

# **Comparison of Iranian and Turkish Traditional Architectures in Hot-Dry Climates**

**Marjaneh Khorsand Mashhadi**

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Approval of the Institute of Graduate Studies and Research

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Prof. Dr. Elvan Yılmaz  
Director

I certify that this thesis satisfies the requirements as a thesis for the degree of Master of Science in Architecture.

---

Assoc. Prof. Dr. Özgür Dinçyürek  
Chair, Department of Architecture

We certify that we have read this thesis and that in our opinion it is fully adequate in scope and quality as a thesis for the degree of Master of Science in Architecture

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Prof. Dr. Mesut Özdeniz  
Supervisor

---

Examining Committee

1. Prof. Dr. Mesut Özdeniz

2. Assist. Prof. Dr. Polat Hançer

3. Assist. Prof. Dr. Nazife Özay

## **ABSTRACT**

Climate is a fundamental environmental factor, which effects the formation of vernacular architecture throughout the world. Environmental factors such as climate, building materials, topography and socio-cultural differences affect the design of old settlements and traditional houses in vernacular architecture. Regardless of these factors, in order to achieve comfortable thermal levels in old settlements, different cooling and heating strategies must be implemented for various different climates.

The traditional houses of Yazd and Diyarbakir are typical examples of structures that are adapted specifically to hot and dry climates. These two regions consider the environment by being eco-friendly and using natural resources to protect not only their surroundings but also the earth as a whole.

The first step of this thesis is to clarify the differences between vernacular and traditional architecture. Design characteristics of traditional houses in two different regions will be introduced in the second stage. The last stage of the thesis will evaluate and compare urban textures and traditional houses in Yazd and Diyarbakir in terms of design characteristics and socio-cultural issues. The importance of the study derives from the climate similarities of Yazd and Diyarbakir. There are some similarities and differences in the design of traditional houses and urban morphologies between the two regions. The core principle criteria will be identified. In fact, the study will find the principles, which provide the most efficient and comfortable for inhabitants in the old

settlements of the two cities. As well as the effect of the cultural aspects in design of the traditional houses. Consequently, the aim of this study is to achieve and compare the similarities and differences between the design characteristic in order to gain natural ventilation and protection from sunlight as well as other issues that may affect them such as socio-cultural aspects between Yazd and Diyarbakir region.

Qualitative methodology will be applied for this research. Document analysis will be used in order to achieve the theoretical framework. Reliable sources such as written and visual documents, official publications and detailed reports will be studied and interpreted to further the reliability of the thesis. Furthermore, observation is another possibility that can be implemented for data collection particularly in the Yazd region of Iran.

The main reason for differences between two regions are due to different traditional styles in each region which are inspired from Iranian and Turkish traditional architectures. Moreover, availability of materials in each region is another major reason for differences in two regions. Finally, although both towns have hot-dry climate, Yazd is more effected from the nearby deserts. However, the similarity in traditional architecture of two regions is related to similar climate and dominant Islamic culture in both regions.

**Keywords:** Vernacular architecture, Traditional house, Environmental and socio-cultural factors, Yazd and Diyarbakir, Iran and Turkey

## ÖZ

İklim tüm dünyada geleneksel mimarinin şekillenmesinde önemli bir çevresel etkidir. İklim, yapı malzemeleri, topoğrafya ve sosyokültürel farklılıklar eski yerleşmelerin ve geleneksel mimarinin şekillenmesinde birlikte rol oynarlar. Bu etkenlere ek olarak, ısı konforunun sağlanması için çeşitli serinletme ve ısıtma stratejileri de uygulanır.

İran Yazd ve Türkiye Diyarbakır kentlerindeki geleneksel yapılar sıcak kuru iklim bölgesine uyum sağlamışlardır. Bu iki bölgede geleneksel yapılar ekoloji dostu olarak, doğal kaynakları yalnız kendi çevreleri için değil, dünya için de korurlar.

