Scientific Research and Essays Vol. 8(1), pp. 6-16, 4 January, 2013
Available online at http://www.academicjournals.org/SRE
DOI: 10.5897/SRE11.518
ISSN 1992-2248 ©2013 Academic Journals

Full Length Research Paper

Bioclimatic analysis of Iranian climate for energy conservation in architecture

Parastoo Pourvahidi and Mesut B. Ozdeniz*

Architecture Department, Eastern Mediterranean University, Gazimağusa, Northern Cyprus, Via Mersin 10, Turkey.

Accepted 16 July, 2012

In order to design energy conscious buildings we need to know the climate of each country. In this study a bioclimatic analysis of Iranian climate had been done. Iran is a large country with different kinds of climate and basically includes four different climatic regions such as temperate-humid in southern shores of Caspian Sea, hot-humid in northern shores of Persian Gulf and Oman Sea, very cold and long winter sessions and very hot and dry summers at the central part of Iran. At first the authors surveyed the existing climatic classifications of Iran. Afterwards by retrieving the climatic data from sixty eight Iranian Meteorological stations, and using the new bioclimatic chart a new climatic classification for architectural purposes has been made. As a result of this, five climates were identified for Iran. In order to prove that this new classification is valid, the traditional architecture of these climatic regions was compared. It was found that the traditional buildings have different features in these five regions.

Key words: Climate, climatic classification, vernacular architecture of Iran, bioclimatic analysis.

INTRODUCTION

In order to design energy conscious buildings we need to know the climate of the area where a building is located. Bioclimatic design identifies the climatic needs of human beings consistent with thermal comfort studies. The bioclimatic chart is the integration of four environmental factors and their effects in terms of human thermal comfort. Due to this, the appropriate cooling strategies for the climate at the building site can be determined by the designer according to bioclimatic charts. There has been some research on bioclimatic analysis of various countries for architectural purposes (Ozdeniz, 1991). In this study a bioclimatic analysis of Iranian climate will be made.

"Climate is integration in time of the physical state of the atmospheric environmental characteristic of a certain geographical location" (Shokouhian, 2007). Climatic division of each region depends on different factors. These factors can be studied on a number of levels such as macro, meso, local and micro climate. The climatic divisions in this research are based on macro climate. In macro climate the difference between the types are more manifest such as hot-dry, temperate-humid, hot-humid and cold climate.

This research has been organized in three steps. The first part of this research will be the review of previous studies related to Iranian climatic classification. In the second part, the climate of Iran will be studied by using a new bioclimatic analysis. By retrieving the climatic data from Iranian Meteorological stations sufficient information about characteristic of each region and for climatic analysis is obtained.

CLIMATIC CLASSIFICATION

There are several methods of climatic divisions in the world. Koppen was the first researcher who classified climate of the world in 1900, with some modifications in 1918 and 1936 (Koppen, 1936). He did it according to vegetation, air temperature and air humidity. Koppen's classification divided Iran into six different climates such as; warm, cold desert, warm semi-arid, cold semi-arid, warm Mediterranean and warm continental climate.

*Corresponding author. E-mail: mesut.ozdeniz@emu.edu.tr. Tel: (+90)0533 866 76 10.

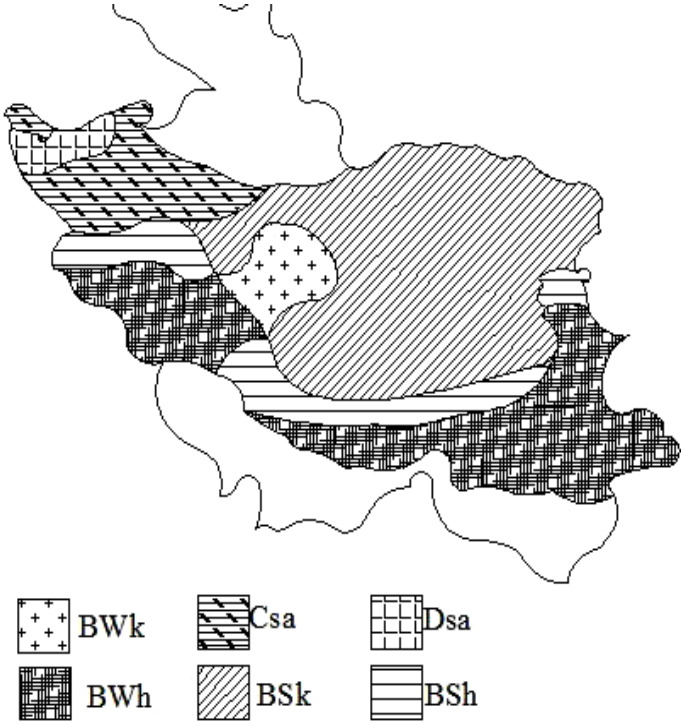


Figure 1. Koppen's classification of Iranian climates (Dsa: Snow-Summer dry- Hot summer, Csa: Warm temperature- summer dry-Hot summer, BWh: Arid- winter dry- hot arid, BWk: Arid- winter dry-Cold arid, BSh: Arid- summer dry- hot arid, BSk: Arid- summer dry-Cold arid,) (Koppen, 1936).

Olgyay did another kind of classification in 1963. For architectural purposes he classified world climates into four different climatic zones such as; cold, temperate, warm humid and hot-dry climate. Szokolay (1980) used Olgyay's classification as well.

Based on Olgyay's (1963) classification, Iran is classified as hot-dry climatic zone. However, the geographical features of Iran, with high mountain ranges and the surrounding seas, create other climatic zones within the country. They are the temperate climate of Caspian coastal plain in the north which is surrounded by the Alborz mountain from the south, the cold climate of the Alborz and Zagros mountains in the west and north-west, the warm humid climatic zone between the coastal plain of Persian gulf and Zagros mountains in the south and the hot and dry desert climate in the central and the eastern part of Iran which occupy two thirds of country as proposed by Kasmaee (2003).

Ozdeniz developed the climatic classification for Turkey which was based on Olgyay's classification. This classification divides Turkey, into seven categories such as; cool, temperate-dry, temperate, temperate-humid, hot-humid, hot-dry, and composite climates (Ozdeniz, 1991). He argues that the vernacular buildings in these seven zones are distinctively different from each other.

