Bioclimatic Analysis of Vernacular Iranian Architecture

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Submitted to the
Institute of Graduate Studies and Research
in partial fulfillment of the requirements for the Degree of

Master of Science
in
Architecture

Eastern Mediterranean University
January 2010
Gazimağusa, North Cyprus

Approval of the Institute of Graduate Studies and Research

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ABSTRACT

Many factors are involved in the evolution of architectural styles around the world. In Iran, environmental and natural phenomena play a very important role in the regions inter-related cultural, economic and social infra-structures. Different settlements in Iran have diverse climate and cultures. Subsequently, for controlling the climate they created different design solutions. Climate has major effects on the buildings and the most critical is to understand how to control the climate with the buildings. Hence, it is essential to classify the climates for architectural purposes to understand Iranian vernacular architecture.

Special importance of this research is that it studies the bioclimatic design principles in whole parts of Iran. Bioclimatic design in the buildings tries to maximize thermal comfort and minimize the buildings need for energy for heating and for cooling. This thesis will analyze the vernacular design principles of different regions of Iran by the means of bioclimatic concepts. Furthermore, this research by retrieving the climatic data from all Iranian Meteorological stations found the characteristic of each region and new bioclimatic charts achieved. Consistent with data plotted of new bioclimatic charts, this research found five different climates in Iran. By using these bioclimatic charts bioclimatic analysis on each region will be possible. Second stage of this thesis will discuss the characteristics of architecture and design principles of these five different climatic regions in Iran. Finally, at the third stage a comparison between the vernacular Iranian architecture and the vernacular architecture of the other countries will be made.

Key words: climate, vernacular, Iran, bioclimatic.

ÖZ

Dünyada mimari tarzların gelişiminde birçok faktörler yer almaktadır. İran'da çevresel ve doğal faktörler bölgelerin kültürel, ekonomik ve sosyal altyapılarında önemli bir rol oynamaktadır. İran'daki farklı yerleşimlerde çok çeşitli iklimsel ve kültürel farklılıklar bulunmaktadır. Bunun sonucunda, iklimi kontrol etmek için farklı dizayn çözümleri yaratılmıştır. İklim binalarda önemli etkilere sahiptir ve bunlardan en önemlisi iklimin binalar sayesinde nasıl kontrol edileceğini anlamaktır. Bundan dolayı, İran'ın bölgesel mimarisini anlamak için iklimleri mimari amaçlar adına sınıflandırmak büyük öneme sahiptir. Bu araştırmanın önemi bütün İran'da bioiklimsel dizayn prensiplerini çalışmasıdır. Binalardaki bioiklimsel dizayn ısı konforunu maksimize ederken binayı ısıtma veya soğutma amacıyla kullanılan enerji sarfiyatını en aza indimeyi amaçlar. Bu tez bioiklimsel konular yoluyla İran'ın farklı bölgelerindeki yerel dizayn prensiplerini analiz etmektedir. Dahası, bu araştırma İran meteoroloji istasyonlarının verilerini kullanarak her bölgenin karakteristik özelliklerini ve ulaşılan yeni tabloları da içermektedir. Yeni bioiklimsel tablolardan elde edilen bilgilere dayanan bu araştırma İran'da mevcut bulunan beş farklı iklimi ele almaktadır. Bu bioiklimsel tabloları kullanarak her bölgenin bioiklimsel analizini yapmak mümkün olmaktadır. Tezin ikinci bölümü İran'daki bu beş farklı iklimsel bölgenin karakteristik mimari özelliklerini ve dizayn prensiplerini tartışmaktadır. Son olarak, üçüncü bölümde İran yerel mimarisi ve farklı ülkelerin yerel mimarisi karşılaştırılmaktadır.

Anahtar Kelimeler: Bioiklimsel, iklim, yerel, İran.

To My Family

ACKNOWLEDGMENT

I would like to express gratitude to my brilliant father Mohamad Ali, gorgeous mother Shahla, my adorable sister Pupak and wonderful brother Alireza for all their devotion during my life and without their help standing in my current position would be impossible. I hope sometimes there would be a chance for me to reimburse all these kindness. Therefore, I dedicate this thesis to them as a very small repair to all their efforts.

I am deeply indebted to my supervisor Prof.Dr. Mesut B. Ozdeniz who is helped me at every stage of the preparation of the thesis. I am grateful to him for his endurable patience, creative suggestion and guidance which kept my motivation alive and provided great inspiration during my studies. I would like to give my sincere thanks to him.

Finally my honest thanks to my best friends Mina, Shayan and Yasmin that always stood by me when I felt desperate and agitated.

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LIST OF FOREIGN PHRASES

Eyvan	Roofed semi-open space usually closed on three sides and open on the fourth which appears on the edge of a courtyard
Do-dari	Large room with two adjoining windows
Seh-dari	Large room with three large adjoining windows
Panj-dari	Large room with five large adjoining windows
Haft-dari	Large room with seven large adjoining windows
Dah-dari	Large room with ten large adjoining windows
Shanzdah-dari	Large room with sixteen large adjoining windows
Tarme	corridor
Shenashil	Traditional shading devices
Talar	balcony
Sume	Special room which is mostly situated at the back part of the bedroom or living room
Godal Baghcheh	Deep yard located at the centre of the main courtyard of the house. Its depth usually reaches one story.
Shabestan	basement
Shuwadan	deep basemen

LIST OF SYMBOLS/ABBREVIATIONS

A	Equatorial
B	Arid
C	Warm temperature
D	Snow
E	Polar
W	Desert
S	Steppe
f	Fully humid
s	Summer dry
w	Winter dry
m	Monsoonal
h	Hot arid
k	Cold arid
a	Hot summer
b	Warm summer
c	Cool summer
d	Extremely continental
F	Polar frost
T	Polar tundra
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
Aw	Equatorial- Winter dry
Af	Equatorial- Fully humid

Chapter 1

INTRODUCTION

1.1 Description of the Thesis

Physical environment factors have direct effect on the psychological satisfaction of humans. Accordingly climate is one of the most important factors, which have a lot of effect on human thermal comfort. Crowther defined the climate as “the regular pattern of weather conditions (temperature, rain, wind, etc) of a particular space, an area or a region” (Crowther, 2000, p.208).

For attaining the physical satisfaction, the human body should be in thermal comfort level. If the heat exchange between the human body and the surrounding would be in balance then the human body will be in thermal comfort.

According to the various factors, the thermal conditions affect a person’s perception of heat. These factors are divided into two groups, such as objective factors like air temperature, air movement, relative humidity, and mean radiant temperature, and also subjective factors such as clothing and metabolic rate. Moreover very generally, in architecture according to the climate characteristics, there are different classifications, such as the cold, temperate, warm-humid and hot-dry climates.

In order to achieve the thermal comfort level in different climates, different cooling and heating strategies should be utilized in buildings. In this respect the climatic data should be inserted to the thermal comfort indices. The thermal comfort

indices are classified into two types, empirical and analytical indices. Among these indices there are two charts which are more general and useful. These two are the bioclimatic and psychrometric charts. By inserting the monthly climatic data to the bioclimatic and psychrometric charts, the cooling and heating strategies, which are needed to be utilized, can be found. This research has chosen the bioclimatic chart to study the effects of climate on vernacular Iranian architecture.

Furthermore, this research chose Iran; since Iran is the eighteenth largest country in the world, with an area of 1,648,000 km^2. In addition, Iran consists of the Iranian Plateau, mountain regions and two domain of water: Caspian Sea and Persian Gulf. Iran covers a large geography so Iran has a lot of different climates. As a result, this research focused on vernacular Iranian architecture in terms of bioclimatic analysis.

Different settlements in Iran have diverse cultures. They created various design solutions for their buildings to control the climate. Culture is another factor that affects the vernacular architecture of Iran besides the climate.

Vernacular Iranian architecture achieves the thermal comfort conditions in interior spaces with less energy and without using expensive and polluting mechanical equipment. Traditional architecture achieves this by minimizing outside surface area by using wind towers, basements, central courtyards, windows and by choosing the appropriate materials for roof, wall and storage.

Therefore, it is essential to classify the climates in order to reveal their impacts on Iranian vernacular architecture.

1.2 Problem Statement

Today's Iranian architecture should create human comfort condition for living consistent with the appropriate Iranian culture and also without wasting a lot of energy. Unfortunately, nowadays most of the people try to provide comfort in their

buildings only with the use of expensive and polluting mechanical equipment, and if this equipment stop working for any reason, life would be impossible. Since the cost of maintenance of the mechanical equipment and the price of energy becomes expensive, then the environment pollution of such equipment also increases. However, at the same time scientists and engineers are becoming increasingly directed towards the use of renewable resources, such as the sun, wind, geothermal and hydro energy.

In order to keep our environment clean and free from certain pollutions and to protect the green and natural areas in and around our cities, and also to reduce oil extraction, it would be better to understand our natural environment by reestablishing the disturbed relation between man and nature.

Although Iran has the vast reserves of oil and natural gas and people utilize them extensively, one day these resources will end. Obviously it is not possible to go back to the ways that our ancestors used to live, but certainly to study and learn from the ways they had used the environment to provide human comfort in buildings is necessary and helpful.

1.3 Aim of the Research

As it was mentioned above, mechanical equipment in the buildings are working successfully, but they are affecting the resources in the earth and creating a lot of pollution. These mechanical systems create a lot of environmental problems and they cause some other difficulties which are related to the human physical and psychological comfort. Thus the question is, can the traditional methods have any benefits to satisfy the totally physiological need of human, beside the psychological ones?

Unfortunately most of the modern buildings without paying attention to the vernacular building, constructed according to the western architecture. Therefore, they forget the experiment of our ancestors and consequently convert the fertile land of Iran into buildings without any identity. In order to keep the energy demand on the possible lowest level in the buildings, and in order to increase the psychological need of human, on the other hand, the aim of this research is to study and learn from the ways that traditional residents had used to live and furthermore, to realize how they provided the human comfort conditions in their buildings. Understanding the utilization of natural environment in vernacular Iranian building is essential.

1.4 Methodology

This research is based on both the quantitive methods that will use the climatic data and interpretative research method which is a type of qualitative research. And it will also use literature review, which would support the theoretical framework. This study will be analyzed according to bioclimatic concept by considering the design principles for each different climate in Iran. Data in this research is based on climate condition. So it is gathered from all Iranian metrological stations.

There have been various types of studies of vernacular Iranian architecture. In Iranian traditional architecture some spaces have more relation with climate than the others. This study attempts to focus on these spaces which control the climate. So the special importance in this research is to study the bioclimatic design principles in whole parts of Iran.

This research has been organized in three steps. The first part of this thesis will be the review of previous studies regarding to Iranian climatic classification. In this part the collection of data is based on theoretical and documentary information, as well as a desk work research and based on literature review on some analyses.

In the second part, the climate of Iran will be studied by using the new bioclimatic analysis. By retrieving the climatic data from Iranian Meteorological stations sufficient information about characteristic of each region and bioclimatic analysis is achieved. According to the bioclimatic analysis of this research, Iran can be divided into five different climatic regions. Afterwards, this resaerch will analyze the spaces that were formed exclusively on the basis of the climatic specification and where the issue of climate has been the main concern will be studied. In order to examine the parameters of the spaces in vernacular Iranian architecture, several examples were selected from the case studies of Yazd, Rasht, Bushehr, Dezful and Tabriz, which are the five important and different climatic cities of the Iran and there are some significant architectural example in these cities. The reason for selection the example from different location was to find out the variation of different parameter of the spaces at different climatic regions.

There would be some logic and reason in many methods and principles that our ancestors had used for constructing buildings in the past thousands of years. Accordingly by observing the environmental factors, material, form and plans of these traditional buildings and by studying design principle of vernacular Iranian architecture. The third stage of thesis will try to compare the Iranian vernacular architecture with the vernacular architecture of the other countries with same climatic region. All of these investigations, which were supported by figures and tables, can assist the researcher to find out the answer of the questions which initiated this thesis.

1.5 Limitation of the Study

The climatic divisions in this research are based on macro climate. In macro climate the difference is more manifest than the other climates. Furthermore, this

research has been analyzing the residential vernacular buildings in terms of bioclimatic analysis.

1.6 Classification of Climate

"Climate is integration in time of the physical state of the atmospheric environmental characteristic of a certain geographical location" (Shokouhian.M, 2007). Climatic division of each region is depended on different factors. Although, regions, which are located in macro climate, have some similarities to each other's but they have some variations from intense of hot and cold, relative humidity, annual rainfall and glacial point of view. As a result, these climates are divided into smaller groups which are named as Meso climate. Usually each macro climate will be segregated into two or more Meso climates. For instance, cold climate are divided into partly cold climate and very cold climate. The regions, which are located in Meso climate, are segregated into smaller groups of local climates. Moreover, there are some diverse characteristics in these climates, which reveal a lot of differences such as geographical position, topography, underground water level, plants and etc. In a small scale like a city there are some climatic variations which is called micro climate. For instance in a house which has winter and summer section a lot of climatic differences exist between the rooms, which are located in a sun direction or reverse (Tahbaz.M, 2008).

Moreover, University of Hong Kong explains that "for the purposes of building design a simple system based on the nature of the thermal problem in the particular location is often used. Furthermore, the general climate (macro climate) is influenced by the topography, the vegetation and the nature of the environment on a regional scale (Meso climate) or at a local level within the site itself (micro climate)" (Hui, 2000).

It is obvious that each part of the world have different climate, which is the cause of differentiation in architectural characteristics. Subsequently, for attainment to the accurate solution, classification of those different climates in the world is significant.

Although there are several methods of climatic divisions in the world, which have been based on climatic data, most of the scientists accept Koppen's method. Koppen-gieger was the first researcher who classified the climate around 1900 (with some further modifications by him, remarkably in 1918 and 1936). He did it according to the vegetation, air temperature and air humidity. He classified the climate into tropical-rainy climate, dry climate, temperate climate, cool-snow-frost climate and polar climate.

A. Tropical rainy climates: Average temperature of every month is above 18°C. These climates have no winter season. Annual rainfall is high and exceeds evaporation.

Af. Tropical rain forest climate: Rainfall of the driest month is 60.96 mm or more.

Am. Monsoon variety of Af: Short dry season. Rainfall of the driest month is less than 60.96 mm.

Aw. Tropical savanna climate: Pronounced dry season. At least one month has less than 60.96 mm of rain.

B. Dry climates: Evaporation exceeds precipitation on the average throughout the year. No water surplus.

BS. Steppe climate: A semiarid climate characterized by grasslands. Mean annual precipitation varies according to mean annual temperature, but roughly between 381 and 762 mm of rain per year.

BW. Desert climate: An arid climate with annual precipitation usually less than 381 mm.

C. Temperate climate: Coldest month has an average temperature under 18℃. The climates have distinct summer/winter seasonality.

Cs. Mediterranean climate: Mild humid climate with a dry summer and wet winter.

D. Cool-snow-frost climate

The average of the temperature in the hottest months of a year is more than 10 ℃ and in the coldest month is less than -3℃. In cold climate mostly rainfalls is like snow and generally in the most of the months grounds cover with snow.

E. Polar climates

In polar climate, average temperature in the hottest month of a year is less than 10℃. One of the remarkable characteristic of these climates, which is reverse of rainy and equatorial climate, is that there is no any hot season (Koppen.W, 1936). Consequently, there is a map that shows the different climatic division of the world according to the Koppen's method (Figures 1) (Koppen.W, 1936).

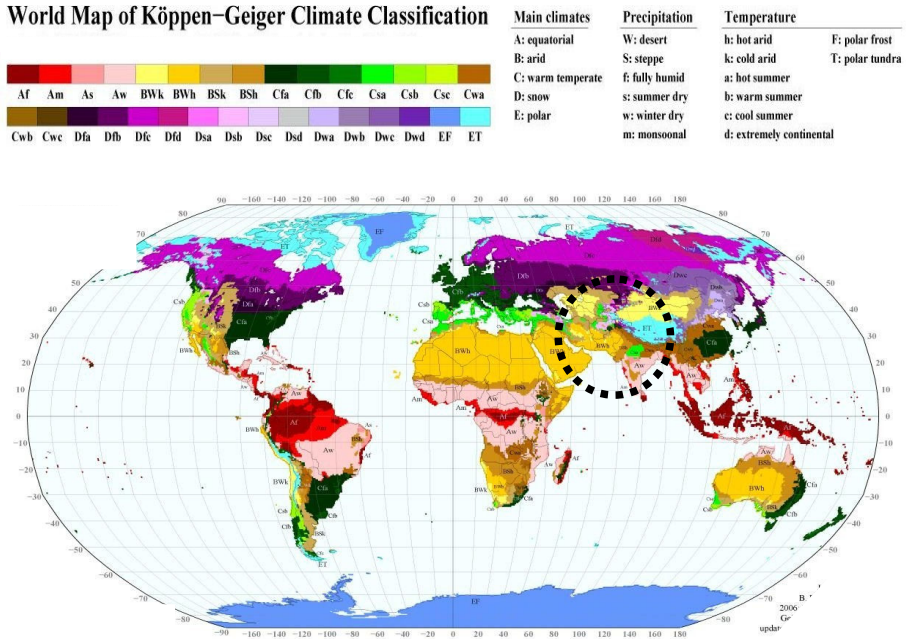


Figure 1: Koppen-Geiger climate type map of the World (Koppen.W, 1936)

As a result, Koppen divides Iran into 6 different climates such as, Warm climate, Cold desert climate, Warm semi-arid climate, Cold semi-arid temperature, Warm Mediterranean climate and Warm continental climate.

Olgyay did another kind of classification in 1963. For architectural purposes he classified the climate into four different climatic zones such as; cold climate, temperate climate, warm humid climate, hot -dry climate. Szokolay in terms of building distinction classified the climate into four classes as well in 1980.

Based on Olgyay's (1963) classification which defines the global climate into four major climates, Iran is classified as hot and arid climatic zone. However the geographical features of Iran, with high mountain ranges and bordering seas, create four distinct climatic zones within the country. The temperate climate of Caspian coastal plain in the north which is boarded 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 (Kasmaee.M, 2003 p.83).

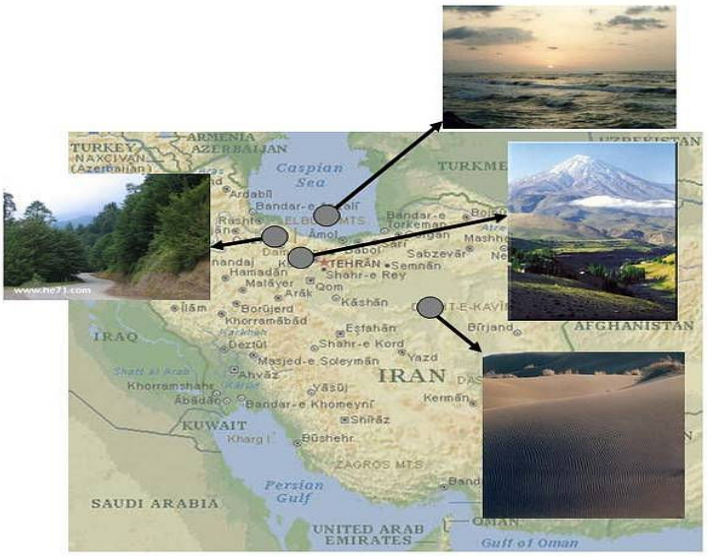


Figure 2: Map of Iran (URL1)

Furthermore Olgyay surveyed on impression of these different climates to the buildings and specified the differentiation of architecture in these climates. Thus figure 2 and figure 3 show the climatic conditions and shape of the roofs in different regions of the world.

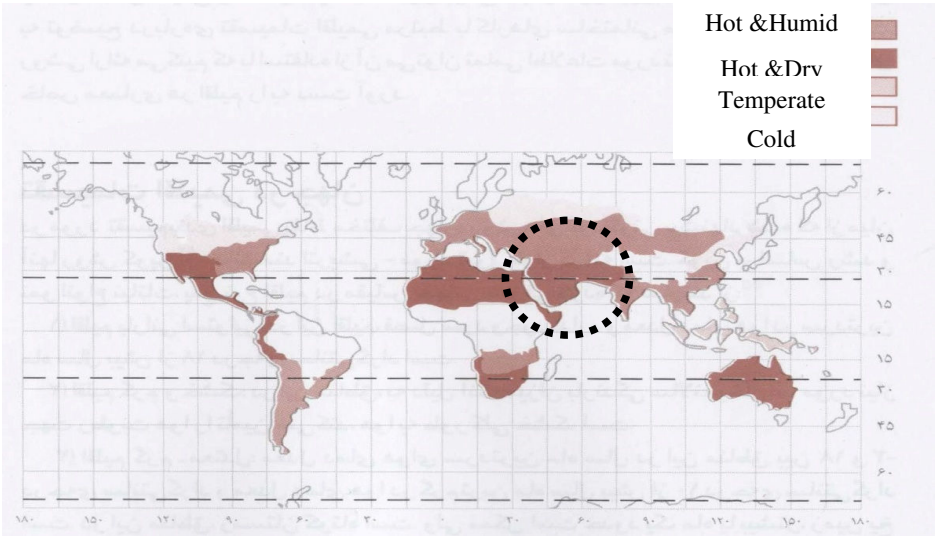


Figure 3: Climatic division of the world (Kasmaee.M, 2003)

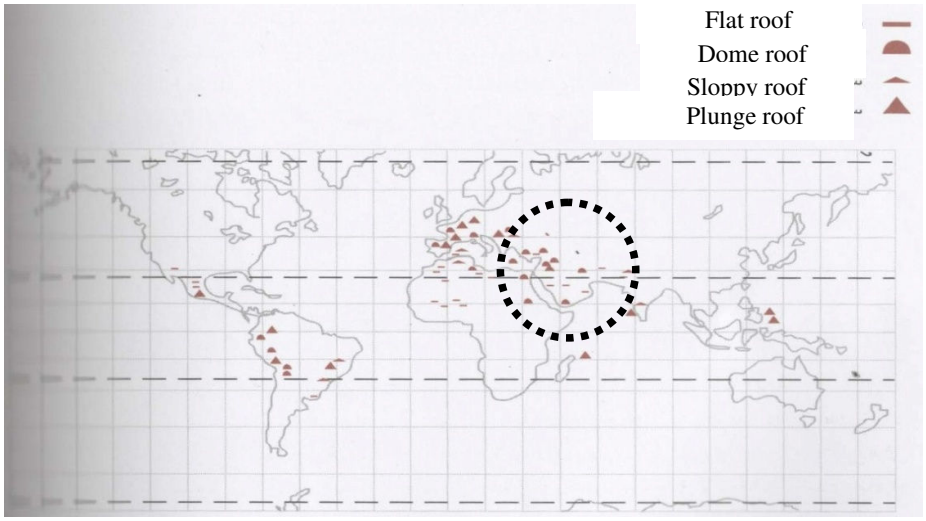


Figure 4: Different types of roofs according to climatic variety (Kasmaee.M, 2003)

Moreover Ozdeniz developed the climatic classification, which is based on Olgyay's classification. This classification groups the climate into seven categories such as; cool, temperate-dry, temperate, temperate-humid, hot-humid climate, hot-dry and finally composite climate for Turkey and Middle East (Ozdeniz.M.B, 1991).

Another climate classifications proposed by other researchers, who divided the globe into the nine climatic variations based on architectural impact (Oliver.P, 1997). These climates are presented as, arctic climate, sub arctic climate, continental, desert or arid climate, maritime climate, monsoon climate, Montana climate, subtropical climate and tropical climate.

Climate simulates needs for shelter and influence local culture, but also provides information on the need of local building's materials. There have been many climatic studies which aim vernacular as well as modern architecture. Each of these studies tried to classify the climatic zones of the selected area. Vitruvious, Koppen-Geiger, Dollfuse and Olgyay are some of the important names who found very useful information about climate and its classification (Szokolay.S.V, 1980). Also there are some Iranian scientists who used different techniques to define the climatic division of Iran. Consequently, this research will explain their divisions.

Scientists, according to the geographical latitude and sea level altitude, specified the different type of climate in most part of the regions in the world. There are different geographical locations in Iran, which this provides various kinds of climates with special characteristics. Subsequently, Iran is situated between 25 and 40 degree of north geographical latitude which means that Iran is located in the hot region of the world and also from the height, Iran is an elevated plateau. Iran surround by two water domain in north and south such as Caspian Sea and Persian Gulf. However, the existence of this two elevated mountains, Alborz and Zagros, in the odd position cause to pretend the effect of humidity to the central regions of Iran. As a result, the effect of Caspian Sea and Persian Gulf are just limited to their neighbor regions.

Some of the Iranian researchers prepared the climatic division of Iran according to Koppen's method. But at that time there wasn't enough climatic information.

Kasmaee in his investigation mentioned that “the aim of climatic division is to distinguishing regions according to the similarities that they have and not only based on their common climatic specifications” (Kasmaee.M, 2003).

Riazee in 1977 was the first researcher, who looks out to the climatic division. He did 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” investigated forty three of meteorological stations in Iran. By doing some bioclimatic analysis he divided Iran into five summer and six winter climates. He also companioned the winter and summer climates and suggest nine different climatic zones in Iran. Furthermore, he emphasized that the lower latitudes and dryness (except at coastal regions of Iran) cause a lot of daily fluctuation in air temperature (Tahbaz.M, 2008). Accordingly table1 demonstrates the Riazee climatic division, which he classified the climate of Iran into 9 different climates.

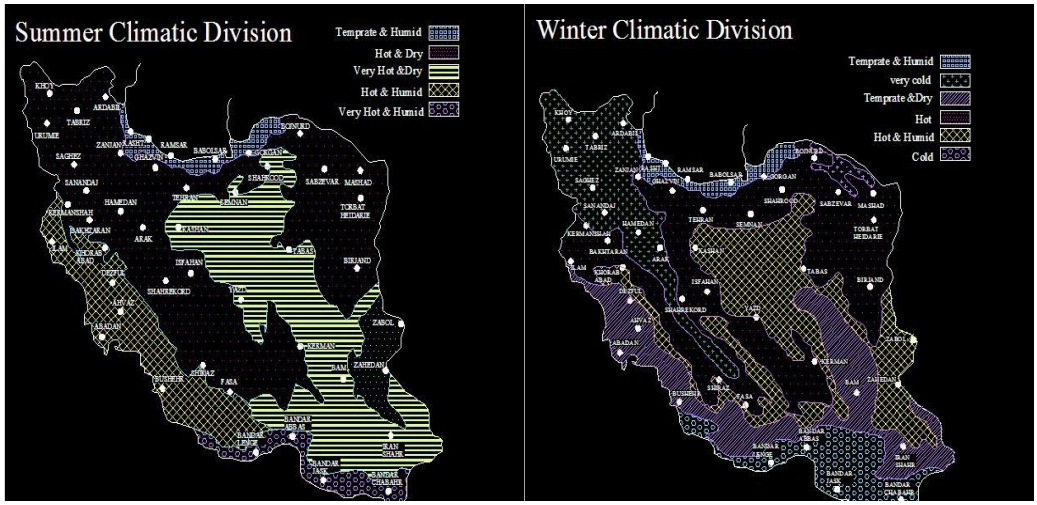


Figure 5: Riazee’s summer and winter climatic divisions (Riazee.J, 1997)

Table 1: Riazee divides Iran into nine different climates (Kasmaee.M, 2003)

climate	specification	Average of maximum temperature in summer(C)	Average of minimum temperature in winter (C)	city
1	Hot and very humid summer, without winter seasons	35 to40℃	10 to 15℃	Jask, Chabahar, Bandr lenge, Bandar Abbas, Bushehr
2	Very hot and humid summer, without winter season	45 to 50℃	5 to 10℃	Abadan, Ahvaz
3	Hot and humid summer, temperate winter season	35 to 40℃	0 to 5℃	Kazerun
4	Very hot summer, without winter season	40 to 45℃	5 to 10℃	Iranshahr
5	Very hot and dry summer, temperate winter season	40 to 45℃	0 to 5℃	Tabas, Kashan
6	Temperate and humid summer, temperate winter season	25 to 30℃	0 to 5℃	Babolsar, Bandr Anzali, Rasht, Gorgan
7	Hot and dry summer, temperate winter	35 to 40℃	0 to 5℃	Zabol, Zahedan, Fasa, Bam
8	Hot and dry summer, cold winter season	35 to 40℃	0 to -5℃	Tehran, Shiraz, Mashahd
9	Hot and dry summer, very cold winter	35 to 40℃	-5 to -10℃	Arak,hamedan,zanjan,tabriz

The best method for dividing climate of Iran can be obtained from Koppen's method, which is based on growing of plants. For achieving to the best solution, some modification should be done on Koppen's method. Furthermore, Ganji proposed a new method based on Koppen, with some improvements. He divided the climatic region of Iran according to geographical latitudes. He suggested four different climates in Iran, which are temperate and humid climate (southern side of Caspian Sea), Cool climate (Western Mountain), Hot and dry climate (central plateau), Hot and humid climate (northern shores of Persian Gulf) (Iran, 1979).

Furthermore, Pakdaman did some investigation for Red Crescent and divided Iran into four different climates (Pakdaman.B, 1978). Ghobadian approved Pakdaman's division and accordingly in his book explained architectural characteristics of these four different climates.

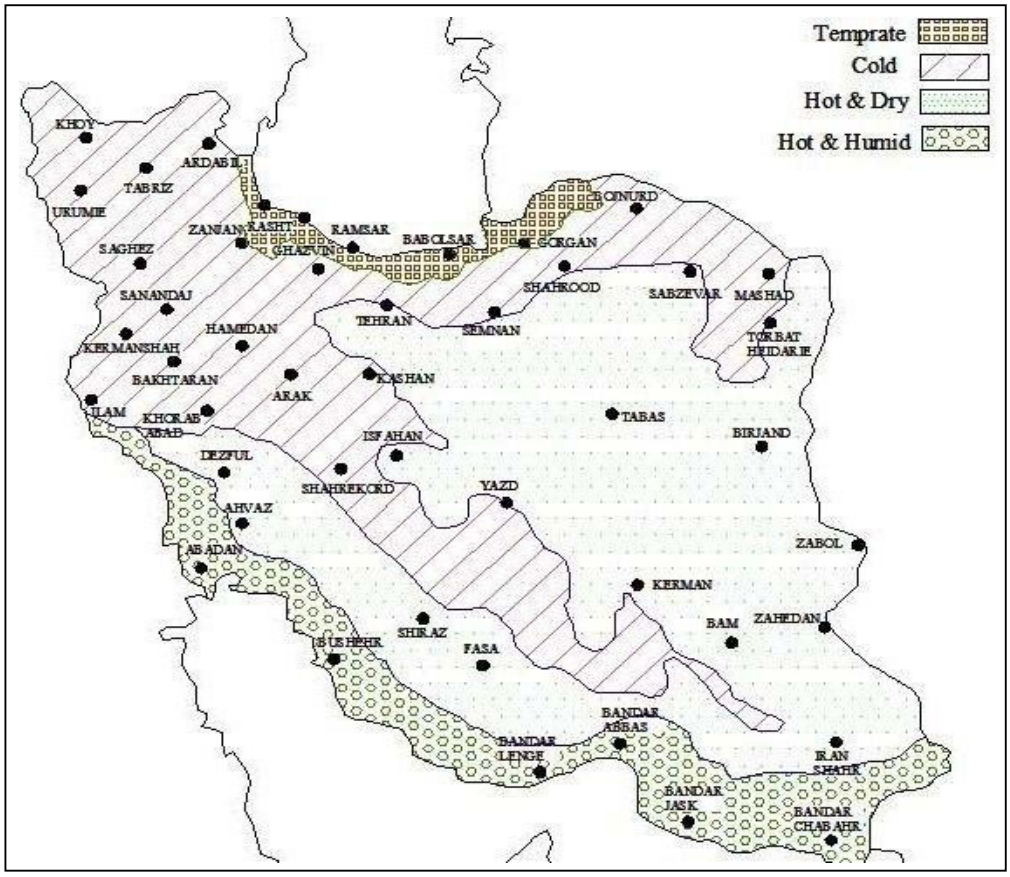


Figure 6: Pakdaman's Climatic division of Iran (Pakdaman.B, 1978)

Tahbazi and Jalilian in 1987 prepared another type of climatic division. They made this division consistent with Olgyay's method and effective temperature. In their study, Iran was divided into eight original groups and they gave some instruction for architectural design for each of these eight different regions (Tahbaz.M, 2008). Therefore, table 2 demonstrates the eight climatic division of Tahbaz.

Table 2: Climatic division of Tahbazi and Jalilian in 1987 (Tahbaz.M, 2008)

no	climate	specification	geography	city
1	Southern shores	Hot and very humid summer, temperate winter	AMTS: 34 to 40 AMTW: 10 to 16	Jask,Chabahr,Bandar lenge,Bandar Abbas,Bushehr
2	Khuzestan plain	Very hot and semi dry summer, temperate winter	AMTS: 44 to 46 AMTW: 3 to 9	Abadan,Ahvaz,Dezful,Shushtar, Minab,Iranshahr,Borazjan
3	plateau	Very hot and dry summer, cold winter	AMTS: 37 to 44 AMTW:0 to 4	Tabas,Bam,Ghom,Kashan, Ardakan,Lar,Kazerun,Zabol ,Fasa,Zahedan,Bam,Khoram Abad
4	desert	Hot and dry summer, cold winter	AMTS: 35 to 39 AMTW:0 to -3	Isfahan, Semnan,Sabzevar, Shiraz,Tehran,Yazd,Birjand ,Saveh,Rafsanjan
5	Low height piedmont	Hypothermal and dry summer, cold winter	AMTS: 31 to 38 AMTW:-2to -6	Sanandaj,Ghazvin,Kermanshah, Mashhad, Torbat Heidaie,Kerman,Arak, Marivan,Damghan,Naeen,Shahrood, Bakhtaran,Boroujerd,Ilam
6	High piedmont	temperate summer , very Cold winter	AMTS: 28 to 35 AMTW:-5to -11	Orumiyeh,Khoy,Tabriz,Zanjan,Saghez,Shahrekord,Hamedan,Malayer, Emam Gheis,Ardabil,Firuzkouh, Miandoub,
7	mountain	temperate summer, very cold winter	AMTS: 28to 31 AMTW:-9	Ab-ali,sarab
8	Northern shores	Temperate and humid summer, temperate winter	AMTS: 26 to 32 AMTW:0 to 4	Babolsar, Bandar Anzali, Rasht, Gorgan,Astara,Ghaemshahr ,Ramsar

Another Iranian climatic division was proposed by Kasmaee in 1993. In his study there were three main groups with different criteria. The aim of the first group was to create the comfortable condition in open spaces and he had done this division according to the bioclimatic analysis of Olgyay. In the first group he divided Iran into 19 different climates. In the second groups Kasmee proposed thirty-two different climatic zones for designing the residential spaces according to Mohaney tables. Finally in the third division, Kasmaee divided Iran into eight zones depending on

Givoni's method (Kasmaee.M, 2003). In his division he met all the requirements of designing buildings according to the climatic regions. For instance Arak city has the average minimum air temperature in summer around 25℃ and the maximum around 43℃, but in the winter time the average of temperature is between 4.5℃ to -26℃. So, this city has hot summer and very cold winter. Therefore, he mentioned that considering this city in hot- dry region or cold region is not a good idea. There are some other cities where has same situation like Arak. These circumstances lead the architecture to investigate a kind of division with more detail. By comparing Tahbazi and Kasmaee's climatic divisions, some similarities between these two researches have been found, because both scientists divided Iran according to seasons. It implies that in order to have climatic design, architectures should consider effects of seasons in their designs and concepts. In summary, table 3 illustrates the method, climatic division and problems of the previous architecture that has made different classification for Iranian climates.

Riazee's division has some advantages. For instance, from this segregation defining four different climates will also be possible. For the reason that he has six winter divisions (temperate and humid, very cold, cold, hot and dry, hot, hot and humid) and five summer divisions (temperate and humid, hot and dry, very hot and dry, hot and humid, very hot and humid) which there are two similarities between them like temperate and humid and hot and humid then the rest are cold and hot and dry consequently reaching to the four different climate will be achievable. Also for attaining to the more climatic information, applying this method is conclusive and useful. Finally by employing this information, it is possible to realize which type of mechanical system is needed for residential buildings as well as becoming conscious about the amount of humidity, heath and cold which is needed for normal buildings.

Table 3: Criticizing each climatic division

ARCHITECTURE	METHOD	CLIMATIC DIVISION	PROBLEM
Koppen	Koppen method	6	Dsa and Csa
Riazee	Olgyay method	9	Seasonal division
Ganjee	Koppen method & geographical latitude	4	Very general
Pakdaman		4	Very general
Tahbazi & Jalilian	Givoni method & penwarden method	8	Just consistent with comfort condition in the open spaces
Kasmaee	Giovni method	8	Investigate on just 43 metrological stations

According to this research, there are some mistakes in Koppen's in the climate of Dsa and Csa. Dsa and Csa are located in the North West part of Iran and Koppen in his division mention that Dsa and Csa have hot summer temperature. However, their average temperature in summer is around 28 to 35 ℃ and the average temperature in winter time is around -5 to -11 ℃. Therefore, considering these climates in summer dry is not a precise division. And also the perception of these regions according to the average temperature is temperate summer and very cold winter; however in Koppen divisions he reveals that Dsa and Csa parts have summer dry climate which is not an accurate classification for these regions.

Table 4: Koppen classified Iran into 6 different regions

NO		Main climate	perception	temperature
1	Bwh	arid	Winter dry	Hot arid
2	Bwk	arid	Winter dry	Cold arid
3	Bsh	arid	steppe	Hot arid
4	Bsk	arid	steppe	Cold arid
5	Csa	Warm temperature	Summer dry	Hot summer
6	Dsa	snow	Summer dry	Hot summer

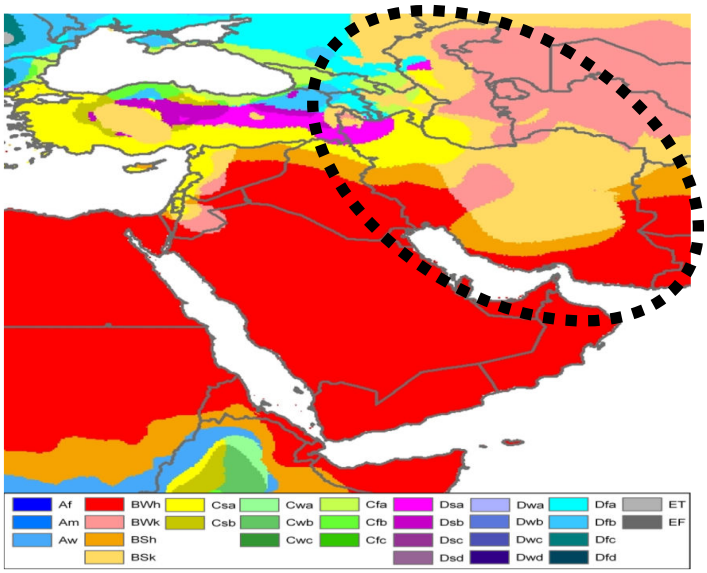


Figure 7: Koppen classifications (Koppen.W, 1936)

Tahbazi, Jalilian, Kasmaee and Riazee did climatic division of Iran consistent with Olgyay and Givoni's method. Also they considered the climatic division along with the seasonal conditions. These divisions have some disadvantages, for instance dividing according to the winter and summer condition is not a precise way to classify the climates, because winter and summer are only seasons. By rapid growth of population in cities and immigration of rural to urban, new problems arise, such as lack of land and space in the cities, which increase the value of the lands on the other hand residents cannot afford to design house according to the seasons although it was realized in large vernacular house in the past. As a result the best solution is to propose a general classification based on the climatic data. Also Riazee and Kasmaee did their research only with forty three meteorological stations. These numbers of cities cannot give sufficient climatic data for understanding the climatic division for a very large country like Iran. Moreover Riazee didn't study the architectural characteristic of these nine different regions.