Bu çalışmanın ilk adımı “vernacular” ve geleneksel mimari arasındaki farkı ortaya koymaktır. İkinci adım her iki bölgedeki geleneksel yapı özelliklerini ortaya koymaktır. Son aşama, her iki bölgedeki geleneksel kent dokusunu, evleri tasarım özellikleri ve sosyo kültürel konular açısından karşılaştırmaktır. Araştırmanın önemi farklı kültürel özelliklere sahip olmakla birlikte her iki bölge de benzer iklime sahiptir. Bölgelerin geleneksel yapılarında da benzer ve farklı özellikler görülür. Çalışma her iki bölgedeki en etkin ve konforlu yapı ilkelerini ortaya çıkarmayı amaçlamaktadır. Sonuç olarak Yazd ve Diyarbakır evlerinde doğal havalandırma, güneşten korunma, ısı kaybı ve kazançları sosyo kültürel konularla birlikte ele alınacaktır.

Bu çalışmada niteliksel araştırma yöntemi uygulanmıştır. Konuyla ilgili literatürde mevcut dökümanlardan yararlanıldığı gibi gözleme, anket çalışması, röleve gibi döküman toplama çalışmaları da yapılmıştır.

Her iki bölgedeki farklılıklar geleneksel alışkanlıklardan oluşur. Farklılığın bir diğer nedeni bulunabilecek inşaat malzemeleridir. Son olarak, her iki iklimin de sıcak-kuru olmasına karşın, Yazd, çevresindeki çöllere daha çok etkilenir ve bu geleneksel yapıların biçimlenişine yansır. Benzerlikler her iki bölgenin de islam kültürünün etkisi altında olmasıdır.

**Anahtar Kelimeler:** Vernacular mimari, geleneksel mimari, çevre ve sosyokültürel etkenler, Yazd, Diyarbakır.

# TO MY FAMILY

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# Chapter 1

## INTRODUCTION

Since the beginning of the recorded history, humans have always strived to live in harmony with nature. However, the unpredictability of nature restricts them to certain activities in order to acclimate to the conditions. People were always faced with restrictions such as the need for clothes and shelter due to their genetic make-up. They try to emulate these barriers to respond to different climate conditions. Throughout history, humans have been developing homes in order to achieve climatic comfort in a variety of climatic conditions. Thus, the use of climatic characteristics in traditional houses has always been considered even in ancient times. (Ozay, 2004)

Traditional houses in vernacular architecture are the best examples, which provide comfortable and sustainable living spaces that are adapted to the climate. Most problems could be solved in the design of a building by looking briefly at the past and differentiating the characteristic designs of traditional houses of vernacular architecture in various climates. Solar protection and solar gain are one of the more substantial factors in the design of traditional houses. From another point of view, passive cooling and heating strategies are common in traditional houses, particularly in hot-dry regions. As a result, these strategies have impacted the design characteristics for achieving comfort indoors. (Zandi, 2006)

The first step in the design of a traditional house is to identify the main climate challenges and the acclimatization strategies of the proposed region. This is achievable by studying bio-climatic charts and the climatic data of every region. The effect of the climate in the design of houses must be studied in order to create a comfortable space for inhabitants.(Pourvahidi, 2010). However, environmental control in vernacular architecture has a direct impact in the design characteristics of a house and traditional settlements have also been influenced by socio-cultural features as well.

Iranian vernacular architecture achieves comforting indoor spaces without using mechanical systems. In other words, traditional houses provide indoor comfort for users by using wind tower, central courtyards, basements, semi open spaces and adequate windows and selecting appropriate material for roofing, storage and walls. (Zandi, 2006)

On the other hand, traditional architecture of Diyarbakir is coherent with their culture and they respect the people and the environmental conditions whilst providing suitable living spaces. In other words, the traditional houses in Diyarbakir are the best examples of ecological architecture which uses natural energy sources, environmental protection and respect for materials as well as the effect of the culture in design characteristics of the houses.(Baran, Yeldirim, & Yelmaz, 2010). Sustainable living spaces such as a central courtyard, basements and semi open spaces allow for a more comfortable and a healthier indoor space for users due to the fact that the building is harmonized with the climate.

