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CLIMATE COMFORT OF VERNACULAR HOUSES IN IRAN

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ABSTRACT

Technology development causes a human oriented design to be forgotten all over the world. In housing design, one of the important factors for human-oriented design is Climate comfort. Today similar architectural patterns in different climate regions in Iran, can't provide residents comfort. While vernacular housing architecture of Iran had different patterns for providing climate comfort in different regions. In this study we want to introduce Iran's different climatic zones and their different vernacular architecture to show how they adopted their buildings to different climate conditions.

Keywords: Comfort; climate comfort; vernacular housing

INTRODUCTION

Built environment has direct effects on human's satisfaction and well-being. Building's response to inhabitants' physical and psychological needs is essential to give them a sense of self-worth, safety, and privacy. In spite of all these, it is necessary for a healthy environment to delight, uplift the spirit, relax or provide contact with nature (Sassi 2006). Therefore for attaining the physical satisfaction, the human body should be in a comfort level that achieving this depends on the accommodation of building design with the outdoor climate. Accordingly climate is one of the most important factors, which can have an effect on human comfort. Hence, due to the differences of climate in a different part of the world, each region needs its designs and construction techniques in its buildings that can provide human comfort. However in recent years, by the development of technology, most of the new buildings are designed without considering human comfort.

In Iran, the same techniques are used in different zones for designing contemporary houses. These similar design patterns for contemporary houses cause some problems that are related to the human physical and psychological comfort. While vernacular housing in Iran was well adapted to its climate by using different strategies in different climates.

The aim of this study is expressing the importance of different architectural design strategies in responding to the climate comfort. As Iran has rich vernacular architecture, scientists can analyze the positive features of the past architecture (not just imitate them) and make an attempt in order to build environmentally compatible structures using the new construction materials and advanced technologies.

CLIMATE COMFORT IN ARCHITECTURE

"One of the effective factors in the human life, health and comfort is climatic conditions. A human being directly and indirectly has been affected by this condition" (Ramezani1, Maghsodi & Shafaghati, 2013). Jahan Bakhsh (1998) presented climate comfort conditions which in aspect of temperature is suitable for 80percent of people, or in other words, human beings under those conditions, neither feeling heat nor cold and neutral state is its other word. Considering climatic comfort in architectural and building design is the subject matter of many kinds of research that clarifies its significance.The building design is the first defense lines against outdoor climatic parameters. The climatic design is looking after providing climatic comfort for human in buildings (Shakor, 2011). Gioni presented a bioclimatic chart of building and Elgi presented humidity and heating conditions about human needs and climate design and drew the bioclimatic chart (Kasmaei, 2008).In Iran, various studies were done in the field of climate role in architecture and urban design. Most studies pay attention to architecture survey consistent with a climate in various climates of the country. For an example, Kasmaei, (2008) studied climatic conditions, climatic parameters and the use of these parameters in the construction, Ghobadian and Mahdavi, (2013) presented different methods for analyzing thermal comfort and climate control methods, Saligheh, (2004) has presented climatic design models compatible with the region climate for the improvement of thermal conditions and raising comfort indexes and Razjooyan, (1988) has tried to analyze the effective factors on comfort by publishing his valuable book, entitled "Comfort by Architecture Compatible with Climate". Based on mentioned researches, built environment is highly associated with the climate. Moreover, according to the climate characteristics, there are different classifications in architecture, such as cold, temperate, warm- humid and hot-dry climates. We can use this classification for achieving climate comfort level in building in different climates.

VERNACULAR ARCHITECTURE AND CLIMATE COMFORT

Different climates require different architectural responses. To satisfy the various necessities, vernacular architectures that developed through the centuries has much original and interesting design practices and technologies (Singh, 2009). The vernacular building construction technique and specifications are more based on knowledge achieved by trial and error rather than conventional practices. Vernacular architecture provides a good solution to the climatic constraints, and there is more than one approach to solving the same climatic constraint (Rakoto-Joseph et al., 2009). It sets a harmony between dwellings, dwellers, and the physical environment. These kinds of structure evolve over time to reflect the environmental, cultural and historical context in which they exist (Helena, 1998).