This research consistent with Ganjee, Pakdaman and Ghobaidan in terms of dividing Iran into four different climates but the method and tools which have been

used in this research are different. For instance Ganjee did his division in consistent with Koppen's method, but the special importance in this research is to study the bioclimatic design principles in whole parts of Iran. The existing divisions used data from forty three meteorological stations but this research collected the climatic data from sixty eight meteorological stations in different cities. Then by evaluating the bioclimatic charts of these cities, five different climates obtained. This division can be applied for creating a comfortable condition for human, inside and outside buildings. Therefore, it will be valuable for architects who want to design the building according to climatic needs.

Chapter 2

BIOCLIMATIC ANALYSIS OF IRAN

2.1 Bioclimatic Chart

Bioclimatic design implies an international policy through the reduction of energy use and other environmental impacts. Hence, if bioclimatic design is the means, the sustainability is the outcome. In our days 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 way in which natural sources are used and managed (Hyde.R, 2008).

Over the past few decades, there have been several attempts to develop a systematic approach that utilizes 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 a ‘‘bioclimatic chart’’ showing the human comfort zone in relation to dry bulb temperature (vertical axis) and relative humidity (horizontal axis) (Olgyay.V, 1963). This chart has been revised by Arens, et al (1981) and named as “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, and air velocity, solar radiation separately on thermal comfort of an average person at sedentary activities and in normal business clothes.

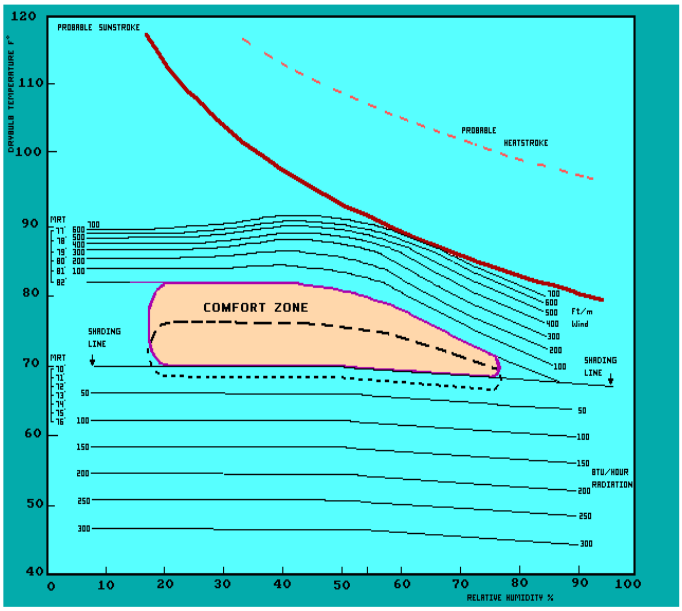


Figure 8: New bioclimatic chart (URL2)

This 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.

All passive cooling strategies which are presented in the bioclimatic charts are based on two main climatic data, which are air temperature (mean max and mean min temperature) and relative humidity (mean max and mean min temperature). Givoni describes Olgyay's chart as a "zone of human comfort in relation to the ambient air temperature and humidity, mean radiant temperature, wind speed, solar radiation and evaporative cooling" (Givoni.B, 1967, p.280).

To employ the bioclimatic chart, the climatic data of each month (temperature and relative humidity) should be inserted in the chart in accordance with the axes of the chart. Each month contain two points, which are connected to each other by a line. One of these points is valued by mean max temperature and mean min relative humidity and another point is valued by mean min temperature and mean max

relative humidity. Therefore, consistent with the number of months there will be twelve lines, where each line presents a separate “zone”.

The comfort zone, where is located in the center of the charts, illustrates the correct humidity and temperature for maximum comfort, which average people feel thermally comfortable. In this respect, the location of each zone below or above the comfort zone will require a different cooling strategy to maintain comfort. Moreover as Ozdeniz explains, the left and right side zones above the comfort zone of the chart are the moisture and wind needed conditions respectively. The zone below the comfort zone indicates the solar radiation and heating needed conditions (Ozdeniz.M.B, 1991, p.325-326).

According to this method, the present research will explore the climatic data which was taken from Iranian net stations at different regions in Iran, and then try to implement bioclimatic approaches by considering the design principles for each different climate. Therefore, collecting the climatic data from sixty eight Iranian meteorological satiations assist the author to create new bioclimatic chart for each climatic region of Iran. Therefore, authors took climatic data from sixty eight meteorological stations of Iran and plotted Mean Highest Air Temperature versus 14.00 hours relative humidity and also Mean Minimum Air Temperature versus 07.00 hours relative humidity for the twelve months. Then the similar charts were grouped. It was found that there were five groups of similar charts. The mean highest 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 hours mean relative humilities are indicating the averages of the highest and the lowest measurements at the stated hours every day in each month. Unit of air temperature is ºC and the relative humilities are given as percentages measured by the Iranian

metrological organization according to the world metrological organization standards. Subsequently, the results of the analysis have been shown on a map in Figure 8.

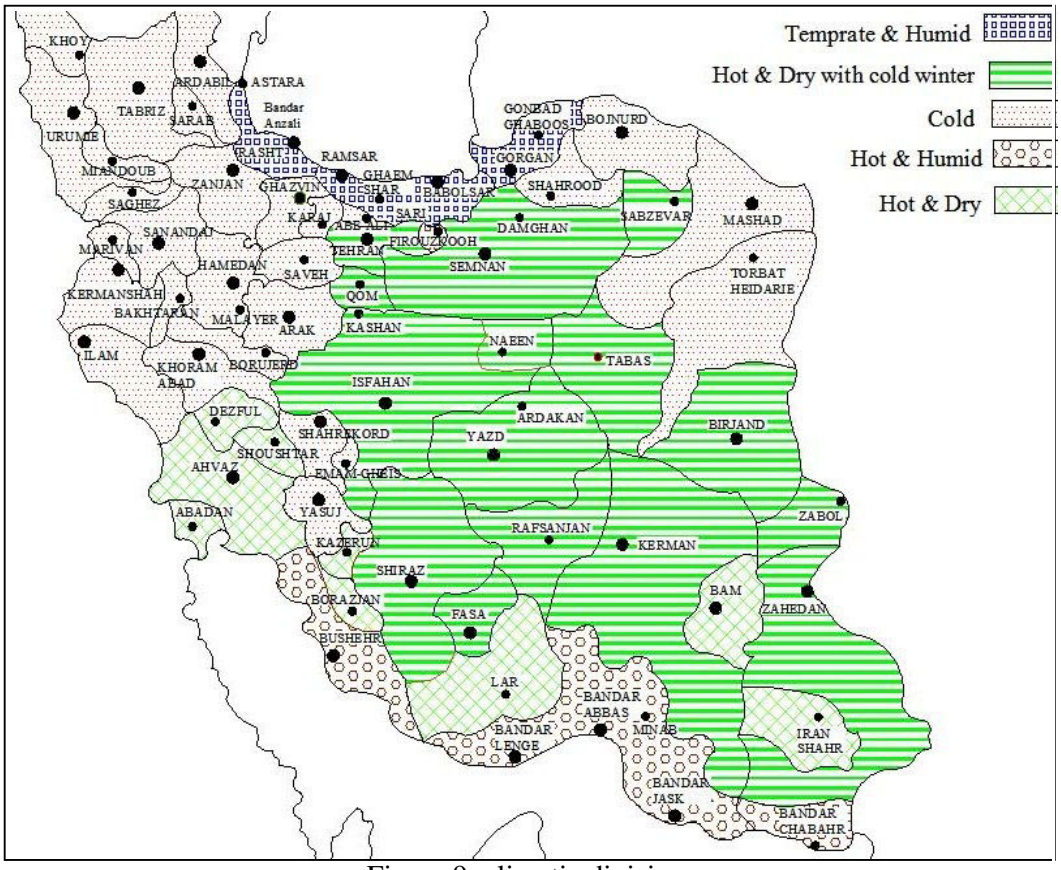


Figure 9: climatic division

It is obvious from figure 8 that this reach classified the climate of Iran into five different categories as: hot-dry with cold winter, hot-dry, Cool, hot-humid and temperate-humid climate. Moreover, the result of this bioclimatic analysis has also been summarized in table 5, which demonstrates the climatic situation of each sixty eight cities in Iran. And also this research selects one typical example from each different climate, which is illustrated in Figure 9.

Table 5: Five diffident climates in Iran

No	Specification	Temperature	City
1	Temperate Humid	AMTS: 26 to 32 AMTW:0 to 4	Babolsar, Bandar Anzali, Rasht, Gorgan,Astara,Ghaemshahr,Ramsar
2	Hot- Dry With cold winter	AMTS: 31 to 46 AMTW:-6 to 9	Isfahan, Semnan,Sabzevar, Shiraz,Tehran,Yazd,Birjand, Ghom,Kashan,Ardakan, Saveh, Kazerun,Zabol,Fasa,Zahedan, Khoram Abad , Rafsanjan, Abadan, Marivan, Damghan, Kerman, Naeen, Ghazvin, Bakhtaran, Boroujerd, Minab, Tabas, Ilam, Arak,
3	Cool	AMTS: 28 to 38 AMTW:-2to-11	Orumiyeh,Khoy,Tabriz,Zanjan, Shahrekord,Hamedan,Malayer , Miandoub,Emam Gheis, Ardabil, Firuzkouh,Ab-ali,Sarab, Torbat Heidaie, Kermanshah, Mashhad, Shahrood, Saghez, Sanandaj,
4	Hot-Dry	AMTS: 44 to 46 AMTW: 3 to 9	Iranshahr, Ahvaz,Dezful, Shushtar, Bam, Lar, Borazjan
5	Hot-Humid	AMTS: 34 to 40 AMTW: 10 to 16	Jask,Chabahr,Bandar lenge, Bandar Abbas,Bushehr

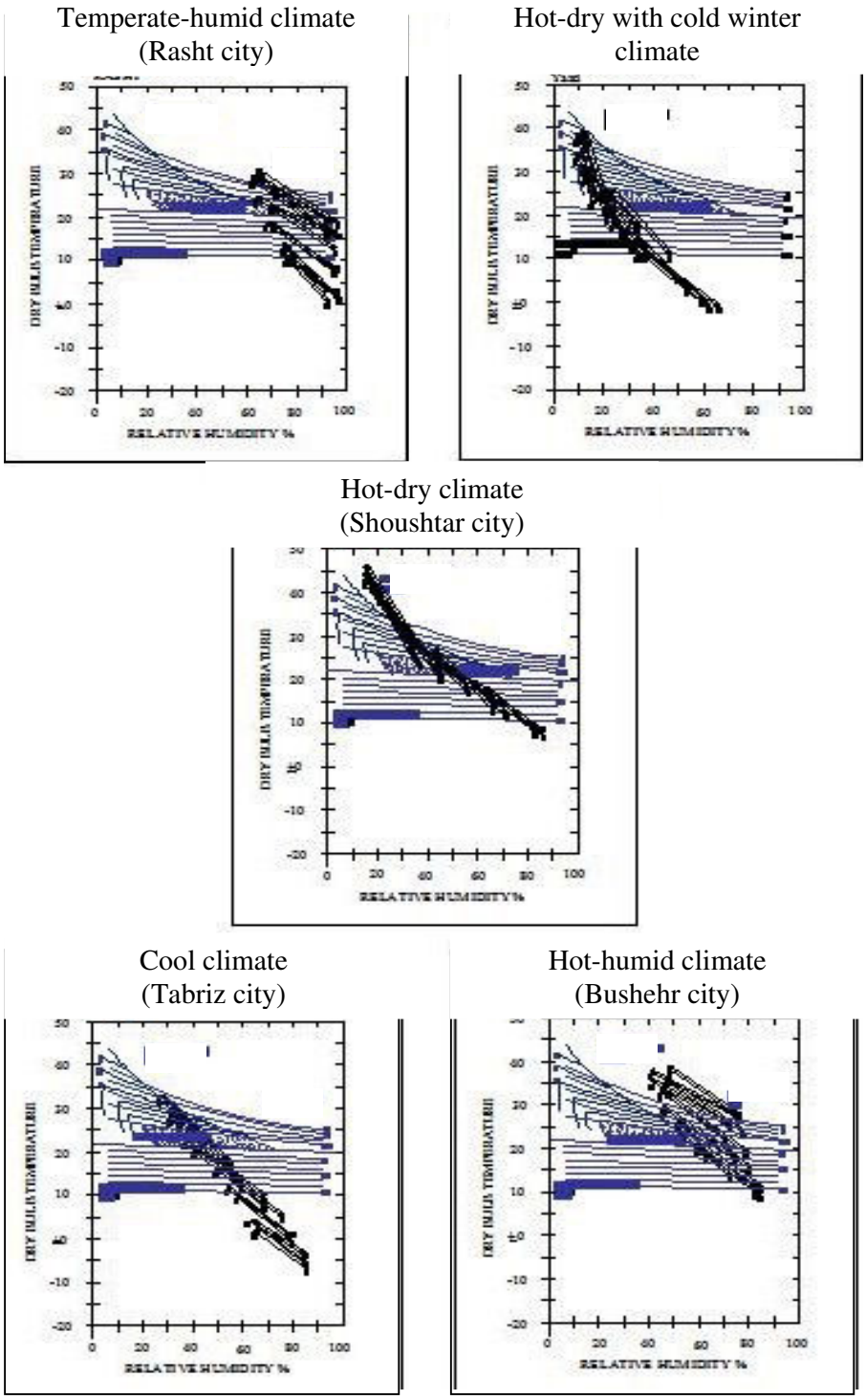


Figure 10: One sample of new bioclimatic charts of each different climate in Iran

2.2 Characteristics of Five Different Climates of Iran

2.2.1 Temperate and Humid Climate

Southern shores of Caspian Sea, which are located between Alborz Mountain and Caspian Sea, have a lot of rainfall. However, the amount of rainfall in this region from west to east becomes lesser. For instance, Bandar Anzali, which is located in the South West of Caspian sea had average of 1818mm rainfall during the 1961 to 1988. However, in Gorgan, where is located in South East of Caspian sea, had 617mm rainfall during the same years. These regions are composed of low plain and by going forward to the east, humidity of air becomes lesser. Furthermore, in the southern shore of Caspian sea, humidity in some of the cities like Rasht, Bandar Anzali, Ramsar and Babolsar is approximately eighty percent, which humidity is more than the human comfort condition. In fact Alborz Mountain, which is located between two antithetical climates, separates Caspian low plain from central plateau.

One of the special characteristics of this region is high humidity and temperate temperature. Therefore, the weather is not cold and usually during the winter temperature is above zero, except that the temperature during the summer time is different. For the reason that, in the morning temperature is around 25 to 30℃ and in the night time is around 20 to 23℃. Furthermore, because of the Caspian Sea and high humidity, there is no any fluctuation of temperature during a day. Moreover, in this temperate-humid climate cloud can works as an isolation material. Consequently, in a cloudy day the fluctuation of temperature is lesser (Kasmaee.M, 2003).

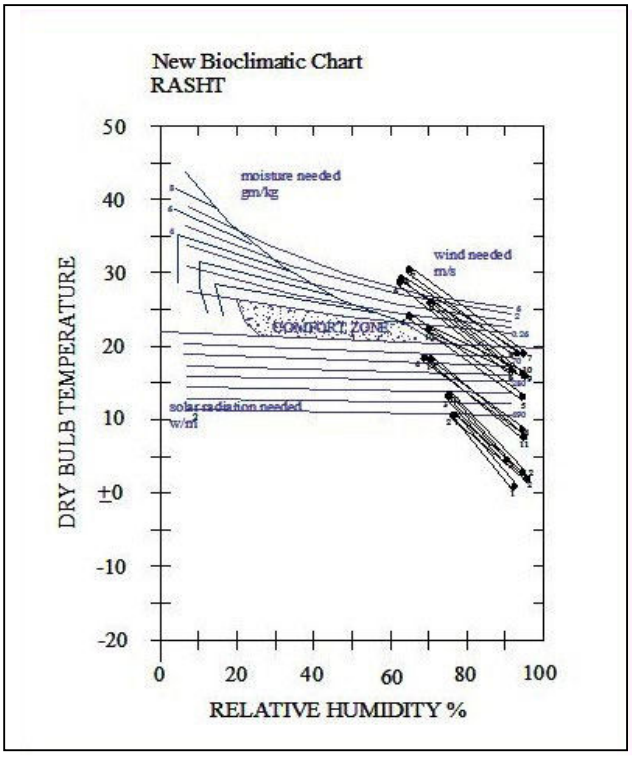


Figure 11: New bioclimatic chart of Rasht city

2.2.2 Cool Climate

The Alborz and Zagros Mountains separate the central plateau of Iran from Caspian Sea in the north and Mesopotamia plain in the west. Shirkooh, Taftan, and the other mountains are located in the centre and eastern part of Iran. Most of the time the mountains, which are located in the northern and western part of Iran, have snow. Alborz Mountains have dense of forests. However, the hillside of Zagros Mountains in western part of Iran have thinly scattered forests, which includes acorn, elm and maple trees.

Western domains of mountains, which are included of western hill of Central Mountain, have different characteristic. For instance, the average temperature in the hottest month of a year is more than 10℃ and the average of minimum temperature in the coldest month of a year is less than -3℃. Furthermore, the chain western mountain appears like a dam and they act as an obstacle for penetrating Mediterranean humidity through the central Iranian plateau. In addition, there is a lot

of sun radiation in the summer time. However, the sun radiation in the winter time is much less. Particularly in compare with other climatic regions of Iran, the number of sunny days in this region is quite rimming. Moreover, in this region winter is so long and most of the time ground is covered by ice and also winter time is very cold in all over the region from Azerbaijan, in North West, to Fars in southwest. In this kind of climate the cold weather starts from first of the November till the end of April. The amount of rainfall in summer is much less. However, there is a lot of rainfall mostly like snow during the winter time. Some of the cities like Tabriz, Ouromiye, Sanandaj and Hamedan are located in this region.

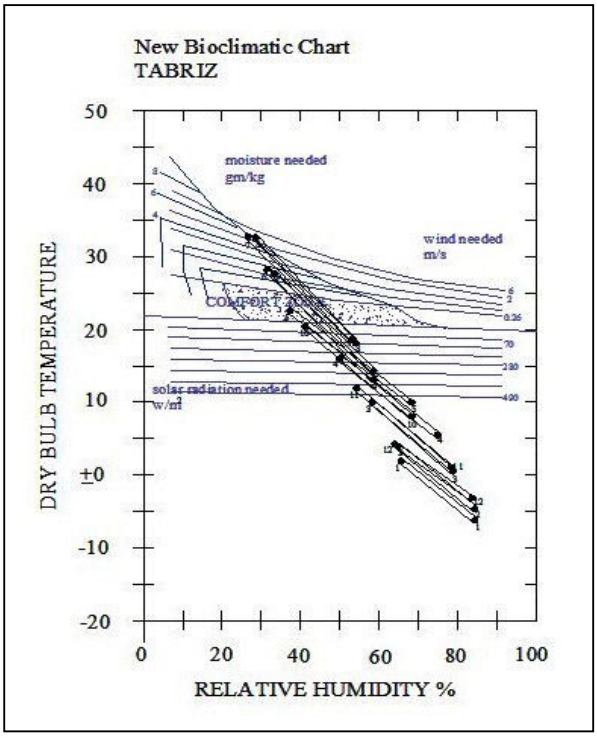


Figure 12: New bioclimatic chart of Tabriz city

2.2.3 Hot and Dry Climate

Weather in this region is hot and dry, since wind which moves from South West and North West to the equatorial regions. High pressure and the movement of weather over the atmosphere in this climate cause that weather become hot and dry in semi equatorial regions. In this region the temperature of the hottest day in a year

is around 40 to 50℃ and in the night time the temperature is around 20 to 25℃. Furthermore, the fluctuations of temperature in this area do not go below zero during the winter time. Some of the cities in Iran, like Shoushtar, Dezful, Ahvaz, Borazjan, Lar, Bam and Iran Shahr, are located in hot-dry climatic region. These cities have very hot summer and mild winter.

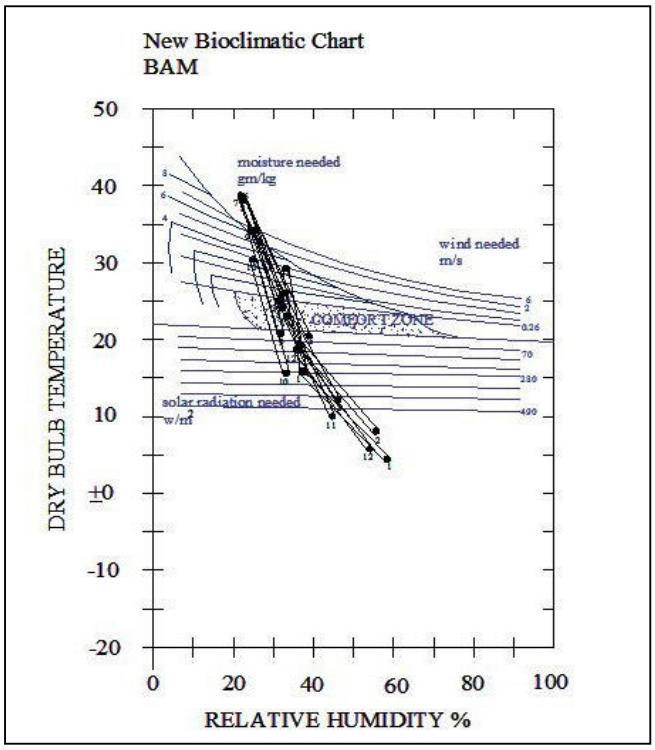


Figure 13: New bioclimatic chart of Bam city

2.2.4 Hot and Dry with Cold Winter Climate

Plateau plains, which are considered as out-standing district of our country, are located mainly in central and east part of Iran. Two regions of Kavir and Lout plateau, which are located in the centre of Iran, occupying one seventh of Iranian area (Ghobadian.V, 2006).

Hot and dry regions mostly composed of semi equatorial regions. Weather in this region is dry because of the wind which moves from South West and North West to the equatorial regions. In hot and dry climate, very low rate of rain, humidity, herbal

cover and lack of cloud cause a lot of differences between day and night temperatures. Sun radiation in summer makes the surface of the ground so hot like 70℃ but in the night the temperature of the ground's surface become less till the 15℃. In this region the temperature of the hottest day in a year is around 40 to 50℃ and in the night time the temperature is around 15 to 25℃.

Central plateau, which is hot and dry with cold winter climate, is the largest regions of Iran and it is blockade by high hills. One of the special characteristics of this region is hard and cold winter and warm and dry summer. Due to the scattered geographical situation, this region has two different climatic regions; desert climate and semi desert climate.

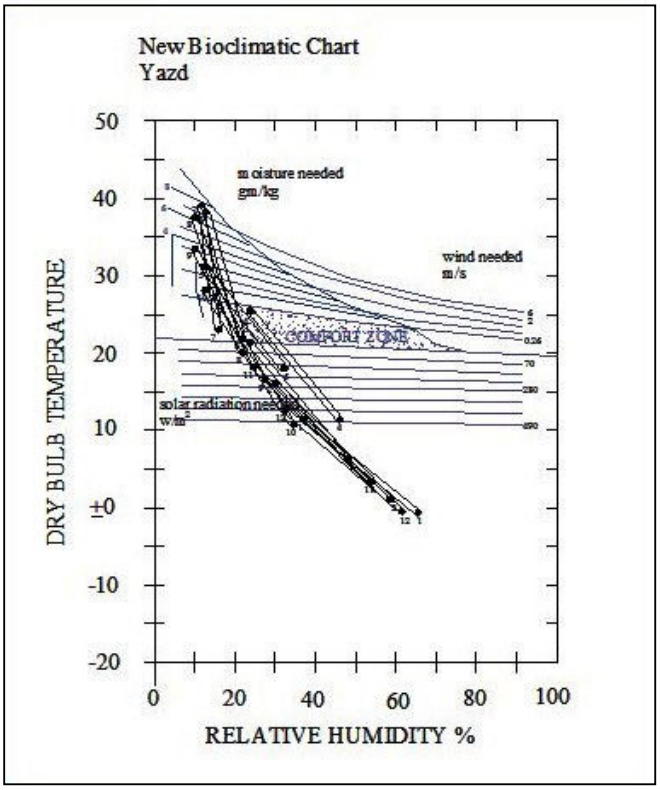


Figure 14: New bioclimatic chart of Yazd city

2.2.4.1 Semi Desert Climate

The existence of slopes of the north, west, south, central mountains, and the east scattered plateaus creates independent zones in the central plateaus. Because, of the elevations and the damp of humid wind passes by these elevations. A mild climate in proportion to the central plateau is created by going from west to east, humid wind decreases while the dry weather increases. Tehran, Meshed, Isfahan and Shiraz are semi-desert cities (Azami.A, 2005).

2.2.4.2 Desert Climatic

Central low plateaus of the east and south east of Iran have desert dry weather. This region of Iran is identified as an unknown region because of lack of meteorological station. One of the characteristics of such climate is high difference of the temperature between day and night times in summer. Lout plain which is the hottest region in Iran has the lowest relative humidity. Some of the Cities like Zahedan and Yazd are located in the desert climate.

2.2.5 Hot and Humid Climate

The northern shores of Persian Gulf, which is located between central plateau and Zagros Mountains, have hot and humid climate. This region has long summer and just two months winter. There isn't any snow in winter time and the weather is not cold. Furthermore, in this region there is a lack of plants and it has calcareous soil. Therefore, the water of rainfall cannot penetrate to the ground and subsequently more rainfall causes flood.

Hot and humid climate, which is located near to the sea, has high humidity. One of the special characteristic of this region is very hot and humid summer and temperate winter. In such a climate maximum temperature in the summer time is

between 35 to 40°C and the maximum of relative humidity is around 70 percent. High relative humidity during the season cause less transition between the temperatures of day and night. Furthermore, the difference between dryness of the surface and sea surface in hot and humid climate cause sea breeze. Additionally, this sea breeze is useful just for the narrow band of the shores. Therefore, the weather inside of the city is calm with low speed wind. Another characteristic of this region is the intensity of sun radiation, which causes eye's inconvenience. As a result, the intensity of sun radiation in a cloudy weather is maximum and the brightness of the sun makes some problem for the eyes. However, when the sky is full of cloud and the ground is covered by plants then the amount of sun radiation that reflects from ground is minimum. In reverse when the sky is clear and the ground is unutilized the reflection of the sun radiation is maximum.

Cities like Jask and Bushehr and etc are located in this climate. In addition, cities, which are located in this hot-humid climate, have some differences of humidity and rainfall according to the distance from the sea and their location in different shores. Particularly northern shores of Persian Gulf have a lot of rainfalls but Oman shores have an irregular rainfall in a year. Moreover, Indian Ocean's wind cause an irregular rainfall therefore there is dearth in most of the years in Oman shores.

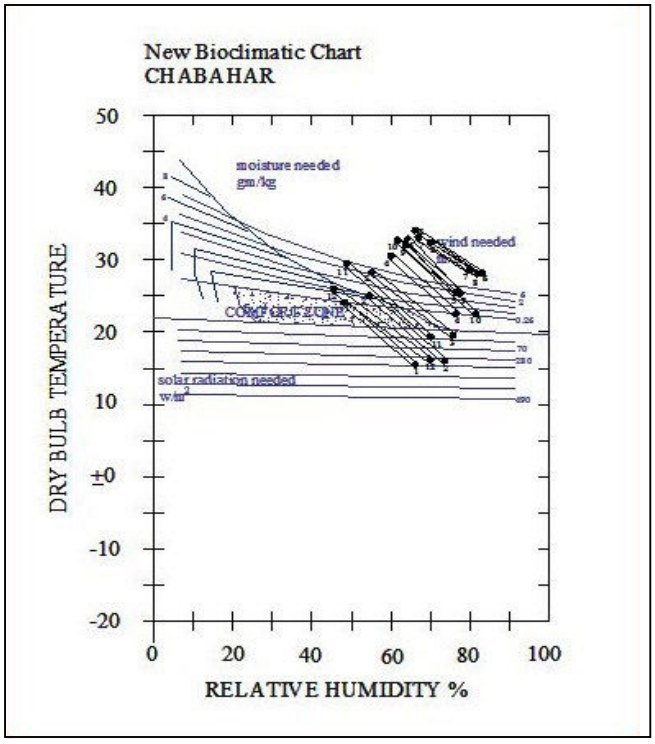


Figure 15: New bioclimatic chart of Chabahar city

2.3 Vernacular Iranian Architecture in Terms of Bioclimatic Analysis

Consistent with the bioclimatic analysis, as it is mentioned before, in the following part this research started to focus on the vernacular Iranian typology. Forms or the formal configuration of the local architecture in different parts of Iran demonstrates the special characteristics of that climate. In addition climate has a lot of impression on the form of the city and formal characteristics of the buildings in Iran. This research tries to understand the relation between the climate and architecture for residential building in Iran. Consequently, this study explained some examples and defined some architecture characteristics in five different regions of Iran, which is helpful for the people to realize the purpose of maximum use of climatic benefit and for minimum using of the mechanical machines for controlling the temperature in the interior spaces of their building.

2.3.1 Specification of Architecture in Temperate-Humid Regions

2.3.1.1 Morphology and Urban Texture:

1. Open and wide spread settlement pattern

2. Extensive city space

3. Width valley

4. Segregate buildings in country side and conjunct buildings at the centre of the city (Ghobadian.V, 2009).

Figure 16: Open and wide spread settlement pattern in temperate-humid region (Ghobadian.V, 2009)

2.3.1.2 The Impacts of the Climate on the Building Form:

Form of the buildings should be compared with rainfall and high humidity so:

1. Roof should have slope

This region has heavy rainfall therefore most of the building's roofs are slopped. These roofs work as an umbrella to cover *eyvan* and buildings. The majority of these roofs have 100 to 150 degree slope.

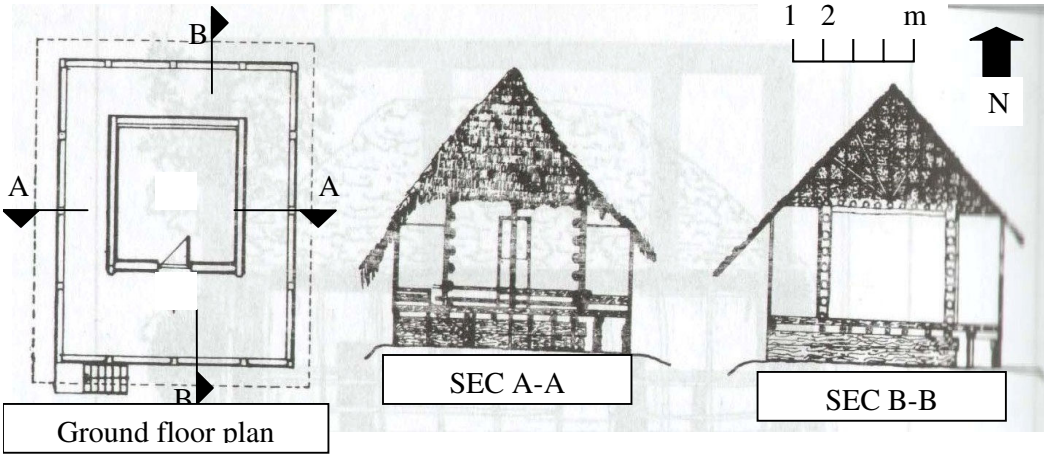


Figure 17: vernacular building with single room in temperate regions (Ghobadian.V, 2006)

2. Eyvan all around of the buildings

Broad and covered *eyvan* in front of all rooms is used for protecting rooms from the rain. These *eyvans* have different functions during the seasons, for instance they use them as a resting and working area in most of the months. Furthermore, *eyvans* are useful for keeping the agriculture products during the cold months of a year (figure 17).

3. No basement

Buildings do not have basement because of high humidity. For the reason that, humidity can penetrate to the basement, consequently, space of the basement is not a desirable place for habitant and also it is not safe place for storing. Because of high humidity everything will decay on the basement (figure 17).

4. Ground floor's slab upper than the ground level

One of the characteristic of this region is high humidity and shallow underground water. Consequently most of the buildings for protecting from humidity and water should be built above the ground level. Particularly from mountain to the sea, humidity becomes more and the depth of underground water becomes less. Therefore buildings near to the sea should have maximum two meter of foundation above the

ground level and in reverse the foundation of the buildings near the mountain should be construct less than two meter (figure 17) (Ghobadian.V, 2006).

5. Extrovert buildings

The extrovert buildings should allow the sun in the coldest month of a year and also prevent sun during the hottest period therefore, most of the vernacular buildings are located in East-West direction. One of the best ways for controlling humidity in this kind of region is employing wind flow and natural ventilation. In temperate-humid climate, most of the buildings are extroverted and they are projected from ground. In other words, most of the buildings in temperate-humid region are built above the ground level and moreover they are open from two or four sides. Conversely, introvert buildings in hot and dry region, which are recessed inside of the ground, are enclosed with long walls in four sides of the buildings.

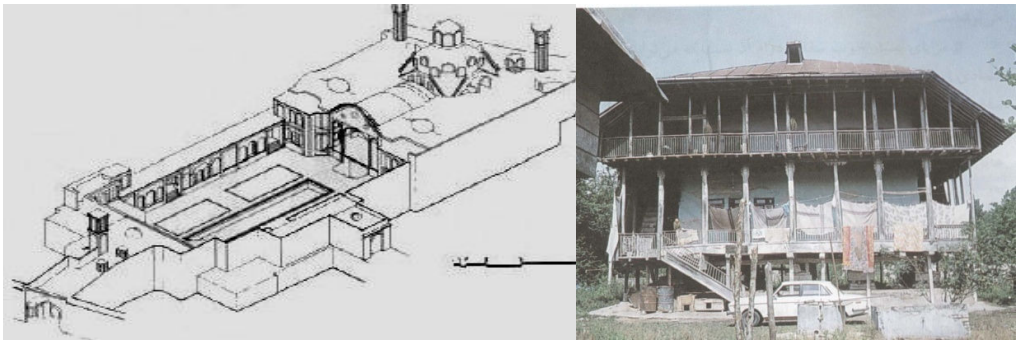


Figure 18: Building in hot-dry with cold winter region and building in temperate-humid region (Ghobadian.V, 2006)

Using natural ventilation in the buildings of these kind of regions is a common way to balance the inside temperature of buildings. In addition, these kinds of buildings are designed in order to provide a broad shade. Furthermore, the configurations of this type of buildings are open and wide plan with geometrical, long and narrow forms. Therefore, this type of form can lead the maximum wind flow through the buildings. Most of buildings are located in the sea breeze direction to receive the maximum breeze form the sea while in the other part of the city which

has an intense and undesirable wind; they designed the building in a way to ban the wind flow. Moreover, for using the maximum wind flow, settlement pattern in such a climate is not compact. Consequently each of the buildings has their own courtyards with a lot of open spaces.

2.3.1.3 Type of Material

The vernacular architecture of the southern shores of Caspian Sea has the same characteristic of the northern part of Alborz Mountain. Southern shores of Caspian Sea have high humidity. Therefore, inhabitants use wooden foundation for protecting their buildings against the humidity. However, the inhabitant in the foot hill of the mountain, which has low humidity, built their houses with stone and mud foundation. Furthermore, most of the buildings in this region are built with the materials, which have minimum thermal capacity (Kasmaee.M, 2003).

Ghobadian in his studies (2006) found that, this region is fertile and composed a lot of plantation in plain and mass of forest in mountain region so most of the building's materials are plants. Wood is also one of the main materials in this climate. Traditional builders use wood for structure and covering buildings. Additionally, wood is divided into two groups, which are soft and hard woods. Hard wood is compact, durable, hard, and beautiful and at least it has a lot of perseverance. Soft wood, unlike the hard wood, does not have same characteristics. The existence of the hard woods in this temperate is like wild acacia tree, acorn tree and pomegranate tree. In addition, the types of the soft woods are like plane tree, willow, maple, and pine and at least cypress tree.

In the forest and mountain region, inhabitants for covering the roof use some kind of a grass, which is found near to lagoon and this grass has wide and long leafs and it

has around 3m height. Furthermore, the other kind of grass, which is placed near to the sea has needle and long leafs and approximately around 8cm height.

2.3.1.4 Case Study, Rasht City

Ghobadian (2009) in his research mentioned that, Rasht city where is located on north part of Iran has temperate-humid climate in the summer, especially in its lowlands. Therefore, the original urban form of this city was open. This means that buildings were detached and the town's public and private spaces and streets were not lined by solid walls or buildings. In this city because of humidity, buildings are detached for allowing the winds to carry away the heavy and stagnant humid airs from the different parts of the town. In this temperate and humid region, humid air is heavier than dry air, and heavy humid air would settle in enclosed urban spaces. Consequently, mostly inhabitants did their activities in open space during the hot months of a year. Furthermore in Rasht city and mostly surrounded of that, the urban spaces were partly open on each side. Therefore, buildings were detached and streets were wide and their sides were fairly open, seaside towns extended along the coastline. In this way, the breeze that came from the sea was utilized for cooling.

Figure 19: location of the Rasht city in Iran (URL3)

Figure 20: Detach and outward oriented buildings in Rasht (Ghobadian.V, 2009)

In this city, there are heavy rainfall, high underground water tables, and hot and humid weather in the summer and cold weather in the winter. Subsequently the buildings and especially houses of this region were built in such a way to provide the human comfort against many undesirable climatic factors.

The vernacular buildings, which are located surroundings of the Rasht city, have gable roof. The gable roofs in here usually have four sides in order to block the rain, from penetrating in to the house, especially during the windy days. Because of the high humidity in the summer time, the cross ventilation is required for all of the buildings. Consequently, most of the building were detached and outward oriented (Ghobadian.V, 2009).