For understanding the effects of socio-culture and environmental control factors in traditional houses, two different regions that have the same climate changes will be studied. Yazd region which is located in Iran and the Diyarbakir region located in Turkey will be the case study which has been investigated and analyzed thoroughly in this study. Both of the regions are situated within the same climate but have totally different design characteristics in terms of traditional housings and urban textures. Consequently, the reasons behind the similarities and the differences in the design characteristics of houses between the two different regions with same climate will be studied in order to comprehend how comfort in indoor spaces is achieved without high amounts of energy consumption.

### **1.1 Background of the Study**

Yazd city is located in the central part of Iran. The climate of this region is hot-dry. Maximum temperature in the heat of summer reaches 50 degrees centigrade and the minimum temperature at night in summer reaches 15 degrees centigrade which shows the high fluctuation of temperature between daytime and night time. The urban aspect of Yazd city provides a shading area for travelers. Therefore, the city is has a compressed urban form where all of the buildings are adjoined. Then narrow streets are covered by arches, which provide shading for travelers. (Pourvahidi, 2010)

As Maziar stated (2006) in his thesis, in spite of the harsh conditions of the weather with minimum rainfall annually, they provide a reasonable comfort level for the inhabitants by changing the air temperature and humidity without consuming high amounts of energy. (Zandi, 2006)

They transfer water from remote locations and store it in Ab-anbars (underground water reservoir) to satisfy their daily needs through a Ghanats (underground water reservoir). A wind catcher is not only symbolic, but it is also a functional element which is used in this region to create natural ventilation for inner spaces through convective and evaporative cooling systems. Courtyard houses are integrated for protection from summer sunlight. Adobe material is the local material that is preferably adapted to this climate. Consequently, wind catchers, underground water reservoirs, central courtyards and appropriate materials are innovative solutions for gaining a passive acclimatization in vernacular architecture of Yazd region. (Zandi, 2006)

Diyarbakir is located in the southeastern part of Turkey. Traditional houses are adapted to hot and dry climates. There are large fluctuations in temperature between daytime and the nighttime throughout the winter and summer time. As Ozdeniz (1991) stated in his paper, the mean highest air temperature reaches 40 degree centigrade in summer. Additionally, Turkish traditional houses adapted to hot-dry regions have a form which resists heat gain.(Ozdeniz, 1991) Diyarbakir city is bounded by city walls and divided into four main parts by streets located on NS and EW axis which is surrounded by shady Narrow Streets. (Suzen, M., Gedik,G., 2007). Courtyards, semi open spaces, suitable building forms (aligned inward) and orientation type (North-south direction) are the solutions adapted in the region by inhabitants who are satisfied.

The most important issue, which has currently not been studied until now, is the comparison of both regions in terms of the design characteristics aspect of traditional houses, urban textures and socio-cultural features.

## **1.2 Problem Statement**

Yazd and Diyarbakir vernacular architecture are formed with consideration to the climate and cultural features. Vernacular architecture traditions in Yazd and Diyarbakir use local solutions for gaining passive acclimatization with socio-cultural aspects. In other words, using renewable energy sources such as wind, sun, geothermal and hydro energy to achieve a comfortable indoor living environment with a consideration to the cultural aspects of the region in vernacular architecture is a key factor. Thesis the general information provided about Yazd and Diyarbakir in books and articles. What is not considered in the available resources is firstly to clarify the environmental and socio-cultural factors and how they have an effect on the design characteristics of vernacular architecture and traditional houses in both regions. In fact, solar protection, natural ventilation and providing cooling spaces due to the hot-dry weather conditions in both regions are the essential factors in the design of the traditional houses as well as the socio-cultural aspects. How do the effects of these features create differences and similarities in traditional housings of two regions? Why are there differences and similarities between two regions within the same climate conditions in terms of design characteristics of the traditional houses and urban textures?

## **1.3 Aims and Objectives**

The aim of this study is to attain the results and compare the similarities and differences in design characteristics between Yazd and Diyarbakir regions. In other words, acquiring and comparing environmental factors and socio-cultural features could have an effect on urban morphologies and traditional houses in both Diyarbakir and Yazd regions with the same climate.