Another climate classification was proposed by Oliver, who divided the globe into nine climatic variations based on architectural impact (Oliver, 1997). These are arctic and sub arctic, continental, desert or arid, maritime, monsoon, montana, subtropical and tropical climates.

There have been many climatic studies that target vernacular as well as modern architecture. Each of these studies tried to classify the climatic zones of the selected area. Vitruvious, Koppen, Dollfuse and Olgyay are some of the important researchers who found very useful information about classification of climates (Szokolay et al., 1974). There are also some Iranian scientists such as Riazee, Kasmee, Ghobadian, Tahbaz and Jalilan, etc. who used different techniques to define the climatic division of Iran.

Iran is a large country with various climatic conditions. It is situated between 25° and 40° N latitude, which means that Iran is located in the hot region of the world. However, due to the height of the land above the sea level and proximity of some regions to the sea, like Caspian Sea in the north and Persian Gulf in the south, it has variations. It has also two very high mountain regions such as Alborz and Zagros in the north and west, which affect the air humidity.

There are some mistakes in Koppen's classification (Figure 1) for Iran in the climates of Dsa and Csa. Dsa and Csa are located in the North West part of Iran and Koppen in his division mentions that Dsa and Csa have hot summer temperatures. However, their average temperature in summer is around 28 to 35°C and the average temperature in the winter time is around -5 to -11°C so considering these climates as summer dry is not a precise division.

Riazee in 1977 was the first researcher in Iran, who studied the climatic divisions. He has done this investigation from the building construction and human comfort conditions point of view by using Olgyay's method. Riazee in his book called "Climate and Comfortability in Buildings" studied the data of forty three meteorological stations in Iran. By doing bioclimatic analysis he divided Iran into five summer and six winter climates. He also combined the winter and summer climates and suggested nine different climatic zones for Iran. He emphasized that at the lower latitudes except at coastal regions, dryness cause a lot of daily fluctuation in air temperature (Riazee, 1977). Later Ganji proposed a new method based on Koppen with some improvements. He divided the climatic region of Iran according to geographical latitudes. He suggests four different climates in Iran. These are temperate and humid climate (southern side of Caspian Sea), cool climate (Western Mountain), hot and dry climate (central plateau), hot and humid climate (southern shores) (Ganji, 2006).

Tahbaz and Jalilian in 1987 prepared another type of climatic division. They had done this division consistent with Olgyay's method and effective temperature. In their study, Iran was divided into eight original groups, and then they gave some instruction for architectural design

for each of these eight different regions (Tahbaz et al., 2008).

Kasmaee proposed another Iranian climatic division in 1993. In his study there were three main stages with different criteria. The aim of the first stage was to create the comfortable conditions in open spaces and he had done this segregation according to the bioclimatic analysis of Olgyay. In this stage he divided Iran into nineteen different climates. In the second stage he proposed thirty two different climatic zones for designing the residential spaces according to Mahoney tables. Finally in the third stage, he divided Iran into eight zones depending on Givoni's method (Givoni, 1976; Kasmaee, 1993). In his division he considered seasonal features on climate. For instance, Arak city has the average minimum air temperature in summer around 25°C and the maximum around 43°C but in the winter time the average of temperature is between 4.5 to -26°C. So this city has hot summers and very cold winters. Therefore he mentioned that considering this city in the hot-dry or cold region is not a good idea. There are some other cities where the situation is similar to Arak. These circumstances led the architects to investigate these divisions with more detail. In comparing Tahbaz and Jalilian's (2008) and Kasmaee's climatic divisions, similarities can be found, because both scientists divided Iran according to seasons. It is implied that in order to have climatic design, architects should consider effects of seasons in their designs as well.

Riazee's division has some advantages. He has six winter divisions as temperate-humid, very cold, cold, hot-dry, hot, hot-humid and five summer divisions as temperate-humid, hot-dry, very hot-dry, hot-humid, very hot-humid. This classification is conclusive and useful in getting more climatic information. By employing this information, it is possible to realize which type of mechanical system is needed for residential buildings.

Conclusions of Tahbaz and Jalilian, Kasmaee and Riazee were consistent with Olgyay's and Givoni's methods. They considered the climatic division along with the seasonal conditions. However, classifying the climates according to winter and summer conditions is not a convenient way, because winter and summer are only seasons. By rapid growth of population in cities and immigration from rural to urban, new problems arise such as increase of the land value. Thus residents cannot afford to have a house with separate spaces for different seasons, although it was realized in vernacular and traditional houses of the past. As a result the best solution is to propose a general classification based on the yearly climatic data. In addition, Riazee and Kasmaee did their research only with forty three meteorological stations. This many meteorological stations cannot give sufficient climatic data for understanding the climatic division of a very large country.

Different classifications of Iranian climates by various researchers indicate that there is a need for a deeper study on the subject. In this research bioclimatic analysis is the main tool and almost twice more meteorological stations were included in the study, in order to reach a sound conclusion. Studying the differences in vernacular architecture of each region will validate the new classification.

BIOCLIMATIC

Bioclimatic design defines the climatic needs of human beings according to thermal comfort studies. If bioclimatic design is the mean, sustainability is the outcome. Nowadays new definitions and standards are emerging related to sustainable developments. More commonly sustainability is discussed with references to the operation of natural systems, with particular references to ways in which natural sources are used and managed (Hyde, 2008).

Over the past few decades, there have been several attempts to develop systematic approaches that utilize human requirements and prevailing climatic conditions during the early stages of building design. The attempts aimed at defining the appropriate building design strategies for a certain region. This systematic approach of bioclimatic building design was first proposed by Olgyay in the 1950s. His method was based on an experimentally derived ''bioclimatic chart'' showing the human comfort zone in relation to dry bulb temperature (vertical axis) and relative humidity (horizontal axis) (Olgyay, 1963). This chart has been revised by Arens et al. (1981) and named as "the new bioclimatic chart". Accordingly, the new bioclimatic chart as a thermal comfort index is suitable to define the climate of a region for architectural purposes. It is a graphical index and indicates the effect of air temperature, humidity, air velocity and solar radiation separately on thermal comfort of an average person at sedentary activities and in normal business clothes.