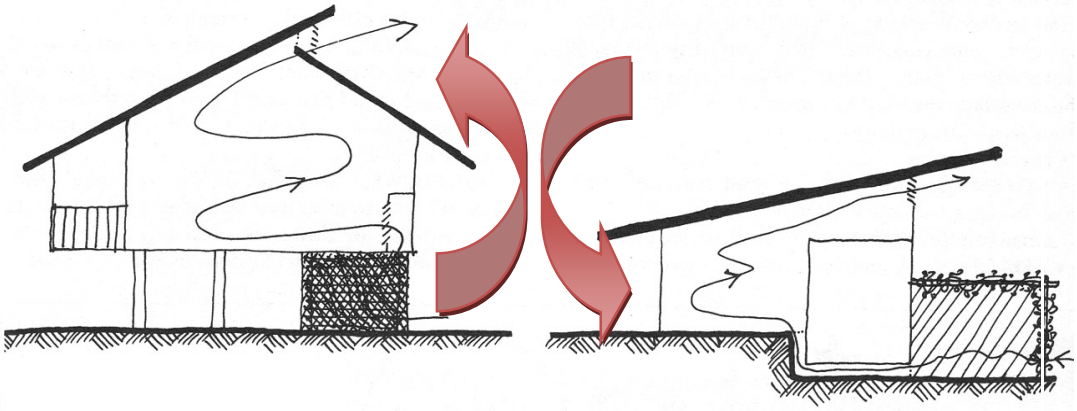
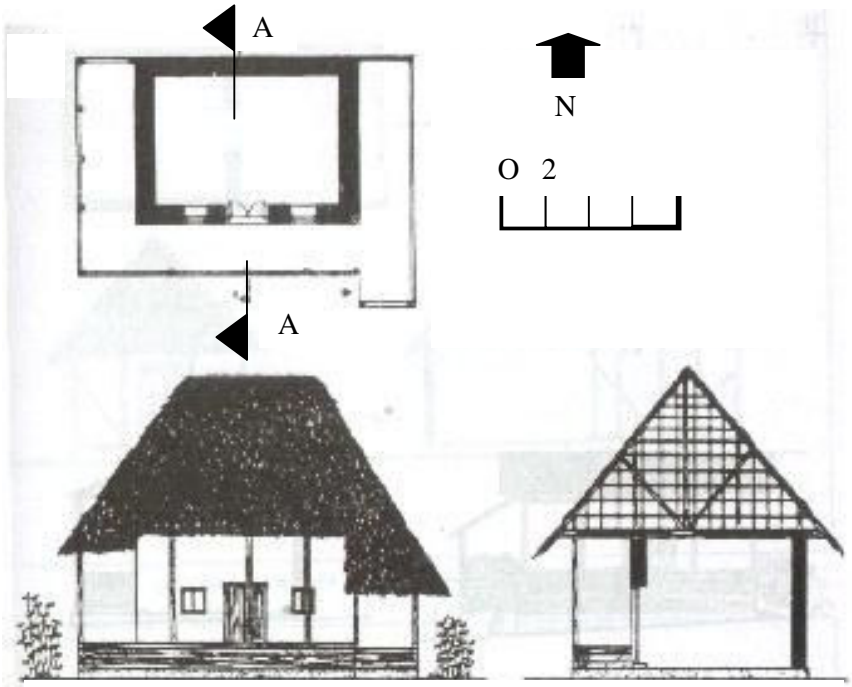


Figure 21: Buildings are detached for allowing the winds (URL4)

Memarian in his research mentioned (2006) that, Vernacular buildings in Rasht have some similarities with other parts of Iran. For instance one of the similarities is having multi functions rooms. For the reason that, inhabitants use their room for different function like bedroom, TV room, dining room, living room and also kitchen. Another resemblance is about seasonal utilizing of the rooms. Since, in the cold season, inhabitant used their rooms as a place for sleeping, eating and also cooking. In addition, balcony will be the multifunctional space and all of these activities will be occurred there during the hot season. Furthermore, in the hottest period kitchen has a small independent space.



South elevation section A-A

Figure 22: One single bedroom in Rasht (Memarian.GH, 2006)

In the case of vernacular buildings, balconies are very important and useful elements of the buildings. There are two reasons for this: the first reason is that this city has hot and humid conditions in the spring and summer. Therefore, most of the activities such as socializing, eating, entertainment, working, sleeping, would take place outside. In addition, during the hot summer air inside the rooms would have

been stuffy and warm. Consequently, balconies were appropriate places for such activities because inhabitants always enjoyed the shade and breeze. The second reason is that, particularly in those kinds of houses most of the walls built with the plastered by a mixture of mud and straw; which means that they had to be protected against the rainwater. Therefore this will be achieved by placing continues balcony all around the buildings and extending the four sided gable roof over it (Ghobadian.V, 2009).

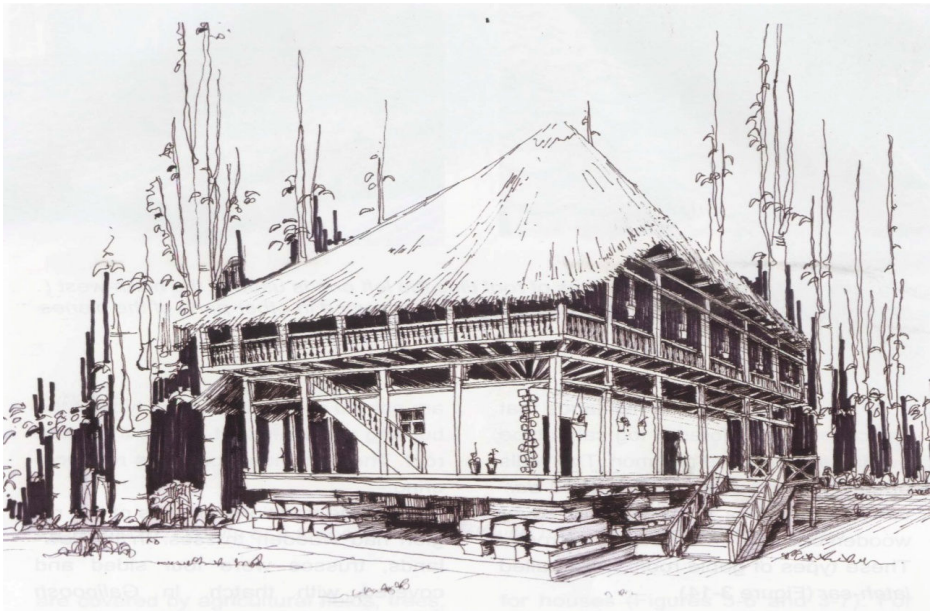


Figure 23: Balconies covered all around the buildings and the four side gable roof over it (Ghobadian.V, 2009)

The shape of the balcony is according to the room's situation. One of the important functions of the balcony in such a humid city is connecting the rooms together. For instance, if rooms placed in one arrow, the balcony will be elongated as a rectangular shape. Sometimes one room is bigger than the other rooms. Subsequently the length of the balcony will be same as the length of the small rooms. However, in some of the building's balcony in the ground floor covers the whole part

the building, but in other building's balcony just cover one or two sides of the building (Memarian.GH, 2006).

There are some other spaces like balcony which inhabitant names them as the *Talar*. There are some differences between *Talar* and balcony. For instance, one of the differences is from the floor's material. Floor's material in the balcony is mostly clay and the floor's material of *Talar* is wood. Furthermore, in Rasht the shape of *Talar* is different city by city. For instance, in some of the cities *Talar* is elongated around two sides and in others cover the whole part of the buildings. Mostly *Talar* is upper than balcony and the function under it is storage (Memarian.GH, 2006).

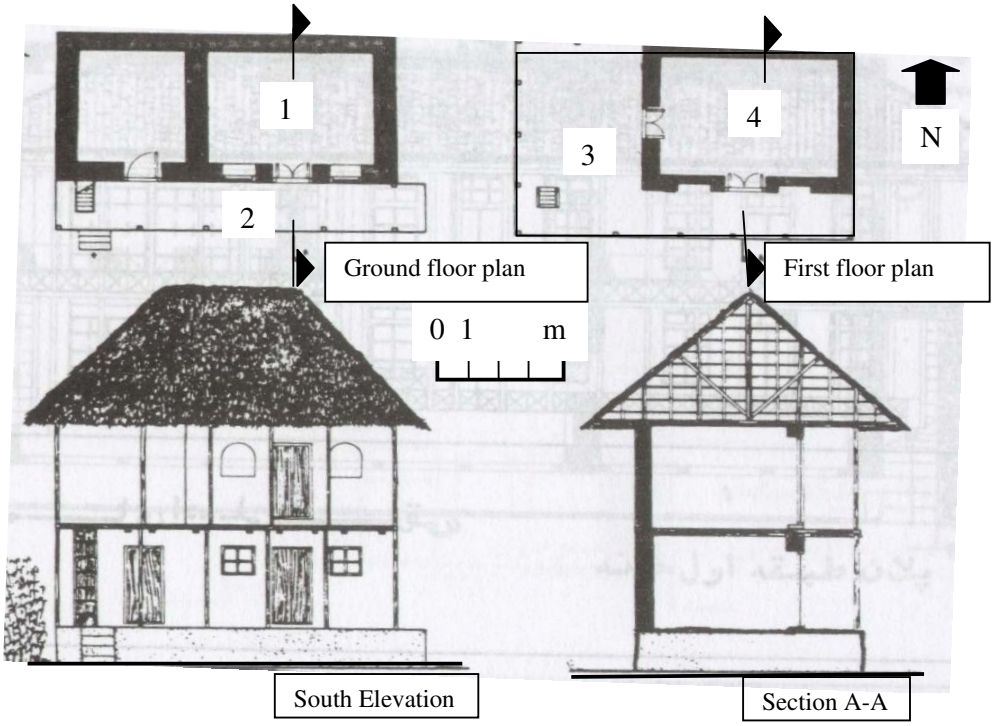


Figure 24: Two floors building, 1-room, 2-balcony, 3-Talar, 4-Guest room (Memarian.GH, 2006)

Furthermore, Memarian (2006) mentioned that, the typical vernacular building in Rasht city has two rooms on the ground floor and one room on the first floor. Additionally, inhabitants used the room, which is located on the first floor as a guest room. Furthermore, the balconies of some of the vernacular buildings have two

symmetrical steps; one of them is prepared for the guest room and another one for *Talar*.

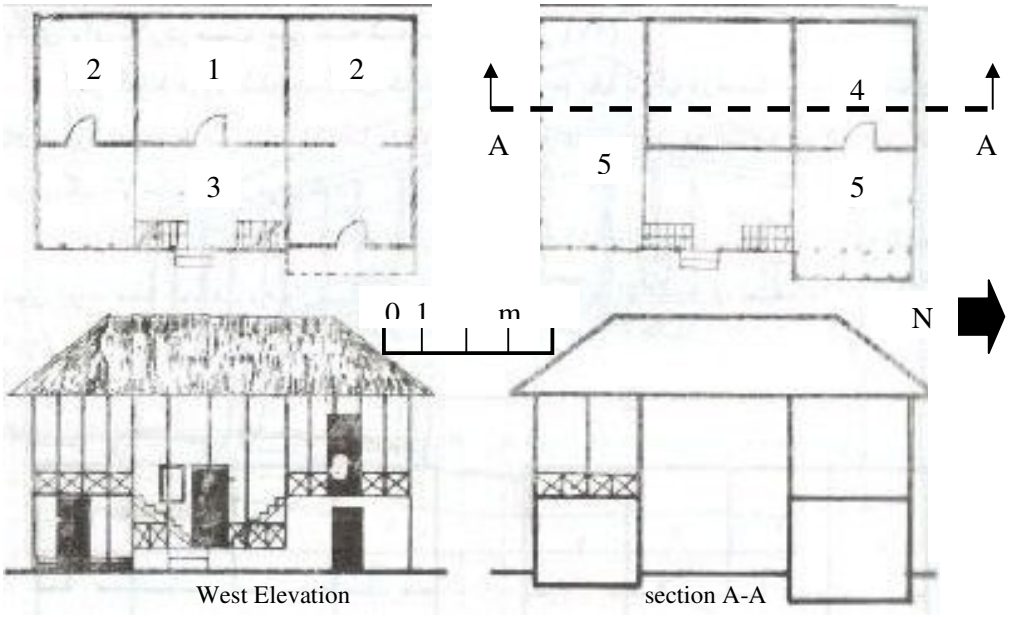


Figure 25: Two floors building with Talar and balcony (1-room, 2-storage, 3-balcony, 4-guset room, 5-talar (Memarian.GH, 2006)

The majority of the buildings in Rasht are constructed above the ground floor. Moreover, there is one special space in vernacular buildings in Rasht city, that inhabitants identified it as *Sume*. *Sume* is mostly situated at the back part of the bedroom or living room. Totally the dimension of the *Sume* is dependent on the plan of the building, but mainly is around 2.50-2.40m. In addition, some of the buildings in Rasht have *Sume* at the back of each room (Memarian.GH, 2006).

2.3.1.5 Building Material

Ghobadian (2009), in his research mentioned, that in the past, there was difficulty for transporting building materials. Therefore the general rule for building's material in relation to the traditional buildings is about availability in any particular area or region. For instance, wood was used in the forest areas, therefore, the main materials in Rasht is wood. Wood has some special characteristics such as lightness, strength against tension, modular and the important availability. Furthermore, the material for

walls was the combination of piece of timber, branches and mud. Consequently, in Rasht city most of the building's frames are made by timber.

Particularly thatched roof is the most common type of roof in this city. Furthermore, in the villages near to the Rasht city most of the vernacular buildings have wooden trusses. They cover up the wooden truss with shingles. These trusses mostly have two or four sides. They did not use nails or screw to attach shingles to trusses. Instead of them, they put pieces of stone over the shingles to keep them in place; In fact it is not a very safe construction method, especially at time of strong winds or earthquakes, but it is cheap.

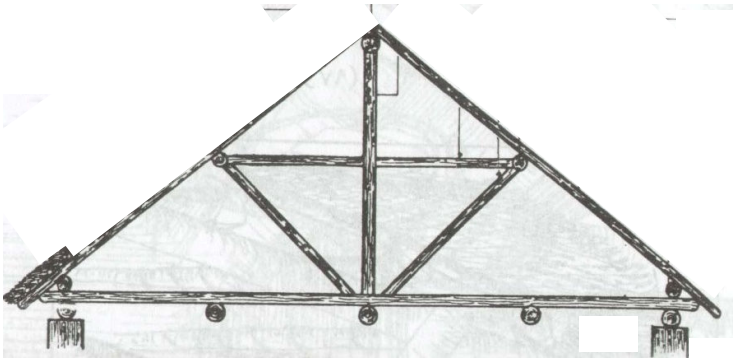


Figure 26: Thatched roof with wooden truss (Memarian.GH, 2006)

Moreover, there are three types of walls which were commonly employed in vernacular buildings. Timber framed walls were constructed in the plains. First a timber frame was erected and then long tree's branch were tied to the erected timbers (on both inside and outside) with ropes made of straw. They filled the empty space between the internal and external layers of braches with semi-dry blocks of mud and straw mixture. Finally, a layer of mixture of mud and straw was plastered over both sides of walls.

In view of the fact that in this city, there is plenty of wood in the forest, interlocking long walls were commonly built in the high lands. Sometimes to fill up

the holes and voids between the pieces of timber, they applied coating of a mixture of mud and straw on both sides of walls.

Sometimes cob or adobe walls were used for delineating properties, or for the walls of barns or storage sheds. Although such walls were fairly easy and cheap to build, they had to be protected against rainwater. For more prominent buildings they were used brick walls. Moreover because of high relative humidity in this region the metal connections or fastener were not used instead. Consequently these were either made of rice stems, tree barks, or the flexible branches of some trees (Ghobadian.V, 2009).

Consequently the primary principles of vernacular Iranian architecture in temperate-humid region are like as follow:

Table 6: Primary principles of vernacular Iranian architecture in temperate-humid region

NO	OVERALL FORM OF THE BUILDING IN TEMPRATE-HUMID REGION	
1.	Detached building	
2.	Four sided gable roofs-in particular houses	
3.	Outward oriented building	

Table 6: primary principles of vernacular Iranian architecture in temperate-humid region (continues)

No	OVERALL FORM OF THE BUILDING IN RASHT	
4	A deep continues balcony that surrounded the house on all sides	
5	Extension of the gable roof above the balcony	
6	No basement and Ground floor were kept higher than street level	

2.3.2 Specification of Architecture in Hot-Dry with Cold Winter Regions

There is lack of water for agriculture and daily consumption for inhabitants in hot and dry region also undesirable wind and sand storm makes a lot of trouble for

inhabitant (Ghobadian.V, 2006). But regardless of these problems, Iranian traditional architecture overcomes the climatic troubles and by having a lot of experiences illustrate some counsels such as:

Particularly in this region most of the buildings built with local materials, which have high thermal capacity. Since, of acute condition of hot and dry climate, most of the buildings are located through the hills or underground to temperate the temperature. Furthermore, sun radiations transfer a lot of temperature to the walls therefore most of the walls have white colors for decreasing the temperature. Buildings in these regions have few windows, where most of them are located at top of the walls to prevent the heat absorption form ground. Moreover, orienting the four sides of the buildings toward the four geographical directions (north, south, east and west) are in the manner to decrease the sun radiation absorption. Additionally, the favorite perspective differs in latitudes. Therefore, the perspective of the plan should be selected in a way that heat absorption from northern and southern façade becomes equal to the heat absorption from eastern and western sides in the hottest season (Kasmaee.M, 2003).

2.3.2.1 Morphology and Urban Texture:

1. Urban texture is condensed and compressed to each other

In these regions the urban texture is condensed and compressed to each other. Houses have merged or combined walls and the border between them cannot be identified. The compression and combination of the buildings leaded the external surface of each building to be the least. Therefore, each home can preserve the energy (Azami.A, 2005). It means that, by employing this method, buildings can create the maximum shade to the external surface as well as low interchange of

temperature. Consequently, by this method, buildings can prevent the penetration of the heat in the summer and also losing the heat in the winter time.

2. Surrounded city

The structure of the city is planned in such a way that cities are open in the direction of desirable winds and close in the direction of undesirable wind and sand storm.

3. Narrow and serrated lanes

One of the reasons for applying narrow lanes, which have high walls and arch's roof, is to create the shadow on the surrounding houses and also to control the wind speed of the plateau.

4. Houses are merged and they have combined walls

5. All of the subsistence space situated according to sun and wind direction.

Particularly they protect all of the subsistence space like pedestrian, courtyard and buildings from climatic problems such as undesirable wind and sand storm (Kasmaee.M, 2003).

2.3.2.2 The Effect of Climate on the Buildings Form

Natural air conditioning should be minimized during the warm days for the reason that entering the warm air to the buildings lead to increase the inside temperature. During the evening and in the night time the outside temperature will be decrease. Therefore, it could provide the best situation, which means the temperature inside the building will be cool. Enough consideration should be given to the fact that conditioning efficiency does not relate to the size of the windows. For the reason that heat absorption from windows could be minimized by coordinating the location, shape and opening type of the windows. For instance, small size of the windows could be contributed to the useful conditioning. Furthermore, if buildings were

located on the underneath, on that time they could absorb less dust in thunderous areas. Since, dust falls down in the higher areas. Moreover, in such a hot-dry with cold winter climate, most of the buildings have large *eyvans*, which are located toward the cool streams, which these *eyvans* can provide a favorite weather in the afternoon (Azami.A, 2005).

Being considered as the focal point, court yard is a social space with an environmental function. The lengthened and narrow form of this court yard, casts enough and needed shadow for this space during summer days. Generally there is a *Godal Baghcheh* or below ground court yard in most of the traditional buildings in this region, which have different kinds of flowers and trees and also a shallow pond or to produce a fresh and cool place for inhabitants. Furthermore, it can provide the shading for increasing the relative humidity. Therefore, *Godal Baghcheh* helps to create a comfort condition in a building and also it is one of the major elements of creating natural cooling system in a house. In addition, all the openings and room entrances are open to the central courtyard. Moreover, when the heat capacity of the air becomes low subsequently the court yard can adapt the temperature of the surrounding environment very soon (Azami.A, 2005).

Azami (2005) in his researches mentioned that, in this region, the height of the building is influential on the absorption of the sun radiation. Since, the increase of the wall's height leads to increase the building façade. Consequently, more façade of the building is able to face to the sun. Furthermore, sun radiance is more radiated on the horizontal than the vertical surfaces. Therefore, it would be better to decrease the roof surface and as opposed to this increase the walls' surface of the building, which this method is obvious on the traditional buildings in Iran. Additionally providing shadows for walls is so much easier than providing shadows for the ceilings.

Generally in order to control sun radiation, the height of the buildings in southern facade should be built higher than northern facade. Furthermore, the two-story buildings may enjoy more heat transition. For the reason that, the insulator or conditioning and splashing water on the roof decrease heat absorption. Moreover, it is a fact that two-story have more façade than one-storey buildings.

In addition, wall is an important element in the vernacular house of hot- dry with cold winter climate. Therefore, the huge Adobe or brick walls have approximately thickness about one meter. Since, they should tolerate the load of dome. Moreover, these walls can lose the heat through transferring and radiation during night. Consequently, their temperature remains in low and average degree during the day, which can provide the enough comfort condition for inhabitants.

Furthermore, in such a climate domed roofs are always exposed to blowing breezes due to their pop up forms. When there is sun shine on roof, this kind of roof can decrease the heat. Furthermore, during the nights heat would be reflected from the roof and removed faster. Iranian architecture solved the problem of cooling the inner space, with two-shielded domed roof. For the reason that, this kind of roof have isolation between the two shields, which this isolation can made the internal shield cooler (Ghobadian.V, 2006).

From geometric point of view, the area of an over arch is approximately three times bigger than its base area. So intensity of sunshine would be decreased on the round part. Furthermore, the lower part of the domed roof would have less temperature. On the other hand domed roof are always exposed to blowing breezes. Therefore, summer heats would affect them less in comparing to the flat roofs. The domed form is also suitable for decreasing the temperature during the nights.

Consequently, it can cool the interior of the building during the night (Azami.A, 2005).

Another reason for choosing dome shape in such a climate is the small amount of rain. Consequently, there is a lack of wood so most of the roofs have dome shape, which was made by mud bricks. However in the semi desert regions which have temperate comparative weather, there is enough existence wood so most of the roofs are flats and they were made by woods (Ghobadian.V, 2006).

Hot-dry with cold winter climate is wind tower. Since the building has only one opening, this is the entrance door to the outside. Therefore, the summer cross ventilation is provided through three wind towers, and the opening around the courtyard. For the reason that, wind towers can conduct the wind through inside of the building. However, when there is no need, wind tower can act as flues, providing vertical ventilation as a result of the chimney effect.

Furthermore, there is some kind of vernacular house in this region, which is called "a house for four seasons". This kind of house has two parts, which during the winter time, residents live in the northern quarter of the house (winter living quarter), where receives direct sunlight and heat at that time of a year. Therefore, it is warmer compared to the other sides. Moreover, at the beginning of the summer, the residents move to the southern part (summer living quarters) since there is always shade and it is a cooler place to live in summer time. In addition, during daytime all the rooms in this part of the house receive indirect natural daylight. The building envelope surrounds the central courtyard. Therefore, it can protect from the harsh climate outside, especially from dust storms. Furthermore, there is a pool, with a fountain, and plants and trees inside the courtyard (Ghobadian.V, 2009). Consequently, in

summertime the microclimates inside the courtyard is relatively more humid and cooler compared to the hot and dry macro climate of the outside.

All of the activities of the residents would be transformed to the courtyard from dusk to dawn. For the reason that, in the summer living quarters of the building is rather warm in the afternoons and evenings during the hot months of a year. In addition, residents would sit, rest, socialize, eat and sleep on wooden platform in the central courtyard in the evenings. Afterwards they would go inside in the morning, when the building fabric became much cooler than the outside. Furthermore residents would live in the winter living quarters during the winter time, which would have been warmer and well protected against cold winter winds (Memarian.GH, 2006).

Furthermore, Ghobdian in his research found (2006) that one of the best examples of typical traditional houses in hot and dry climate of Iran is Boroujerdiha house. Boroujerdiha house is a typical traditional house, which is located in the city of Kashan. It has a big central courtyard and it has just one opening to the outside, which is the entrance door. Except for this, all of the openings open on to the central courtyard. In order to enter to the house, first residents should pass through the entrance door, a circular vestibule, along corridor and then they can reach to the central courtyard. Furthermore, circulation, daylight, ventilation, and views are all provided with courtyard.

Boroujerdiha house is basically divided in to two quarters, where one part is on the north, and the other part is summer living quarter on the south. In addition this house has the ground floor and a basement. The basement is usually used during the summer, especially in the afternoons. Since, basement is cooler compared to the ground floor during the hottest period. Furthermore, the construction of the building is with load-bearing walls, vaults, and domes. These kinds of materials are adobe and

brick, which can be easily reused for new constructions. The external surfaces of the buildings are made by bricks and the interior surface is rendered with plaster. The walls have thickness about 60cm. Therefore, they can act as a thermal mass for minimizing the fluctuation of temperature between day and night.

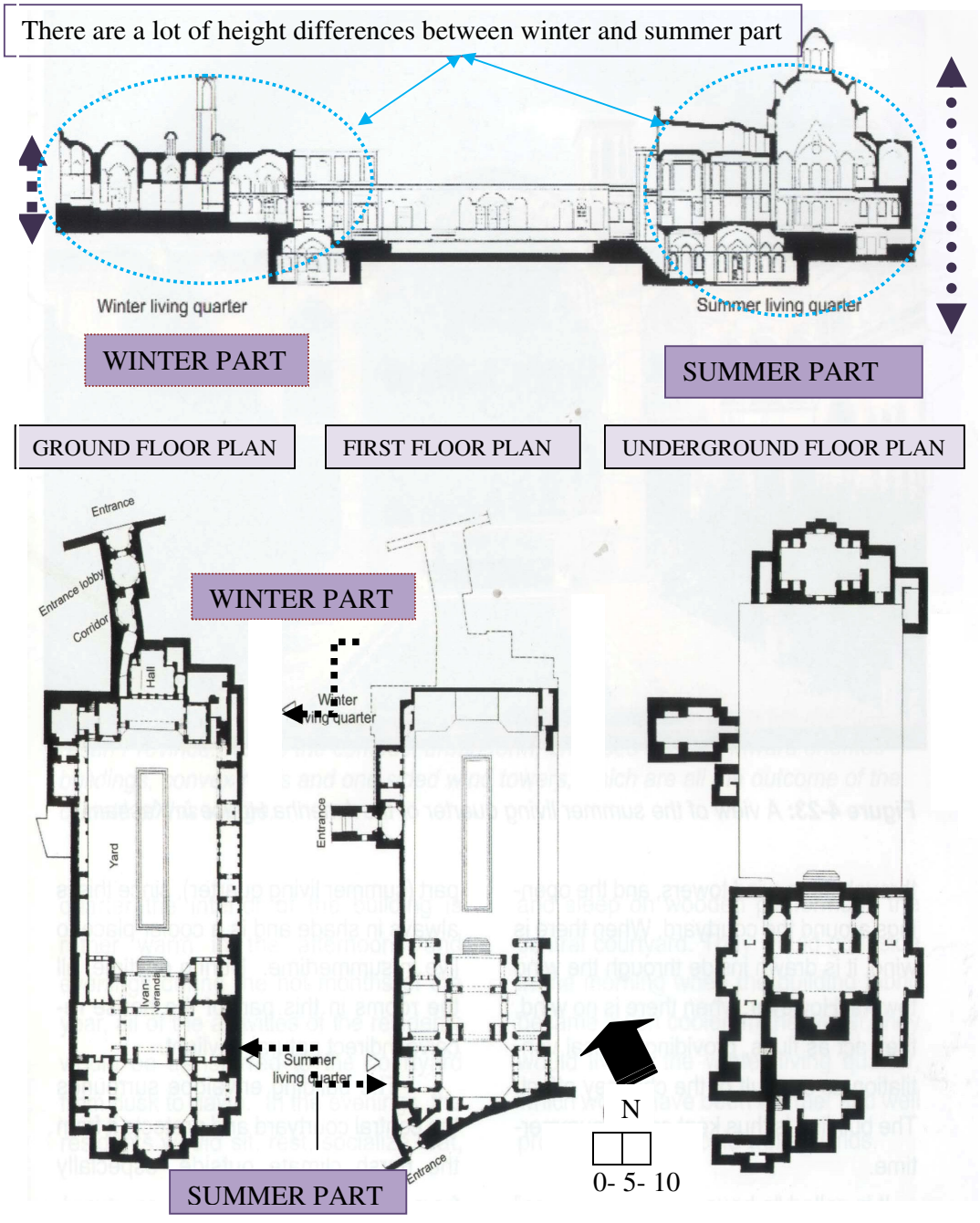


Figure 27: Plan and section A-A of Borujerdiha house in hot and dry region (Ghobadian.V, 2006)

2.3.2.3 Material

The common material for constructing huge wall in hot-dry with cold winter regions includes mud, mud brick, stone, brick, mortar, lime and wood. The thermo-physical specifications of these materials are the important factors in this region. These materials have thermal resistance, high heat capacity and they can absorb the sun radiation by their external surfaces.

Furthermore, the light color of mud reflects the sun heat. As a result, the heat does not enter to the building. Moreover, it is better to use the light materials for constructing the part of the building, which is mostly used at night. In addition, heavy materials are the best choice for the parts, which is used during a day (Azami.A, 2005).

2.3.2.4 Wind Tower

Ghobadian (2009) in his research mentioned that, wind towers can be found only in two regions of Iran such as central plateau region, especially on Yazd city and also along the northern coasts of Persian Gulf between Bushehr and Bandar Abbas city.

Almost all of the traditional buildings of the central plateau region were inward oriented. There were no openings on the external walls, except for the entrance doors. The summers in these regions are so hot. Therefore, many buildings had wind towers. Therefore, the cool summer breezes would go through the buildings. Sometimes there was a small pool and a fountain under the wind towers. Thus, by having pool and fountain under the wind tower, air before entering to the building would be cooler and humid. In addition, if there was not any wind then, the wind catchers would still cool the building, as a result of the chimney effect.

Moreover, there were basically three types of wind towers in Iran; one sided, four sided, and eight sided wind towers. Most of the buildings in cities near to the central

desert have one sided wind towers. Their openings would be built away from the desert and dusty winds. Consequently most of the wind towers were face to the cool summer breeze. In cities such as Ardakan, Bam, and specially Meybod, there are still many of this type of wind towers. Furthermore, four sides wind tower were the most common type. Most of the cities in this region such as Tehran, Esfehan, Shiraz, Kerman and some other cities have four sides wind tower. Using the four sides wind tower is appropriate for those cities. Because dusty winds were not frequent inside of the buildings and also four sided wind towers could drag the wind from any directions. Moreover, four side wind tower is commonly used along the Persian Gulf coast. There was no need for one sided wind towers. Since, the hot-humid region did not have sand storms.

There are some differences between the wind towers in Bushehr and the wind towers in Yazd city. The dissimilarity is that the four sided wind tower in Bsuhehr is bigger in cross section and shorter in height. The reason is that, Bushehr city has a lot of humidity, so the wind tower should be in such an order, to circulate more air between the land and the sea. Furthermore, there is less dust in this city rather than Yazd city. Subsequently, the wind tower in this hot-humid city can be bigger and in four sided directions.

Taller wind towers should be built in regions, which have less dust. However, the lateral force of the wind on a tall wind towers could cause them to collapse. Consequently, eight sided wind towers were employed in preference to four sided ones. In addition, the plan of the eight sided wind towers is similar to a circle and it can minimize the pressure of strong lateral forces by wind (Ghobadian.V, 2009).

2.3.2.5 Case Study of Yazd City

Yazd city where is located at the center of Iran has hot-dry with cold winter climatic condition.

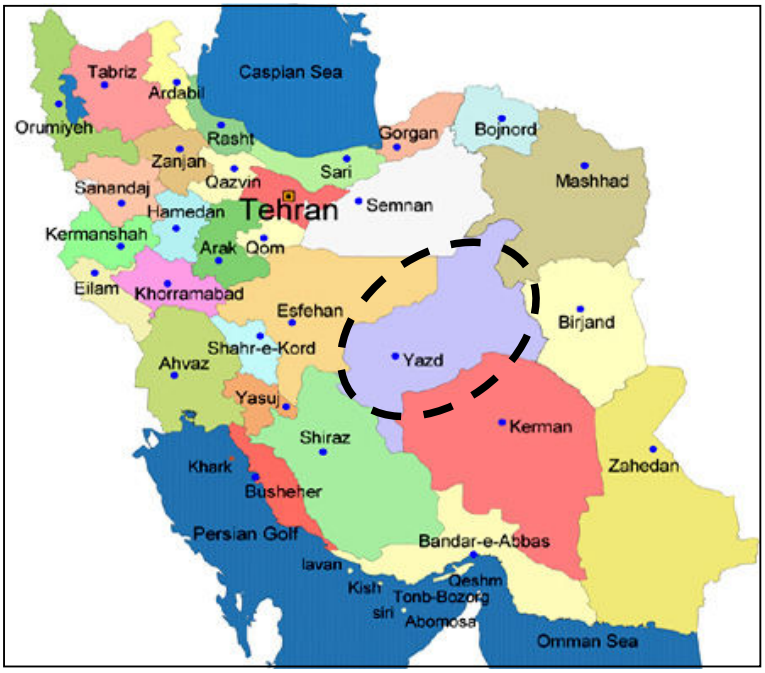


Figure 28: Location of Yazd city in Iran (URL3)

Therefore, the urban form of the Yazd city has to take shape to provide a comfortable living environment. Thus the urban form of this region has these main characteristics:

1. Compactness

2. Enclosed urban spaces and streets

3. Narrow and irregular streets, sometimes covered with vaults or domes

4. Adjoined buildings

5. Prevailing from winds and sunlight are the two main factors for orientation and configuration of the urban fabric (Ghobadian.V, 2009).

Figure 29: The urban form in Yazd city is compact (URL5)

Ghobadian (2009) mentioned that in this city urban compactness and adjoined buildings have some advantages. Firstly, enclosure urban spaces can help the city against the harsh climatic factors. Since, enclosure urban spaces can create comfortable environment for residents of this city. Secondly, outside surface of the buildings would be less exposed to the outside conditions. Therefore less heat can transfer from the buildings during the winter time. Consequently, buildings can lose less heat.

Furthermore, one of the main disturbances of this city is sand storm. Therefore, for protecting the buildings against sand storms, the urban paces and streets had to be closed on different sides. In addition, the orientation of the buildings in such a situation should be in a manner that to protect the building from cool summer winds, which came from mountain area, as well as, sand storms that came from desert. In other words, if there were not any difficulty of sand storm in this city, the urban form would be oriented on a southern direction in order to take advantage of the sun radiation during the winter time.

In order to enter to these kinds of inward oriented buildings, first inhabitant should enter from the entrance door or to the small lobby. Afterwards, from there to the corridor which would lead the people to the central courtyard.

In addition, there is a shortage of water in this city. Therefore each neighborhood of the city would be allocated a few hours of the water for a specific number of days and or a week. Usually this water ran in small open channels in streets. Each of the household could take a certain amount of it in order to water the plants and to fill its cistern for drinking water (Ghobadian.V, 2009). Consequently, the ground floors of the buildings were lower than the streets so that water could be transferred into the houses naturally by the force of gravity.

This region does not have many trees suitable for construction. Subsequently, masonry in this city is usually adobe or brick vaults or domes. In addition, most of the building had convex roof (Memarian.GH, 2006). In Yazd city the walls should be thick in order to support the heavy dead loads of these vaults and domes. Thick masonry walls acted as a very good thermal mass and minimized the day and night temperature fluctuations between the interiors and exterior parts of the buildings. Accordingly, Figure 30 and 31 presenting the example of two vernacular building in Yazd city, which one of them has flat roof and the other one has convex roof.

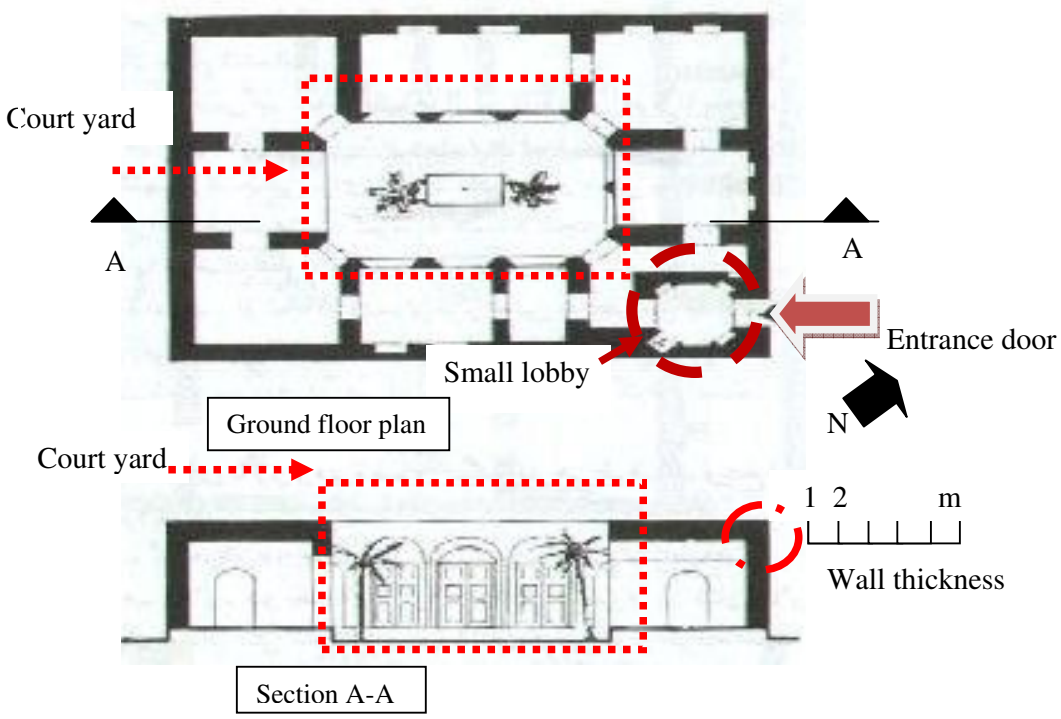


Figure 30: Ground floor plan and section of vernacular house in Yazd (Memarian.GH, 2006)

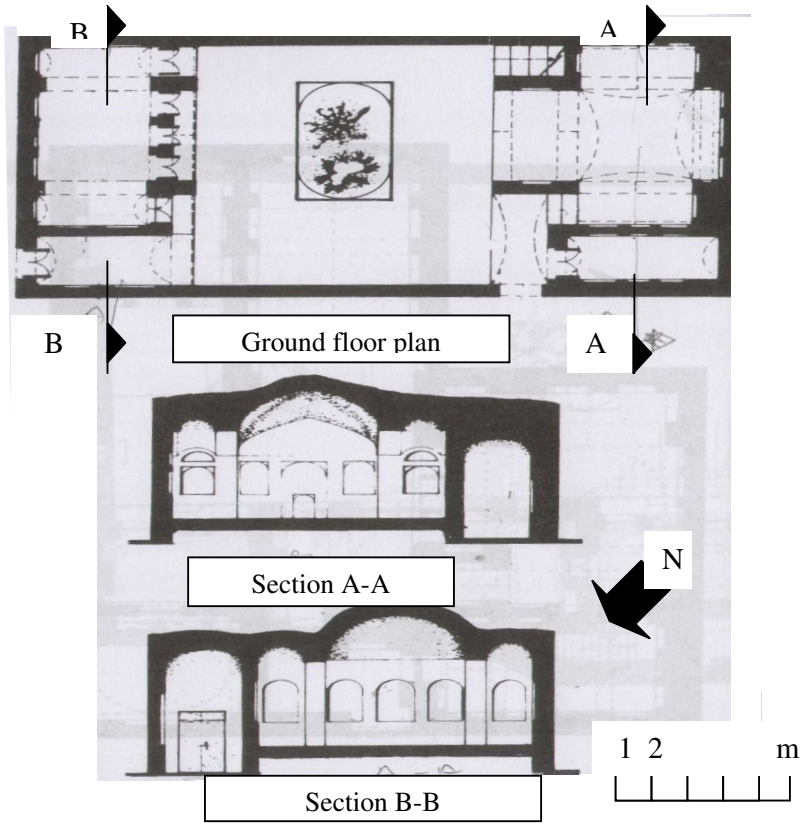


Figure 31: Ground floor plan and section of vernacular house in Yazd (Memarian.GH, 2006)

One of the best examples in Yazd city is the four seasons House. That during the winter the northern part of the house received direct sunlight and heat (through the central courtyard) was used as a family living quarter. In this manner one of this four seasons house was for Mr Akhavan Sigari.