One of the most important issues, which should be considered in both regions, is the reason to the differences in the design characteristics between Yazd and Diyarbakir in spite of the same climate characteristics. How has socio-cultural factors affected the design of the traditional buildings in each region? Additionally, the most important factors in forming the vernacular architecture and traditional houses of every region should be discovered. In other words, which of the socio cultural challenges or the environment control aspects had a substantial impact on the design of the traditional houses in both regions and the reasons for every factor should be clarified.

#### **1.4 Research Methodology**

Qualitative methodology will be employed for the research of this thesis. It is classified in two sections. Literature survey and field studies are to be performed which is based on documents and observation in Yazd region.

#### **1.5 Literature Survey**

Data collection method is according to the document's analysis for achieving the theoretical framework. Reliable sources such as written and visual documents, official publications and reports will be studied and interpreted. Literature survey helps achieve reliable documents which are related to the focus of this study and demonstrates different points of view for the subject.

##### **1.5.1 Field Study**

Data collection and analysis in this method is related to the field study. Two different cities in hot and dry climate of Iran and Turkey have been selected. Different traditional houses in Yazd and Diyarbakir cities will be analyzed.

Visiting the Yazd region in order to observe and experience the atmosphere by taking some photos and visiting some traditional houses are fundamental in the field survey. The data analysis in Yazd region is based on observation, taking photos. Five traditional houses have been investigated and are studied deeply. The reason for selecting five case studies is that their characteristics are very much related. Tehrani's house with the direct connection to the underground water network in basement, Goshan's house with three different court yards, Rasoulia's house with the Godalbaghche and Orusi, Semsar's house with one courtyard and a simple house without a wind catcher will be observed and will be analyzed as a part of the case study.

Data collection of Diyarbakir relies heavily on consistent documents. Therefore, the design characteristic of the traditional houses and the passive methods of cooling and effects of socio-cultural features will be attained by observation Yazd region.

The process of the thesis is categorized into three stages. Firstly, the theoretical framework of vernacular architecture and the traditional architecture will be interpreted and the factors which affect the design of the traditional settlements will be determined by referring to reliable Documents. Moreover, general information about Yazd and Diyarbakir will include climatic data and vernacular architecture of the region will be clarified. Additionally, the differences and similarities in the design characteristics of old settlements will be analyzed one by one with illustrated examples from every region by giving the reasons to the similarities and differences between the two.



## **1.6 Limitation**

The first limitation is the traditional houses which are referring to rural architecture, buildings with architects. The second limitation is the traditions, domestic routines, politics, and economical issues which are related to cultural issues that will not be studied and compared in this research. The third limitation is the environmental factors and socio-cultural issues between Iran and Turkey in the same climate will be investigated. The last limitation is the two hot-dry regions from Iran and Turkey will be analyzed and not the whole of the cities located within the hot-dry region. As a result, Yazd from Iran and Diyarbakir from Turkey will be analyzed and compared as a part of the study.

## **1.7 Significance of the Study**

The importance of this research could be perceived in contemporary architecture. Considering environmental factors and response to the environmental issues is missing these days. Moreover, it is fundamental to be inspired from tradition architecture for contemporary architecture because whole patterns in traditional house contexts are according to the acclimatization. However, these issues have completely been phased out nowadays. In other words, old settlements have been designed with respect to the environment more than anything else. So, passive heating and cooling systems were more considerable in design the characteristics of traditional houses. The socio-cultural challenges have been mentioned in the design of traditional settlements as well. Therefore, these two regions could be a good example for presenting the design characteristics in terms of passive cooling systems for achieving the indoor environment comfort without neglecting the cultural aspects in the design houses. Consequently,

these features could be patterns for contemporary architecture in order to provide comfort for users by using sources of natural energy.

## Chapter 2

# THEORETICAL FRAMEWORKS OF IRANIAN & TURKISH VERNACULAR & TRADITIONAL ARCHITECTURES IN HOT-DRY CLIMATES

Vernacular architecture has been discussed many times since long ago by researchers. There are a variety of viewpoints about this kind of architecture and the differences to the traditional architecture. This part of the study clarifies the differences between vernacular architecture and traditional architecture and introduces the impact of hot-dry climates in vernacular and traditional architectures in Iran and Turkey. In other words, the vernacular architecture and the factors which shaped these types of architectures in two regions which are located in hot-dry climates of Iran and Turkey will be studied.