The bioclimatic analysis of Iran

The authors took climatic data from sixty-eight meteorological stations of Iran and plotted Mean Maximum Air Temperature versus 14:00 hours Relative Humidity, and also Mean Minimum Air Temperature versus 07:00 hours Relative Humidity for the twelve months. The symbols were drawn as large dots and the numbers of each month were also written near them. Thus, there are twenty-four dots for the twelve months. The Mean Maximum Air Temperature is the mean of the maximum daily temperatures in each of the twelve months and averaged over the observation period. The 07:00 and 14:00 h Mean Relative Humilities indicate the averages of the highest and the lowest measurements at the stated hours every day in each month. Unit of air

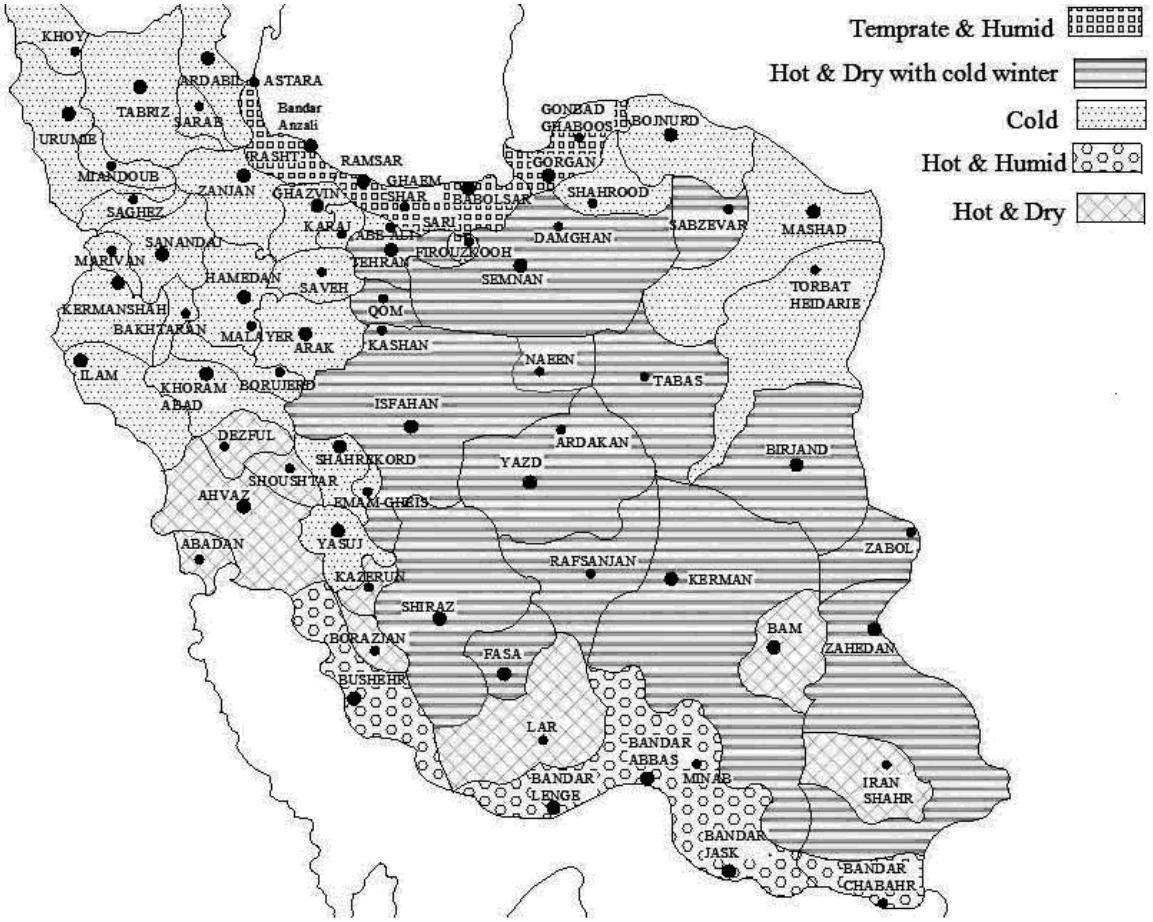


Figure 2. Climatic zones of Iran according to the New Bioclimatic Analysis.

temperature is °C and the relative humidity is given as percentages. They were measured by Iranian meteorological organization according to the world meteorological organization standards. Then the similar charts were grouped according to the distribution of plots around the comfort zone. It was found that there are five groups of similar charts.

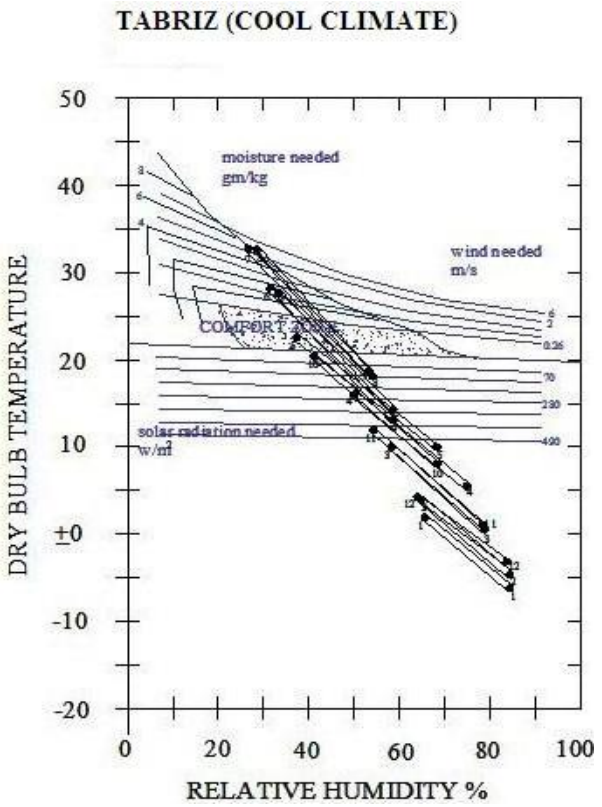
These are cool, temperate-humid, hot-humid, hot-dry with cold winters, and hot-dry climates. The results of the analysis have been shown on a map in Figure 2. One example of the new bioclimatic analysis has been selected from each climatic zone and given in Figures 3 to 7. A typical vernacular house has been selected from each zone and given in Figures 8 to 11. The results have also been summarized in Table 1.