According to the documents of the Iranian cultural heritage organization, various parts of the house were built in the early, middle and late Qajar period and part of it belong to the Pahlavi period. There is no any information concerning the commissioner. However, it was owned for a long time by Mr Akhavan Sigari, who was the tradesman of Yazd. This house commonly called after him (University, 2005).

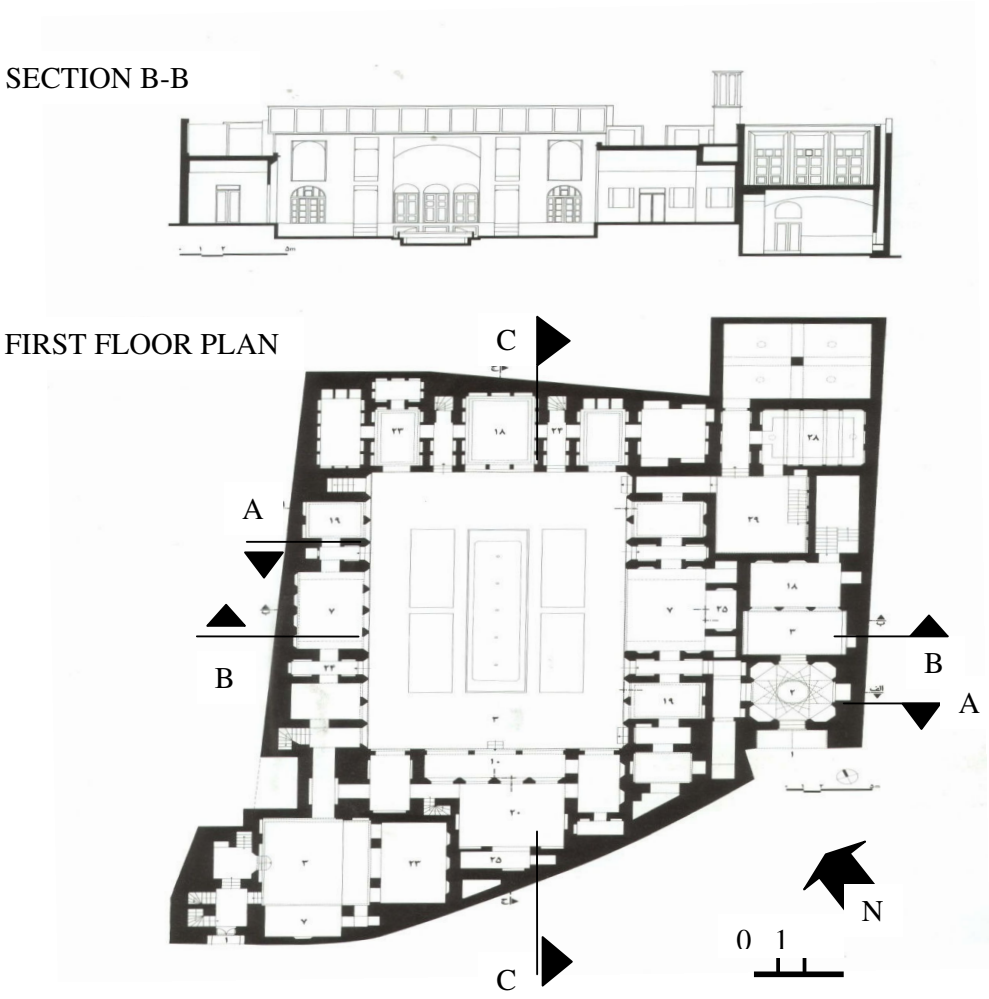


Figure 32: First floor and section B-B of Sigari's house (University, 2005)

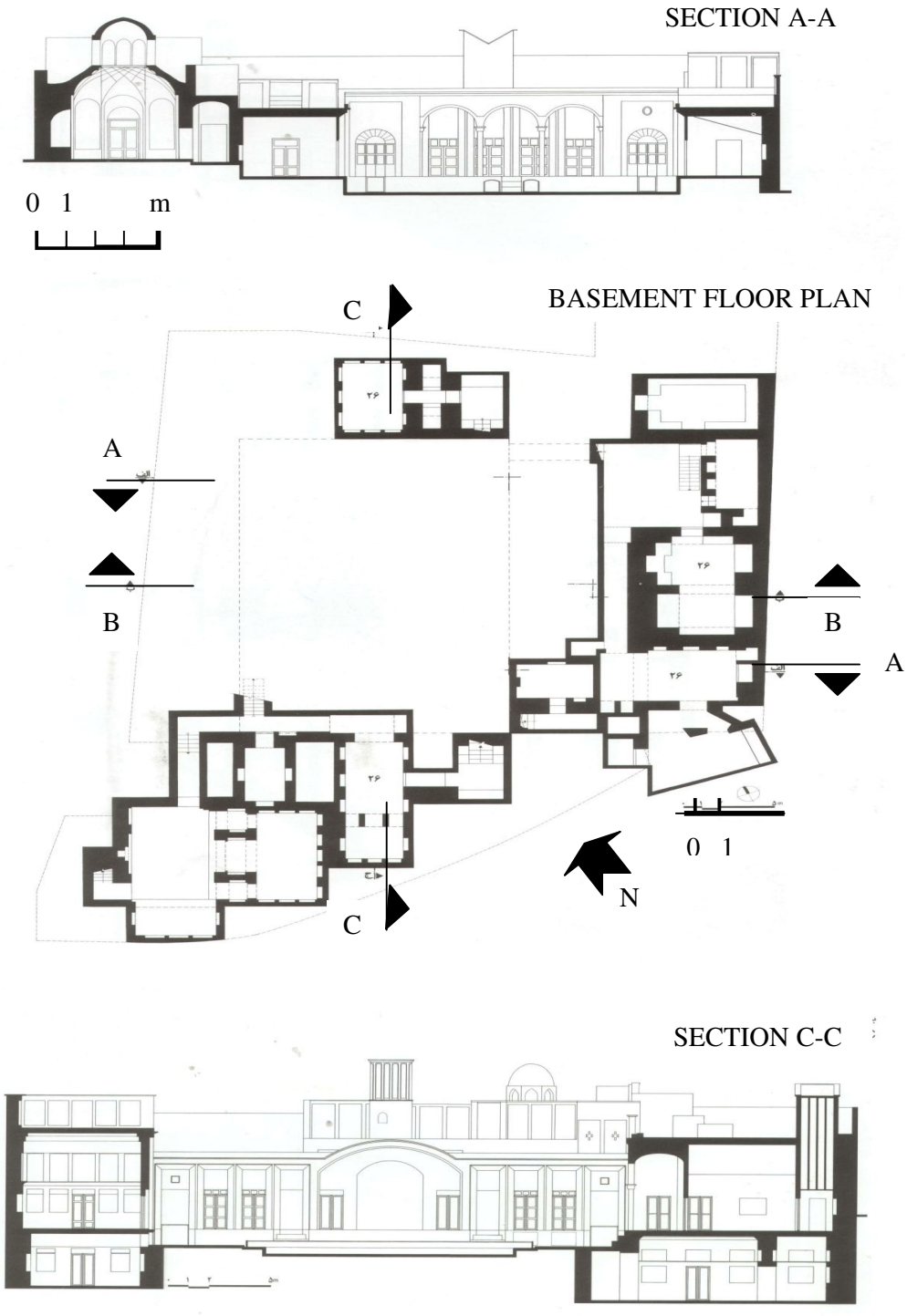


Figure 33: Basement, section A-A and C-C of Sigari's house (University, 2005)

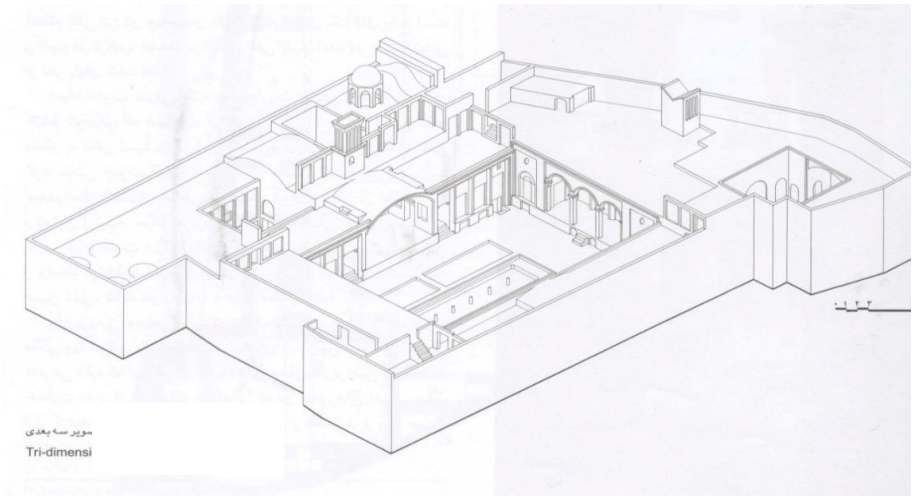


Figure 34: Three dimensional of Sigari's house (University, 2005)

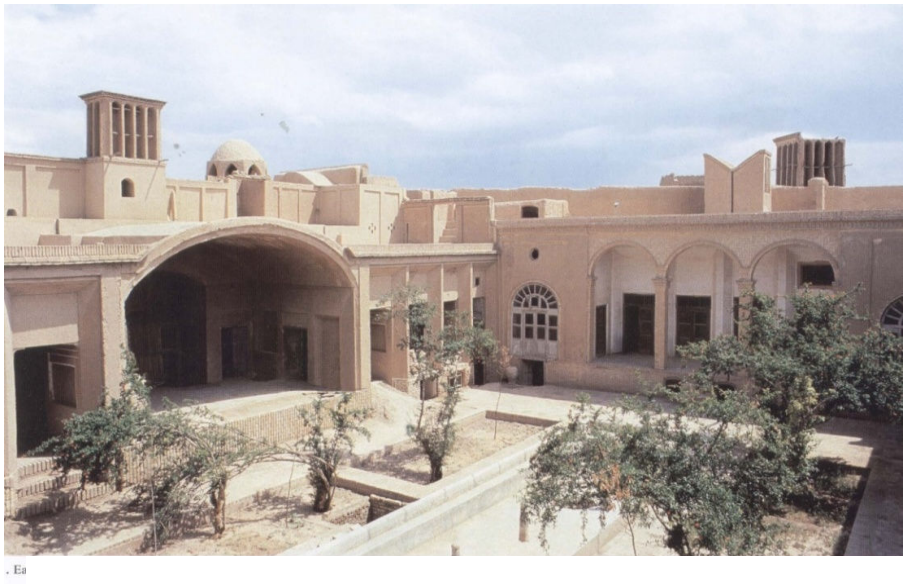


Figure 35: Eastern and southern side of the courtyard of Sigari's house (University, 2005)

With reference to the Ganjanmeh book (Yazd Houses), this thesis investigates the Mr Akhavan Sigari's house. The majority of the built areas in Yazd are face to the courtyards, which represent a lot of attraction for their surrounding spaces and link them to each other. Furthermore Sigari's building has a large central courtyard, three backyards and two entrances. In these traditional houses in Yazd, one of the distinctive members and special elements of the house is courtyard. For the reasons that, during the summer from afternoon till the morning all of the activities would

happen in the central courtyard. Since the great thermal mass of the building fabric in the interiors of the house would be hot. Therefore, it was more comfortable for residents to stay in the courtyard.

In the afternoon residents water the plants and the courtyard floor. In this way watering the plants help to cool the central courtyard air. Subsequently the inhabitants would stay in the courtyard. Children usually played in the courtyard, and there was a large wooden platform on which carpets were laid for sitting, socializing, eating and sleeping. After morning and waking up, everyone would return inside again. By this time, the building fabric had lost much of its heat from the day before. In the courtyard Plants, trees, pools, and its fountain would humidify and cool the place and also they can create a comfortable micro-climate in the central courtyard. The courtyard was protected from the harsh and dry macro climate of the outside by means of the walls and the rooms around it (Ghobadian.V, 2009). Thus, this concept is visible in the main courtyard of this house also this is remarkable in the case of the smaller secondary yards. Occasionally, these small yards closed with walls which faced with colonnades.

As this research mentioned before, the house has two separate entrances, one of them is complicated and the other one is small and simple. The main entrance which has a portico and vestibule is connected, on one side to the eastern backyards and from another side with a corridor to the large main courtyard of the house.

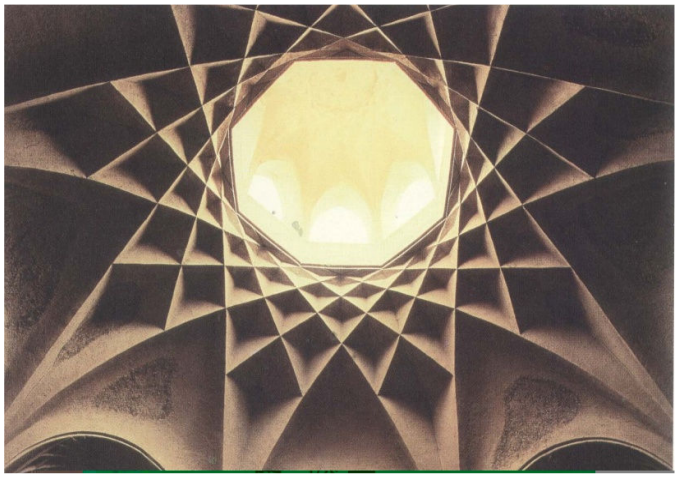


Figure 36: Vestibule ceiling (University, 2005)

The second entrance leads to the other backyard (located on the southwest of the house). This backyard has separate entrance existence so it is independent from the main courtyard. Furthermore there would have been two entirely independent houses if the corridor connecting to the two courtyards had not existed. At the same time, this connecting corridor put the back yard on the path leading to the courtyard. Particularly in this situation, this back yard and its surrounding built areas count as another entrance to the courtyard. In other words, the entrance of the house is a small house itself. Moreover, most of the vernacular buildings in Yazd city have only one opening from inside to the outside, where is located on the main entrance. In the case of the town itself, individual buildings had to be protected against sand storms or dusty winds. Consequently, buildings and their central courtyards had thick walls around them (Ghobadian.V, 2009).

Furthermore the main courtyard in Sigari's house has a rectangular shape and oriented approximately along a north-south axis. Its facades face and converse with each other two by two. For the reason that, in this case study the shape of the courtyard, in the northern and southern facades of the courtyard are different and on the eastern and western ones are similar and symmetrical. The center of the northern

facade is occupied by a columnar balcony. The facade of the northern side is varied and attractive. Moreover the southern facade has wind tower on top of it. As a result, the southern facade is an important facade as well. Most of the buildings in this city have wind towers which they used them for cross ventilation during summer. Furthermore the wind towers brought air from the outside into the building.

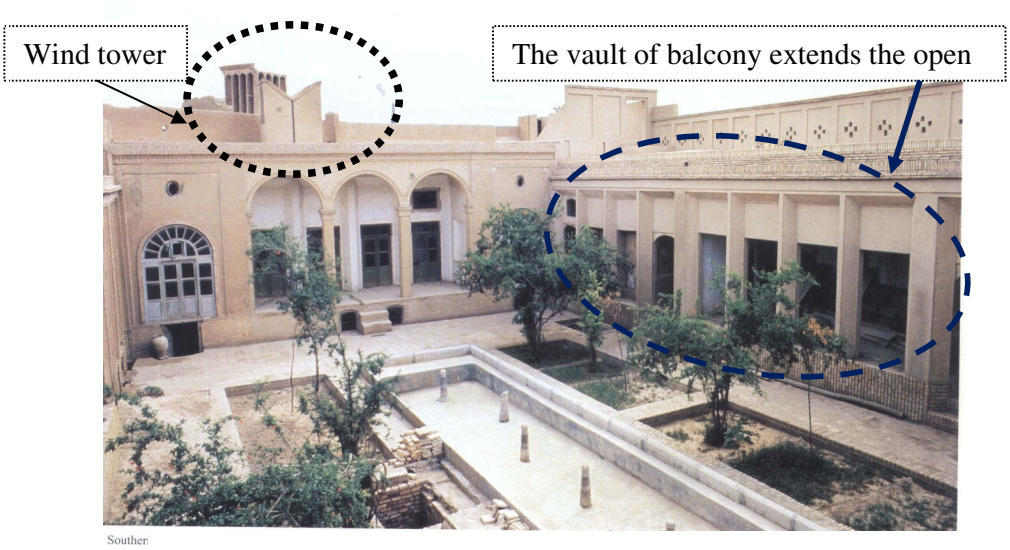


Figure 37: Southern and western side of the courtyard of Sigari's house (University, 2005)

The eastern and western sides Sigari's house have several similarities in terms of spatial organization and facade design and it has just some small differences. For instance, one of the similarities in facade is a wide central balcony flanked and supported by closed spaces. In addition, the location of two balconies opposite of each other together with the presence of wind tower on top of the eastern facade, have distinguished the east-west axis of the courtyard.

Figure 38: Northern and western side of the courtyard of Sigari's (University, 2005)

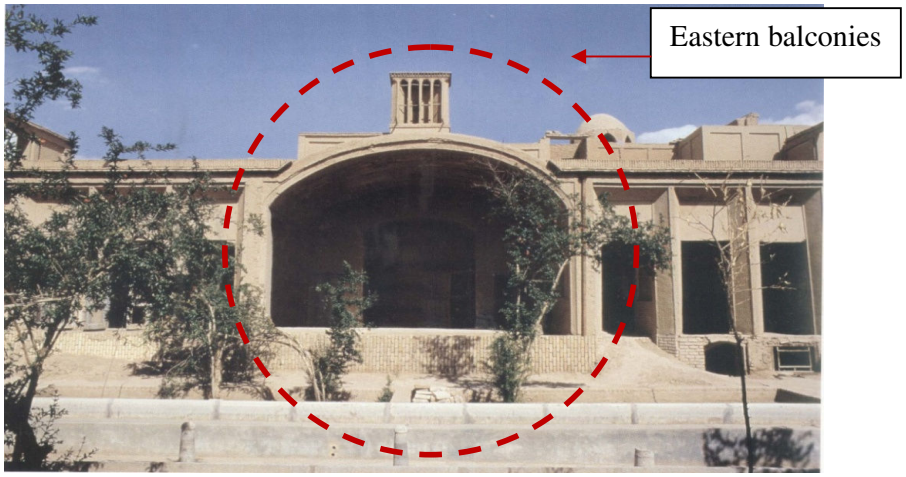


Figure 39: Eastern balconies in Sigari's house (University, 2005)

Moreover, the southern side of the house was used during the hot months of a year; since, the southern side is always located in shade. Additionally, wind towers would be provided for this side of the house. Therefore the summer section of the house was cooler and more comfortable to live in, during the hot period. Often there was a basement below this side, and the shaft of the wind towers was connected to the basement too. In addition, it is important that in these sorts of houses, main balcony to be placed on the southern side of the courtyard. Since, it is shaded in most of the times.

The eastern backyard of the house adjoined the entrance vestibule. This small backyard, which is approximately equal to the vestibule, belongs entirely to the

relative large room which may play the role of the outer courtyard of the house. Furthermore, the southwestern part of the house is rather design complicated. It has a central balcony and a room. Thus, this courtyard has all the main elements of traditional house. The other backyard, which is located on the north east, is an open service area and an intermediary means of a communication with the kitchen and its adjacent covered space. For this reason, this back yard perhaps can be designed as the house's kitchen backyard.

In this hot and dry climatic situation, basements were used in the summer because of their relative humidity coolness compared to the upper floor. Because of the great thermal mass of the earth around basement, basement is cooler. In so doing this Sigari's building has a vast basement which in some area extends beyond the limits of the property. Among these, the spaces located on the main axis of the courtyard are most sophisticated and the rest are mostly service areas. The residents usually move to basement for afternoon sleep since it was too hot to live on the ground floor (Ghobadian.V, 2009).

2.3.2.6 Building Material

The only material that is abundant, cheap, and readily available in this region is clay. The three common building materials of mud, adobe, and brick are made with clay. Almost every part of the building fabric such as walls, ceiling, and roofs were made with these materials (Memarian.GH, 2006). Clay is the main climatic advantage of the building materials since it has a high thermal capacity and it can minimize the temperature fluctuations between day and night. Usually foundations would be made with stone and lime mortar. Moreover they use timber for building openings. Consequently, the primary principles of the vernacular Iranian architecture in hot-dry with cold winter are as follow:

Table 7: Primary principles of the vernacular Iranian architecture in hot-dry with cold winter region

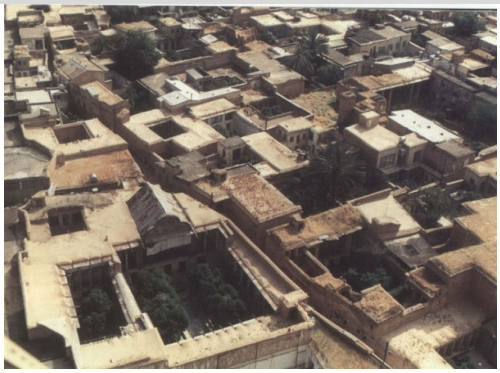
NO	OVERALL FORM OF THE BUILDING IN HOT-DRY WITH COLD WINTER REGION	
1.	Enclosed urban spaces	
2.	Adjoined buildings	
3.	The ground floor levels of houses and courtyards were lower than entrance and street levels.	
4.	Building were in warded oriented	

Table 7: Primary principles of the vernacular Iranian architecture in hot-dry with cold winter region (continues)

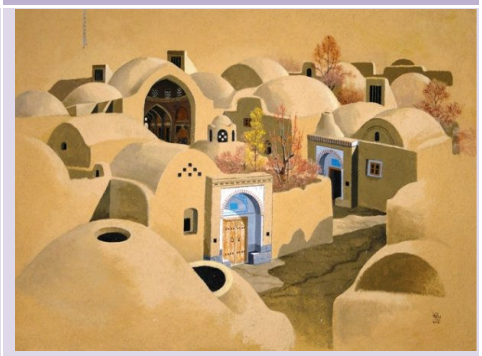
No	OVERALL FORM OF THE BUILDING IN HOT-DRY WITH COLD WINTER REGION	
5	Every building had central courtyard and wind towers	
6	Convex roofs	
7	Thick walls	
8	Construction a material: brick, adobe and mud	

Table 7: Primary principles of the vernacular Iranian architecture in hot-dry with cold winter region (continues)

No	OVERALL FORM OF THE BUILDING IN HOT-DRY WITH COLD WINTER REGION	
9.	Most of the buildings had basement, Ivans (veranda), and often wind towers	
10.	High ceiling, especially on the southern side of courtyards	

2.3.3 Specification of Architecture in Hot-Dry Climate

According to the bioclimatic analysis of this research, there are some of the cities in Iran like Shoushtar, Dezful, Ahvaz, Borazjan, Lar, Bam and Iran Shahr, which are located in hot-dry climatic region. These cities have very hot summer and mild winter. Furthermore, the fluctuations of temperature in these areas do not go below zero during the winter time.

2.3.3.1 Morphology and Urban Texture

Most of the buildings in these regions are semi-detached. Therefore, the settlement pattern in such a region is semi-open. Furthermore, according to Ghodbian's research (2009), these hot-dry regions can be considered as a sub-

climatic region. As a matter of fact, the climate of these regions is between the climate of hot-humid in the southern coast and the climate of hot- dry in central plateau. Moreover, most of the cities, which have same climatic conditions as hot and dry climate, are located between the Persian Gulf to the south and the Zagros mountain range to the north and the west. Accordingly the weather in these regions is very hot from the middle of the spring into early autumn. However, there is a distance between these cities and Persian Gulf, but the relative humid is high during the winter time. Although in these regions the relative humidity are not always as high as the southern coastal region.

Figure 40: Arial view of the old quarter of the city of Shoushtar, which is located on the north part of the Khuzestan plain (Ghobadian.V, 2009)

2.3.3.2 The Effect of the Climate on Building Form:

1. Flat and convex roofs

The weather in this region is very hot and dry. Therefore, the majority of the buildings has flat or dome roofs.

2. Inward-outward oriented buildings

According to the bioclimatic analysis of this research, there are some of the cities in Iran which have hot and dry climate. Hence Shoushtar and Dezful are the two beautiful and historic cities in this hot-dry region. The urban form in Shoushtar and Dezful was semi-open and semi-compact. The urban patterns of these cities are similar to the cities, which are located in southern of coastal region of Iran.

Buildings forms in this region were also between the forms in southern coastal region and the forms in central plateau. For the reason that, the buildings form in this hot and dry region have a sense of having central courtyard like the building in central plateau. In addition, they have a lot of openings both around the central courtyard as well as the exterior walls of the buildings in the southern coast region of Iran. As a result most of the buildings in this region were semi-detached. Moreover, semi detached buildings assist the cross ventilation during the hot months of the year through the cities. Furthermore, there are a few numbers of buildings in Shoushtar and Dezful, which have wind towers (Ghobadian.V, 2009).

Figure 41: One of the traditional houses with central courtyard in Dezful (kiani, 1995)

3. Deep basement

According to the Ghobidan's investigation (2009), one of the main differences of the buildings in hot- dry and in hot-humid climate is that most of the buildings in these regions were constructed on the ground. In other words, most of the houses in hot and dry region have a *Shabestan* (basement) and a *Shuwadan* (deep basement). Moreover, inhabitants would go to the *Shabestan* of their buildings during the hot period of a year. For the reason that, in these traditional house *Shabestan* was cooler than the other floors above the ground. However, if the *Shabestan* was still not cool and comfortable enough, inhabitant would move to the cooler *Shuwadan*. In these traditional houses, *Shuwadan* was constructed about six to seven meters below the central courtyard. For the reason that, the thermal mass of the earth above and around this space cause, the minimum fluctuations of the temperature in the *Shuawdan*. Furthermore, the temperature inside the *Shuwadan* was always around 22 degrees, which was the same as the annual temperature on the ground. In *Shuwadan*, light and ventilation would be provided from the courtyard through the vertical shafts.

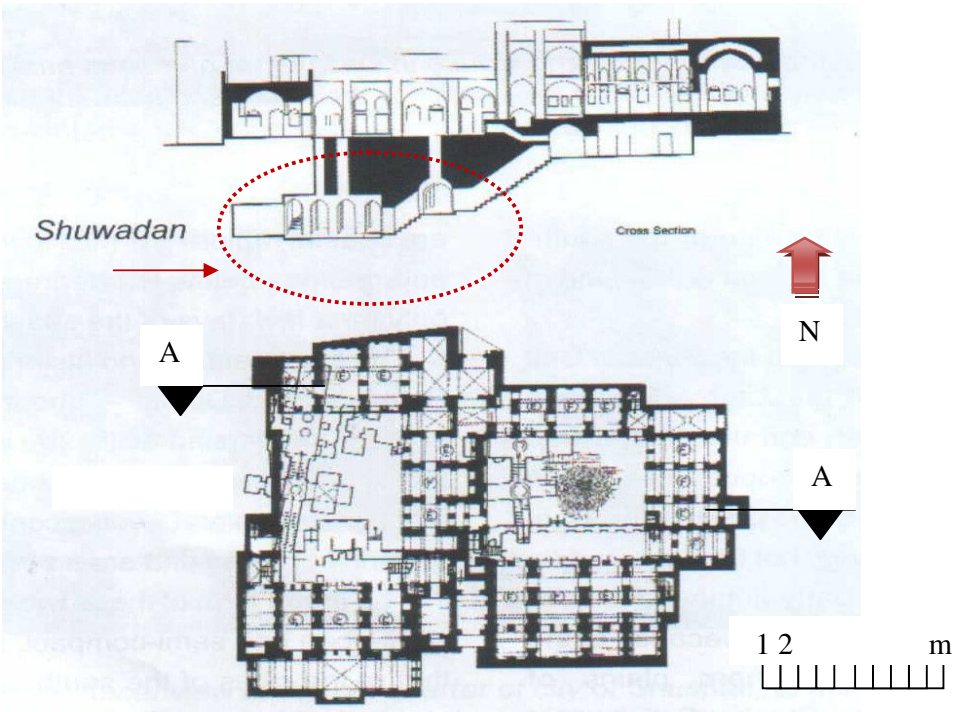


Figure 42: Section and plan of the Moeen-Ol-Tojjar house in Shushtar (kiani, 1995)

For having better ventilation or for circulating the air between the houses, traditional builders made some canals or narrow underground walkways between the *Shuwadan* of different houses. Moreover, these underground canals assist the neighbors and relatives to visit each other without going to the ground level.

4. Central courtyard

As opposed to the cool region, most of the buildings in this hot-dry region did not have winter living quarter on the north of the central courtyard, since the weather is not cold during the winter season. Therefore, most of the buildings in this hot-dry region have living space on the south part of the central courtyard. Thus, in such a hot and dry climate south side of the building is always shade and cooler than the other side.

2.3.3.3 Material

In this hot and dry region most of the roofs are constructed with brick domes or vaults. Furthermore, Rubble is a common material for walls in Shushtar city, since Shushtar city is located on the rocky hills. In Dezful, brick or adobe are most common materials. Consequently, brick and occasionally adobe were used in both cities for roof. Moreover, some of the most beautiful brickwork patterns can be found in this region of Iran.

Figure 43: The entrance faced of the building of the Rashidian house in Dezful. In this city most of the buildings have beautiful patterned brick work on both external and internal facade (Ghobadian.V,2009)

2.3.3.4 Case Study Shoushtar City

For the case study in such a hot-dry climate, this research chooses Shoushtar city, which is located in Southwest part of Iran and it is one of the historical city in this kind of climate. As this reach mentioned before, this region has very hot summer and mild winter. Consequently, in order to avoided the heat in this hot-dry city, the traditional houses (Mostofi house) have living quarter on the south part of the central courtyard. For that reason, south part is always in shade and it is cooler than the other part. Furthermore, residents in this vernacular house lived on the basement during the summer time and in the winter time they moved to the ground floor. Moreover, Mostofi house is one of the oldest buildings in this city, which was built according to the climatic conditions.

Figure 44: Location of Shoushtar in map of Iran (URL3)

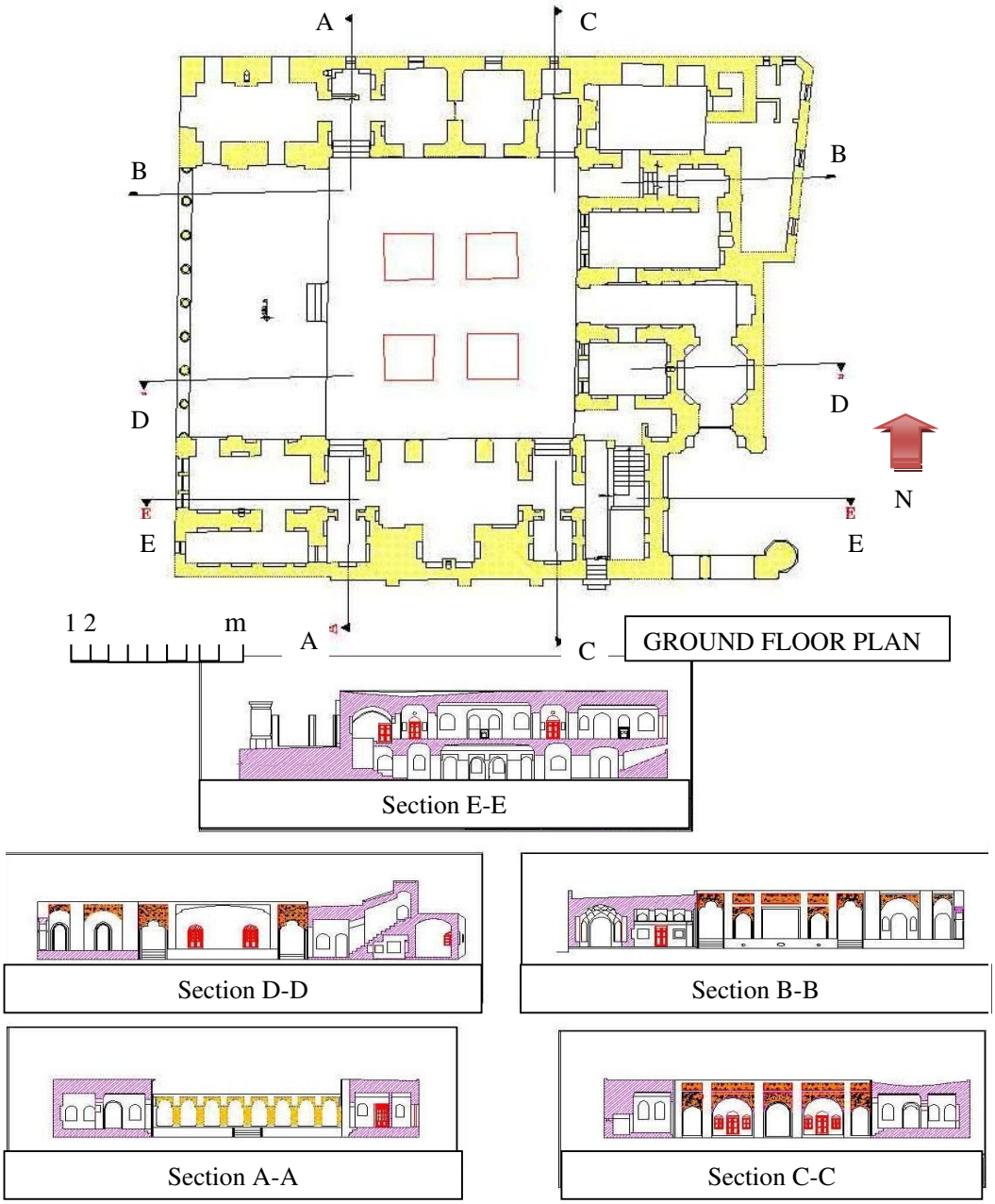


Figure 45 : Mostofi house has a lot of opening to the central courtyard (URL6)

Consequently, the primary principles of the vernacular Iranian architecture in hot-dry region are as follow:

Table 8: Primary principles of the vernacular Iranian architecture in hot-dry region

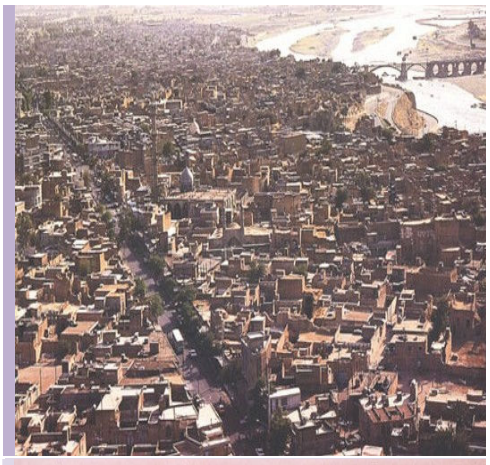
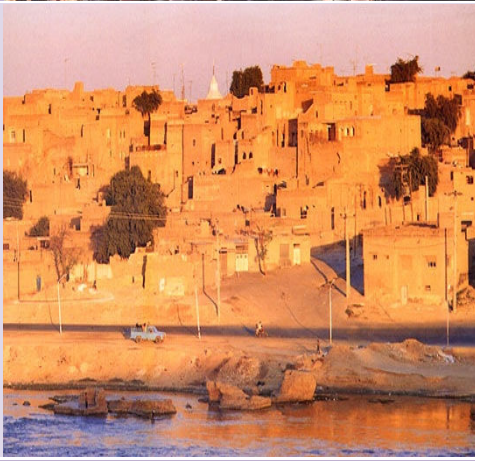
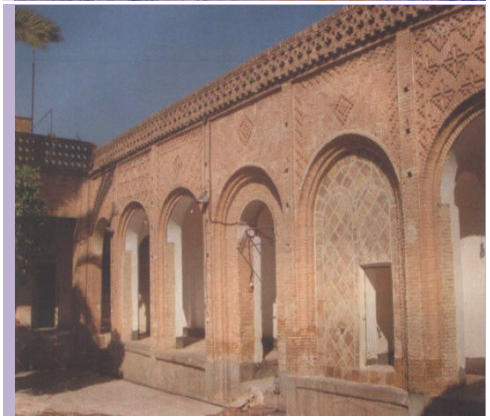
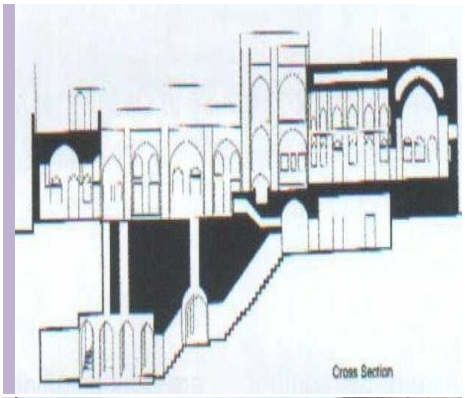
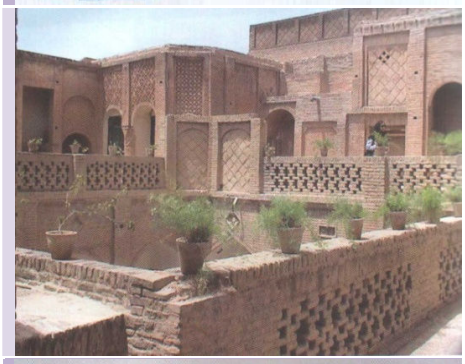
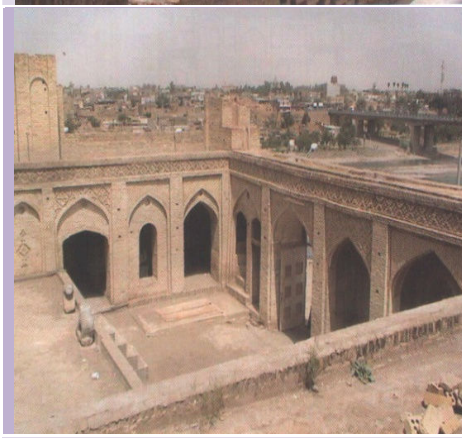
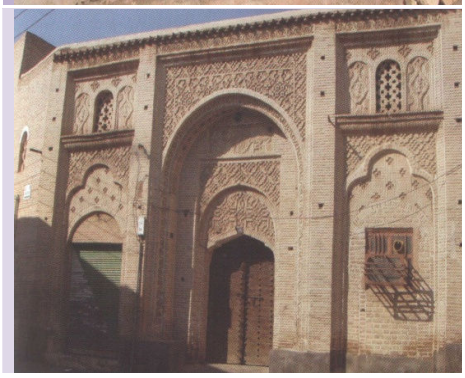
NO	OVERAL FORM OF THE BUIDLING IN HOT-DRY REGION	
1.	Semi-open urban spaces	
2.	Semi-detached buildings	
3.	Flat and convex roofs	

Table 8: Primary principles of the vernacular Iranian architecture in hot-dry region (continues)

No	OVERAL FORM OF THE BUIDLING IN HOT-DRY REGION	
4.	Deep basement	
5.	Inward-outward oriented buildings	
6.	Central courtyard	
7.	Construction materials: rubble, brick, adobe	

2.3.4 Specification of Architecture in Cool Regions

Although there is some diversity in the amount of coldness in different regions, particularly the principles for saving energy in buildings are similar to hot and dry climate except some differences. For instance, in the cool region heat supply is inside of the building. Inhabitants try to use the natural sources for heating the buildings in cool regions. Therefore, they use accumulation and compact plans for minimizing the external surface from covered volume. Furthermore, they use the material with high-quality thermal capacity. Moreover, residents in such a cool climate attempt to protect the buildings from cold winds and also keep the thermal heath inside of the buildings.