### 2.1 Vernacular Architecture

Generally, one of the most important meanings for the term “**vernacular**” is specific built environments. However, specialists use varieties of terminologies in order to define similarly built environments. Therefore, the synonym of vernacular must be defined in this study.(Dincyurek, 2002)

The vernacular is the native idiom in the study of the language. Oliver (1997) mentioned in his book that, the term vernacular originated from the Latin word **vernaculus**, which

means native. He also indicated that vernacular is “the local or regional dialect, the common speech of the building. As such it comprises a range of building traditions as wide as that of the linguistic traditions”. (Oliver, 1997)

There are many synonyms for vernacular; these include “**anonymous, folk, indigenous, primitive, popular, and spontaneous**”. Dincyurek defined this word in his thesis as, “architecture without an architect and non-pedigreed architecture”. (Dincyurek, 2002)

Oliver used the term “**shelter**” to emphasize the essential motivation for building because the need of a shelter was the fundamental issue against the unfavorable environmental conditions such as rain, storm, cold weather and it was even influenced from the period of Adam and Eve. Some writers have used the term “**indigenous architecture**”, although much non-formal architecture was not built by the locals. In fact, it was built by the immigrants and colonists. (Oliver, 1997)

At the time of inception and construction, every building has an owner or a builder who are never anonymous. Only in critical situations, we could call it anonymous, because there is no document to prove that it has a creator. So, “**anonymous architecture**” reflects the observer’s bias towards buildings by named architects, while “**spontaneous architecture**” implies that building was constructed without conscious volition (desire or decision)”. (Rapoport, 1969)

“**Folk**” is the majority of the people in the lower culture, and it is a reference used amongst ordinary people. “**Popular**” comes from the ordinary people which are

discriminated from a select group. These definitions and words were being used by different writers. (Rapoport, 1969)

Vernacular architecture defines the majority of the built environment. Some writers recall this as “the architecture of the people”.(Dincyurek, 2002). Vernacular is the architecture of common, ordinary people in the lower class environment at the same scale and repeated patterns which can be identified as the artifacts, building and settlement scale.(Dincyurek, 2002). Rapoport (1997) indicated that one of the main differences between vernacular and other environments is related to the determination of the process of environment during conceive, design and the build.(Rapoport & Oliver, 1997).

Brunskill (1992) defined vernacular as a kind of building, which is inspired from traditional ways instead of academic and consider the ordinary activities of common people in order to satisfy their initial needs by using local and available materials. (Brunskill, 1992)

Consequently, vernacular architecture is the functional architecture of common people which belong to current environmental characteristics, socio-cultural features with the traditional technology and available material.

## **2.2 Traditional Architecture**

In order to clarify the traditional architecture, it is better to refer to the word “tradition”. There are different definitions about tradition by the researchers, scholars of different fields of art and social scientists. It is classified in two categories. The first definitions

embody the principles, methods and ideas, which is mostly related to the religious and innate beliefs of the community. The second definition belongs to the material and sources which formed the traditions. In fact, social and cultural factors had an effect on the formation of traditions by collecting the principles, methods, phenomena and ideas through the ages. (Ahadi, 2011)

Ahadi stated that there is a difference between “**tradition**” and “**traditional**”. He defined that “Traditional means the limitation of the past and traditions means constancy”. (Ahadi, 2011)

Traditions include a collection of the features, materials, compositions, designs and principles which have been formed gradually since the beginning of the history in the field of architecture in a dynamic way with the base of environmental conditions and other effective factors such as social and cultural which has shaped architectural spaces.(Soltanzadeh, 2006)

Traditional features can be explained in terms of the environment, which include traditional buildings with functions that illustrate the traditional patterns of the particular region.(Oktay, 2002). Oliver (2002) defined “traditional environments” as a term which referred vernacular settlements and monument buildings and any settlements which introduce the culture of the region and have an adaption with the environmental values. (Oliver, 2002)