COMPARISON OF IRANIAN VERNACULAR ARCHITECTURE OF DIFFERENT CLIMATIC ZONES IN TERMS OF BIOCLIMATIC ANALYSIS

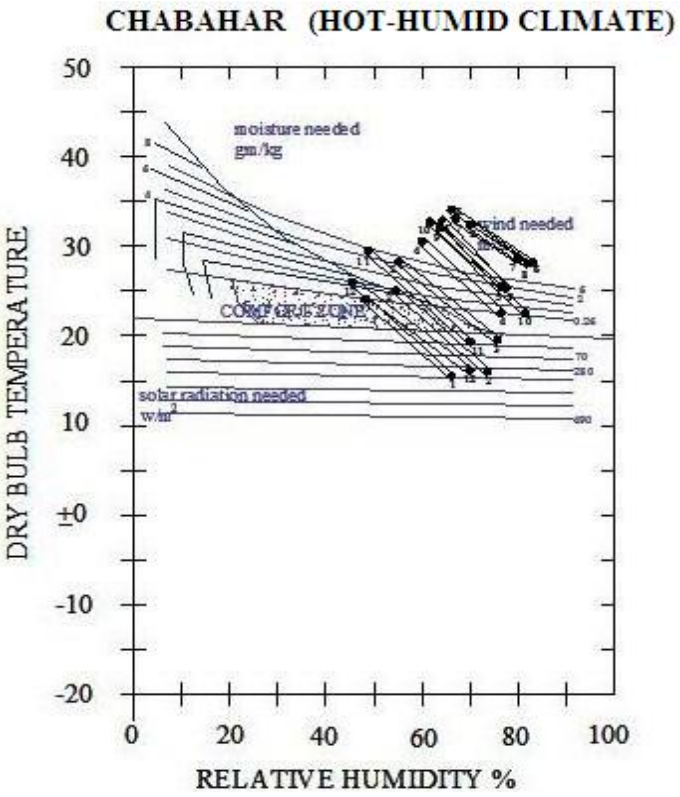
Builders of vernacular and traditional architecture did not have modern tools for controlling the thermal environment and they invented different ways of controlling thermal environment in every climatic zone with their buildings. Hence to verify that the proposed classification is valid, differences and similarities of Iranian vernacular traditional buildings will be studied.

Cool climate

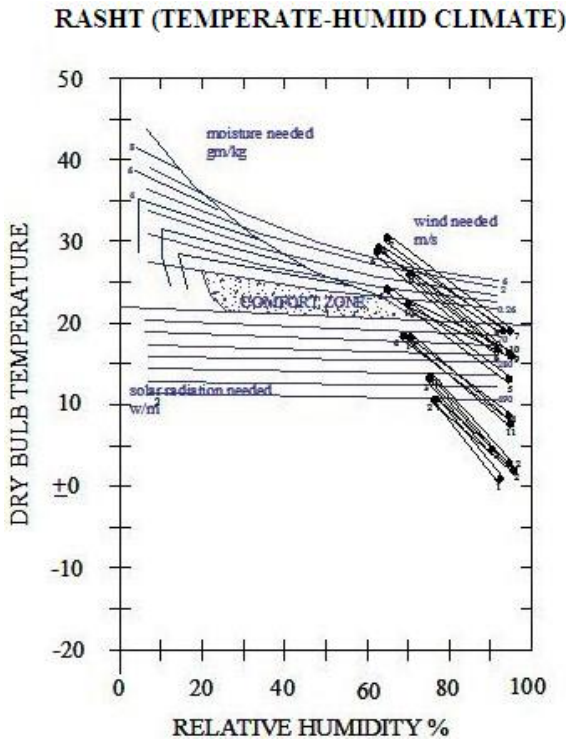
In this climate winters are longer than summers. There is a very short hot and dry summer period. Rain is also less and much of the precipitation is snow in winter. Most of the time, ground is covered by ice. West and northwest parts of Iran have cool climate. In cool climate it is important to keep the buildings warm in the winter. Building layout should be compact in order to shelter from cold winds and the best building forms are cubic forms which have less ratio of exterior surface to the volume. Small sizes of windows are used. All the vernacular houses of the cool region have these features. There are no large spaces in these buildings since warming them is hard. Most of the rooms have low ceilings. Another feature is flat roof. It can keep snow and provide thermal



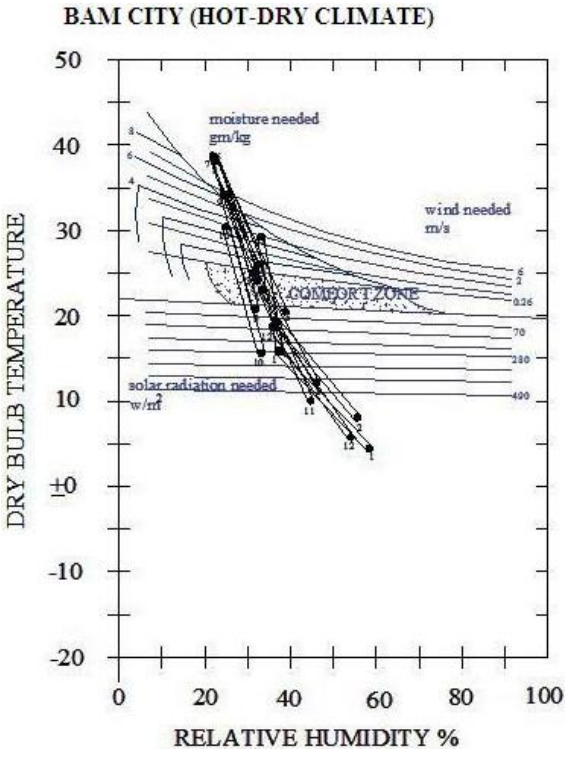
Figures 3. Meteorological data plotted according to the New Bioclimatic Charts from Tabriz.