Iranian vernacular architecture achieved the climate comfort conditions in interior spaces by using of intelligent strategies and adapted to the natural and social conditions of a specific locations in which it exists. Different studies about Iranian vernacular architecture have revealed that bioclimatic is a critical parameter for achieving human comfort (Kasmae, 1996; Ghobadian, 1996 & 2006; Pourvahidi, 2010).

Therefore, it is essential to classify the climates to reveal their impacts on vernacular architecture. This is while, because of some reasons, the continuity of the vernacular architecture and features of them ignored in recent years. However, it may not be appropriate to adopt these models as readymade solutions for modern architecture. Our advanced technical capability and cultural context prevent us from returning to these old-fashioned architectural forms. But we can learn a lesson from the approach of the builders who acknowledged the interdependence of human beings, buildings and physical environment (Helena, 1998).

METHODOLOGY

This study analyzed climate comfort in vernacular houses by considering the design principles for each different climate in Iran.
"Koppen divided the world based on growing of plants. Accordingly, Iran is basically divided into four climatic regions: temperate and wet climates, cold climates, hot and dry climates, hot and wet climates" (Shokouhian & Soflaee, 2007). We have selected four cities (such as Yazd, Rasht, Bushehr, and Urmia) from four main climates of Iran as representatives of their climate region (Fig. 1).These cities were selected to find out the parameters of human-oriented design in different climatic regions.

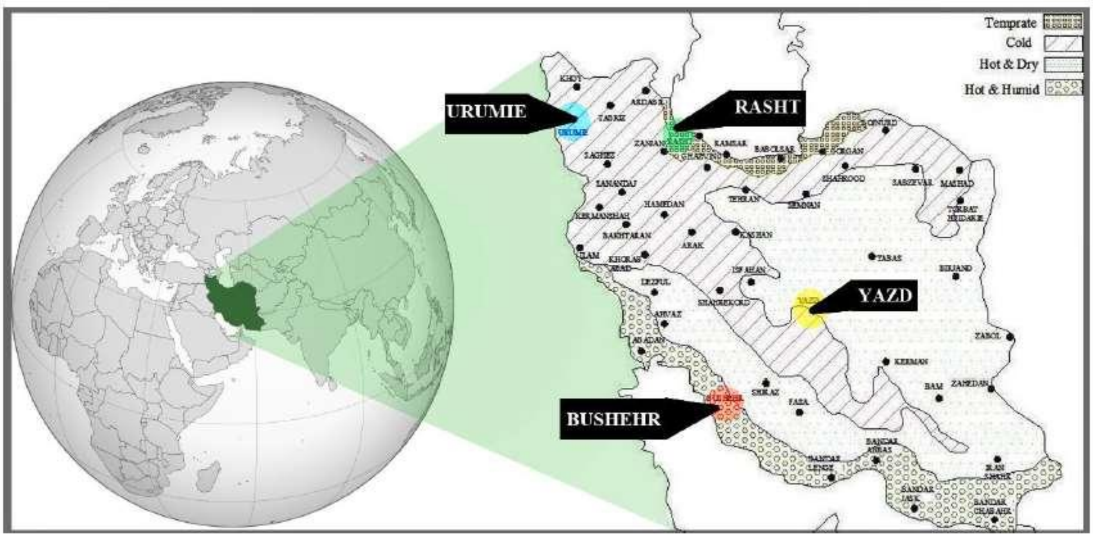


Fig. 1. Climatic division of Iran and location of Urmia, Rasht, Bushehr, Yazd city in this country.