**“Traditional architecture”** is the most widely used of the alternative term of vernacular architecture but while majority of building forms discussed in the encyclopedia of vernacular architecture of the world originates from traditions, **”traditional architecture”** is also generally applicable to a variety of monuments or buildings which are designed by architects or specialists. (Oliver, 1997)

There is a major difference between traditional and vernacular architecture. Traditional architecture is designed by professionals and architects with consideration to both the function and the aesthetic elements in the construction of the holy, monumental and residential buildings while the vernacular architecture is constructed by indigenous people without any knowledge about architecture which is a more functional design rather than an aesthetic design for satisfying the initial needs and protections from wind, rain and harsh climatic situations.

However, there is another word that is used **“vernacular tradition”** that Cavacanty (1996) mentioned in his book. “It is the direct and unselfconscious translation in to the physical form of culture, its needs and values-as well as the creativities, desires, dreams, and passions of a people”.(Cavalcanity, 1996)

### **2.3 Environmental Factors in Traditional and Vernacular Architectures**

Available material has been collected by man during the construction of vernacular houses from their immediate surroundings that brought them to construction site and form the materials into useful shapes for their houses with simple tools. Adaption of

houses in the existing environmental conditions is one of the most important considerations during the construction process. (Oktay, 2002)

Oliver (1997) focused on the important relationship between “environmental factors and vernacular architecture” and he described this relationship as: “All existing vernacular cultures are shaped by their environmental contexts”. (Oliver,1997).In fact, vernacular settlements are initial forms of shelters to protect humans from harsh climatic conditions. These conditions and cultural features have an effect on the formation of vernacular houses. Consequently, climate, topography, building materials and techniques for construction are the most important environmental factors, which have an impact on vernacular/traditional architecture.

### **2.3.1 The Impact of Hot-Dry Climate in Vernacular and Traditional Architectures**

Historically, people invariably need a shelter against unfavorable environmental conditions such as rain, storm, cold weather etc.. “Climate is integration in time of the physical state of the atmospheric environmental characteristic of a certain geographical location” (Shokouhian, 2007). Climate is one of most fundamental factors which have an effect on the formation of the vernacular and traditional houses as a whole. Throughout different time spans, humans have been developing their houses in order to achieve climatic comfort in a variety of climatic conditions, thus, the use of characteristics of a climate in housing has been considered since the beginning of the history. (Oktay, 2001)

Wind and sun direction, humidity, air pressure, temperature and rainfall demonstrate the climate which has an effect on form, orientation and material of houses. (Yaldiz, 2009).



As a result, obviously climate conditions are diverse in natural environments, which cause variety of building approaches in vernacular architecture. In fact, there are some elements which demonstrate the impact of climate for particular regions. In this part of the study, the author investigates the impact of hot-dry climates in vernacular and traditional architectures. The hot-dry climate has a direct effect on urban morphology, design characteristics and construction in vernacular and traditional architectures. Compact urban environments with narrow streets which are covered with vault, dome and other shading elements is the impact of hot-dry climates in vernacular and traditional architectures avoid intense solar radiations. These kinds of urban textures in hot-dry climates provide shading for passengers because it is a highly essential feature to have in this sort of climate. Consequently, prevailing winds and sunlight are the two major factors for orientation and configuration of the urban fabric in the hot-dry climates. (Ghobadian, 2009). Moreover, the hot-dry climate has a direct effect on form, orientation and materials used for the buildings. As a result, design characteristics and urban morphology in hot-dry climates should adapt with the climate in order to have indoor environment comfort for users by using natural elements or passive energy consumption.