Figure 46: Modern street pattern have been laid over the irregular and narrow streets of the compact urban form of the traditional city of Kermanshah (Ghobadian.V, 2009)

2.3.4.1 Morphology and Urban Texture:

1. Small and compact settlement pattern

In this region weather is very cold during the most months of a year. Therefore, settlement pattern is compact and the majority of the buildings are connected

together. Thus, by connecting the buildings together the contact of the warm space of the building with the cold environment will be less. The settlement pattern of the city in such a cool region should be surrounded and be small till the cold wind could not penetrate through the city space (Ghobadian.V, 2006).

2. Location of the building is according to the sun radiation

Most of the buildings in the cool region are located in the middle and in the south side of the submontane, which has four reasons. Firstly, there is a danger of flood if they built their houses on the valley. Secondly in the night time the cold weather is heavy. As a result, the cold weather would be gone to the valley; therefore, this causes a lot of coldness to the buildings. Thirdly, the north side of the mountain is always shade and cold so it is not a comfort place for living. Finally, there are a lot of ground's unevenness on the upper part of the mountain subsequently this part of the mountain is not a comfortable place for living (Ghobadian.V, 2006).

3. Narrow Streets are located parallel to the ground level

In the cold region most of the districts of the city are connected together with corridor, which can protect the pedestrian from the cold wind during the winter time. These corridors are covered by roof and they create semi private space in front of the buildings.

2.3.4.2 The Effect of the Climate on the Building form:

1. Introverted Buildings with central courtyard

Traditional buildings in this region like hot and dry region of Iran have central courtyard. For using the maximum of sun radiation in the winter time, most of the rooms are located on the northern side of the courtyard. Inhabitants use the southern side of the building less than the other side. Because, in such a cool climate summer period is just two months and the temperature is temperate. The function of the

southern rooms and also the rooms, which are located in east and west, directions are used for storage or servant. Moreover, inhabitant use basement in the summer time, since it has low height and the weather is cooler than the part of the building.

2. Low height rooms

There is no any big space in the vernacular building of the cool region. Because, warming the extensive space in this cool region is hard so most of the rooms are small and they have low height roofs.

3. Flat roof

Most of the buildings have flat roof in the cool region of Iran. Because flat roof can keep snow works like an isolation element. However, there are some traditional buildings in the Northern side of Alborz Mountain, which have gable roofs.

4. Small opening

5. Small eyvan and courtyard

The size of the courtyard in this vernacular building is small; because the weather is cold in most months of a year. As a result, the main activities happen inside of the rooms. Particularly courtyard in this region is smaller than the hot and dry region.

6. Thickness of the walls

Walls absorb the heath form the sun radiation during a day and they preserve the heat till the night time. Consequently, thickness of the wall and fewer openings prevent the exchanging of the heat between inside and outside of the buildings.

7. The proportion of outer surface area to the volume of the building is less

One of the main dissimilarities between the architecture of hot and dry and the cool climate is about conducting the sun radiation through the building or employing much more energy from sun radiation. Subsequently, most of the walls of traditional house are painted in dark colors. Moreover, the size and the number of the windows

in this cool region are more than the buildings, which are located in hot and dry region. Particularly inhabitants in this region try to create less correlation between the surface of the building and the cold outside weather, in the manner that to protect the heath inside of the building. Consequently, the best volume for the buildings in this cool region is cubic and rectangular cubic; because the proportion of the outer space of the cubic and rectangular cubic is less than the inside volume of the building (Ghobadian.V,2006).

2.4.4.3 Type of Material

Traditional builders in this region used the local materials, which were available and accessible. Therefore, most of the walls are made by stone and also they use wood and thatch for covering the ceiling and roofs.

2.3.4.5 Case Study, Tabriz

For the cool climatic region in Iran, this research chose Tabriz city as case study which is located in North West part of Iran and has cool climatic conditions.

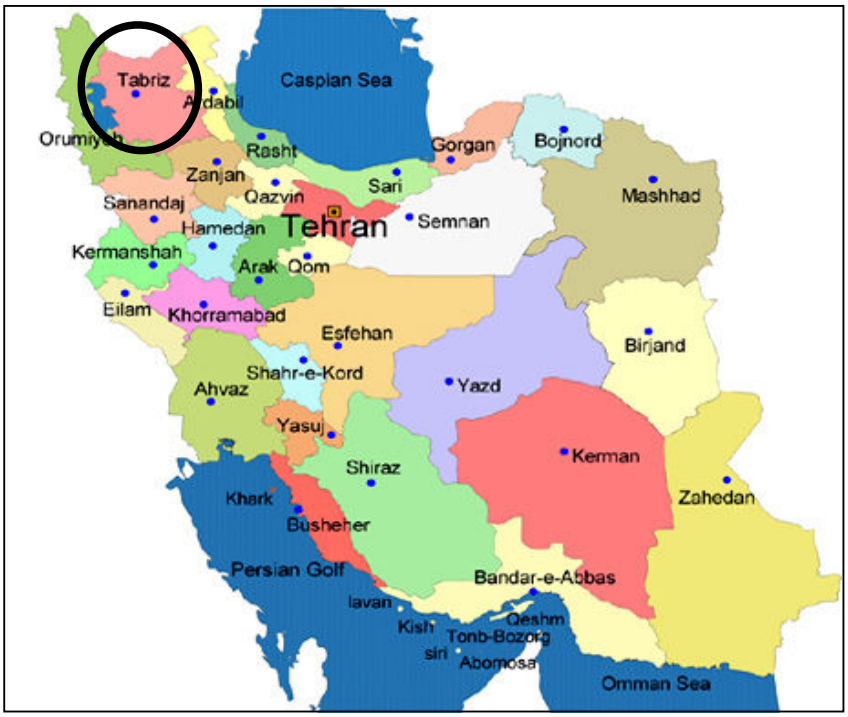


Figure 47: Location of Tabriz city in map of Iran (URL3)

Cold weather is the main climatic problem in this city. Therefore, the major concerns for the traditional builders of these high latitudes were to create a warm and comfortable environment for human activities. Consequently, the main factor for shaping the towns and villages in this region is to associate with cold weather climatic conditions. The main characteristics of the forms of the city in Tabriz had the following characteristics:

1. Dense and compact urban configurations

2. Enclosed urban spaces

3. Orientations of the urban fabric towards the southern winter sunlight

4. The importance of topography in the configuration of the urban fabric (Ghobadian.V,2009).

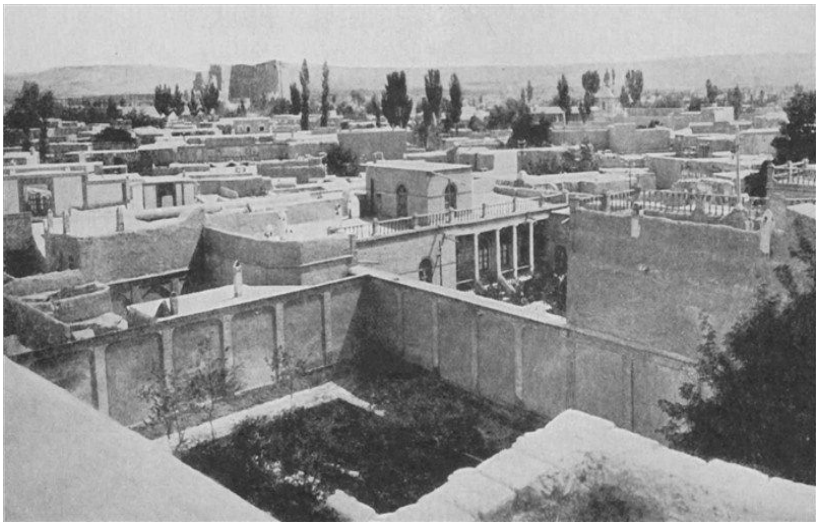


Figure 48: Enclosed urban spaces in Tabriz (URL7)

Middle of the southern slopes in the mountainous areas were the best location for setting the small towns or villages. That was because of the fact that the town or village could get a lot of benefit from solar heat in south direction in the winter time (Sultanzadeh.H, 1997). Furthermore, by locating the village or town in the middle of the mountain inhabitants could have access to the water, since they would be close enough to their respective rivers. In addition, living on the elevated part of the

mountain is not safe place to live. That is because; it is cooler than the other place and also elevated part is too far from the river. Consequently, elevated part of the mountain will not be a comfortable place for living.

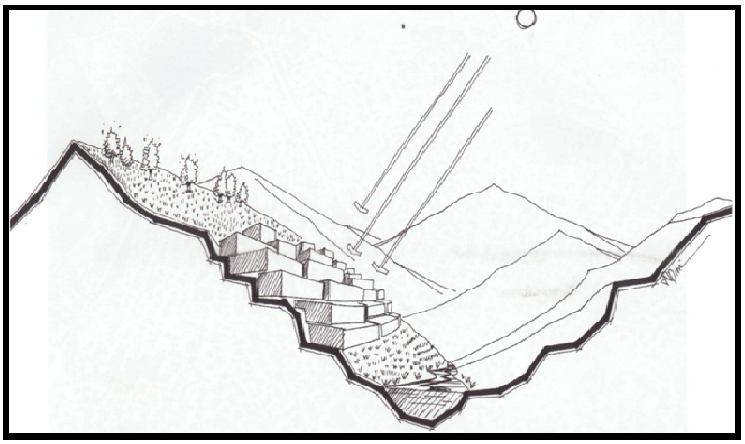


Figure 49: Villages in valley, stretch parallel to the ground contour line (Ghobadian.V, 2009)

Ghobadian in his research (2009) mentions that, the direction of the physical development and growth of towns was parallel to the contour lines of the topography. It means that the direction is directly horizontally developed to the particular slope. Moreover, the land between a settlement and a river would be used for agriculture. The topography can form the settlement and also it would be utilized as pasture for livestock. "Bigger town needed plateau or more or less flat area for development. They also needed solar heat and direct solar radiation. Therefore cities such as Tabriz (altitude 1349 m) for getting benefit from heat and direct solar radiation, is developed on the southern plains of the mountains in Iran" (Ghobadian.V,2009). This research finds these Behnam house and Gadaki house as case studies from cultural heritage organization of Iran (Kleiss.W, 1995 p.778).

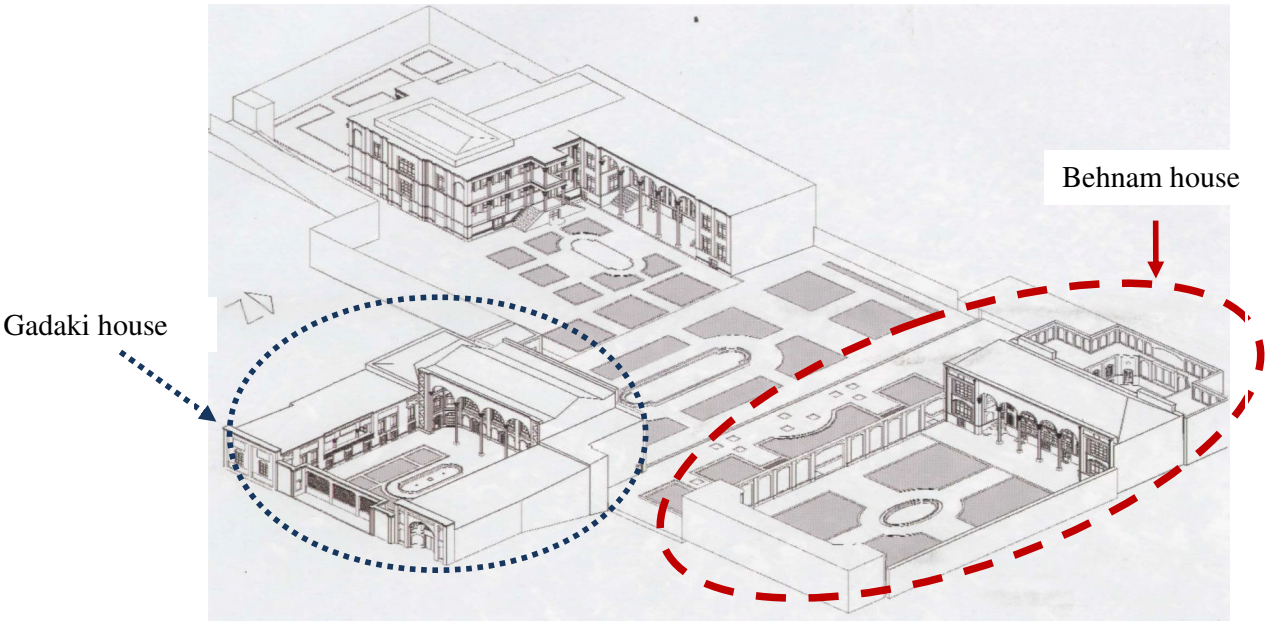


Figure 50: South east axonometric views of traditional buildings in Tabriz, from west to east Behnam house and Gadaki house, none of them has summer living quarter part (Kleiss.W, 1995)

Figure 51: One of the vernacular buildings (Behnam House) in Tabriz which has central courtyard, but no summer living quarter (Kleiss.W, 1995)

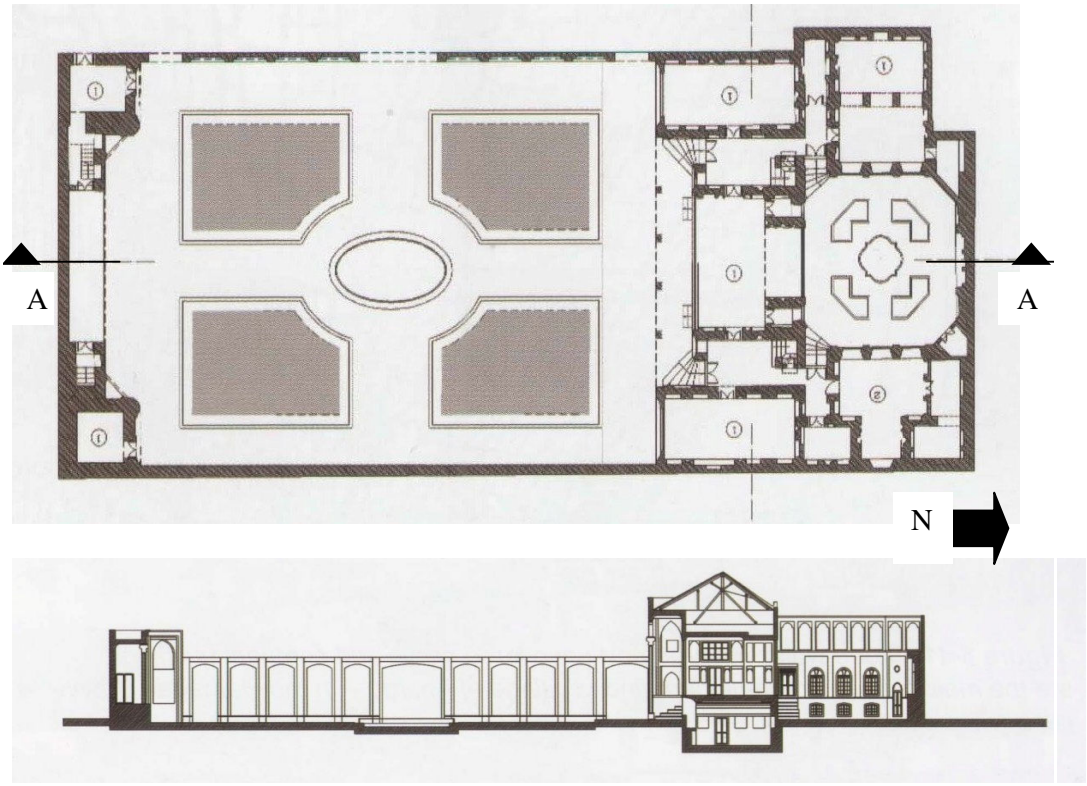


Figure 52: First floor plan and section A-A of Behnam House (Kleiss.W, 1995)

Figure 53: One of the vernacular buildings (Gadaki House) in Tabriz which has central courtyard, but no summer living quarter (Kleiss.W, 1995)

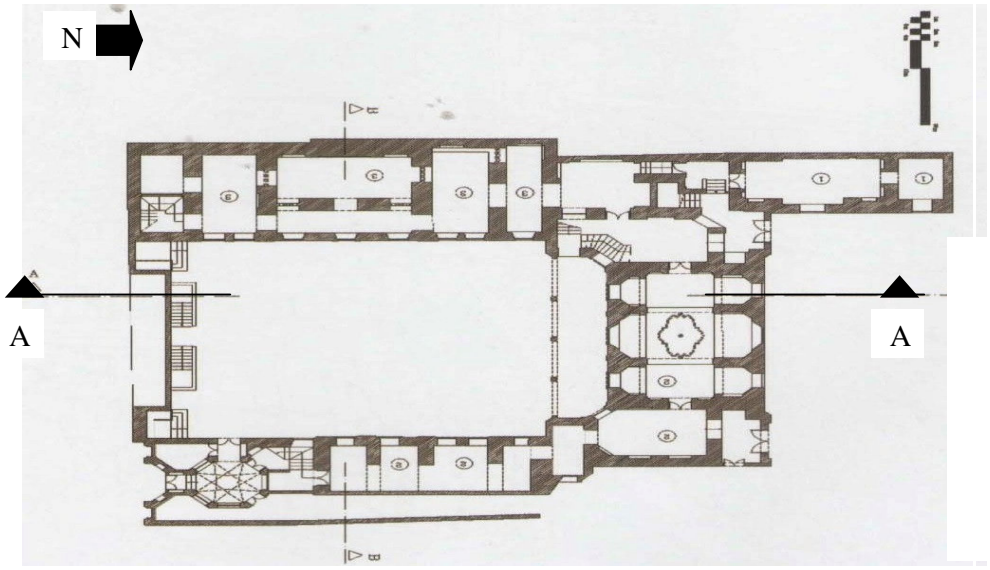


Figure 54: First floor plan of Gadaki House (Kleiss.W, 1995)

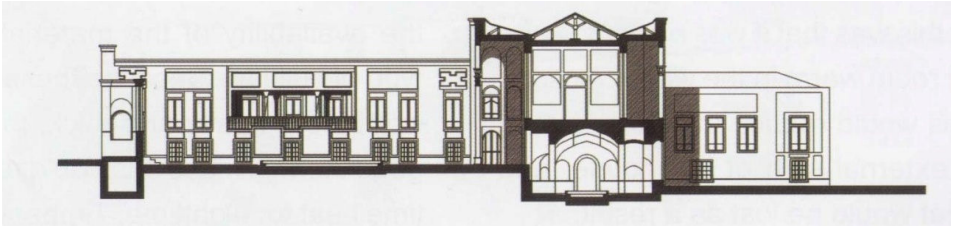


Figure 55: Cross section of Gadaki House (Kleiss.W, 1995)

The urban fabric in Tabriz was compacted and spaces were enclosed. Because, this compacted spaces was utilized for buildings to keep the heat in the winter time. Moreover, spaces would be protected against the winter winds. Buildings forms in this city were also designed according to the cold climatic conditions. Therefore, building form in Tabriz had the following characteristics;

1. Buildings were adjoined buildings
2. Buildings were inward oriented and had a central courtyard
3. Low ceiling
4. Flat roofs for houses
5. Small or no verandas
6. Thick masonry walls (Ghobadian.V,2009).

In two-story traditional houses in Tabriz villages, the ground floor was used for keeping animals, and the first floor used for living. If the vernacular house had only one floor and it was situated on a slope, afterward the stable would be at a lower level to the south (Ghobadian.V,2006). In this way, the inhabitants could look over the stable and have a view to the outside.

Most of the buildings in Tabriz are inward oriented and they had central courtyard**.** Conte De Sersi (1983) in his writing about Tabriz vernacular houses mentioned that there are high walls in streets of Tabriz city, where there is just one opening between them. This opening is appropriate for entering one person to the building. However when resident passes form narrow corridor, they will reach to the central courtyard, which is always full of trees and green area (Sersi, 1983).

In addition, most of the houses in Tabriz have one entrance door which has indirect approach to the buildings. Furthermore in Tabriz, some of the larger vernacular buildings have two parts, which are inward and outward oriented (Lafova.D, 1982).

Usually vernacular buildings in Tabriz to utilize the light, ventilation and view for the rooms have inward courtyard. Accordingly, Sultanzadeh claimed (1997) that in Tabriz vernacular buildings there are four different methods for situating rooms around the central courtyard. In the first method, buildings were constructed on three directions and wall situated on just one direction of the courtyard. In the second method, buildings are constructed in a perpendicular orientation just on two direction. In the third method buildings are constructed on the two parallel directions. Finally, in the forth method buildings are constructed only on one side of the courtyard.

In Tabriz city, the main parts of the buildings were constructed on the north direction of the courtyard. In so doing the rooms, which are located on the north can get a lot of benefit from sun radiation. Furthermore rooms, which are not significant, situated on the east and west directions (Ghobadian.V, 2009).

Sultanzade (1997) in his studies mentioned that, the main part of the building like *Panj-dari*, *Haft-dari*, Orosi and balcony were located on the main axis of the courtyard and the other spaces like *Seh-dari* in two other direction of the building. Furthermore, the secondary and service spaces were positioned at the back of the main parts and sometimes they are positioned on the corner of the courtyard. In Tabriz city, exactly like Yazd city, the entrance part of the vernacular building had vestibule and corridor. Traditional builders designed the entrance hall in a way that they protect the residents from unknown entry. In addition, entering form courtyard to the rooms has different ways. In the simple and primitive way in a small building, residents can enter directly from courtyard to the rooms. But in a medium and large house, the accessibility of the rooms from courtyard is not direct and simple. Hence, residents should use the connecting space for entering to the rooms. In this situation, Sultanzade (1997) mentioned that there are two types of designs. In the first one there is a corridor between the rooms and courtyards which make an accessible way to the rooms. It means that residents after passing from the courtyard should first enter to the corridor afterwards to the rooms. Mostly this kind of corridor has five entering doors. In some of the traditional houses, there is a room which works as a connecting space to the other rooms. The characteristics of this connecting space are like a hall, which can divide the movement to the rooms and other spaces.

Most of the vernacular buildings in Tabriz have simple volume compositions. In some of the vernacular buildings, several volumes of the buildings are elevated form

the ending point of building. There are some columnar balconies in some of the buildings, which are the important elements in the traditional building in Tabriz city. In some of the vernacular buildings in Tabriz, columnar balconies situated on the ground floor and in others positioned on the first floor. Moreover, in some further buildings, these columnar balconies with high height are located in front of the two floor buildings (Sultanzadeh.H, 1997).

Furthermore, Sultanzade (1997) mentioned that one of the special characteristics of the vernacular architecture in Tabriz is about the brick arrangement. Most of the surface of the buildings in Tabriz covered with special kind of bricks.

In the middle of Qajar period in Tabriz, residents used western ornamentation for designing the buildings. Therefore, they ornament on top of the column and the surfaces are influenced by the western method plaster. Moreover some of these decorations have the shape of the animal or human figure. Moreover, most of these shapes got the inspiration from nature.

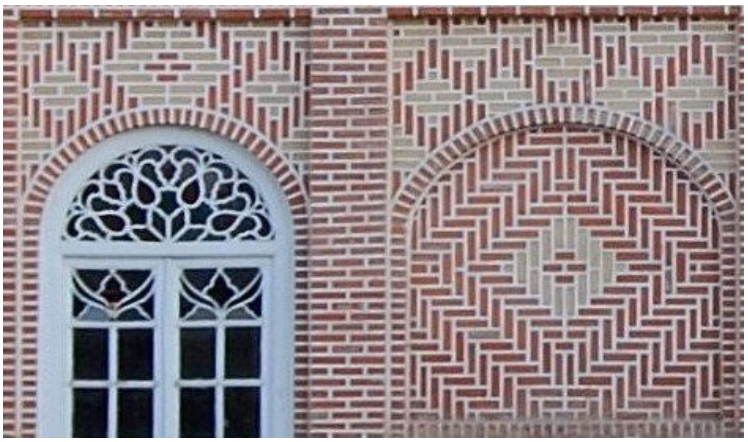


Figure 56: Ornamentation of vernacular buildings in Tabriz (Sultanzadeh.H, 1997)

2.3.4.6 Building Material

Similar to the other regions, the materials that were used for traditional buildings in Tabriz city were those which were easily accessible. For that reason, depending on

the availability of the material and the type of building, rubble or ashlars and occasionally brick or adobe were used for the walls (Ghobadian.V, 2006). Furthermore, these kinds of masonry walls were heavy and thick, and they could retain daytime heat for the nighttime; because they had a good thermal mass. Moreover, timber was used for the roofs of some of the traditional buildings in Tabriz city. Consequently the primary principles of the vernacular Iranian architecture in cool regions are as follow:

Table 9: Primary principles of the vernacular Iranian architecture in cool region

NO	OVERALL FORM OF THE BUILDING IN COOL REGION	
1.	Enclosed urban spaces	
2.	Adjoined buildings	
3.	Flat and convex roofs	
4.	Ground floor lower than natural ground level	

Table 9: Primary principles of the vernacular Iranian architecture in cool region (continues)

No	OVERALL FORM OF THE BUILDING IN COOL REGION	
5.	Inward oriented buildings	
6.	Central courtyard	
7.	Construction materials: rub, brick, adobe and timber	

2.3.5 Specification of Architecture in Hot and Humid Regions

The architectural principles in hot-humid climate are similar to temperate -humid climate. For instance, most of the buildings in such a climate are located in complete shade and also they have elongated and cover *eyvan*, which can protect the interior

parts of the building form the rain. Moreover, most of the buildings are counteracted with the material with the low thermal capacity (Kasmaee.M, 2003).

2.3.5.1 Morphology and Urban Texture

1. Settlement pattern in the city is semi compact

The pattern of the city in such a hot-humid climate is more compact rather than the country side which is because of, population growth, economic problems and high price of the land in the city.

2. Settlement pattern in the country side is semi-open

3. City space is semi-surrounded

The pattern of the city and countryside, which are located far away from the sea, are more surrounded like the old pattern of Khoramshahr which has 70 K distance from the sea (Ghobadian.V, 2006).

2.3.5.2 The Effect of Climate on Building Form

1. Semi-inverted buildings with central courtyard

In this region the majority of the buildings are inverted and most of the rooms are located around the central courtyard. The main differences between the houses in hot -humid and the houses in the hot-dry with cold winter climate are that, although they are inverted, they have a good connection with the outside area. For that reason, most of the buildings have long and wide windows and also they have extensive *eyvan* in second or third floor, which has a face to the alley (Ghobadian.V, 2006).Windows are facing to the central courtyard and another window is looking to alley; because with this method they can create cross ventilation, which causes decreasing the intensity of heath during the summer.

2. Minimum use of shade and natural ventilation

In the regions near to the sea, nearly all of the buildings have huge wind catchers for catching the sea breeze. However, in the regions far from the sea most of the buildings have small and short wind catcher. In this region, because of hot and humid weather, natural ventilation is not significant. Consequently, inside of the buildings, there is no any forecasting for draught of wind (Kasmaee.M, 2003).

3. Rooms with high height and long and wide window

The height of the rooms in this hot-humid region is more than the other climates. For instance, sometimes the highest rooms have height more than four meters. Mostly rooms in this climate have four meters since hot weather can ascend in the interior space. Subsequently, the temperature of the rooms will be decreasing. Furthermore, by putting windows on two sides of the room and under the roof, cross ventilating in the rooms would be occurring (Ghobadian.V,2006).

4. Extensive eyvan

In this climate, *eyvans* are very extensive and long. In addition, *eyvan* is a good place for ventilation. During a hot season most of the daily activities take place in *eyvans*, because *eyvan* is located in complete shade. Extensive *eyvans*, which are situated in one or two sides of the outer side of the buildings, mostly placed around the central courtyard. Consequently, it is one of the important spaces in the building.

5. No basement

Buildings in Bushehr have no any basements, because Bushehr has high humidity and shallow underground water. Consequently always the function of the ground floor is kitchen or storage. In such a hot-humid region inhabitant mostly lives on the first and second floor. For that reason, upper floors have good cross ventilation than the ground floor and also the upper windows are protected from pedestrian sight.

6. Flat roofs

Most of the buildings in this region have flat shape (Ghobadian.V, 2006).

2.3.5.3 Type of Material

In such a hot-humid climate inhabitant cannot use the material which could not preserve them from the heat, because of severe climatic conditions in this region. Therefore, wood is the best material in such a climate. Because, wood has ability to transfer the heath slowly and also wood can preserve the heat during a day and in the night time they lose the heath by blowing breeze. Therefore, wood will be cool in the night time. However, there is a lack of wood in such a hot and humid region. Therefore, inhabitant should use the local materials which are available and accessible. Consequently, residents mostly use wood just for windows, doors and roofs and they use high thermal capacity material for thick wall (Ghobadian.V, 2006).

2.3.5.4 Case Study, Bushehr City

Bushehr city which is located on south part of Iran has insufferable heat and humidity. Therefore, the best way in this city for keeping human in comfort condition by natural means is providing shade and ventilation for them. Consequently, the port towns and villages of this city are oriented south towards the sea (Ghobadian.V, 2009); because in this direction they can cool their building by utilizing the advantage of the air between the land and the sea. Furthermore, buildings can protect themselves from the intense of southern sunrays, by having deep awning verandas.

Figure 57: Location of Bushehr city in a map of Iran (URL3)

Ghobadian (2009) in his research claimed that, in general, the urban form of Bushehr city had the following characteristics:

1. Big cities were located near to the sea

2. Port cities and villages were oriented towards the sea and spread along the coastline

3. The urban form was semi-compact and semi-open

4. Urban spaces and streets were semi-open and mostly open on to the sea


Figure 58: Urban context of Bushehr city (Ghobadian.V, 2009)

The urban form in Bushehr city was something between Rasht city (temperate-humid climates), Yazd city (hot-dry with cold winter climate) and Tabriz city (cool climates). This means that the context and density of Bushehr city was not open as Rasht city and not dense or compact as Yazd and Tabriz city. In so doing, Ghobadian (2009) claimed that Bushehr city does not have many trees. Therefore, the open and spread out urban spaces could not be protected from solar radiation. Consequently, the buildings had to be close enough to each other in order to provide shade in the streets and the public spaces. In addition, if the urban form was very compact like Yazd and Tabriz cities, subsequently there would not have been sufficient airflow. As a result, stagnant humid air would settle in the enclosed spaces of the city. Consequently, there would have been a very uncomfortable place for any kind of human activities.

Moreover Ghobadian (2009) in his research mentioned that in Bushehr city the inhabitants prefer to live near to the sea because of several reasons. Firstly, the company of the region depends on the sea trade and fishing, since there was not a lot of agriculture or industrial activity. Therefore, living close to the sea was considered to be a great advantage for inhabitants. Secondly, another advantage is related to the climatic conditions. This means that inhabitants can get the benefit from the air between the land and the sea. Consequently, buildings which are located near to the sea can get a lot of benefit from the sea.

As this research mentioned before, buildings in Bushehr are detached or semi-detached, the reason for that is to creating cross ventilation inside of the buildings. In Bushehr city with hot-humid climate, both internal and external elevations were significant and articulated. Conversely, vernacular buildings of the two previous

regions such as hot-dry with cold winter and cool region that were inward looking and only the elevations around the courtyards were important and articulated.

Memarian (2006) in his studied claimed that in the old pattern of Bushehr city, most of the buildings extended in height; because during a hot period of a year the high ceilings and windows would allow the air to circulate in the interiors of the buildings. Therefore, mainly most of the buildings in Bushehr are two or three floors. Moreover, big and spacious verandas provided shade and a pleasant place for the rest of the activities in the summer time.

Most of the buildings in Bushehr city were approximately about one meter above the ground level, which is the reason of high subterranean water tables. In addition, humid air is heavy, therefore it could settle on the basement. Subsequently, the air will be stagnant on the basement. As a result, the basement could not have been a good place for any kind of human activities or even as a space for storage in such a hot-humid region (Ghobadian.V, 2009).

Entrance of the vernacular buildings in Bushehr, like the other cities in Iran, directly invites the people to inside of the buildings. Entrance door is mostly built in a simple or complicated form. In addition, the entrance door in Bushehr city have opening on top of the door, which these kinds of openings are being able to receive the light and also they can work as a ventilator. Furthermore, these openings built with different kind of material, such as wood, stone and iron (Memarian.GH, 2006).

Memarian (2006) in his research mentioned that in most of the vernacular buildings in Bushehr, entering to the courtyard is directly from entrance door, which is positioned on the corner or middle of the central courtyard. Moreover, according to the needs of inhabitant and type of the buildings, the function of the courtyard is different. For instance in small and simple building the central courtyard have small

pool, garden and well. In addition, the dimension of the courtyard depends on the building dimension, but mostly the area of the central courtyard is approximately around one or two square meter. Moreover, spaces in vernacular building of Bushehr city are organized according to the central courtyard.

Vernacular buildings in Bushehr have two types of rooms: winter and summer rooms. Mostly the summer rooms are located on the first floor and winter room are situated on the ground floor or a little below the ground level. Winter rooms have little openings to be warmer than the other rooms in cold period of a year. As opposed to this, summer rooms are the spaces, which have a lot of openings in different directions. In some of the vernacular buildings, summer rooms can work as a wind tower; because it has sixteen opening in four sides of the rooms. In addition, some of the vernacular buildings in Bushehr' city have summer rooms, which have, *seh-dari*, *chahar-dari*, *panj-dari*, *shish-dari*, *haft-dari*, *hasht-dari*, *dah-dari*, *davazdah-dari*, *shanzadah-dari*. This kind of summer Rooms with different ways have some connections to other spaces. For instance, the rooms which are located on the ground floor have direct ways to the courtyard. Moreover, for connecting the different spaces, *Tarme* (the balcony between the spaces) is the easiest way (Memarian.GH, 2006).

Memarian (2006) in his research mentioned that the meaning of *Tarme* in vernacular architecture of Bushehr is linking. Particularly, *Tarme* is a kind of place, such as balcony, which is mostly common in Iranian architecture. Furthermore, occasionally *Tarme* is open just from one side. Sometimes *Tarme* does not have any roof, except most of the times it has a roof. Mostly residents use *Tarme* as a seasonal temporary hall. Therefore, the main function of *Tarme* is seasonal hall. Furthermore,

inhabitants use *Tarme* as a connecting space in their buildings. Consequently, *Tarme* in these types of vernacular building has a role like corroder.

The size of the *Tarme* is depending on a dimension of the building. For instance, width of the *Tarme* is approximately as same as the width of the double staircase. Sometimes the size of the *Tarme* is as same as the width and length of a room or even more than one room. Therefore, the size of the length and the width of the *Tarme* are variable. Moreover, *Tarme* has variable shape but the simple shape of *Tarme* is square or extensive rectangle, which can be combined together as an L or U shapes. Also some of the *Tarme* has a trapezium shape (Memarian.GH, 2006).

In addition, Memarian (2006) mentioned that *Shenashil* in vernacular building in Bushehr has a lot of functions. At first *Shenashil* is a place for utilizing the breeze of wind flow. In addition, the houses which are located on the south coasts, the view of Persian Gulf from *Shenashil* can be seen. Furthermore, *Shenashil* can be built in one or more different sides of the first floor. Moreover, there are some kinds of *Shenashil*, which have wooden shading element. These shading elements can take the sea breeze inside of the house and also they can protect the interior of the building from direct sun radiation.

