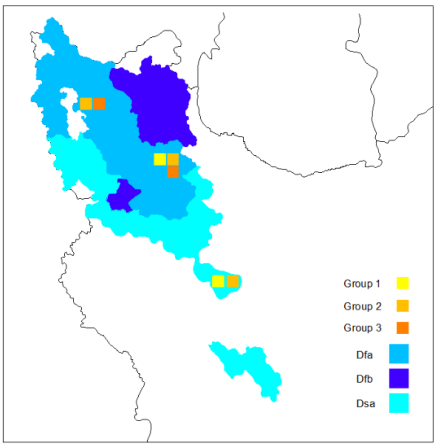

Fig. 2: The Map of the Distribution of Climatic Housing in Cold Region.

Also the physical characteristics of the types resulting from the samples classification are mentioned in Table3. In this table ,in case of the qualitative indexes , the most frequent state in each index and in case of the quantitative indexes, the index evaluation average of the group members are determined as the group representative.

Conclusion:

The valuation results of the selected samples from the houses with the courtyard in the cold climate, gives us three patterns that are distributed in different parts of the cold climate. In the studied cities, more than one pattern is observed, as well. As it is mentioned in Table 4, one pattern is observed in all the three cities and at the same time, one of the patterns in each city has had the most frequency which can be regarded as the

dominant pattern. By referring to table 3, it can be observed that the second pattern which is common in all the three cities, involves the form of the courtyard with two opposite building masses, in north-south sides.

Table 3: The Physical Characteristics Resulting from the Climatic Classification of the Samples.

Group	BF	BO	BL	BMCE	L:W	BA: CA	BA: TBA			
							North	South	East	West
1	CF1	North-South East-West	North	BCL	1:1.26	1:0.70	1:1.00	***	***	***
2	CF2	North-South	North-South	BCL	1:1.41	1:1.01	1:1.72	1:4.10	***	***
3	CF5	North-South East-West	North-South-East-West	ACL BCL	1:1.30	1:2.42	1:2.10	1:12.09	1:5.89	1:5.46

Group	FA: TFA				OA: FA			
	North	South	East	West	North	South	East	West
1	1:2.66	1:4.67	1:5.05	1:5.06	1:2.91	***	***	***
2	1:2.90	1:3.76	1:5.55	1:5.54	1:2.74	1:12.69	***	***
3	1:3.53	1:5.01	1:4.25	1:3.72	1:1.59	1:5.38	1:11.12	1:6.63

Group	Residential Function Area: Total Functions Area				Service Function Area: Total Functions Area				Communication Function Area: Total Functions Area			
	North	South	East	West	North	South	East	West	North	South	East	West
1	1:2.90	***	***	***	1:6.39	***	***	***	1:5.42	***	***	***
2	1:3.07	1:4.32	***	***	1:10.5	1:4.37	***	***	1:5.39	1:2.04	***	***
3	1:2.84	***	1:3.79	1:2.81	1:6.47	1:8.37	1:3.27	1:6.26	1:5.44	1:4.77	1:10.49	1:14.40

Table 4: Distribution of the Physical Patterns of Housing in the Studied Cities.

City	Available Group	Dominant Groups
Zanjan	1,2,3	1,2
Tabriz	2,3	2
Hamedan	1,2	2

Comparing the distribution of the physical patterns of the housing in the three studied cities of the cold region of Iran, shows the following results:

- The courtyard houses in Zanjan, Tabriz and Hamedan from the cold climate of Iran have similar features.
- The similarity of the physical features in different housing patterns of the mentioned cities shows the effect of the environmental conditions of the cold microclimates.
- The common physical pattern in the houses with courtyard of the cities, which involves the physical form of the courtyard with two opposite building masses, demonstrates that the patterns are formed in adaptation with the climatic conditions.
- The north-south orientation in the common pattern of the cities shows that the physical characteristics are formed in accordance with the location of the sun and in relation with the different seasonal situations.

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