Urmia city (37°40'N, 45°03'E) is situated in the Far northwestern of Iran has a cold climate condition with cold winters, mild springs, hot summers and warm autumns. Rasht city (37°19'N, 49°37'E) is situated in the north of Iran has Temperate and humid climate conditions with heavy rainfall, hot and humid summers and cold winters. Bushehr city (28°57'N, 50°49'E) is situated in the south of Iran has insufferable heat and humidity climate conditions with hot summer and mild winter. Furthermore, the fluctuations of temperature in these areas do not go below zero during the winter time. Yazd city (31°53'N, 54°16'E) is situated in the center of Iran has hot and dry climate conditions with an average annual rainfall of only 60millimeters (2.4 in), and also the hottest north of the Persian Gulf coast, with summer temperatures very frequently above 40°C (104°F) in blazing sunshine with no humidity.

Studying the bioclimatic design principles in these cities of Iran is essential to investigate the climate comfort differences between vernacular and contemporary houses and explore the effects of the climate to enhance the level of human comfort.

The study identifies the dominating bioclimatic design strategies for the four main climate zones using Givoni's Psychrometric chart (Fig. 2). Givoni's chart predicts the comfort conditions within the building based on outside climate factor. In this chart, the combination of monthly temperature and relative humidity indicates the recommended passive design strategy for each month (Givoni, 1969). To conduct this research, meteorological data effective on climate comforts such as temperature and relative humidity of the synoptic station of Iran's cities have been extracted from the meteorological station in a 20-year period (1990-2010).

For explain comfort level of vernacular houses, first principles of climatic design were analyzed from Givoni's Psychrometric chart. Then we categorized climate comfort design parameters of each region. We selected 24 houses (6 houses for each climate region) and rated their level of climate comfort design parameters on a 5-point Likert scale. As the nonparametric test, we used the Mann-Whitney U test to analyze the data. All the statistical analyzes performed in SPSS version18.

For more reliable results, more cities and number of samples should be investigated. In this study, four main Climate of the country has been chosen as the representatives of Iran's weather while this vast country has other microclimates.

FINDINGS

- **Research climate- responsive design strategies for Iran**

Following design recommendation are identified by using Givoni's charts for four climates, which are drawn in Fig2 by extracting meteorological data effective on climate comfort such as temperature and relative humidity from the synoptic station of Iran's cities.

In the following the results and solutions of climatic design for each city have been explained separately according to the Givonis charts of each city (Fig. 2, 3).

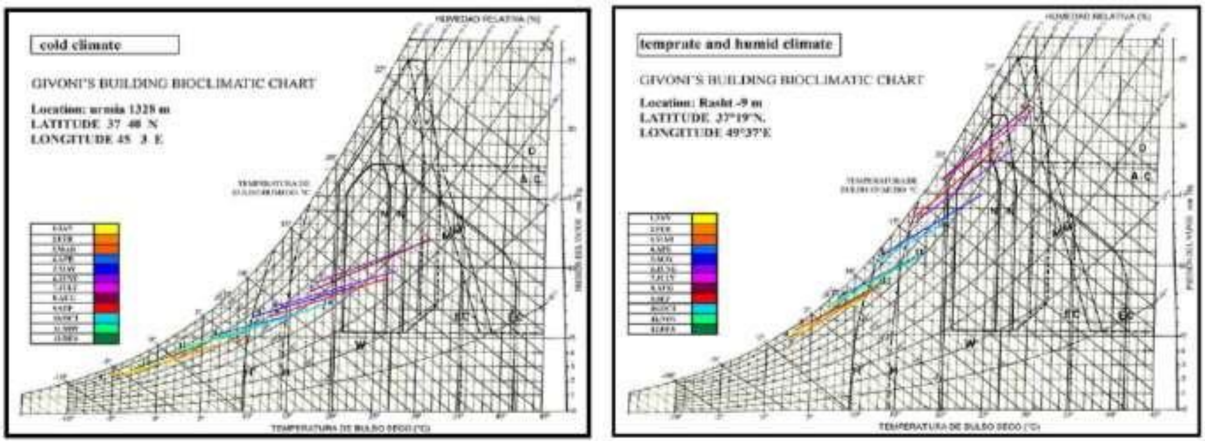


Fig. 2. (a) Urmia Bioclimatic Chart; (b) Rasht Bioclimatic chart.