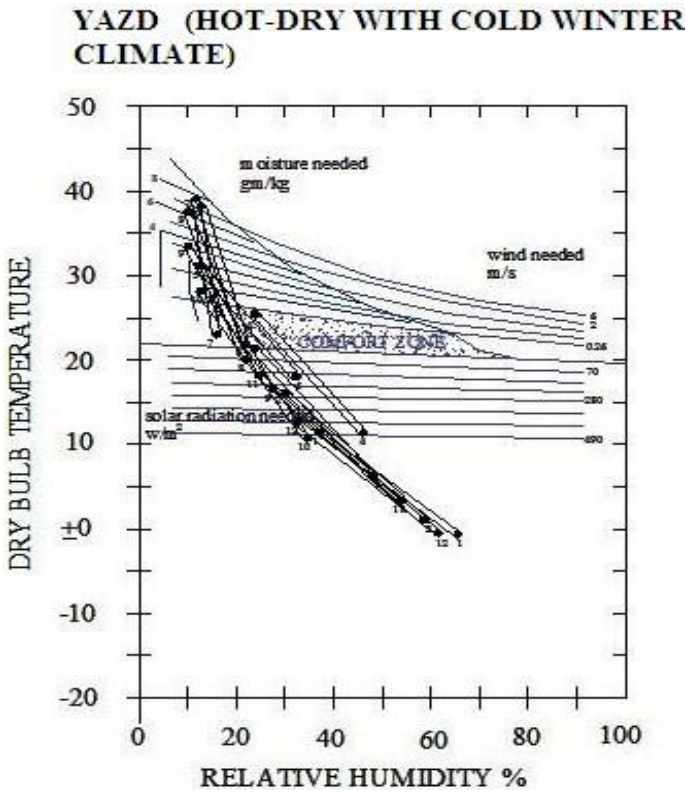
Figures 5. Meteorological data plotted according to the New Bioclimatic Charts from Chabahar.



Figures 4. Meteorological data plotted according to the New Bioclimatic Charts from Rasht.



Figures 6. Meteorological data plotted according to the New Bioclimatic Charts from Bam City.



Figures 7. Meteorological data plotted according to New Bioclimatic Charts from Yazd.

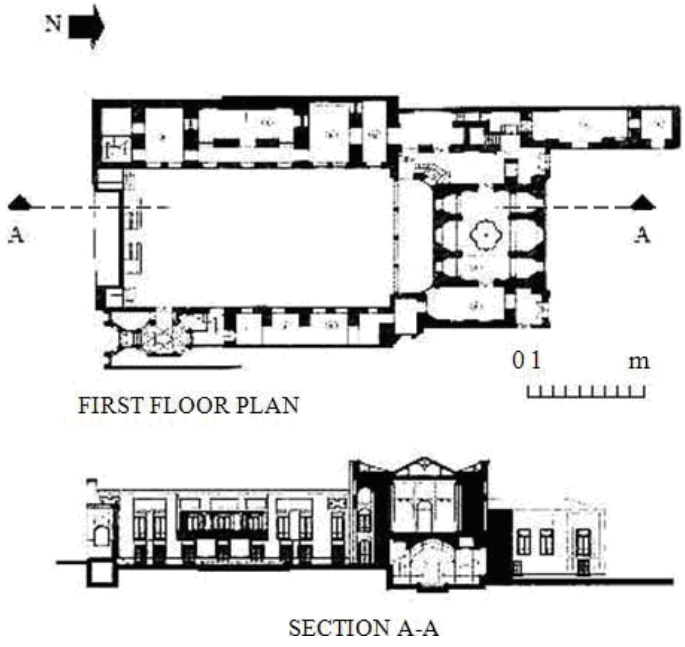


Figure 8. A vernacular house from cool region of Iran (Ghobaidan, 2009).

insulation against freezing winter winds. In order to reduce the heat loss from the spaces, all the rooms are

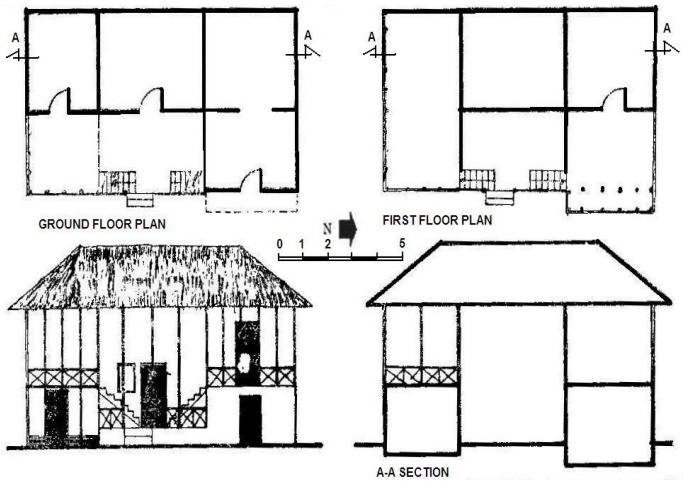


Figure 9. Vernacular house from temperate-humid region of Iran (Memarian, 2006).

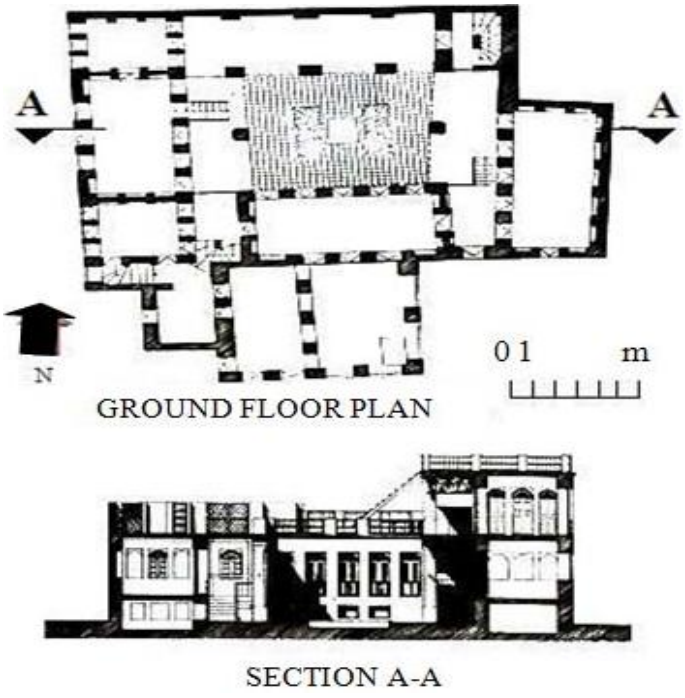


Figure 10. A vernacular house from hot-humid region of Iran (Ghobadian, 2006).

separated from each other with doors and partitions. Thick walls absorb the heat and heat the users even when the heaters were turned off.