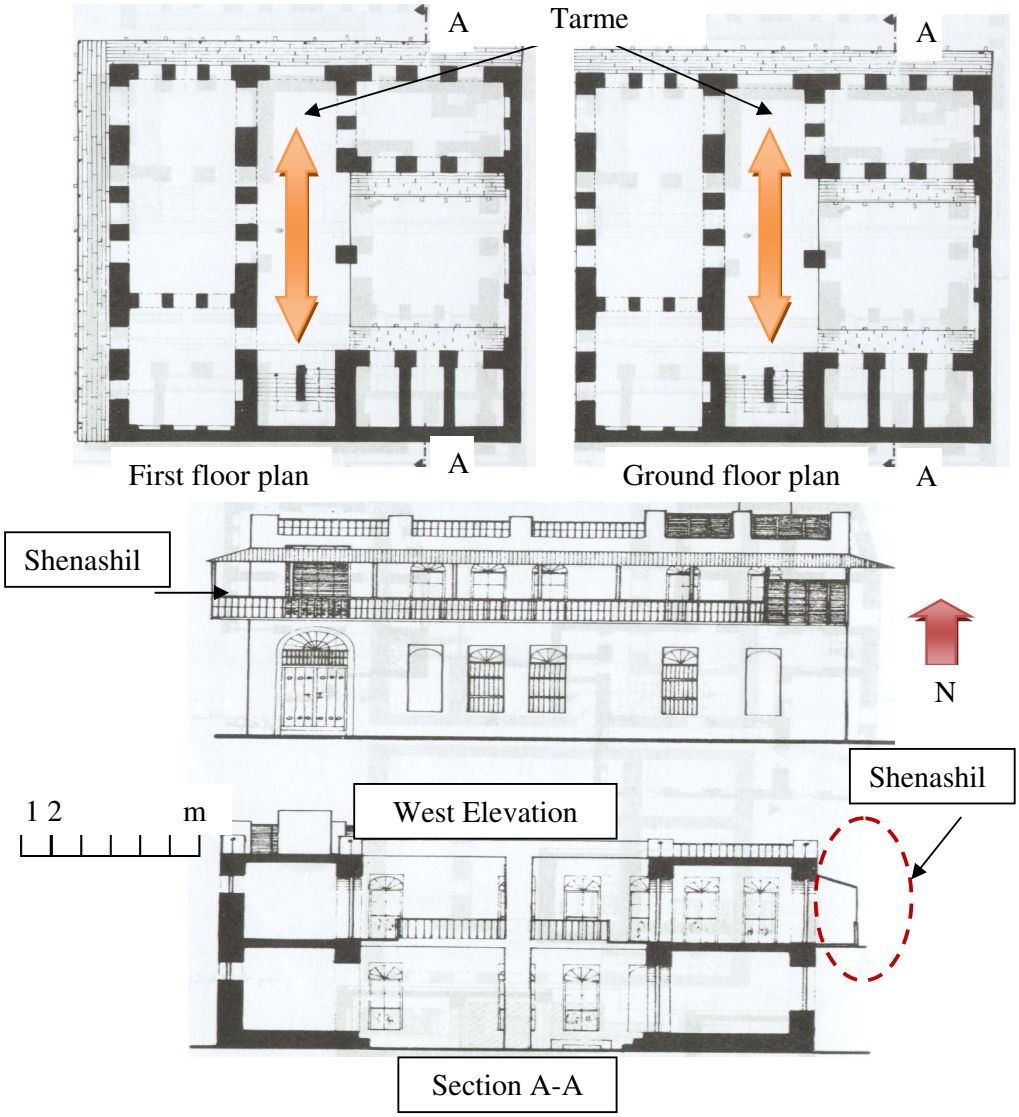


Figure 59: Positions of Tarme and Shenashil in one of the vernacular buildings in Bushehr (Memarian.GH, 2006)

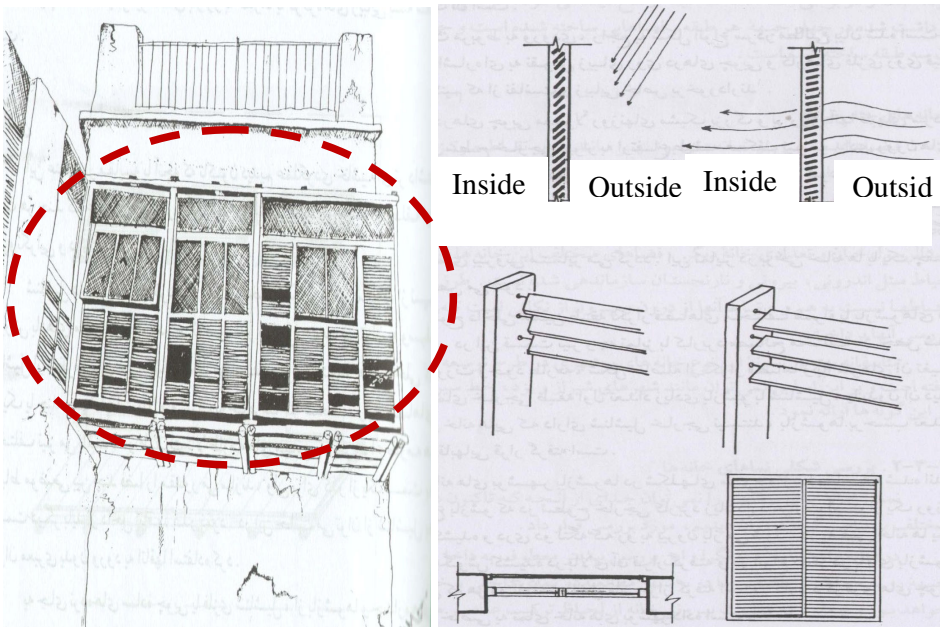


Figure 60: Most of the Shenashil Preventing the interior from direct sun radiation and also allowing appropriate wind flow to come inside (Memarian.GH, 2006)

Shenashil has two different types: with cover and without any covering. In the second type, the wooden roof will cover the whole or part of the *Shenashil* or just cover the openings. The load of the wooden roof will be on the small diagonal wooden column. Furthermore, the dimension of the *Shenashil* is diverse, from two to twenty meters. *Shenashil* has an extensive rectangular shape, which can be as an L shape according to the situation on the interior and exterior of the building. Moreover, some of the vernacular buildings in Bushehr have *Shenashil* on whole part of the interior facades (Memarian.GH, 2006).

As this research mentioned before, most of the vernacular buildings in Bushehr are extending in height. Therefore, the staircase is one of the important elements in these kinds of vernacular buildings. The staircase on the ground floor has approximately two meters width and it can work as a connection element between the courtyard and the spaces on the ground floor. The width of the staircase on the first floor is approximately one to eight meters and mostly it has spiral shape. Furthermore, most of the time, staircase of the ground and the first floor are located

in *Tarme* (Memarian.GH, 2006). In addition, vernacular buildings in Bushehr have other spaces like kitchen, storage and well, except these spaces.

Furthermore, Memarian (2006) mentioned that, spaces in most of the vernacular buildings in Bushehr are located on one side of the courtyard. However, on the bigger and aristocratic houses, spaces are divided into some inside and outside courtyards. Unfortunately most of the houses, which have these kinds of situation, are now destructed. The different spaces of one courtyard houses are like this;

1. Spaces are just situated on one side of the courtyard

In some of the vernacular buildings which have one or two floors, the rooms and *Tarme* are located on one side of the courtyard. The simplest design of such a building has two rooms and one *Tarme* in between these rooms. In addition, the staircases of this kind of building are mostly located on courtyard or in *Tarme*.

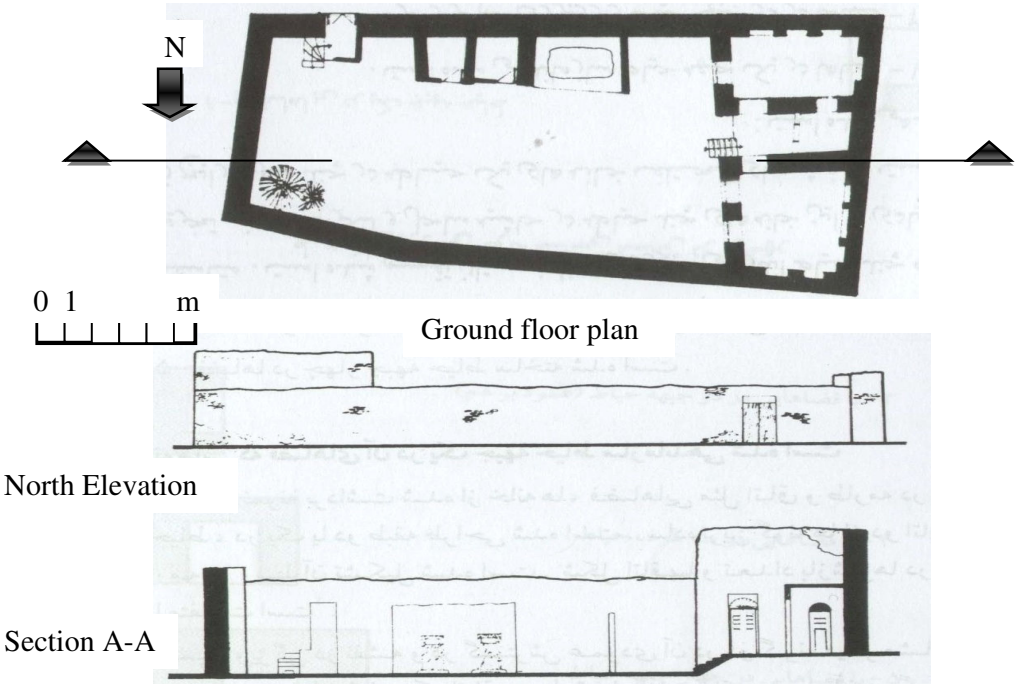


Figure 61: Vernacular building situated just on one side of the courtyard (Memarian.GH, 2006)

2. Spaces are situated on two sides of the courtyard

In this group, different spaces are located in front of each other on two sides. One of the reasons of this kind of design is small width of the buildings. Design of the vernacular buildings with these kinds of situations has some characteristics. For instance, one side of the building has two floors and the other part has just one floor. In addition, the staircases in these kinds of buildings are located in *Tarme* and also the area of the courtyard is below the area of the ground floor.

3. Spaces in a perpendicular shape are positioned on two sides of the courtyard

These kinds of houses were extended in height with variable shapes. The reason for extending in height is that, in a hot period of a year, building can receive the appropriate wind flow from the opening. Consequently, most of the rooms on the first floor have a lot of openings. Moreover, the staircases in these kinds of buildings are situated in courtyard or in *Tarme* or in a closet space. In addition, *Shenashil* is constructed on the exterior and interior facade. Moreover, the plan of the ground floor is somehow same as the plan of first floor (Figure 62).

4. Spaces are situated on three sides of the courtyard

These kinds of houses have one or two floors. The first floor of some of these houses has less or same spaces in relation with ground floor. In addition, the important characteristic of these kinds of buildings are like this:

Tarme have an important element in these kinds of houses. The staircase mostly located in *Tarme* or closet space. Moreover, in some of the vernacular houses with two floors, the ground floor has different spaces such as, winter rooms, storage, well and *Tarme*.

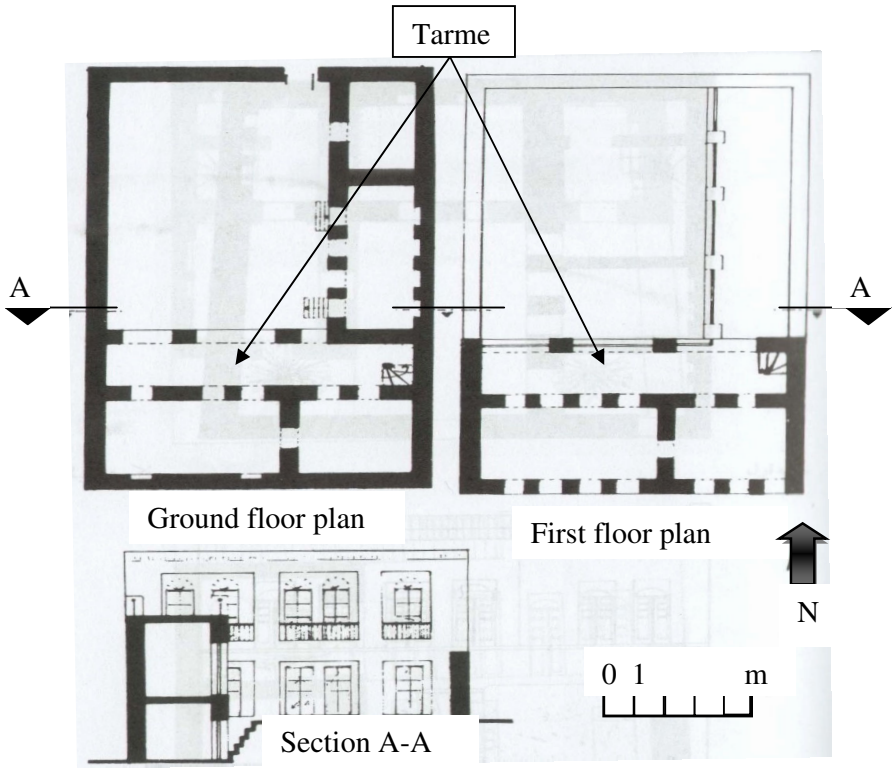


Figure 62: Vernacular buildings are situated on two sides of the courtyard in the perpendicular shape (Memarian.GH, 2006)

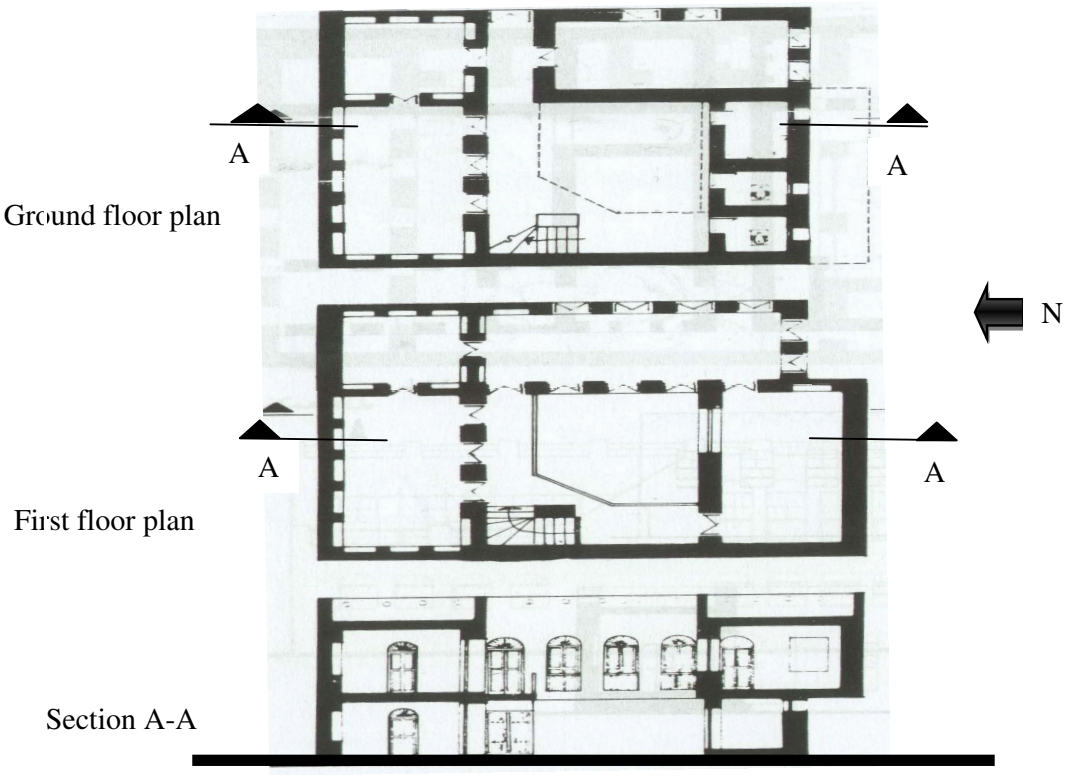


Figure 63: Spaces are situated on three sides of the courtyard (Memarian.GH, 2006)

5. Spaces are situated on four sides of the courtyard

There are two types of buildings in this group. One of them has spaces on four sides of the ground floor and there are just a few spaces on the first floor. Furthermore, spaces are constructed completely on four sides of the ground and first floor. In some of the vernacular buildings, ground floor are composed of variable spaces like winter rooms, storage, well, kitchen, entrance, corridor and *Tarme*. Moreover, Courtyard in these kinds of houses has important elements. Hence for creating the summer part in some of the vernacular buildings courtyard is constructed on one or two sides of the first floor (Memarian.GH, 2006).

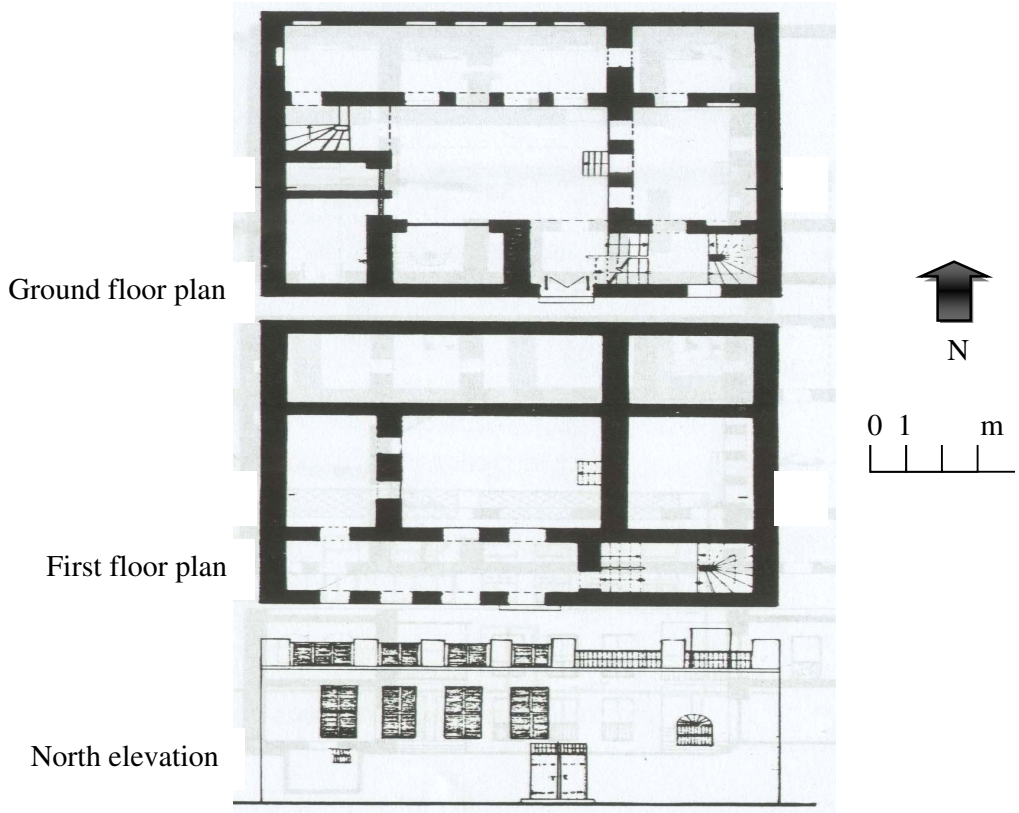


Figure 64: Spaces are situated on four sides of the courtyard (Memarian.GH, 2006)

One of the special architectural characteristics in vernacular buildings in Bushehr city is Central courtyard. Central courtyard in this kind of building is significant since there are some periphery spaces around central courtyard. Furthermore central

courtyard has a direct connection to the outside with two elements like *Tarme* and *Shenashil* (Ghobadian.V, 2009).

According to the hot and humid climate of this city, there are a lot of opening on the exterior and interior facade of the buildings which have some connection to central courtyard. Accordingly, by having opening on the exterior façade and central courtyard on the centre, cross vitiation will occur. Consequently, central courtyard works as an artificial ventilator. In addition, *Tarme* and *Shenashil* also can work as an artificial ventilator (Memarian.GH, 2006).

2.3.5.5 Building Materials

Ghobadian (2009) in his recently research claimed that, in hot and humid region like Bushehr city, using the wooden material is the best. Because wood has very low thermal mass, so it does not retain the day time heat. Otherwise wood can radiate the heat back at night. Furthermore, wood and plant are the most common materials in vernacular buildings of Bushehr city. In addition, in Bushehr is depended on which material was more available and the importance of the building, the walls were built with stone, brick, adobe, or coral stones. Moreover, roofs were built with timber and covered with palm tree fronds tied with ropes and twenty centimeter layer of a mixture of mud and straw. Consequently, the main characteristics of building forms in this hot-humid region can be described as follows:

Table 10: Primary principles of the vernacular Iranian architecture in hot-humid region

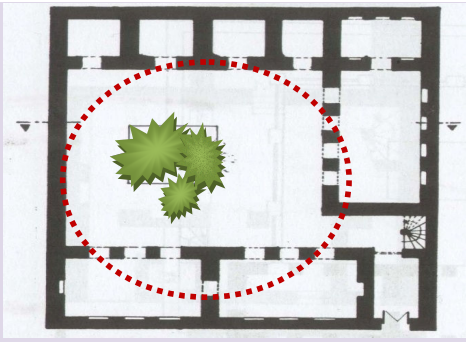
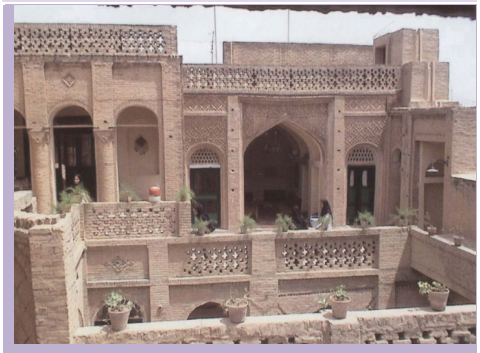
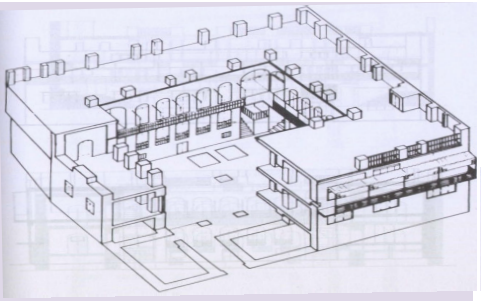
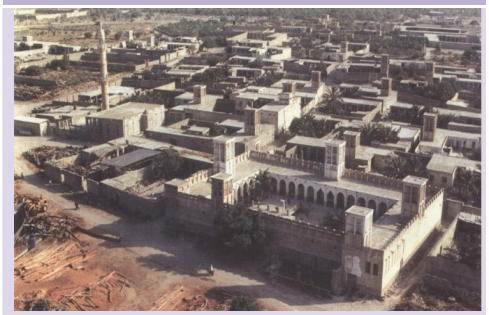
No	OVERALL FORM OF THE BUILDING IN HOT-HUMID REGION	
1	Detached or semi-detached buildings	
2	Central courtyard	
3	Partly inward oriented	
4	High ceiling and windows	

Table 10: Primary principles of the vernacular Iranian architecture in hot-humid region (continues)

No	OVERALL FORM OF THE BUILDING IN HOT-HUMID REGION	
5	Big and spacious verandas	
6	Mostly flat roofs	
7	Buildings were raised about one meter above the natural ground, mostly without basements	

2.4. Comparison of Iranian Vernacular Architecture Elements in Different Climates

2.4.1 Settlement Pattern

In the cold and hot-dry with cold winter regions of Iran, settlement patterns are more compact than the others. For that reason, in these kinds of climates compact settlement pattern has some advantages. Firstly, enclosure urban spaces in hot-dry with cold winter climate can help the city against the harsh climate; because it would

be creating comfortable environment for residents of this city. Secondly, less outside surface of the buildings would be exposed to the outside conditions and therefore less heat transfer would occur in the winter time. Consequently, building can lose heat less.

In addition in the cool region where the weather in most of the month is cold, the compact settlement pattern can keep the space of the building warmer, since the contact of the interior space of the building with cold environment will be less. Consequently, the best settlement pattern for protecting the buildings form cold wind is to be compacted and surrounded.

Conversely, in temperate-humid region of Iran, the settlement pattern is open and wide; because in such a region the relative humidity is so high. Therefore, for having better natural ventilation in the city, building should be detached from each other. Finally, the settlement pattern in hot and dry and hot-humid region is between the temperate-humid, hot-dry with cold winter and cool region of Iran. For the reason that, the urban context of this region was not as open as temperate-humid and not as dense or compact as hot-dry and cool region. Furthermore, hot and humid region does not have many trees. Therefore the open and spread out urban spaces could not be protected from solar radiation. Consequently, the buildings had to be closed enough to each other in order to provide shade in the streets and public spaces. Furthermore, if the form of the urban were very compact, as in the hot-dry with cold winter and cool region, subsequently there would not have been sufficient airflow, and stagnant humid air-compared to dry air would settle in and fill the enclosed spaces of the city. As a result, the settlement pattern in this region is diffused and semi-open.

2.4.2 Configuration of the Building

One of the main dissimilarities between the architecture of hot and dry with cold winter and cool climate is about conducting sun radiation through the building or employing much more energy from sun radiation. Therefore, most of the walls in cool climate are painted in dark colors and also the size and the number of the windows are more than the buildings, which are located in hot and dry with cold winter climate. Particularly, in this region, for preventing the heath inside the building, inhabitants try to create less correlation between surface of the building and the cold outside weather. Consequently, the best volume of the buildings are like cubic and rectangular cubic that the proportion of the outer space is less than the inside volume of the buildings. However, hot-dry with cold winter region has harsh climatic condition, which is so hot during the summer period and also it is cold during the winter time. Moreover, hot-dry with cold winter climate has low relative humidity. Therefore, the configuration of the building in hot-dry with cold winter climate is like a rectangular shape which has a hole at the centre of it. Furthermore, this central courtyard can work as a ventilator for the building during the hottest period.

Conversely, configuration of the building in temperate-humid is totally different than the other climates. Because the configurations of this type of buildings are open and wide plan with geometrical, long and narrow forms. So they can lead the maximum wind flow through the buildings. Most of the buildings are located according to the sea breeze direction for receiving the maximum breeze from the sea while in the other part of the city which has an intense and undesirable wind, they designed the building in a way to ban wind flow. Moreover in hot- dry and hot-humid, the configuration of the buildings are between temperate-humid and hot-dry

climate of Iran. That is because, the building form in this hot and dry region has a sense of having central courtyard like the building in hot-dry with cold winter region and also it has a lot of openings both around the central courtyard as well as the exterior walls of the buildings like the vernacular buildings in hot-humid. Accordingly, most of the buildings in these regions were semi-detached. Therefore, cross ventilation was possible in them during the hot months of the year. Moreover, in hot-humid as well as hot-dry region most of the buildings are detached or semi-detached, the reason for that is to creating cross ventilation inside the buildings. Consequently, the configuration of the building in this hot-humid region is rectangular shape, which is extended in height because the high ceilings and windows in summer would allow the circulation of greater volumes of air in the interiors.

2.4.3 Roof

One of the main differences between the buildings which are located in temperate-humid and the other climate of Iran is according to the shape of roof. Since, there is a lot of rain during a year in temperate-humid region. Therefore, most of the buildings have slope roof. These slope roofs work as an umbrella to cover the balcony all around the buildings.

However, in hot-dry with cold winter, hot-dry, hot-humid and cool climate of Iran the majority of the buildings have flat roof. Because in the cool region, these flat roofs can keep the snow on top of it. As a result, the snow can work as an isolation element to protect the heat inside the buildings. Although in hot-dry with cold winter and hot-dry climate there is a small amount of rain in most part of the region. So, there is a lack of wood. Therefore most of the roofs have dome or flat shape. Traditional builders made these roofs by mud bricks. Additionally, in hot-dry with

cold winter climate some of the buildings have semi-lunar dome. That is because, in such a hot and dry climate, this kind of roof can decrease the heat when there is sun shine on the roof and also during the night heat reflected form the roof would remove faster. Nevertheless, in hot-humid region there is not any dome shape roofs and most of the buildings have flat shape.

2.4.4 Eyvan and Courtyard

In temperate-humid climate, most of the buildings have balcony all around the building. Therefore, these balconies which were built in front of the room can protect the rooms form rain. In addition these kind of balconies can have different functions during the seasons; for instance inhabitant use them as a resting and working area in most of the months in a year and also in such a climate, balconies are useful for maintaining the agricultural products in the cold months of the year. In such a climate, most of the buildings have courtyard in front of the building. Furthermore, in cool region of Iran most of the buildings have central court yard, which the size of is small, because the weather in most of the months is cold. Therefore, the main activities will happen inside the rooms. Particularly courtyard in cool region is smaller than the hot and dry region and also the depth of the *eyvan* is less than the hot and humid region. Moreover, in hot-dry and hot-dry with cold winter regions of Iran, large *eyvan* are situated toward the cool streams in warm and dry areas. Those *eyvans* can provide a favorite weather in the afternoon.

In addition, in hot-humid like hot-dry climate, *eyvan* is a good place for ventilating and it is one of the important spaces in the building; so they are very extensive and long. Furthermore, during a hot season most of the daily activities take place in *eyvans* because *eyvan* is located in complete shade. Extensive *eyvans* where

are in one or two sides of the outer side of the buildings, mostly placed in the south and around the central courtyard which is always shade.

2.4.5 Basement

In temperate and humid region of Iran most of the buildings don't have any basement. Because of humidity that can penetrate in to the basement. In addition, the space of the basement is not a comfortable place for inhabitant and also it is not safe for storing; because everything will decay. Furthermore, there is a high humidity and shallow underground water in hot-humid region of Iran like temperate-humid. Consequently, always in such a climate inhabitant lives on the first and second floor and the function of the ground floor is kitchen or storage. However, in hot-dry climate because of harsh situation of the hot weather, the basement is dipper than the hot-dry with cold winter climate. Furthermore, in these climatic situations, Basement has high relative humidity and coolness compared to the upper floor. Consequently, inhabitant used this space in the summer, especially in the afternoons. Furthermore, in cool region of Iran like hot-dry and hot-dry with cold winter, inhabitant use basement for sleeping during the summer time because the height of the basement is low therefore the weather on that part is cold during the summer. In contrast, with other climatic region, in hot-dry and hot-dry with cold winter regions of Iran, basement is an important space of the building.

2.4.6 Ground Floor's Slab Elevated from Ground

There is high humidity and shallow underground water in temperate-humid region of Iran. Therefore, most of the buildings, for protection from humidity, should be built above the ground level. Furthermore, in hot-humid region of Iran like temperate-humid most of the buildings were approximately about one meter above ground level, which is because of high subterranean water tables. In addition, humid

air is heavy, so could settle on the basement and the air will be stagnant on the basement. Therefore, a basement could not have been a good place for any kind of human activities or even as a space for storage. However, in hot-dry and hot-dry with cold winter and cool region of Iran, building's level and especially courtyard level is lower than pedestrian level. Moreover, because of low relative humidity in these climatic conditions, as opposed to the temperate-humid, most of the buildings were built below the ground level.

2.4.7 Extroverted and Introverted Buildings

The extrovert buildings should be prevented from wind and allow sun in the coldest month of a year and also prevent sun during the hottest period. As a result most of the buildings in temperate-humid region of Iran are elongated toward the East-West directions. One of the best ways for controlling humidity in this kind of region is employing wind flow and natural ventilation. Despite introvert buildings in hot and dry with cold winter region, which are recessed inside the ground and four sides of the buildings, are enclosed with long walls. Furthermore, in hot-dry with cold winter region of Iran most of the buildings are inverted and they have central courtyard. The buildings in such a climate envelope surround the central courtyard and also for protecting the building from outside harsh climate and especially from dust storms, most of the vernacular buildings are oriented toward south to southeast directions which is mostly shade. Inside the courtyard, there is a pool, with a fountain, and plants and trees. Consequently, in summer time the micro climates inside the courtyard is relatively more humid and cooler compared to the hot and dry macro climate of the outside. Moreover, traditional buildings in cool regions like hot and dry with cold winter region of Iran have central courtyard. Most of the rooms in cool regions of Iran, for maximum usage of sun radiation in the winter time, are

located on the northern side of the courtyard and also they are big and extensive. Inhabitants use the south side of the buildings lesser than the other sides. Because in such a climate, summer period is just two months and the temperature is temperate. The function of the southern rooms, as well as the rooms, which are located in east and west directions, is to use them for storage or servants.

On the contrary, in temperate-humid climate, most of the buildings are extroverted and they are projected from ground. It means that most of the buildings are open from two or four sides and they are built above the ground level.

Moreover, as opposed to the two regions of Iran, which are hot-dry with cold winter and temperate-humid in hot-dry and hot-humid regions, both introverted and extroverted buildings are existed. Most of the buildings in hot-humid region, for creating cross ventilation inside the buildings, are detached or semi-detached. Unlike the buildings in hot-dry with cold winter region that were inward looking and only the elevations around the courtyards were important and articulated, in hot-dry and hot-humid regions , both internal and external elevations were significant and important.

2.4.8 Height of the Ceiling

Temperate-humid region of Iran have moderate climatic condition; therefore, the height of the building is approximately around three meter. Furthermore, in cool region of Iran, because of cool climate warming, the extensive space is hard so there is not any big space in the building and moreover most of the rooms have low height roofs.

In addition in hot-humid region of Iran, compared to the other climates, the height of the rooms in this region is more than the other climatic region. Because in such a climate hot weather can ascend in the interior space subsequently the

temperature of the rooms will be decreasing. Therefore, most of the buildings have 4m height. The height of the building in hot- dry with cold winter and hot-dry climate is influential on the absorption of sun radiation. Because increasing the height causes the façade to be exposed to sun radiation. Furthermore, sun radiance is more on horizontal surfaces than vertical surfaces, so it is better to decrease roof surface and increase walls' surface. Additionally, providing shadows for walls is so much easier than providing shadows for the ceilings. Moreover, in order to control sun radiation in this climate, buildings in the southern area should be built above the northern area.

2.4.9 Thickness of the Walls

In hot-dry with cold winter, hot-dry and cool climatic regions of Iran thickness of the wall works as an important element. For that reason in these region, the huge walls which mostly made by Adobe and brick have approximately thickness about one meter. This much thickness can create the comfort condition for inhabitants; because they lose the heat through transferring and radiation during night. Therefore, its temperature remains in low and average degree during the day. Furthermore, in cool region of Iran, wall absorbs the heath form the sun radiation during a day and they preserve the heath until night time. Consequently, thickness of the wall prevents the heath to be exchanged between inside and outside of the buildings. However, in two other climates, temperate-humid and hot-humid, thickness of the wall is not that much significant.

2.4.10 Material

In temperate-humid region of Iran most of the buildings were built with the materials which have minimum thermal capacity, and if they use the heavy material then they try to use the material with the minimum thickness; because heavy material

can decrease the draught and ventilation, which is necessary for this region. Therefore, in this region the majority of the buildings were built by wooden material. Furthermore, because of severe climatic conditions most of the buildings in hot-dry and temperate-humid region of Iran are built with the material that cannot preserve the heat although wood is the best material in such a climate. Because wood has ability to transfer the heath slowly also they can preserve the heat during a day and in the night time by blowing breeze and they lose the heath; therefore wood will be cool in the night time. But unfortunately there is a lack of wood in such a hot and humid region so inhabitant should use the local materials like brick which are available and accessible. Consequently, residents mostly employ wood just for windows, doors and roofs and they use high thermal capacity material for thicker walls. Moreover, in cool regions of Iran, inhabitants use the stone for covering the ceiling and also they use wood and thatch for roofs. Finally in hot-dry with cold winter region the best material for constructing the building is mud, mud-brick, stone, brick, lime and wood. That is because of the fact that, this kind of material is available and accessible for residents in such a region and also these materials have thermal resistance, high heat capacity and they absorb the sun radiation by their external surfaces.

2.4.11 Wind Tower

There is a difference between the wind towers in hot-humid and the wind towers in hot-dry with cold winter regions. The dissimilarity is that the four sided wind towers in hot-humid are bigger in cross section and shorter in height. The reason is that this climate has a lot of humidity so the wind tower should accumulate air circulate between the land and the sea. Furthermore, there is less dust in the cities like Bushehr, which is located in hot-humid climate, rather than cities like Yazd

which is located in the hot-dry with cold winter climate. Subsequently the wind tower can be bigger and in four sided. Moreover there is less building with wind tower in hot-dry climate. Consequently because of climatic conditions, wind tower is mostly used in hot-dry with cold winter and hot-humid climates.

Finally this research specified the primary principle of vernacular Iranian architecture on the table 11, which is useful for comparing the diverse characteristics of buildings in different climate. There are a lot of variations between the characteristics of the vernacular architecture in these different climates of Iran. Consequently, employing this chart can be valuable for designing the buildings in accordance with climatic conditions.

Table 11: Comparing the diverse characteristic of vernacular Iranian building in different climates

CLIMATE	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 convex	Flat and Dome	flat	Slope	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 wall	Thick wall	Thick wall	Thin wall	Thin wall
Natural ventilation	high	low	low	high	Low to high
Color	light	light	dark	free	light
Windows	many	few	few	many	medium
Material	low thermal capacity	High thermal capacity	High thermal capacity	Low thermal capacity	Low thermal capacity
Configuration of the building	Introvert-extrovert	introvert	introvert	extrovert	Introvert-extrovert
Height of the building	normal	high	low	normal	normal
Direction	South to south east	South to south east	South to south west	East to west	South to south east
Wind tower	One or two sides	Four sides	No	No	Four sides

Chapter 3

COMPARISON OF IRANIAN VERNACULAR ARCHITECTURE WITH THE VERNACULAR ARCHITECTURE OF OTHER COUNTRIES

3.1 Hot-Dry with Cold Winter Climate

In hot and dry climate, very low rate of rain, humidity and lack of cloud cause a lot of differences between day and night temperatures. In this climate the temperature of the hottest day in a year is around 40 to 50℃ and in the night time the temperature is around 15 to 25℃. Moreover, one of the special characteristics of this region is hard and cold winter and warm and dry summer.

Accordingly, the central plateau of Iran has hot-dry with cold winter climate. Therefore, in this part, this study selects one vernacular building from Yazd city as a case study, which is located on the central region of Iran and it has hot-dry with cold winter climate. Furthermore, consistent with Koppen classification, this study evaluated the Iranian's case study with other buildings which are located in Turkey and China. The reason for this is, in Koppen classification Northwest of India and Northern China have hot-dry with cold winter climate, which is same as the climate of central plateaus in Iran. Subsequently, this research selected two buildings from Oliver's book as a case study from Bikaner city which is located on the Northwest of India and Beijing which is located in the Northern China, both of which have hot-dry with cold winter climate.