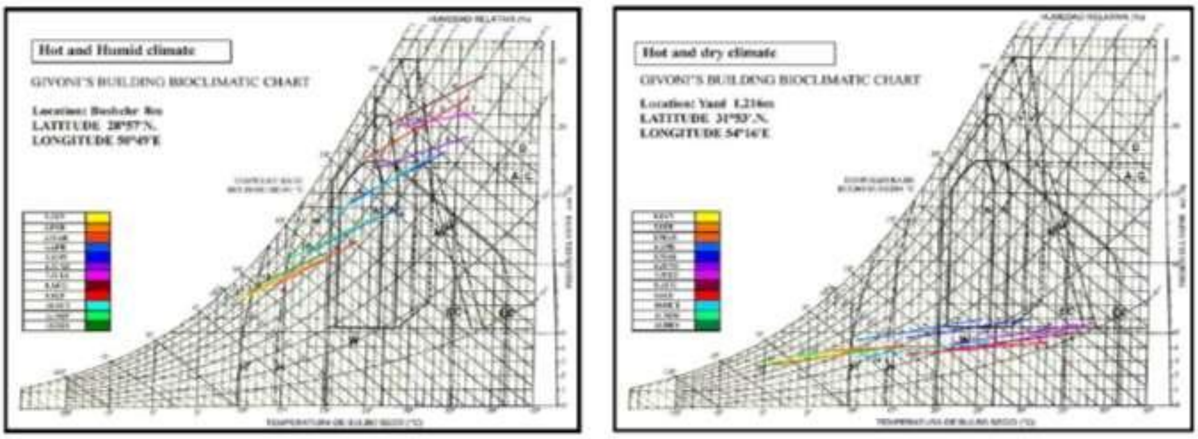


Fig. 3. (a) Yazd Bioclimatic; (b) Bushehr Bioclimatic Chart.

Month	TIME	ZONE	DESCRIPTION
Dec, Jan, Feb, March		Under heated	Require heat sources, minimum heat exchange with the outside, Using solar heat
Nov	Day	Cold, H'	Materials with high thermal capacity, Using solar heat
	Night	Under heated	Require heat sources, mechanical equipment
Apr, Oct	Day	H	Using solar heat, Suitable building materials
	Night	Cold, H'	Materials with high thermal capacity
May	Day	H, N'	Using solar heat, Materials with high thermal capacity
	Night	H', H	Materials with high thermal capacity, minimum heat exchange
June, Sep	Day	N', N	Comfort zone
	Night	H', H	Materials with high thermal capacity, minimum heat exchange
July, Aug	Day	M, V, N'	Need for natural ventilation, Tolerable thermal condition with Suitable materials
	Night	N, H	Tolerable thermal condition, minimum heat exchange

Table 1. Analyzing bioclimatic chart of Urmia.

Table 1 shows the principles of climate design for Urmia city from Givoni's psychometric chart (Fig. 2a). We categorized design principles for each climate region. In this city, the weather is very cold during more than six months of the year. Therefore for achieving the climate comfort, introverted building with a compact layout, small openings, veranda with Low height and small central courtyard located according to the sun radiation are recommended. Heavy external and internal walls are dominant climate-responsive design strategies to enhance the solar passive heating effect for great temperatures swing between day and night. Active solar or artificial heating is required during long winter periods. In summer days, the comfort level can be achieved by temporary provision for humid air movement and using thermal mass can store enough heat from solar radiation during the day for the nights.