Traditional buildings have central courtyard as in hot-dry climate. It protects the building from cold winter winds but the rooms around the courtyard are arranged in order to get the maximum sunshine. Most of the rooms were located on the northern side of the courtyard. The south side of the building is less used than the other sides. The rooms in east and west sides are used for storage.

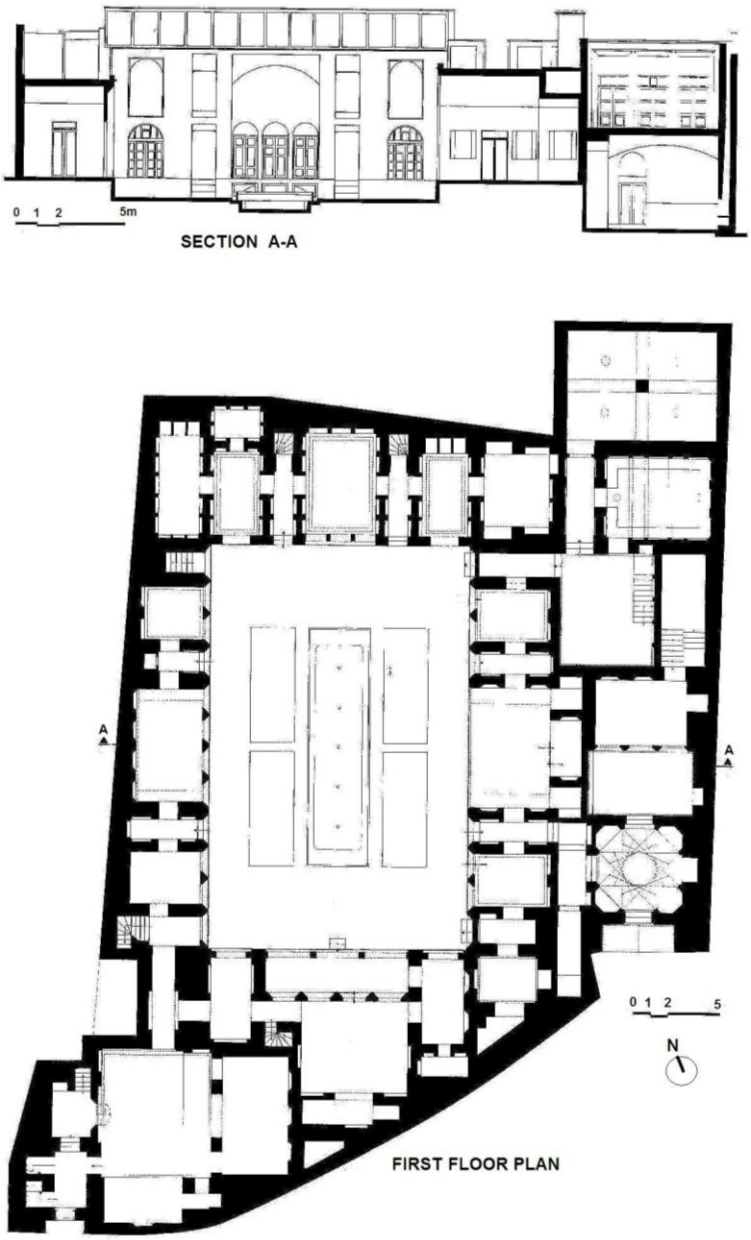


Figure 11. A vernacular house from hot-dry with cold winter region of Iran (University, 2005).

Temperate-humid climate

Although it is not too hot in summer and not too cold in winter, there is a lot of rainfall and high levels of relative humidity in temperate-humid climate. The north part of Iran has this climate.

In temperate-humid climate one of the features of vernacular architecture is the balcony. Most of the vernacular buildings have balconies. Balcony can work as an important and useful element in a humid climate. It is used for most of the activities such as socializing, eating, entertainment, working, even sleeping. Users enjoy the shade and breeze of balconies since inside the buildings it would be stuffy and warm. Another feature is the entrance door. The space outside the entrance door is also used for social activities. When the land is sloppy vernacular buildings are entered through the balcony.

In this climate cross ventilation is necessary to cool the house, thus plans are arranged in order to provide it. All the roofs are sloped because of too much rain. It is the easiest way to make a building rain proof. Yet another similarity is the use of large overhangs to protect the walls from rain. To protect the building from moisture and humidity it is elevated from ground about one meter.

Hot-humid climate

This climate has more than five months of summer and it is tremendously hot-humid during summer. Winters are temperate. Temperature range between day and night is not too much. The northern shore of Persian Gulf has this climate.

As in temperate-humid climate we see lots of balconies. The basement is not a pleasant space to live in this climate. Most of the vernacular buildings do not have basement. Even the ground floor is used for cooking and storage. People use the upper floors for living because they get more breezes. People also prefer to use external spaces for living and sleeping during the hot-humid seasons. Tall and frequent windows were used for cross ventilation. Most of the vernacular buildings have sloped roofs, but flat roofs were also used. Although it is not fit for this climate, courtyards were also used because of cultural preferences, which require privacy for the family.

Hot-dry with cold winters climate

The difference of this climate from hot-dry climate is the winter season which is very cold instead of being temperate. Vernacular buildings of hot-dry climate are very similar to cool climate buildings. The main difference between the vernacular buildings of hot-dry and hot-dry with cold winters is the provision of more open spaces. Central courtyard is very suitable for summer to keep the coolness and humidity of night and give refreshment during the summer days. It is also suitable for winter to protect the rooms from winter winds. The rooms around the courtyard have windows opening to the courtyard. Most of the daily activities will take place in the courtyard in summers and springs. Since, the great thermal mass of the building fabric makes the interiors of the house hot, it is more comfortable for residents to stay in the courtyard. The courtyard is completely enclosed by rooms and walls. The only opening to the outside is through the entrance door. It is designed so that when the door is opened the whole courtyard cannot be seen. This is a cultural aspect in one sense, because privacy in Iran is very important. Courtyard provides a protected environment for women. They can move freely without worries of being observed by strangers. It is also needed for protecting the building from sand storms which are very frequent in northern Iran.