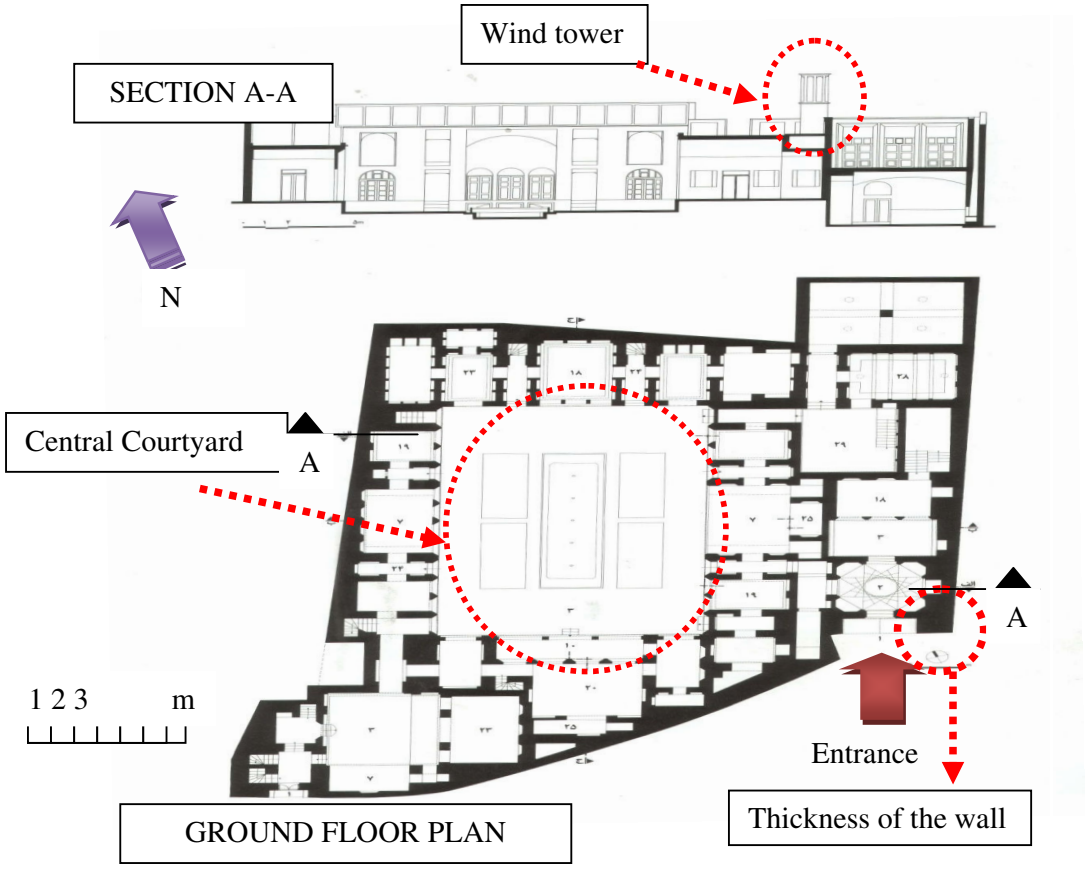


Figure 65: Building from Yazd city which has hot-dry with cold winter climate (University, 2005)

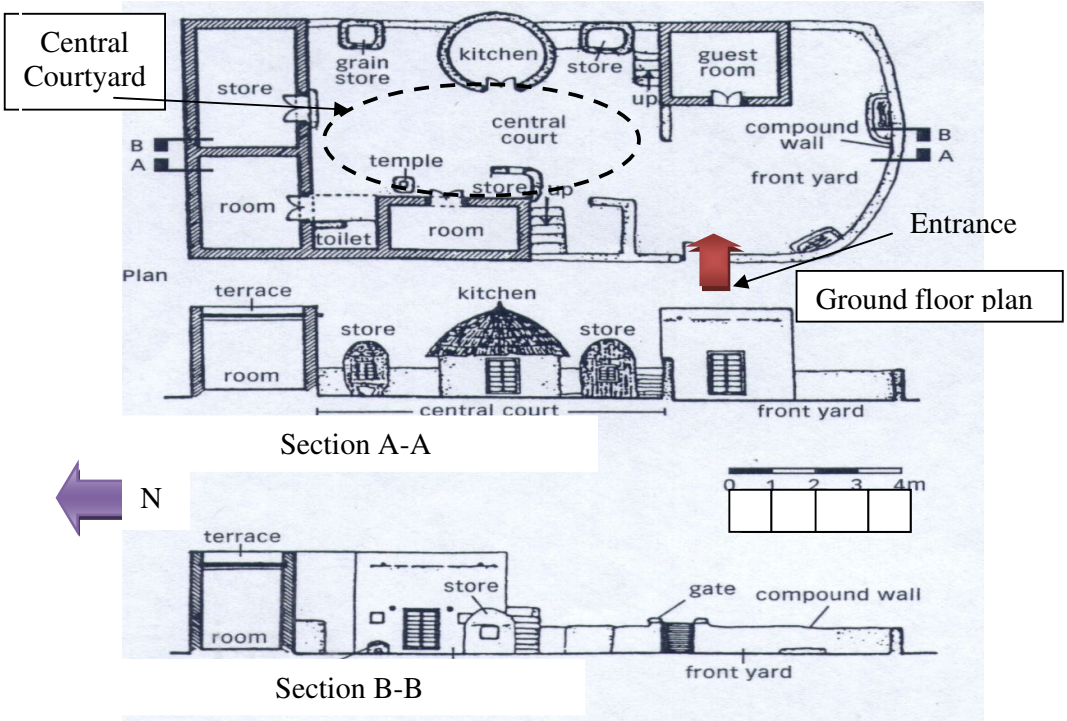


Figure 66: Building from northwest of India which has hot-dry with cold winter climate (Oliver.P, 1997)

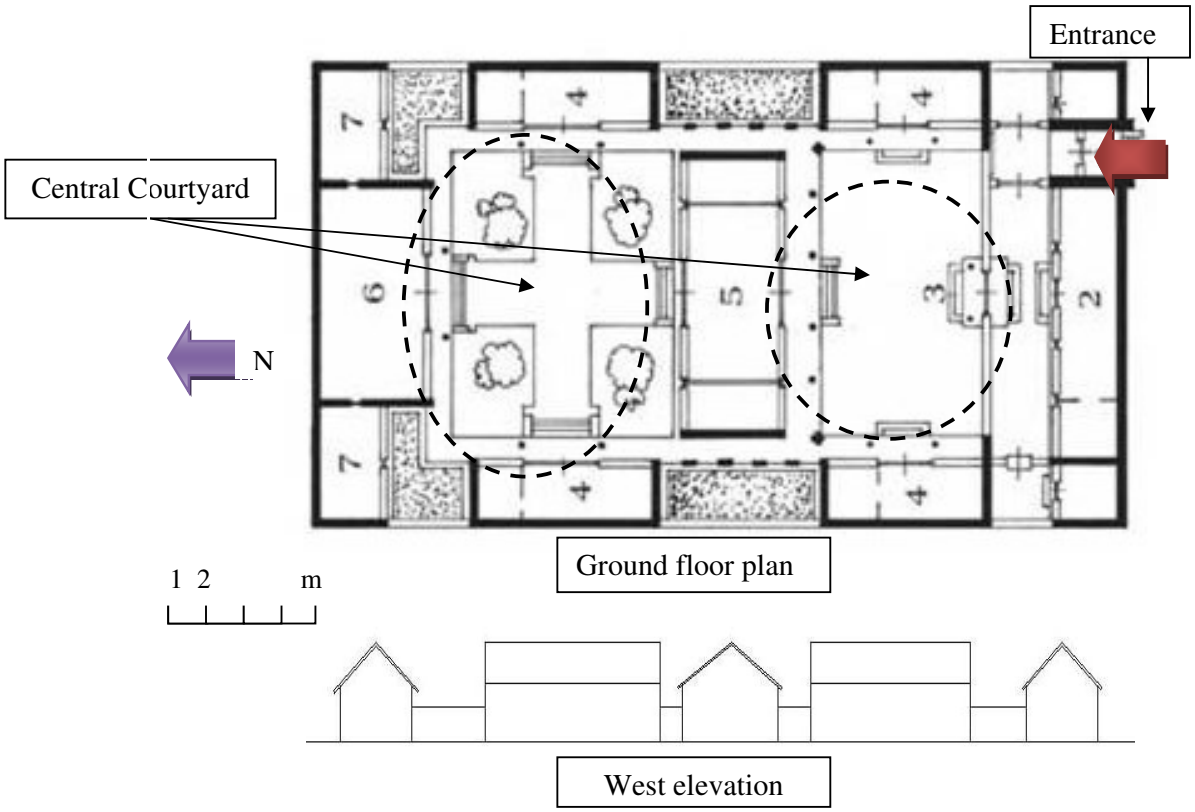
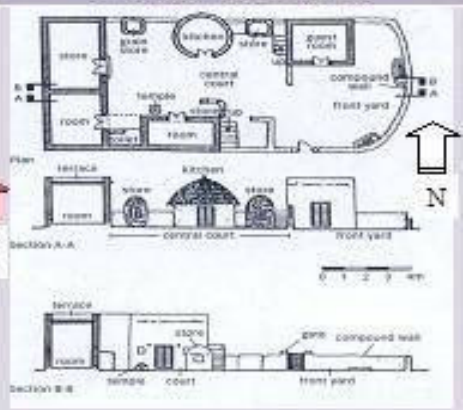
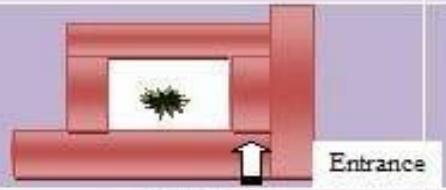
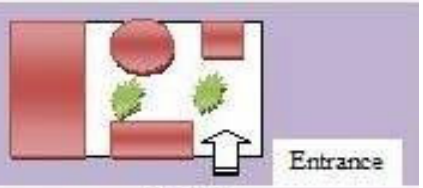


Figure 67: Building from north of china which has hot-dry with cold winter climate (Chongnian.Y, 1987,P.247)

Consistent with the comparison of these three buildings, this research illustrates the similarities and differences in table 12.

Table 12: Comparison in hot-dry with cold winter climate

TYPE OF CLIMATE	HOT-DRY WITH COLD WINTER CLIMATE		
COUNTRY	IRAN	CHINA	NORTHWEST INDIA
PLAN			
PLAN CONFIGURATION			
ROOF	FLAT	slope	FLAT
THICKNESS OF THE WALL	1m	0.30-0.40m	0.30-0.40m
WINDOW	FEW	FEW	FEW
WINTERR AND SUMMER ROOM	YES	NO	YES
DIRECT ENTRANCE	NO	NO	YES
MATERIAL	HIGH THERMAL CAPACITY	HIGH THERMAL CAPACITY	HIGH THERMAL CAPACITY

According to table 12, the configuration of the buildings in central plateau of Iran, Northwest India and Northern China are like a rectangular shape, which has the hole at the centre of the building. In these types of buildings courtyard can keep the coolness and humidity of the night and gives refreshment through the summer days.

Subsequently, in hot-dry with cold climatic region, during the summer from afternoon tills the morning, all of the activities would happen in central courtyard. Because the great thermal mass of the building fabric makes the interiors of the house hot. Therefore, it was more comfortable for residents to stay in the courtyard. Furthermore, the courtyard of the vernacular buildings in China, Northwest India and Iran is completely enclosed by buildings and walls. However the walls around the central courtyard in China and northwest India are shorter than Iran. This longer wall in Iranian building in such a climate is because of the cultural aspect and also it is needed to be protected from sand storm. Therefore, buildings in Iran are likely to be exposed to undesirable wind and sand storm.

There are no windows on the outside walls of buildings in China and Iran, and usually the only opening to the outside is through the entrance door; because the walls around the central courtyard not only give privacy and some protection from burglary, but also it creates sharp distinction between the rear and inner quarters. Therefore, women would be protected from the environment and also they can move freely without worrying about being observed by strangers. Furthermore, they have a lot of large windows towards the central courtyard, which is mostly full of trees and pool, can cool the air, and subsequently from the opening to the buildings.

Another difference between these countries is about the entrance of the buildings. For instance, in Iran and China, for entering to the building, resident first should pass

from the corridor afterward to the central courtyard, which this kind of difference in entering is because the cultural aspects. Therefore, if someone looks through the first doorway of the house, they can only seen a brick screen wall. Conversely, inhabitant in India directly enters to the central courtyard.

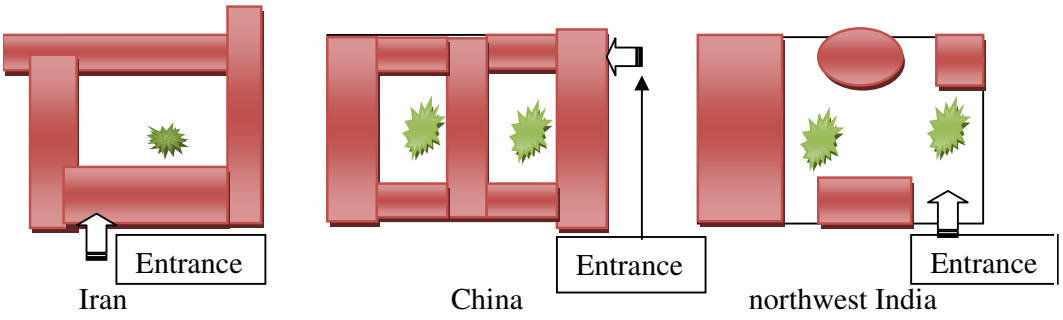


Figure 68: Arrangement of the building in Iran, China and northwest India

Moreover, buildings in Iran have winter and summer rooms. The summer rooms are located toward the courtyard rooms and it has a lot of openings. Also the summer rooms, which are cooler in hot period of year, are larger and have higher ceiling than the winter room has. Conversely, there is no any winter and summer rooms in China. However, in northwest India the arrangement of the coldest and hottest period is different. Because in such a vernacular building, during the cold winter time, three rooms which have opening into the courtyard are used for sleeping and drying grains, and the flat roofs of the rectangular rooms are used for sleeping during the summer period.

In addition, there is less rain during a year in such a climatic condition. Therefore, cases in Iran and northwest India have flat or convex roof. However, the vernacular buildings in China have slope roofs. Furthermore, wall in hot-dry climate works as an important element in these kinds of buildings. Hence, the walls of vernacular buildings in Iran have the thickness approximate around one meter. This much thickness through transferring and radiation during night can lose the heat

subsequently during a day the temperature remains low. Thus, thickness of the walls can provide enough comfort for residents. However, the wall thickness of the buildings in China and India in the same situation is between 0.30-0.40. Furthermore, in such a hot-dry with cold winter climate, the material for the wall in China is mostly earth and wood, in northwest India is brick masonry and in Iran is brick, adobe and mud. All of these materials in these three countries have high thermal capacity, which is good for this kind of climatic conditions.

Moreover, wind tower is another difference between these three countries. Traditional people in Iran noticed that intolerable hotness and dryness of this region can be solved by putting wind tower in their buildings. Therefore, a wind catcher is one of the most important elements of the Iranian buildings in hot and dry with cold winter climate. These wind towers in Iranian buildings can work as ventilator for cooling the interior space. However, the other two countries did not have such an element for cooling their buildings during the hot period.

In conclusion, this research found that all of these three buildings which are located in hot-dry with cold winter climatic conditions have some similarities in the main architectural characteristics. For instance, the climatic conditions force them to have similar plan configuration, which have rectangular forms, or buildings are circulated in a rectangular shape like in India. In addition, all of these three buildings have central courtyard because of hot climate during the summer period. Furthermore, most of the windows in these buildings face to the central courtyard. Moreover, because of cold weather in winter time all of these buildings have few windows on external walls for keeping interior part of the building warmer. Consequently, all of these three buildings in China, Northwest India and Iran with

different cultural aspects have some resemblance in most important design principles, which similarities can preserve them from harsh climatic conditions.

3.2 Temperate-Humid Climate

There is a lot of rainfall in temperate-humid climate. One of the special characteristic of this climate is high humidity and temperate temperature. The weather is not cold and usually the temperature during the winter is more than zero but the temperature during the summer time is around 20 to 30°C.

As in the previous chapter of this research, the Northern Iran has temperate-humid climate. Therefore, this study selects one vernacular building from Rasht city as a case study which is located on the Northern Iran. Afterward, this study evaluates the differences and similarities between the cases study of Iran and two other vernacular buildings from Turkey and China which have the same temperate-humid climatic conditions. Furthermore, Ozdeniz in his climate classification investigated that, Trabzon city has temperate-humid climate. As a result, this research selected one building from Ozdeniz's paper as a case study from Trabzon city. Moreover, Koppen in his classification found that South East of China has temperate-humid climate. Therefore, this research from Oliver' book chose the vernacular building from Anhui which is located in the South East of China.

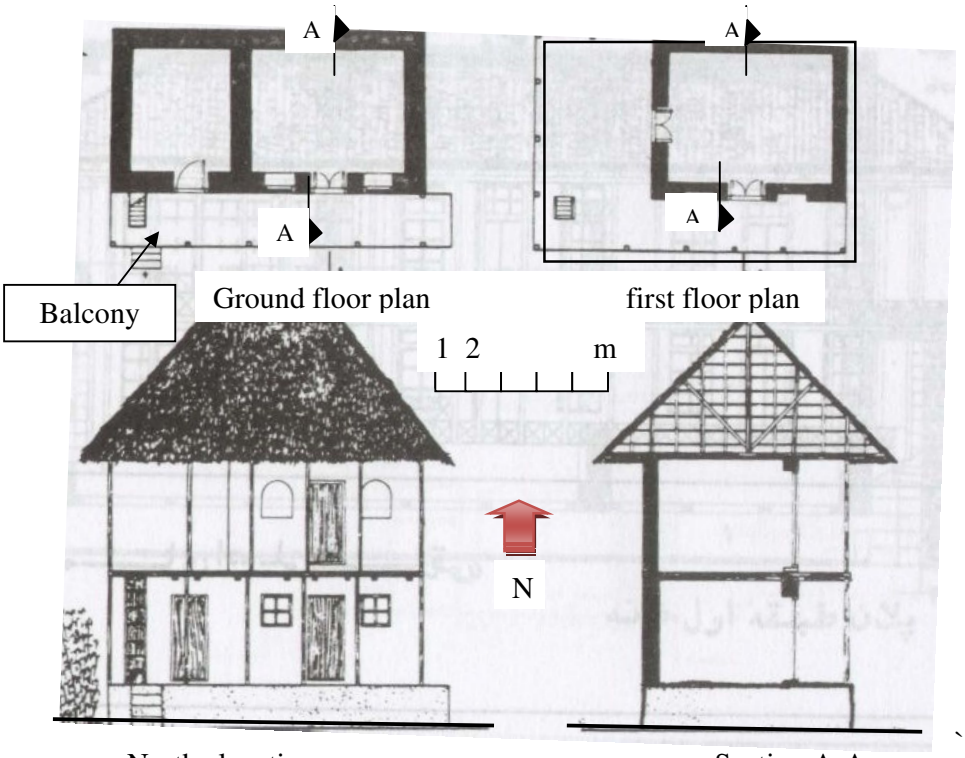


Figure 69: Building from Rasht city in Iran which has temperate-humid climate (Memarian.GH, 2006)

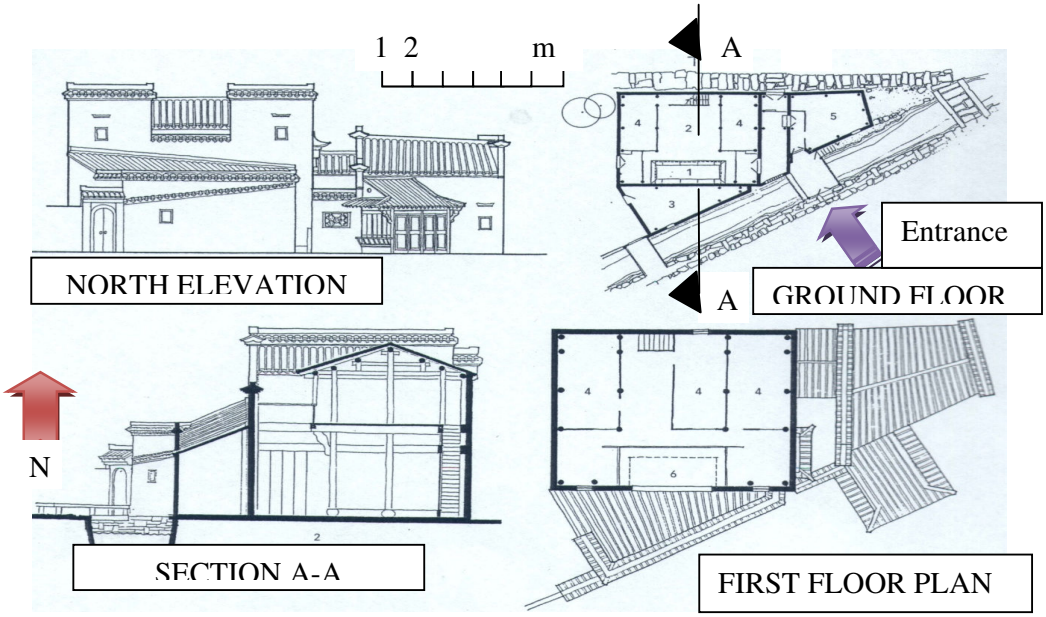


Figure 70: Building from Anhui City in china which has temperate-humid climate (Oliver.P, 1997)

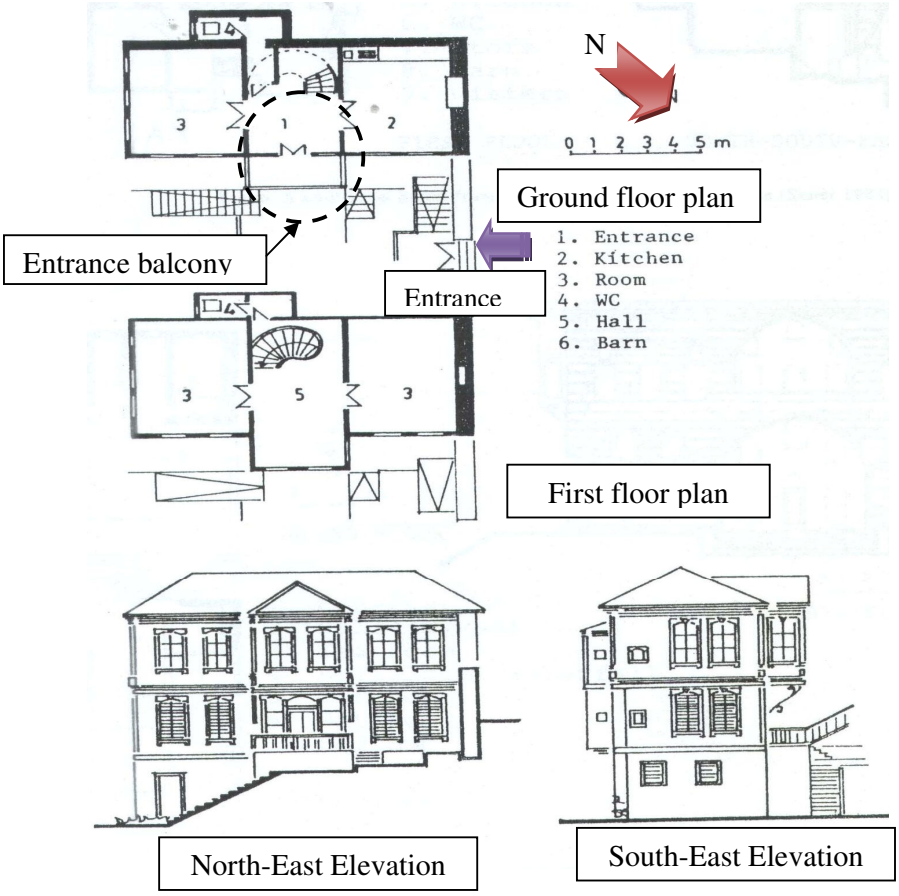
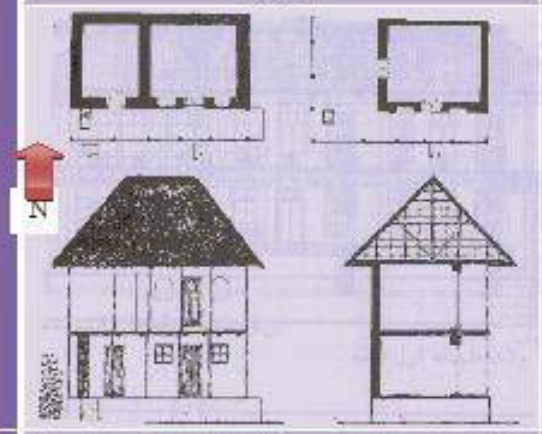
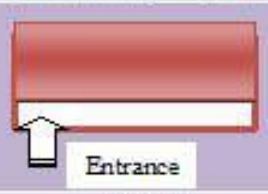
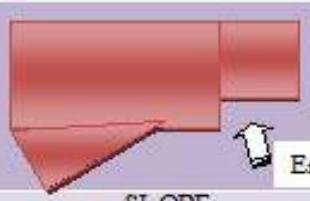
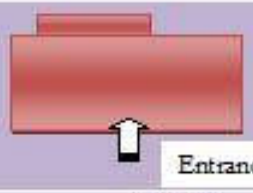


Figure 71: Building from Trabzon city in Turkey which has temperate-humid climate (Ozdeniz.M.B, 1991)

In accordance with comparison of all these three buildings, this research found the table 13, which illustrates the similarities and differences of these three vernacular buildings in China, Turkey and Iran.

Table 13: Comparison in temperate-humid climate

TYPE OF CLIMATE	TEMPRATE-HUMID CLIMATE		
COUNTRY	IRAN	CHINA	TURKEY
PLAN			
PLAN CONFIGURATION			
ROOF	SLOPE	SLOPE	SLOPE
WINDOW ON EXTERNAL FACADE	MANY	FEW	MANY
BUIDLING CONCETION TO THE GORUND	WOODEN FOUNDATION	NO FOUNDATION	STONE FOUNDATION
DIRECT ENTRANCE	NO	NO	YES
MATERIAL	LOW THERMAL CAPACITY	LOW THERMAL CAPACITY	LOW THERMAL CAPACITY

In accordance with table 13, in such a temperate-humid climate one of the differences between these vernacular buildings is balcony. Most of the vernacular buildings in Turkey and Iran have balconies, which works as an important and useful element in this humid climate. That is because temperate and humid conditions in the spring and summer cause most of the activities such as socializing, eating, entertainment, working, sleeping, would take place in outside area; because in summer time the air inside the rooms would be stuffy and warm. Consequently, balconies are the appropriate places for such activities and inhabitants always enjoy the shade and breeze on balconies. However, there is not any balcony in the case of China.

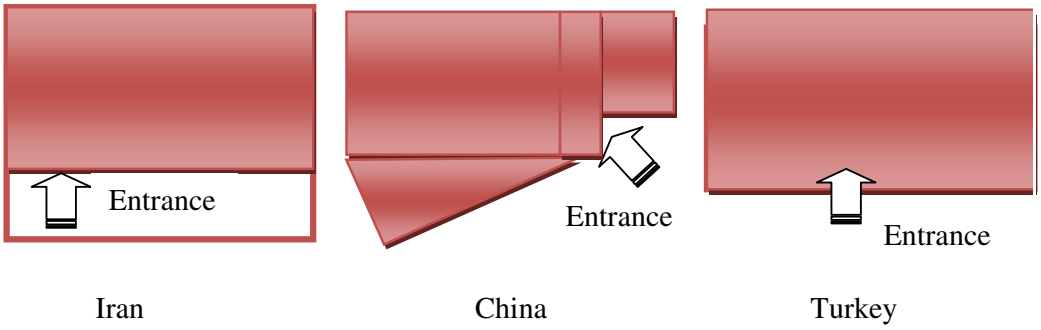


Figure 72: Arrangement of the building in Iran, China and Turkey

Another difference is the entrance door. The design of the vernacular building in Iran is in such a manner that inhabitant should first passes form balcony then to the building. However, in Turkey and China inhabitants can directly enter to the building. Furthermore, this climate has high humidity. Thus, one of the important climatic principles in this kind of climate is to create appropriate ventilation in interior of the buildings. In this way, according to the openings on the façade, cross ventilation would occur in all these three buildings.

One of the similarities between the buildings in Turkey, China and Iran is the plans of the buildings. All these three cases have same situation since the plan of

them are extrusions in order to disperse summer heat to the outside easily. Another similarity between these cases is about roof. There is a lot of rain in such a climate so all of these three vernacular buildings have sloppy roof. Furthermore, for protecting the walls of the ground floor form moisture and humidity in Turkey, most of the buildings were built with stone.

Also in Iran and China like Turkey used wood for constructing the building, since wood do not store heat during the summer period. Moreover, traditional builders in Iran to protect their building from moisture and humidity use another method. For instance, for protecting the building from moisture and humidity they construct the building approximately one meter above the ground level. Besides for protecting the building from rain they construct the balcony in four side of the building, which this balcony is covered by roof. In addition, in China for protecting the building from rain, traditional builders construct the overhang roof. This over hang roof can protect the building from rain and also it can protect the first floor of the building from direct sun radiation.

In summary, this study comes across that all of these three buildings, which are located in temperate-humid climatic conditions have several same architectural characteristics. For instance, because of high humidity in this region, the climatic conditions force them to have similar plan configuration to employ more from natural ventilation. In addition, there is a lot of rain in these regions. Therefore, all of these three buildings have sloppy roof, which works as an umbrella to protect the buildings from rain. Consequently, this research reaches to the point that, although all of these three vernacular buildings in China, Turkey and Iran have different culture, they have some similarities to the main design principles. In other words, design with climate in these vernacular buildings causes these similarities.

3.3 Cool Climate

The average temperature in the cool climate in the hottest month of a year is more than 10°C and the minimum average of temperatures in the coldest month of a year is less than -3°C. Particularly number of sunny days in this region is quite rimming in compare to the other climatic regions of Iran. Furthermore, in this region, winter is so long and most of the time ground is covered by ice and also winter time is very cold in all over the region. The amount of rainfall in summer is so less but there is a lot of rainfall mostly as snow during the winter time.

As in the previous chapter, this research mentioned before, the Western and North West part of Iran has cool climate. Therefore, this study chose one vernacular building from North West part of Iran as a case study from Tabriz city, which has cool climate. Afterwards, this research compares the case study of Iran with two other countries, which have same cool climatic conditions like Iran. Therefore, consistent with Ozdeniz's classification, which he found out Erzurum city in Turkey has cool climate, this research selected one vernacular building from Ozdeniz's paper as a case study from Erzurum city. Moreover, according to Koppen classification this research selected one vernacular building from Nepal. Because Koppen in his classification found that Nepal has cool climate. Consequently, this research selected one building from Hanaoka's paper as a case study from Nepal's mountainous regions.

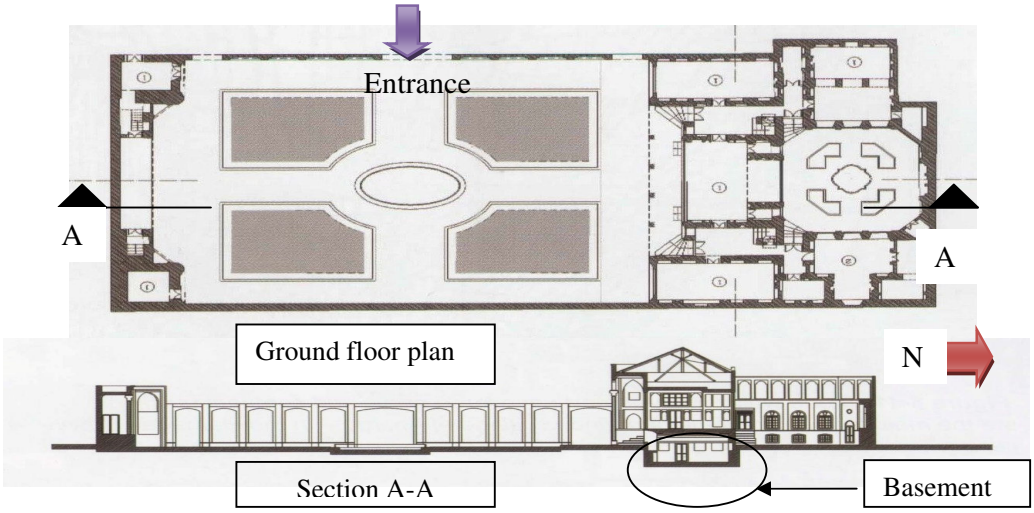


Figure 73: Building from Tabriz city in Iran which has cool climate (Ghobadian.V, 2009)

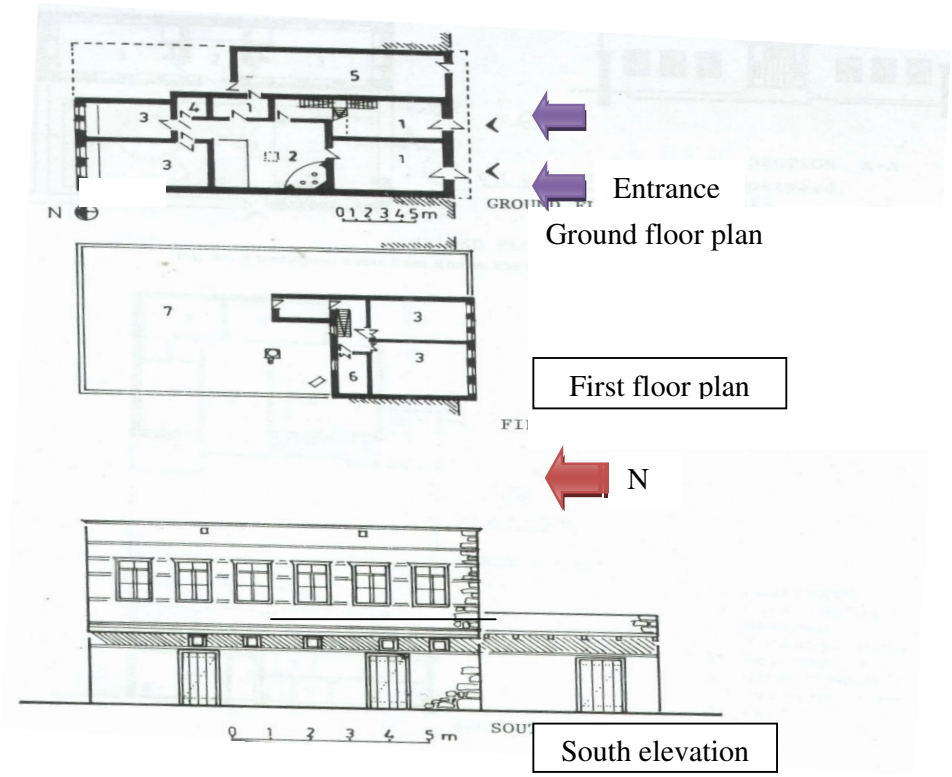


Figure 74: Building from Erzurum city in Turkey which has cool climate (Ozdeniz.M.B, 1991)

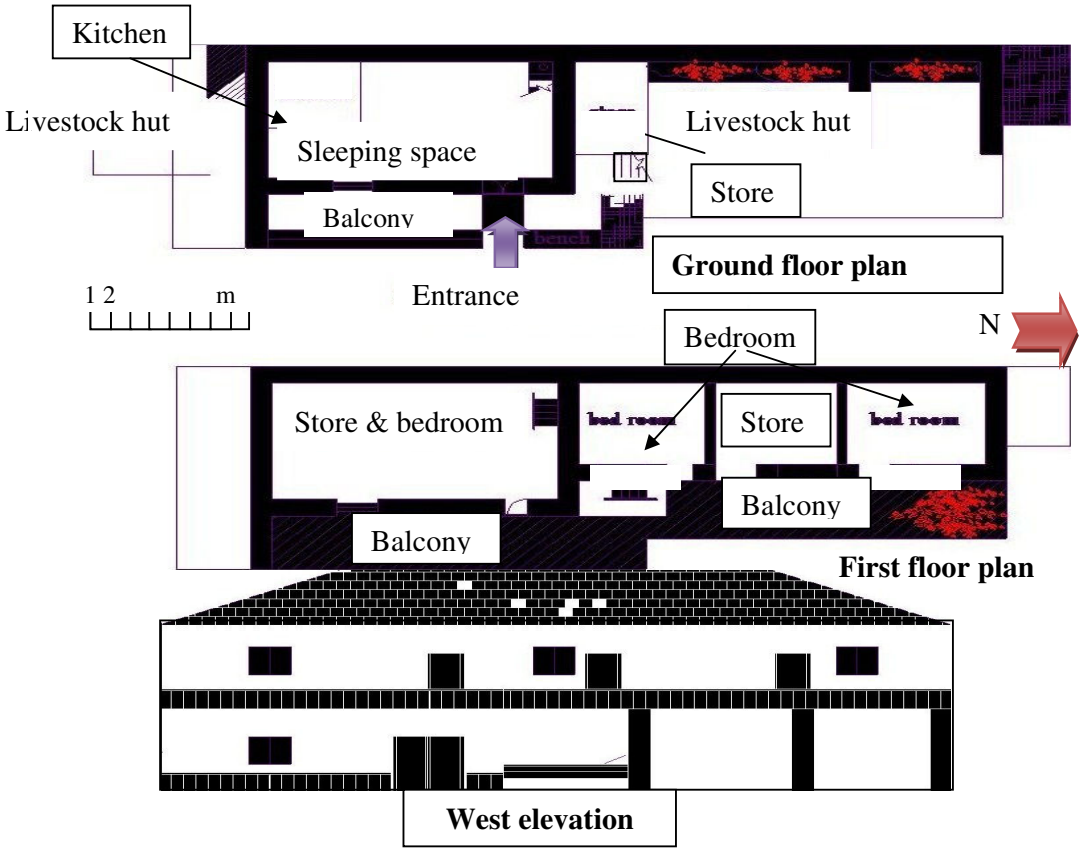
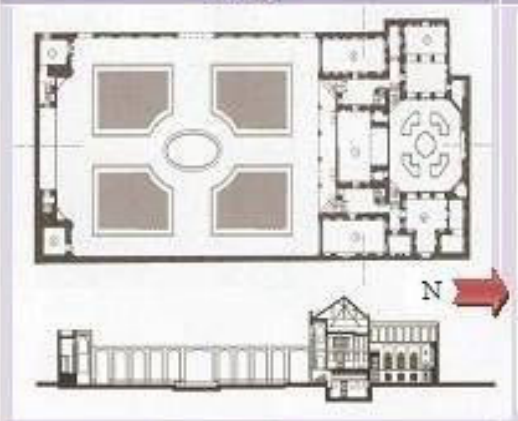
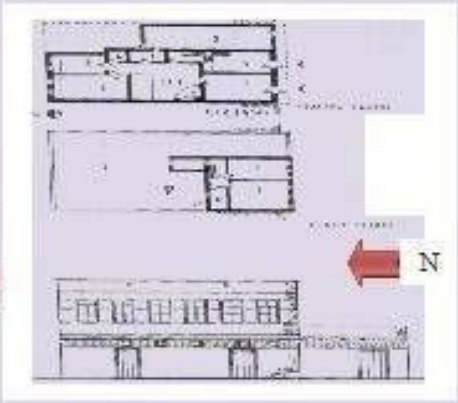
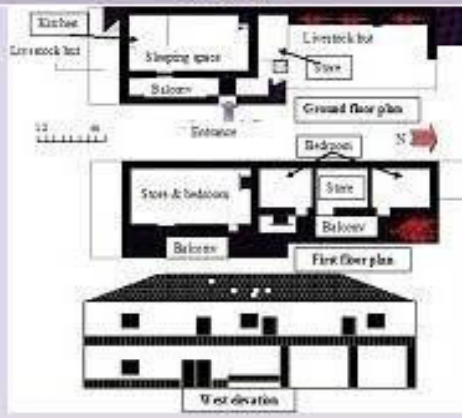
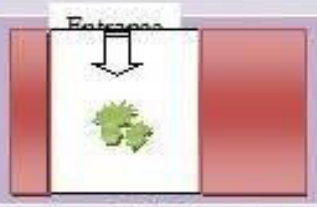
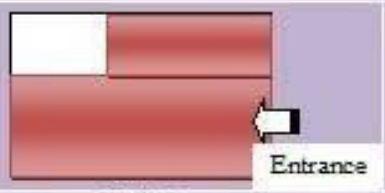
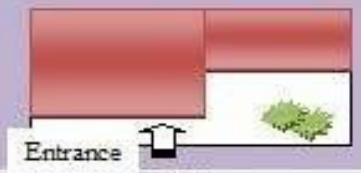


Figure 75: Building from Nepal in China which has cool climate (Hanao.S, 2009)

In consistent with plan and shape of the buildings, this research scrutinized the table 14, which exemplifies the similarities and differences of these three buildings in Nepal, Turkey and Iran.

Table 14: Comparison in cool climate

TYPE OF CLIMATE	COOL CLIMATE		
COUNTRY	IRAN	TURKEY	NEPAL
PLAN			
PLAN CONFIGURATION			
ROOF	FLAT	FLAT	SLOPE
WINDOW ON EXTERNAL FACADE	FEW	FEW	FEW
BUILDLING CONCETION TO THE GROUND	ON THE GROUND	ON THE GROUND	ON THE GROUND
DIRECT ENTRANCE	NO	YES	YES
MATERIAL	HIGH THERMAL CAPACITY	HIGH THERMAL CAPACITY	HIGH THERMAL CAPACITY

According to the table 14, particularly in these regions for preserve the heat inside of the building, inhabitants try to create less correlation between surface of the building and the cold outside weather. Consequently, the best forms of the buildings in such a cool climate are cubic or rectangular cubic, since the proportion of the outer space of them is less than the inside volume of the building. Therefore, the buildings which are located in Turkey, Iran and Nepal have rectangular shape, which is the best shape in this cool climate.

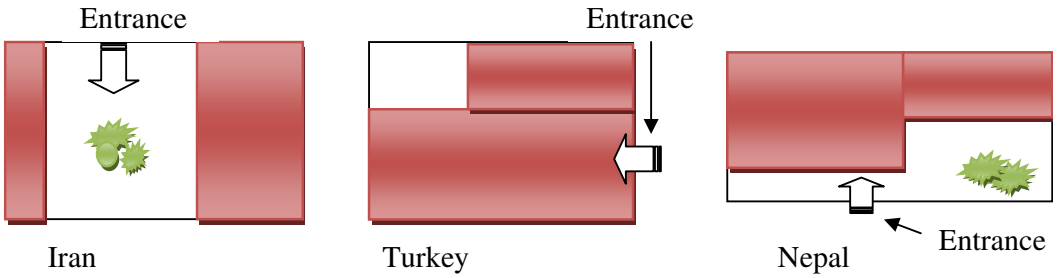


Figure 76: Arrangement of the building in Iran, Turkey and Nepal

Having small spaces is one of the similarities between Turkey, Nepal and Iran. There is no any big space in these buildings since warming the extensive space is hard. Also in these cases, most of the rooms have low height roofs. Furthermore, Ozdeniz in his paper mentioned that, in Turkey the “tandirevi” which is located at the centre of the building can serve both as kitchen and living room. Therefore, the heat would be produced by “tandirevi” keep the building warm.