MONTH	TIME	ZONE	DESCRIPTION
Jan, Feb		Under heated	Dehumidifying, Require heat sources, minimum heat exchange with the outside, Using solar heat
Dec, March,	Day	Cold, H'	Selecting suitable building materials, Sometimes requiring heat sources
	Night	Under heated	Dehumidifying, Require heat sources, minimum heat exchange with the outside
Apr, Nov	Day	H, H'	Using solar heat, minimum heat exchange with the outside
	Night	Cold, H'	Selecting suitable materials, Sometimes requiring heat source, Using solar heat
May, Oct	Day	N, H	minimum heat exchange
	Night	H, H'	Using solar heat, minimum heat exchange
June, Sep	Day	N, N'	Comfort zone
	Night	N', H	minimum heat exchange, Dress appropriately
July, Aug	Day Night	V, N'	Tolerable thermal condition, need for natural ventilation

Table 2. Analyzing bioclimatic chart of Rasht.

Table 2 shows the principles of climate design for Rasht city from Givoni's psychometric chart (Fig. 2b). In this city, the weather is very humid and protecting the building from heavy humidity, and rainfall is necessary.
According to the Givoni's chart, for achieving the climate comfort, cross ventilation is required therefore settlement pattern should be spread open and wide and buildings with deep continuous balcony and extending gable roofs are recommended.

Furthermore, buildings should be orientated with their bigger façade toward the south in order to gain solar heat in the winter when the sun angle is low. Because of heavy rains, the ground floors slab should be upper than the ground level. And the wood with minimum thermal capacity can be used as structural and covering material that is widely available in this area.

MONTH	TIME	ZONE	DESCRIPTION
Dec, Jan, Feb	Day	H	Using solar heat, suitable building materials
	Night	H'	Using solar heat, minimum heat exchange with the outside
March, Apr, Nov	Day	N	Comfort zone
	Night	H	Using solar heat, suitable building materials,
May, Oct	Day	M, V, V'	Use of materials with low thermal capacity, need for natural ventilation
	Night	N	Comfort zone
June, Sep	Day	V', D	air conditioner, dehumidifier, the device is required
	Night	V, N'	Tolerable thermal condition natural ventilation,
July, Aug	Day	D	Natural methods are not sufficient, dehumidifier device is required
	Night	V, V'	conditioning is a more serious problem, need for natural ventilation

Table 3. Analyzing bioclimatic chart of Bushehr.

Table 3 shows the principles of climate design for Bushehr city from Givoni's psychometric chart (Fig. 3a). In this city, the weather is very hot and humidity. Therefore, for achieving the climate comfort protecting the building from the intensity of sun radiation is essential. The buildings should be built with complete shade, and they also have extensive deep verandas. For preventing excessive absorption of heat, using indigenous materials with low thermal capacity and bright colors for exteriors of buildings are recommended. Orientation towards the prevailing wind from the sea, having minimum joints walls with neighbors, central courtyard and windows on both sides of single-banked rooms, high ceiling and wide windows enhance the air circulation to provide comfort during summer.

MONTH	TIME	ZONE	DESCRIPTION
Dec, Jan, Feb,	Day	Cold, H'	Materials with high thermal capacity, Using solar heat
	Night	Under heated	Require heat sources and mechanical equipment, minimum heat exchange
Nov, March	Day	H', H	Materials with high thermal capacity, Using solar heat, minimum heat exchange
	Night	Cold, H'	Materials with high thermal capacity, Sometimes requiring heat sources
Apr, Oct	Day	N, W	Need to Increase humidity
	Night	H', H	Materials with high thermal capacity, minimum heat exchange with the outside
May,	Day	N, V	Need to natural ventilation
	Night	W, H	Materials with high thermal capacity, Need to Increase humidity
Sep	Day	EC	Need to natural ventilation and Increasing humidity
	Night	W, H	Materials with high thermal capacity, Need to Increase humidity
June, July, Aug	Day	EC	Need to natural ventilation and Increasing humidity
	Night	W	Need to Increase humidity

Table 4. Analyzing bioclimatic chart of Yazd.