There are also different rooms for winter and summer use. The summer rooms are in the north side of the courtyard. They are oriented to the south, and have more openings. The ceilings of the summer rooms are higher than the ceilings of winter rooms. The flat roofs are used for sleeping during the summer period because the heat absorbed by the building makes it impossible to sleep inside.

There is less rain in such a climate. A wall in hot-dry climate works as an important climatic regulator. The walls of vernacular buildings in Iran have approximately one meter thickness, made of brick, adobe and mud. In summer they store the heat of the day and give it at night when it is cool. They also provide thermal insulation both in winter and summer.

Hot-dry climate

This kind of climate has hot-dry summers and mild winters. It is seen in the central part of Iran. Vernacular buildings of this climate have almost square plan and a central courtyard. Courtyard in this type of buildings can keep the coolness and humidity of the night and gives refreshment throughout the summer days. Additionally, the courtyard protects the building from sand storms. The courtyard is used for most of the daily activities because building mass stores the heat and makes the rooms very hot in summer. There are no windows of the courtyard walls. They provide protection from burglary, sand storms and also provide privacy. The arrangement of entrance to the courtyard is same as hot-dry with cold winters climate.

Different spaces for winter and summer are also used in this climate, and the summer rooms have higher ceiling height than the winter rooms. There is less rain in this climate and the buildings have either flat or domed roofs. Walls are also very thick in order to store the heat of the day and give it off at night when it is cool. Wind towers are widely used in the vernacular buildings of this climate. They provide air ventilation free from dust storms and they can provide humidified air.

DISCUSSION

By using the bioclimatic analysis, five different climatic zones for Iran have been proposed. These are Cool, Temperate-humid, Hot-humid, Hot-dry with cold winters, and Hot-dry climates. This is different than what the other researchers such as Ghobadian and Pakdaman are proposed. More meteorological stations were included in this research. The differences between the vernacular buildings of each region have also been studied.

Settlement pattern

In the cold and hot-dry with cold winter regions of Iran, settlement patterns are more compact than the others. By this way it is possible to provide a sheltered exposure to the house and also to reduce the heat loss by reducing the external surfaces of the building. In temper-humid region of Iran, the settlement pattern is open and wide. This provides a better natural ventilation in and around the buildings.

Configuration of the building

One of the main dissimilarities between the architecture of hot and dry with cold winter and cool climate is the way of admitting solar radiation through buildings. Most of the walls in cool climate are painted in dark colors and also the size and the number of the windows are similar. In both climates buildings have cubic forms with less F/V (surface to volume ratio). Central courtyard can keep the humidity and coolness of night and give it to the inner spaces during the day.

Configuration of the building in temperate-humid is totally different than the other climates. Vernacular buildings in this climate are open and wide, with long and narrow forms. Most of the buildings are semi-detached. Thus they are easily cross ventilated during the hot months of the year.

Roof

One of the main differences of the vernacular building in temperate-humid and the other climate of Iran is the shape of the roof. Because of lots of rain in this climate most of the building have sloped roof. It is the best nontechnical solution to shed rain water away from the building. In other climatic region of Iran, majority of the buildings have flat roof. These roofs can keep the snow and provide insulation against the cold winter winds. In hot-dry climates because of less rain there is lack of wood as well and this also results in domes, semi-domed or flat roofs. Domes provide shade to the roofs and at summer night they cool faster (Ozdeniz and Sadegi, 2010).

Balcony, Eyvan and Courtyard

In temperate-humid climate, most of the buildings have balcony all around the building. Therefore, these balconies can protect the facades from rain and provide shade. They also provide semi-open living and working spaces and help in storing some agriculture products.

In such a climate, most of the buildings have courtyard in front of the building. However, in cool region of Iran most of the buildings have central court yard, with smaller size. In the hot and dry region in addition to central courtyard, there is a semi-open room called “eyvan” looking to the courtyard. The width of the *eyvan* is less in the hot-humid region. In hot-dry and hot-dry with cold winter regions of Iran, large *eyvans* are oriented to south and provide comfortable, shaded space in the summer afternoons and the daily activities take place there.

Basement

In temperate and humid region of Iran most of the buildings don’t have any basement. People live on the ground and first floors with the kitchen and storage on the ground floor. Because humid air settles in low spaces, basements are not suitable for living or storage. This is sar temperate-humid climate as well. In hot-dry climate cool basement were used as living, working and sleeping spaces. Inhabitants use this space in the summer, especially in the afternoons. In contrast to the other climatic regions, basement is an important space of the building.

Elevation of ground floor slab from ground

In temperate-humid climate there is too much rain, humidity and ground moisture. Thus, differently from the dry regions the ground floor slab is elevated. The same approach is seen in hot-humid regions as well and the elevation from ground is approximately one meter. However, in hot-dry and hot-dry with cold winter and cool regions of Iran, building level and especially courtyard level is lower than the pedestrian level.

Extroverted and introverted buildings

Extroverted buildings are those which are open to the outside. In humid climates this kind of building is adapted. However, during the cold months they should be protected from winds and allow sunshine to enter the house. They should also prevent the sun in the hot period. Thus the vernacular buildings in this region are elongated towards the east and west directions. One of the best ways of controlling humidity and cooling the house is employing wind flow and natural ventilation.

Introverted buildings are those with inner courtyard. Thus, they are suitable for hot-dry climates. They are also partly buried in the ground and four sides of the buildings are enclosed with long walls. Not only the arrangements of the rooms around the courtyard provide thermal comfort but the courtyard protects the rooms form dust storms. Inside the courtyard here is a pool with a foundation, plants and trees which provide a pleasant micro climate.

Height of the ceiling

Temperate-humid regions of Iran have moderate climatic condition; therefore, the height of the vernacular building is approximately three meters. In cool region of Iran, in order to heat the houses easily, low ceiling heights were adopted. In hot-humid region of Iran, the heights of the rooms are more and approximately four meter high due to the adverse effect of low ceilings on the thermal comfort of users.

Thickness of the walls

In hot-dry with cold winter, hot-dry and cool climatic

Table 1. Comparison of Iranian vernacular building features in five different climatic zones.