The other similarity between Iran and Turkey is about flat roof. For the reason that in such a climate flat roof can keep snow. Therefore, snow can work like thermal insulation element for the buildings. Conversely, in the case from Nepal building has slope roof. In addition, all of these three buildings have few windows. Also the size of the windows in the case of Iran, Nepal and Turkey are very small and few, which this size can keep the building warmer. Furthermore, in the cases from Turkey and Iran, in order to reduce the heat loss and also to keep inside more warm, all the

rooms are separated by each other with doors and portions. Moreover, both in Turkey and Nepal houses have some bedrooms, which are situated over the barns in order to utilize the heat of the animals.

Walls absorb the heat from the sun radiation during a day and they preserve the heat till night time. Consequently, thickness of the wall and fewer openings can prevent the heath to be exchanging between inside and outside of the buildings. As a result, the walls in most of the buildings in cool region of Iran were made by brick and adobe. These kinds of masonry walls were heavy and thick, and they could retain daytime heat for night time. Likewise, external walls in Turkey were made with stone, which these stone walls had the thickness around 0.90 to 1.5m. Moreover, the thickness of the wall in Nepal is around 0.55m, which is sufficient for keeping the interior space warmer.

Furthermore, traditional buildings in Iran like the hot and dry region have central courtyard. Therefore, for utilizing the maximum of sun radiation in the winter time, most of the rooms are located on the northern side of the courtyard. In addition, mostly in such a cool climate Iranian inhabitants use the south side of the building less than the other side; because summer period is just two months and the temperature is temperate. Consequently, the function of the southern rooms and also the rooms which are located in east and west directions are storage. Also buildings in Turkey are constructed on the north side of courtyard for utilizing from the maximum sun radiation during the cold period of a year. However building in Nepal is constructed from south to north direction.

One of the differences between the buildings which are located in Iran and two other countries is that, most of the vernacular buildings in Iran has basement, in which inhabitant use the basement during the hottest period. This kind of basement

has low height so the weather on that part is colder than the other part of the building. However, there is no any basement in the case from Turkey and Nepal.

To sum up, this study found that, although all of these buildings in Nepal, Turkey and Iran have different culture, they have some similarities in the main design principles. All of these three vernacular buildings are constructed according to the climatic conditions, which can protect the buildings from cool climatic conditions. For instance, in order to keep the interior of the building warmer, cool climatic conditions force them to have rectangular plan configuration with few windows. In addition, because of cool weather all these three buildings have low height ceiling, which can preserve the interior heat. Furthermore, the thickness of the wall in such a climate is very important. Hence, all of these three cases have thickness about 0.5 to one meter, which can work as a good thermal element in these vernacular buildings.

3.4 Hot-Humid Climate

This climate has more than five months summer and the weather is tremendously hot-humid during the summer. Subsequently, one of the special characteristic of this region is very hot and humid summer and temperate winter. In such a climate maximum temperature in the summer time is between35 to 40℃ and the maximum of relative humidity is around 70 percent. High relative humidity during the season causes less transition between the temperatures of day and night.

As in the previous chapter, this research point out before, the northern shores of Persian Gulf which is located on the southern part of Iran has hot-humid climate. Therefore, this study chose one vernacular building from Bushehr city as a case study which is located on the south part of Iran. Subsequently, this research compared the case study of Iran with other vernacular buildings of two countries such as Turkey and Thailand, which have same hot-humid climatic condition similar

to Iran. Furthermore, according to the Ozdeniz classification Alanya city in Turkey has hot-humid climate. Therefore, this research selected one building from Ozdeniz's paper as a case study from Alanya city. Moreover, this consistent with Koppen classification, which he found that Thailand has hot-humid. This research selected one vernacular building from Oliver's book as a case study from Siamese city which is located at the center of Thailand.

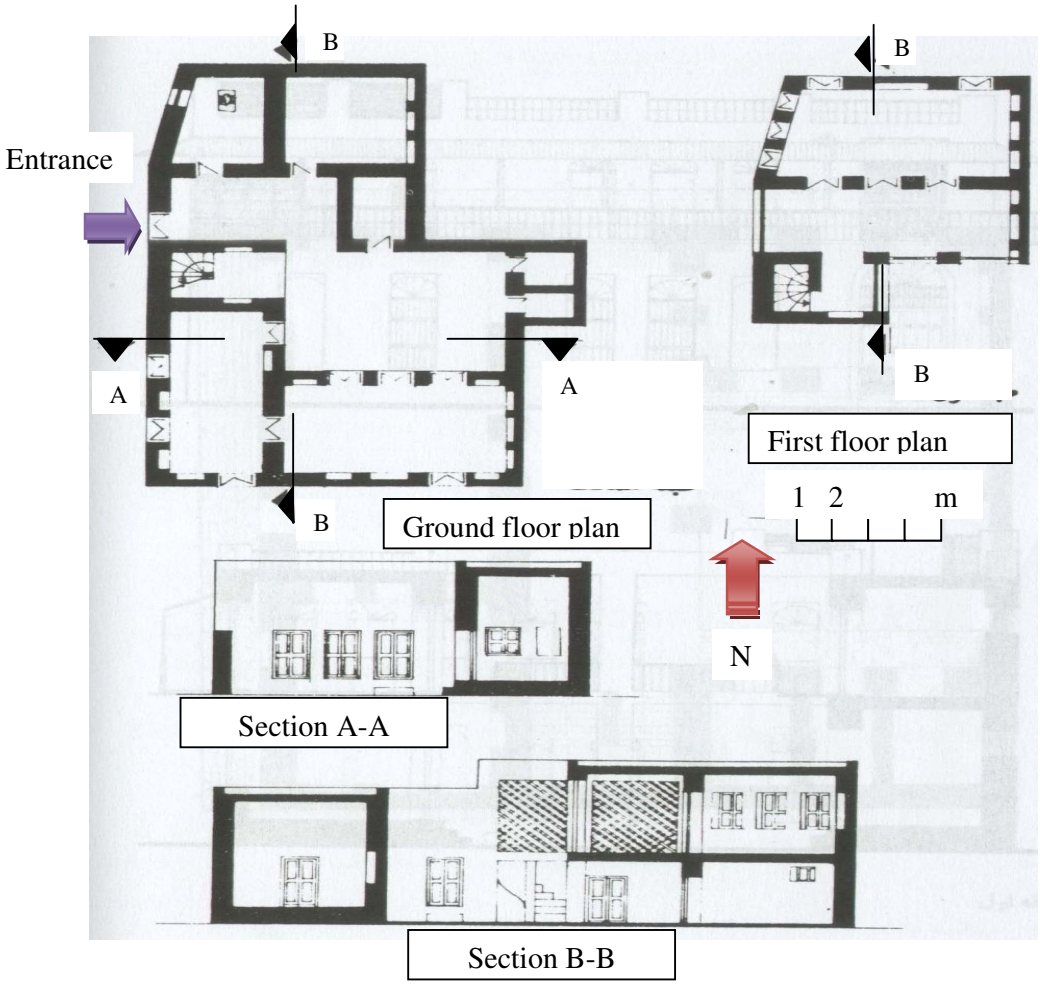


Figure 77: Building from Bushehr city in Iran which has hot-humid climate (Memarian.GH, 2006)

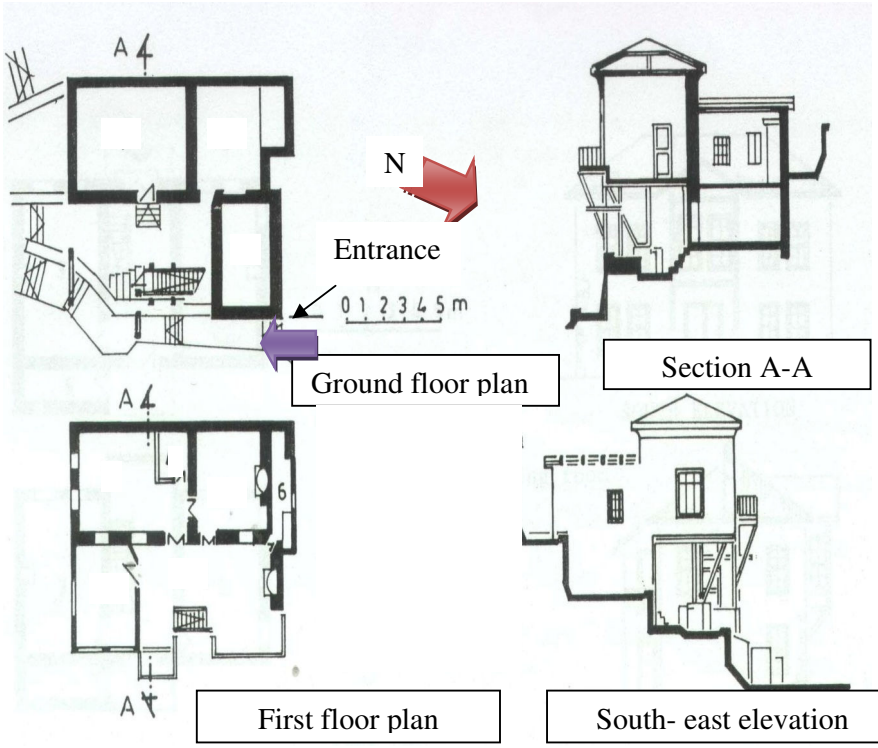


Figure 78: Building from Alanya city in Turkey which has hot-humid climate (Ozdeniz.M.B, 1991)

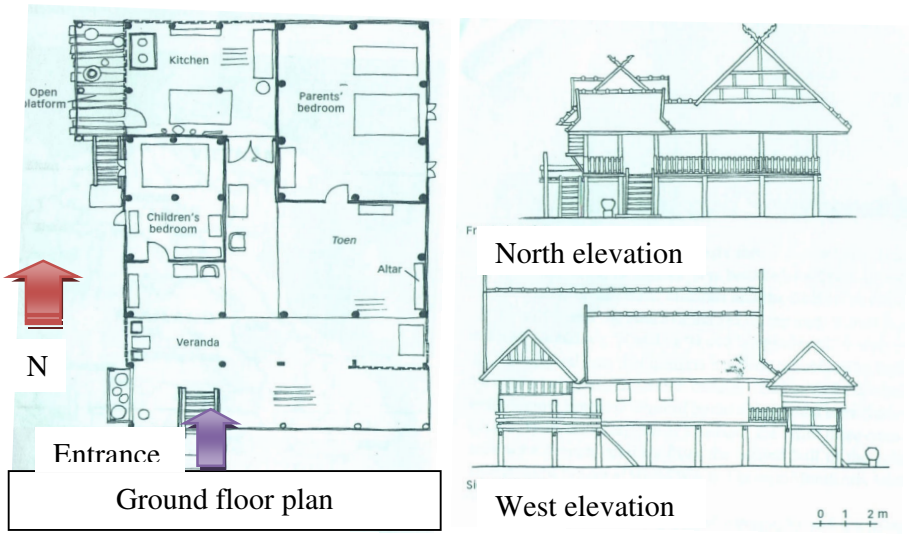
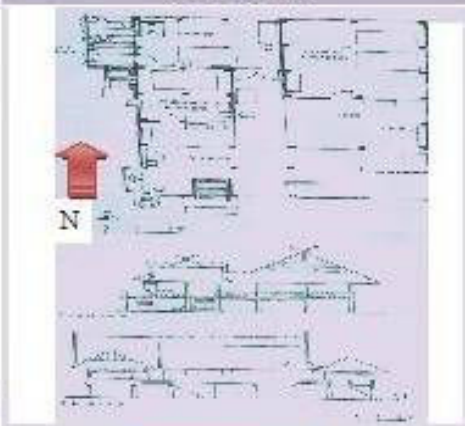
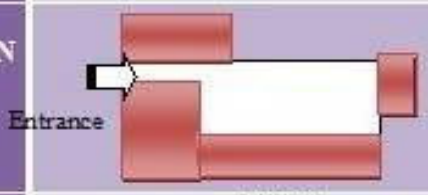
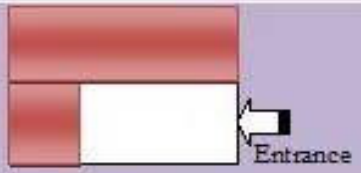
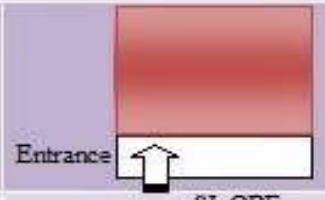


Figure 79: Building from Siamese city in Thailand which has hot-humid climate (Oliver.P, 1997)

Accordingly, this research scrutinized the table 15, which this table demonstrates the similarities and differences of these three vernacular buildings in Thailand, Turkey and Iran.

Table 15: Comparison in hot-humid climate

TYPE OF CLIMATE	HOT-HUMID CLIMATE		
COUNTRY	IRAN	TURKEY	THAILAND
PLAN			
PLAN CONFIGURATION			
ROOF	FLAT	FLAT-SLOPE	SLOPE
BUIDLING CONCETION TO THE GORUND	ON THE GROUND	ON THE GROUND	FOUNDATION
WINDOW	NORMAL	NORMAL	NORMAL
WINETR AND SUMMER ROOM	NO	YES	NO
DIRECT ENTRANCE	NO	NO	NO
MATERIAL	LOW THERMAL CAPACITY	LOW THERMAL CAPACITY	LOW THERMAL CAPACITY

One of the similarities between Iranian, Turkish and Thailand's buildings is balcony. In this hot-humid climate, balcony is a good place for ventilation. During a hot season most of the daily activities take place in a balcony. Therefore, balconies in these buildings are very extensive and long. However, vernacular building of Turkey instead of one extensive balcony has some small balconies.

The other similarity between these three countries is basement. Because of high humidity, none of them have basement in their buildings. So, always the function of the ground floor is kitchen or storage. Furthermore, inhabitant in such a hot-humid mostly lives on the first and second floor. That is because, upper floors have well cross ventilation than the ground floor and also the upper windows prevent from pedestrian sight. Similarly, vernacular building in Turkey, like Iran, is built in two floors. However, in the case of Thailand, vernacular buildings have just one floor.

Furthermore, most of the buildings in Turkey, like Iran, are elevated on piers and walls in order to catch the cool breezes. Because catching the cool breeze can decrease the intensity of heath during a summer time. In addition, these kinds of buildings in Iran are inverted for having better ventilation. Furthermore, because of long and wide windows, these vernacular buildings have a good connection with the outside area. Moreover, they have extensive balcony in second or third floor, which has a face to the alley. Additionally, for creating cross ventilation in this kind of building, some of the windows are facing to the central courtyard and other windows are looking to the alley. Furthermore Thailand employs both methods of Iranian and Turkish for creating natural ventilation through the buildings. Because, vernacular building in Thailand exactly like Turkey are elevated from ground levels for catching the best breeze. Also vernacular building in Thailand, similar to Iran, have good

connection to the outside. Thus, having long and wide windows which has face to the alley can create the natural ventilation inside of the buildings.

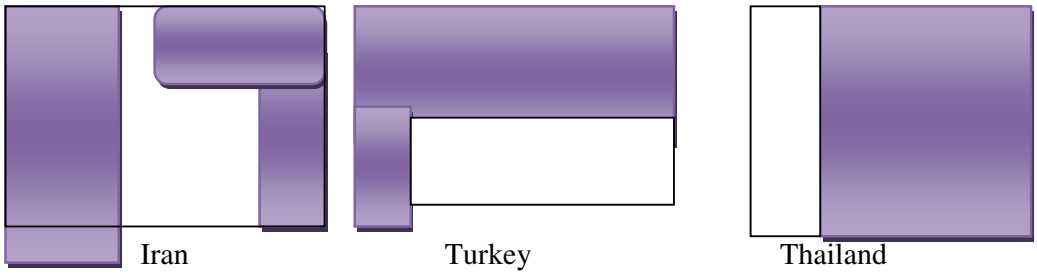


Figure 80: Arrangement of the building in Iran, Turkey and Thailand

Iranian buildings have a kind of entrance which makes people first enter to the courtyard then to the building. In addition, the entrance door in most of the Iranian buildings have opening on top of the door. That is because, these kinds of openings are being able to receive the light and also they can work as a ventilator. Conversely, the entrance door in Turkey invites the people directly to the building. Furthermore, the entrance door of the case from Thailand is somehow similar to Turkey, but first people should pass from the balcony then they can enter to the buildings.

One of the differences between the design of the building in Iran and in two other countries is having the central courtyard in the middle of the house. As this research mentioned before, in such a climate most of the vernacular buildings in Iran, entering to the courtyard is directly from entrance door which is positioned on the corner or middle of the central courtyard. Moreover, according to the needs of inhabitant and type of the buildings, the function of the courtyard is different. For instance in small and simple building the central courtyard have small pool, garden and well. Moreover, in Iranian vernacular building, spaces are organized according to the central courtyard. Conversely vernacular building in Turkey which is located on the topography has natural central courtyard, since this building is enclosed by river on

one side and valley on the other side. However there is not nay central courtyard in the case of Thailand. Although Thailand has balconies in front of the building that inhabitants use them during the hot period of a year, it cannot work as a central courtyard.

Furthermore, the height of the rooms in such a hot and humid climate is more than the other climates. For instance, sometimes the highest rooms have four meter or more height. They use four meter height for the rooms because hot weather can ascend in the interior space. Subsequently, the temperature of the rooms will be decreasing. In addition, for creating cross ventilation in such a hot-humid climate, traditional builders construct more windows under the roof and in two sides of the buildings. Consequently, both Turkish and Iranian buildings have same characteristics in the height of the buildings. However in the case of Thailand, building has three meter height.

Moreover, one of the differences between the vernacular building in Iran and two other countries is about the roof. Most of the buildings in Iran have flat roof. However in the case of Turkey and Thailand, buildings have slop roofs.

Finally, this study found that all of these three buildings which are located in hot-humid climatic conditions have some architectural characteristics which are similar with each other. For instance, hot-humid conditions force them to use natural ventilation. Therefore, all of these buildings have many windows on the external walls. Furthermore, this kind of climate has high humidity. As a result, inhabitants prefer to be in balcony during the hot period. Consequently, this research found that all of these three vernacular buildings in Thailand, Turkey and Iran, consistent with the climatic conditions, have similarity in the main design principles.

3.5 Hot-Dry Climate

This kind of climate has very hot summer and mild winter. The fluctuation of temperature in this climate does not go below zero during the winter time. The mean highest air temperature reaches 40 C in summer time.

As in the previous chapter, this research pointed out before; there are some cities in the Southern and Central Iran which has hot-dry climate. Therefore, this research selected one of the vernacular building from Dezful city as a case study where is located on the South West of Iran. Afterwards this research compares the selected building in Iran with the vernacular buildings from two other countries, Turkey and China which have the same hot-dry climates like Iran have. Furthermore according to the Ozdeniz's classification which he found out that Diyarbakir city in Turkey has hot-dry climate. This research selected one building from Ozdeniz's paper as a case study from Diyarbakir city. Moreover, this research, according to Bouillot classification, chose one vernacular building from Shanxi in China. Because, Bouillot in his investigation found that North East of China, where Shanxi is located, has hot-dry climate.

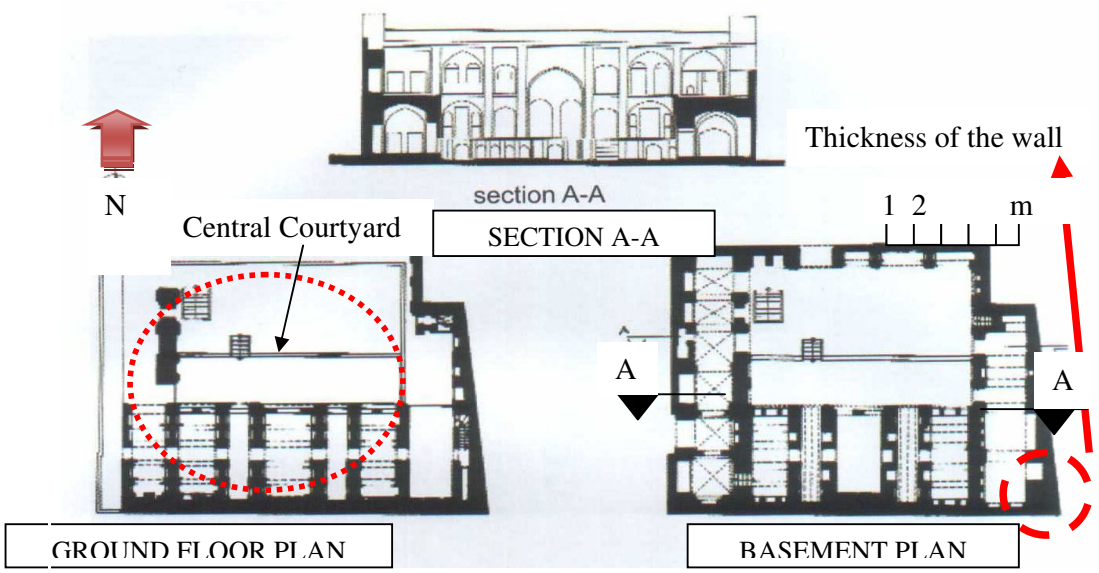


Figure 81: Tizno's house is located in Dezful city (Ghobadian.V, 2009)

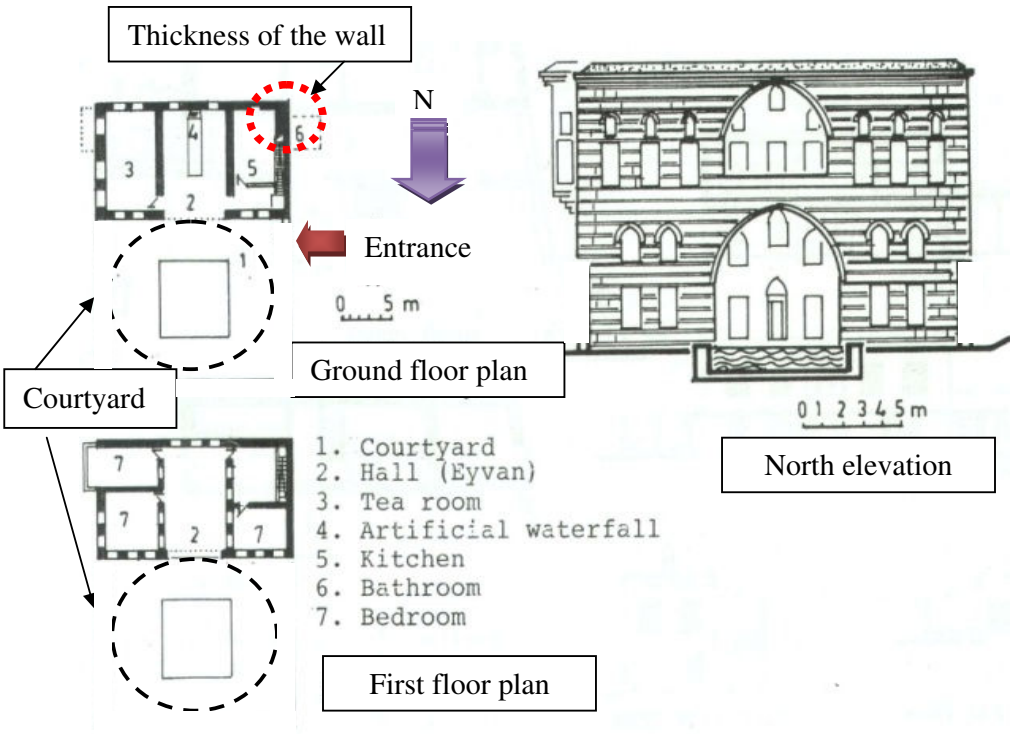


Figure 82: Building from Diyarbakir city in Turkey which has hot-dry climate (Ozdeniz.M.B, 1991)

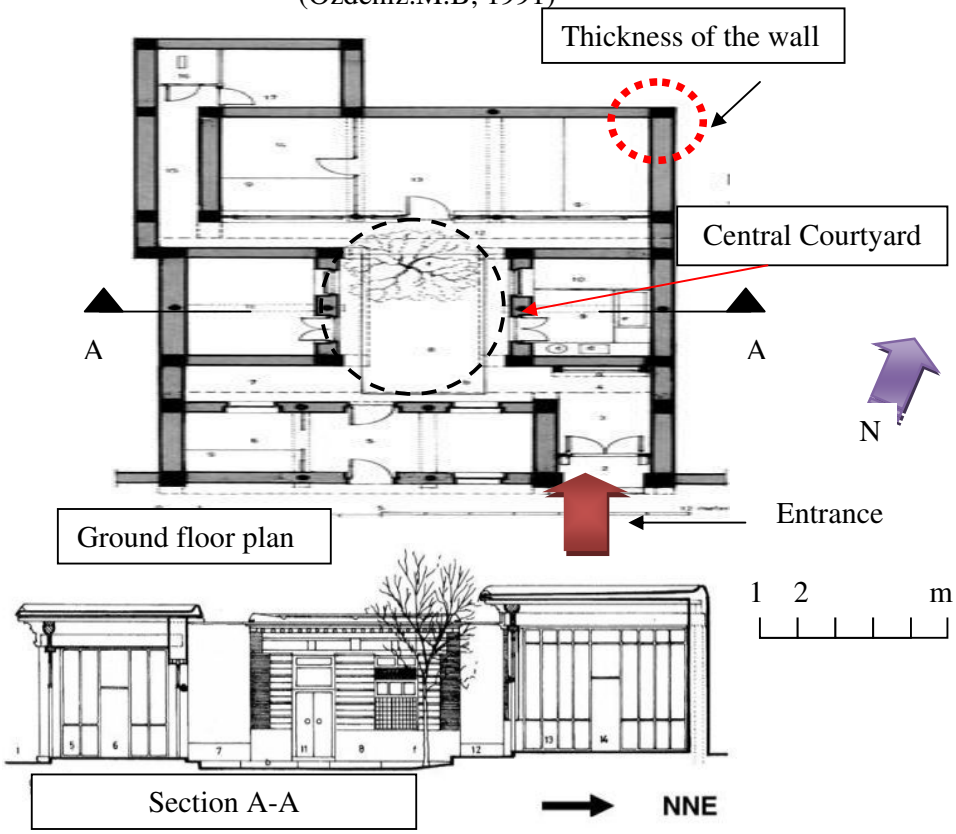
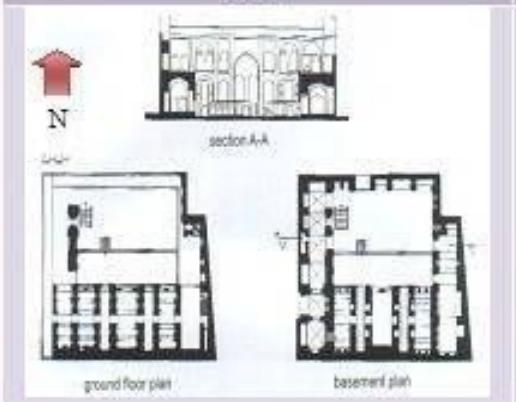
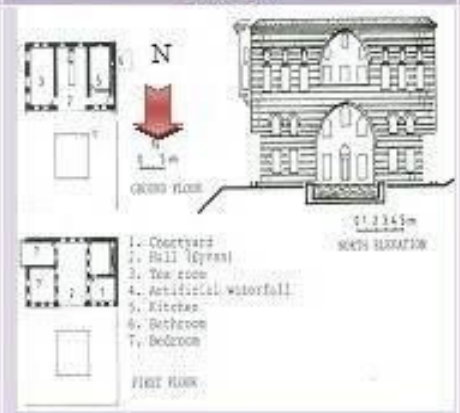
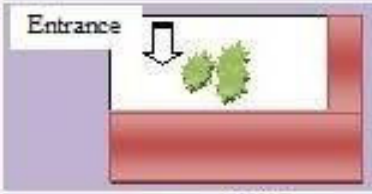
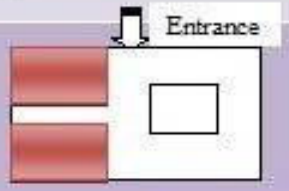
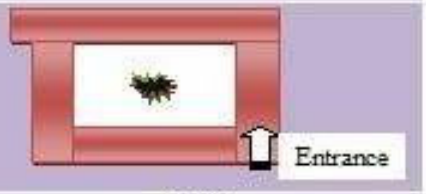


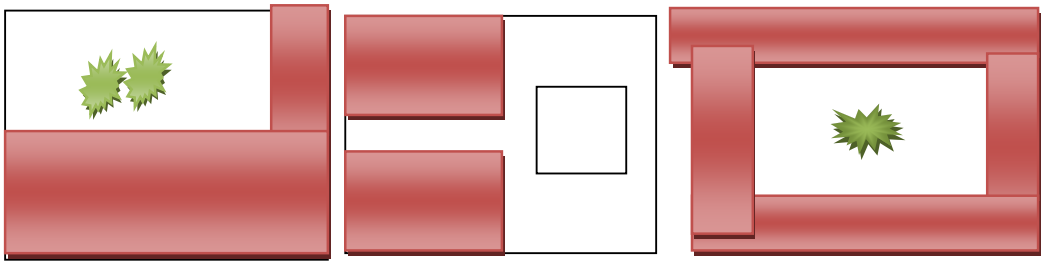
Figure 83: Building from Shanxi City in china which has hot-dry climate (Bouillot.J, 2008)

Table 16: Comparison in hot-dry climate

TYPE OF CLIMATE	HOT-DRY CLIMATE		
COUNTRY	IRAN	TURKEY	CHINA
PLAN			
PLAN CONFIGURATION			
ROOF	FLAT	FLAT	FLAT
WINDOW ON EXTERNAL FACADE	FEW	FEW	FEW
BUIDLING CONCETION TO THE GORUND	ON THE GROUND	ON THE GROUND	ON THE GROUND
DIRECT ENTRANCE	NO	YES	YES
MATERIAL	HIGH THERMAL CAPACITY	HIGH THERMAL CAPACITY	HIGH THERMAL CAPACITY

In constant with table 16, the configuration of the buildings in Iran and China are like square, which has the hole at the centre of the building. Courtyard in this type of buildings can keeps the coolness and humidity of the night and gives refreshment through the summer days. Additionally the configuration of the building in Iran is in the manner to protect the building form sand storm. Therefore, building is likely to be exposed to undesirable wind and sand storm. However, vernacular building in Turkey has a rectangle shape which has a courtyard on the northern side of the main building. Moreover, Ozdeniz in his research found that "buildings in Turkey have *eyvan*, which is a hall open to one side and covered with a vault. The open side faces the courtyard. The summer rooms may have some opening to the *eyvan*. Also the water following over the pool at the courtyard runs through the joints of the stone ground plates. The evaporation of this water provides refreshment in the dry climate. There are also artificial waterfalls at the *eyvan* and the basement rooms used for living in summer".

However, in Iran and China all of the paces of the buildings are located around the courtyard; because in hot-dry climatic region, all of the activities would happen in the central courtyard during the summer from afternoon tills the morning. Furthermore, the great thermal mass of its building fabric causes the interiors of the house to become hot. Therefore, it was more comfortable for residents to stay in the courtyard. In addition, the courtyard in China and Iran is completely enclosed by buildings and walls. There are no windows on the outside walls, and usually the only opening to the outside is through the entrance door. Since, the walls around the central courtyard not only give privacy and some protection from burglary. For instance, women can move freely in the courtyard, without worrying about being observed by strangers.



Iran Turkey China

Figure 84: Arrangement of the building in Iran, Turkey and China

Another difference between these countries is about the entrance of the buildings. In this respect, in Iran and China, for entering to the building, resident first should pass from the corridor afterward to the central courtyard. Moreover, because of the cultural aspect in these countries courtyards were constructed in such a way that, when someone looked through the first doorway of the house, only a brick screen was visible. Conversely, inhabitant in Turkey directly entered to the courtyard then to the building.

Moreover, there are one more similarities between the vernacular buildings in these entire regions, which had less and small windows in exterior façade, although they have a lot of large window towards a central courtyard. This central courtyard in Iran, China and Turkey mostly is full of trees and pool which can cool the air. Subsequently, this cool air can enter form the opening to the buildings.

Moreover, another similarity between vernacular building in Iran, Turkey and China is having summer and winter room. As a result of the fact, summer rooms in vernacular buildings of Turkey, China and Iran are located toward the courtyard rooms and they have a lot of openings. These summer rooms, for being cooler in hot period of year, are larger and have higher ceiling than the winter room.

In addition, there is less rain during a year in such a climatic condition. Therefore, these vernacular buildings in Iran, China and Turkey have flat or convex roof. Furthermore, wall in hot-dry climate works as an important element in these kinds of

buildings. Therefore, in Iran some of the building's walls have the thickness around one meter. Because this much of thickness can lose heat through transferring, and radiation during night and its temperature remain in low and average degree during a day. Thus it can provide enough comfort for residents. Moreover, the wall thickness of the building in China and Turkey in this kind of situation is between 0.50-0.6, which also can work as a good thermal insulation. Additionally, in such a hot-dry with cold winter climate the material for the wall in Turkey is mostly stone and in China is mostly earth and wood and in Iran is brick, adobe and mud, which have high thermal capacity. Therefore, there are appropriate materials for this hot-dry climate.

Moreover another difference between these three countries are wind tower, which in Iran traditional people noticed that intolerable hotness and dryness of this region can be solved by putting them in their buildings. Therefore wind catchers is one of the other elements of the Iranian buildings which are located in hot and dry with cold winter climate, which the other two countries did not have such an element for cooling their buildings during the hot period. These wind towers in Iranian building can works as ventilator for cooling the interior space.

Finally, this study found that all of these three vernacular buildings which are located in hot-dry climatic conditions have some similar architecture characteristics. For instance, hot-dry conditions force them to use natural ventilation. Thus, all of these buildings have central courtyard. Furthermore, all these three buildings have many windows face to the central courtyard and *eyvan* to conduct the natural ventilation inside of the house. In addition in such a climate, rainfall is less during a year. Therefore, all of these building have flat roofs. Moreover, because of harsh hot climate during the summer period, most of the buildings have material with high thermal capacity. Consequently this research reaches to the point that, all of these

buildings in China, Turkey and Iran with different culture have same design principles according to the climatic conditions. As a result, special designing according to the climate in these cases causes to preserve the buildings from hot-dry climatic conditions.

Chapter 4

4 CONCLUSIONS

In the absence of modern technologies and with very limited resources, the traditional builders of Iran had advanced techniques for controlling the climate. They provided comfort conditions by using only the natural materials such as earth, sand, stone, water and plants. In addition, they utilized more from sun and wind energies. They constructed with restricted alternatives. They had to understand the environmental elements and factors to make the best use of them. Otherwise, their buildings would have been very cold in winter and very hot in summer.

In the past, people of the central plateau used to sleep on the roofs at nights and stay in their cool basements in the afternoons during the hot summer days. The plants would be watered and the ground of the courtyard sprinkled with water in the afternoons. Hence, the air could be cooled and humidified by evaporation. In order to protect the buildings from summer heat, straw canopies would be stretched in front of their deep and long southern balconies. However, architects of today provide the comfortable conditions by means of expensive and polluting mechanical equipments. The present methods for constructing are based on the maximum consumption of resources and maximum production of waste. Today's, in spite of the new construction materials and technology, most of the buildings are built very expensively. Despite these prices and waste of energy, people cannot feel comfortable to live in such modern buildings. Furthermore, the cost of the maintenance of mechanical equipments and the price of energy are becoming increasingly expensive. On the other hand, such equipments increase the

environmental pollution. Scientists, architects, and engineers of today should try to use renewable sources such as solar, wind, geothermal, and hydro energies. This research aims at analysis the climate of Iran by bioclimatic method in order to assist architects to design climatically adaptive buildings. Consistent with the bioclimatic analysis, Iran has five different climatic regions.

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 methods and principles that our ancestors employed for thousands of years in constructing buildings, which in these methods sense and reason could be brought by utilizing the environment. Thus, in the second stage of this research, vernacular Iranian architecture was studied in terms of bioclimatic analysis.

In the past, Iran was one of the central places of bioclimatic architecture, and now these vernacular buildings present the appropriate answer to sustainability.

Each climatic region of Iran has different approach in architecture, building typology and city structure. For instance, in the cool climatic region, the city has compact layout and the buildings are oriented to the south; since, in that direction spaces can be protected from cold wind and they receive more solar heat. At hot-dry and hot humid regions of Iran buildings are more open to the environment. In hot-dry with cold winter climate, which most of the vernacular buildings are organized around the courtyard, the central courtyard can work as a perfect and efficient thermal mechanism. Central courtyard at the same time provides protection from sand storms. In these different climates of Iran buildings are designed in order to catch the local breeze. Thus, sun shading, wind ventilation and water features are the main factors for designing the compact or open city.

This comparison of vernacular architecture at the different climate regions would be helpful for getting the new thoughts for the modern architecture. Consistent with the bioclimatic analysis and comparison of vernacular Iranian architecture, this research found that if form follows function in modern architecture, in Iran's traditional built environment, urban context, building form and construction materials are follows the climate. This means that in each different climatic region in Iran, buildings are designed and built with regard to the climatic conditions of that specific region. Clarifying the vernacular Iranian buildings can assist the architects to get some new deliberation from the experience which our ancestor tried to achieve in previous years.

At the third stage this research compares the vernacular Iranian architecture of each climatic zone with the vernacular architecture of the same climatically zone in the world. As a conclusion of this study, it can be said that in accordance with the comparison, these case studies in spite of different cultures have similar architecture

characteristic. These similarities appear from different factors, which one of them is climate since all of these vernacular buildings are constructed according to the climatic conditions. For instance, in cool region of Iran, most of the rooms have low height roof because it is hard to heat large volumes. However, the height of the building in hot- dry climate is influential on the absorption of solar radiation, since increasing the height leads to increase on the building façade area. Furthermore, sun radiance is more on the horizontal surfaces than the vertical surfaces, so it is better to decrease roof surface and increase walls' surface.

Designing according to the climate can preserve the buildings from harsh climatic conditions and can provide the comfort climatic conditions for inhabitants. Traditional builders in all these countries chose material, form and plans of these vernacular buildings consistent with environmental factors. There were some certain intelligence and logic in many methods and principles that our ancestors had used for constructing vernacular buildings in the past thousands of years.

This study can be thought as an investigation about employing the old building principles and technique in modern buildings. For instance, wind tower, *Shenshil* and central courtyard and also some other climatic elements of vernacular architecture can be used in modern buildings. Further study is needed on how today architects can employ the climatic elements from vernacular architecture in modern building or how architects can design the sustainable modern building consistent with vernacular architecture.

Finally, this research concludes that it would be better if people understand the value of their natural environment. So they can keep the environment cleaner and free from pollution and noise. It will be better to use the mechanical equipment when climatic design cannot satisfy the conditions for human comfort.

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