Table 4 shows the principles of climate design for Yazd city from Givoni's psychrometric chart (Fig.3, b). In this city, the weather is very hot. It has dry summers with cold winters and has a high difference of the temperature between day and night in summers. Therefore, having a dense settlement pattern with central courtyards, orienting towards the sunlight and using earth sheltered constructions and wind towers are recommended. Heavy external and internal walls with high thermal capacity materials can reduce the need for conventional heating and minimize the temperature fluctuations between day and night.

Analyzing climate comfort in Vernacular houses

Tables 5, 6, 7, 8 show the comparisons between 12 houses in 4 climate regions in Iran. The level of having climate comfort design parameters of houses were rated and tested by Mann-Whitney U test ($p<0.05$).

Table 5. Analyzing climate comfort in Vernacular houses in Urmia city (Cold Climate).

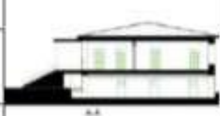
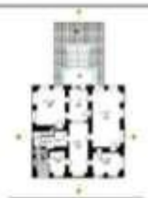
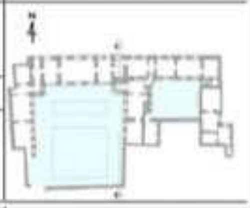
Climate component	Architectural Strategies	Majidi Afshar house		Hedayat House		Ansari house	
Disposal of rainwater	gentle sloped roofs	5		5		5	
absorption of heat	Ground floor lower than a natural ground level	3		5		5	
	small verandas	3		5		0	
	Introverted Buildings with southern courtyard	2		4		5	
	Using thermal mass	5		3		3	
temporary provision for air movement	using windows to enhance air movement	5		5		5	
Receive solar radiation in winter	Located according to the sun radiation. Plan proportions 2 to 3	2		5		5	
	large windows in the southern Front of building	5		5		5	
Total score		30/40		37/40		36/40	

Table 6. Analyzing climate comfort in Vernacular houses in Rasht city (Temperate Humid Climate).

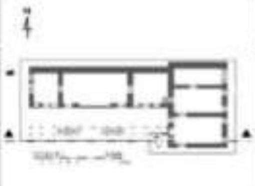
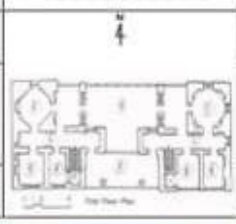
Climate component	Architectural Strategies	Avadis house		Samiei house		Abrishami house	
Disposal of rainwater	extending gable roof over balconies	5		4		4	
No moisture absorption	Ground floor's slab upper than the ground level	5		4		5	
Heating in the winter	Orientation toward South	5		5		5	
	spread Open and wide settlement pattern, Plan proportions 1 to 3	5		5		4	
enhancement of air turbulences	deep continues balcony	5		2		4	
	material with minimum thermal capacity	5		3		3	
	large number of openings	4		4		5	
Total score		34/35		27/35		30/35	

Table 7. Analyzing climate comfort vernacular houses in Bushehr city (Hot and humid Climate).

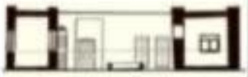
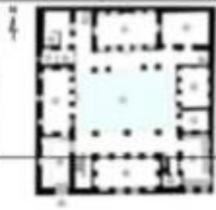
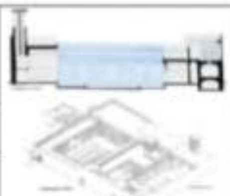
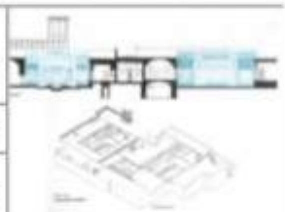
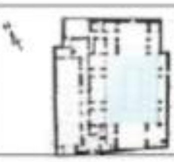
Climate component	Architectural Strategies	Mehraban house		Mokhtarzade		Tabib house	
exclude direct sunlight	cover extensive deep verandas	5		0		4	
	small central courtyards	5		5		5	
enhancement of air turbulences	high ceiling and wide windows	5		3		5	
	windows on both sides of single-banked rooms	5		4		3	
	minimum joint walls with neighbors	5		4		3	
	oriented towards the wind from the sea	5		5		5	
preventing excessive absorption of heat	Indigenous materials with the low thermal capacity	5		5		5	
	brightly colored exteriors	5		5		5	
Total score		40/0		31/40		35/40	