Parameter	Hot-dry	Hot-dry with cold winter	Cool	Temperate- humid	Hot-humid
Settlement pattern	Semi-open	Compact	Compact	Diffused	Diffused
Plan	Extensive	Compact	Compact	Extensive	Extensive
Roof	Flat and domed	Flat and domed	Flat	Sloped	Flat
Central courtyard	YES	YES	YES	NO	NO
Basement	YES	YES	YES	NO	NO
Connection of building to ground	On the ground	On the ground	On the ground	Foundation	Foundation
Wall thickness	Thick	Thick	Thick	Thin	Thin
Natural ventilation	Medium	Medium	Low	High	Low to high
Exterior color	Light	Light	Dart	Free	Light
Windows	Many	Few	Few	Many	Medium
Materials	High thermal capacity	High thermal capacity	High thermal capacity	Low thermal capacity	Low thermal capacity
Wind tower	On one or two sides	On four sides	None	None	On four sides

regions of Iran thickness of the external wall works as an important element. The walls which were mostly made by Adobe and brick have approximately thickness about one meter thickness. This thickness provides a good thermal insulation and time lag. Thus the heat stored during the day is used during the cold nights. However, in temperate-humid and hot-humid regions, thickness of the wall is not significant.

Materials

In temperate-humid region of Iran most of the buildings were built with the materials which have minimum thermal capacity, and if heavy material is used, it is used with the minimum thickness. Thus timber is a very widely used material. In cool regions of Iran, stone is used to cover the ceiling and wood and thatch is used to cover the roofs. For hot-dry with cold winter and hot-dry regions the best material for constructing is mud, mud-brick, stone, brick, lime and wood.

Wind tower

There is a difference between the wind towers of hot-humid and hot-dry with cold winter regions. The dissimilarity is that the four sided wind towers in hot-humid region have larger cross section and shorter in height because there is more humidity and less dust.

The Iranian vernacular houses in these climatic regions show a clear distinction in settlement pattern, building form, plan, space organization, building elements and materials. The differences are due to the harsh climatic conditions. All the differences and similarities of five climatic regions of Iran are summarized in Table 1.

Conclusions

This research analyzed the climate of Iran by bioclimatic approach in order to assist architects to design climatically adaptive buildings. It was found that, Iran has five different climatic regions.

In order to validate this classification vernacular architecture of Iran was studied. In the absence of modern air-conditioning devices, traditional builders chose sites, orientations, building forms, plans, and materials of these vernacular buildings consistent with environmental factors. There were some kind of logic in many methods and principles that our ancestors had used for constructing vernacular buildings in the past thousands of years. In this research it was found that vernacular architecture of each region was very different from the others.

In region one (temperate-humid), which embraces the southern coasts of the Caspian Sea that has a lot of rainfall during a year and the humidity ratio, is about eighty percent for most of the months in a year. Region two (hot-dry with cold winter climate), which consists of most of the central Iranian plateau, receives almost no rain for at least six months of the year. This climate is very dry and hot in the summer and cold in the winter. Region three (cool climate) is the mountainous region. It covers the northern and western parts of the country. In this cool climate, cold weather and snow reduce outdoor activities during the long winter months. Region four (hot-dry climate) is located in the central and southern part of Iran, has hot and dry climate in most of the months. Finally, there is region five (hot-humid) which cover the Northern coast of the Persian Gulf and the sea of Oman. It has high humidity besides the hot weather. These classifications help the architects to design more sustainable buildings according to the climatic conditions. There are many features of Iranian vernacular and traditional architecture which can be studied to provide insight for the design of sustainable housing. The authors plan to study space organization in terms of climatic and cultural differences in Iran.

REFERENCES

Arens E, Zeren L, Gonzales R, Berglund L, McNalls PE (1981). A new bioclimatic chart for environmental design. In Fernandes; Woods; Faist, eds. Proceedings of International Symposium on Building Energy Management. Oxford: Pergamon Press pp. 645-657.

Ganji H (2006). Climatic Analysis of the Iranian Traditional Buildings. 4th edition. Tehran: Tehran University Publications.

Ghobadian V (2006). Climatic Analysis of the Iranian Traditional Buildings. 4th edition. Tehran: Tehran University Publications.

Ghobadian V (2009). Sustainable traditional buildings of Iran. Dubai: Islamic Azad University, Dubai: Campus Publications.

Givoni B (1976). Man, Climate and Architecture. Applied Science Publisher Ltd, Second Edition, Amsterdam.

Hyde R (2008). Bioclimatic housing, Innovative designs for warm climates. UK, Earth scan in the UK and USA.

Kasmee M (1993). Iranian climate classification. Tehran, Building and Housing Research Center.

Kasmee M (2003). Architecture and climate. Isfahan, Nashre Khak Publications.

Koppen W (1936). Das Geographisca System der Klimate. In: Handbuch der Klimatologie, Edited by: Koppen, W. and Geiger, G., 1. C. Gebr, Borntraeger, pp. 1-44.

Memarian G (2006). Residential architecture of Iran, Tehran, Soroush & Danesh Publications.

Olgyay V (1963). Design with climate. 2nd edition, New Jersey: Princeton University Press.

Oliver P (1997). Encyclopedia of vernacular architecture of the world, Volumes 1, 2 and 3. Cambridge.

Ozdeniz MB (1991). Bioclimatic analysis of Turkish traditional houses.

Ozdeniz MB, Sadegi F (2010). Sustaınable solutions from traditional architecture of hot-dry regions. SAUD International Conference on Architecture and Urban Development, Amman, Jordan 11-14 July, 2010.

Riazee J (1977). Climate and comfortability in building. Building Research Center, Tehran.

Shokouhian MS (2007). Enviromental effect of the courtyrad in sustainable architecture of Iran. Tehran: Islamic Azad University.

Szokolay SV (1980). Environmental Science Handbook. New York: Halsted Press Book.

Szokolay SV, Mayhew A, Ingersol TG, Koenigsberger OH (1974). Manuel of tropical housing and building. Part one: Climatic design. Longman Group Limited.

Tahbaz M, Jalilian S (2008). Design principle of architecture according to the Iranian climatic with case study of mosque. Shahid Beheshti University, Tehran.

University SB (2005). Encyclopedia of Iranian Islamic Architecture. Tehran: Publishers, Rowzaneh.