Table 8. Analyzing climate comfort vernacular houses in Yazd city (Hot and Dry Climate).

DISCUSSION

Results illustrate that vernacular housing in Iran used design strategies that enrich climate comfort. Today's climate comfort decreased according to the lack of human-oriented design by using new technologies that are not appropriate solutions for all the climate zones. Therefore, principles retrieved from Givonis psychometric chart that are applied in vernacular houses, can be used as guidelines for achieving the human oriented design in contemporary houses (Table9).

Climate component	Architectural Strategies	Rasulian house		Arabha House		Golshan house	
The use of heat capacity of the soil to air cooling	the ground floor level lower than street levels	5		4		5	
	using basements	5		5		5	
enhancement of air turbulences	using wind towers	5		5		5	
	Windows toward courtyard	5		5		5	
Increasing indoor heat in the winter	Orientation to south-eastern	5		5		5	
	The dense settlement pattern	5		5		5	
Reducing high difference of the temperature between day and night	using materials with high thermal capacity and heavy external and internal walls	5		5		5	
Increase humidity	water pool and trees in the courtyard	5		5		4	
Total score		40/40		39/40		39/40	

City	Climate component	Architectural Strategies
Urmia city (cold climate)	Disposal of rainwater	gentle sloped roofs
	absorption of heat	Ground floor lower than natural ground level, small verandas, Introverted Buildings with southern courtyard, Using thermal mass
	temporary provision for air movement	using windows to enhance air movement
	Receive solar radiation in winter	Located according to the sun radiation, Plan proportions 2 to 3, large windows in the southern Front of building
Bushehr city (a Hot and Humid Climate)	exclude direct sunlight	cover extensive deep verandas, small central courtyards
	enhancement of air turbulences	high ceiling and wide windows on both sides of single-banked rooms, minimum joint walls, oriented towards the sea
	preventing excessive absorption of heat	Indigenous materials with the low thermal capacity, brightly colored
Rasht city (Temperate Humid Climate)	Disposal of rainwater	extending gable roof over balconies and protecting the walls
	No moisture absorption	Ground floor's slab upper than the ground level
	Heating in the winter	Buildings should be oriented with the longer facade toward South
	enhancement of air turbulence	spread Open and wide settlement pattern, Plan proportions 1 to 3
Yazd city (Hot and dry climate)	air cooling	use of heat capacity of the soil, using water and trees in the courtyard
	air turbulences	sing wind towers, Windows toward a courtyard
	Heating in the winter	Getting sun radiation, Orientation of building to southeastern
	Reducing difference of the temperature between day and night	dense settlement pattern, using materials with high thermal capacity and heavy external and internal walls

Table 9. Guidelines for achieving climate comfort in contemporary houses in each region.

CONCLUSION

This study revealed that vernacular houses could provide a higher level of climate comfort by using building design strategies that influenced by the outdoor environmental conditions and climatic zones.

The vernacular architecture approach is coordinating between human beings, buildings, and physical environment in order to achieve comfort in Energy efficient buildings. While these factors are not significant in contemporary houses of Iran and using similar design patterns based on technology can't provide human comfort.

To enhance the level of comfort, especially climate comfort in today's housing of Iran, it is recommended using the climate-responsive design strategies retrieved from Givoni's Psychrometric chart, identified for each region, with using technology in a proper way.

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