### **2.3.1.1 The impact of Hot-Dry Climates on Building Forms**

As it is mentioned, the forms of houses are influenced by the climate. In other words, the forms of the houses are built around solar protection and solar absorption needs in different seasons. The best form of a house has minimum heat loss in the winter and maximum solar protection in summer. The cubic and the compactness of the courtyard is the best form for hot-dry climates in order to minimize the area exposed the solar radiation. In spite of large spaces around it, it has the smallest outdoor surface which is

affected by the solar radiation. In fact, the inner forms of the courtyard in the middle provide shading and natural ventilation for inhabitants by using high walls around the perimeter and plants in the courtyard. (Ghobadian, 2006)



Figure 1: Best form in hot-dry climate (Ghobadian, 2006)

### **2.3.1.2 The Impact of Hot-Dry Climate on House Orientation**

The direction of the building depends on its topography, adequate private spaces, sound control, wind and solar radiation. One of the most important duties for a designer is to consider building the building in the direction that will reap the maximum benefit from solar radiation. Felix Marbutin calculates the sun radiation in different seasons and directions and below is the results of his research:

- 1) The main facade should be facing south to provide indoor environment comfort (warm air in winter and cool air in summer).
  
- 2) However, the southeast and southwest facades receive the same sunlight; they are warmer in the summer time and cooler in winter compared to the south facade.
  
- 3) East and west walls are cooler in winter and warmer in summer than south, southeast and southwest walls. (Ghobadian, 2006)

Generally, courtyard plans which are oriented mainly on the northerly-southerly axis achieve the minimum east and west sun light exposure in summer and the maximum amount of south solar radiation in winter. (Zandi, 2006)

### **2.3.1.3 The impact of Hot-Dry Climate on Material**

Climate has an effect in selecting the materials for buildings. However, the availability and the locality of materials also have an impact in choosing materials as well. Therefore, in different climates, materials which can be adapted to the climates should be considered. The main characteristics of material that should be considered are thermal capacity and thermal resistance. Characteristics of the materials should be identified according to the critical seasonal periods in the region. For instance, in hot-dry climates with cold winters, the hot day occurrences are subsequently more than the occurrences of cold days. Critical seasons would be the hot periods in this case, so the materials for this kind of climate should be adapted to the hot days. In fact, outdoor hot air should not penetrate indoor spaces in hot-dry climates.(Ghobadian, 2006)

The parts of building which are used during the day should be constructed with heavy materials and other parts of the building which are used at night should be constructed with low thermal capacity and not heavy material because of the high fluctuation of temperature between the day and night times in hot-dry climates.(Ghobadian, 2006)

Material such as adobe or stone with high heat capacity and high time lag could be an adequate material for this kind of climate. Regardless of physical approval, the warm air always moves between the cold areas and vice versa. In fact, the outer walls, which are exposed to direct sunlight could store warmth for a long time during the day and then can transfer that to the indoor spaces because of the low temperature within the indoor

spaces during the nights in hot-dry climates. As a result, the inner walls would be cool during the day and users would feel comfortable. (Zandi, 2006)

### **2.3.2 Impact of Geography in Hot-Dry Climates**

The geography (latitude and longitude) of every region exhibits the climate of that particular region. Koenigsberger stated climate as the “integration in time of the physical states of atmospheric environment, characteristic of a certain geographical location. Therefore, climate can be defined as “the integration in time of weather conditions” where it is “the result of interaction between broad global flow patterns and regional pressure”.(Koenigsberger, 1973). Additionally, the regional and global geographical aspects have a direct effect on these patterns. For example, in the northern hemisphere, the solar radiation is different in every season with comparison to the southern hemisphere.

The important factor in climate is the air temperature of the weather, which are the result of sun’s discrepancy and the effect of heating of water, land and forests. Climatic factor such as temperature depends on the condition of the atmosphere, which is related to the amount of incoming solar radiation and outgoing radiation (Szokolay.S.V, 1980). As a result, large amounts of incoming and outgoing solar radiation cause a wide range of temperature changes in the days without clouds. However, the limited incoming and outgoing solar radiation is less likely to affect the diurnal range of temperature.(Zandi, 2006)

In addition, “the amount of incoming and outgoing solar radiation is affected by the amount of evaporated water, moisture and the humidity in the air”. As Lechner explains,

“the amount of moisture in the air has a substantial effect on the ambient temperature”. Consequently, the reason for such high temperature in the summer days of hot-dry climates is the absence of moisture, where the solar radiation is not blocked from reaching the ground. However, there is little moisture to block the outgoing long-wave rays at night, and consequently, nights are cool and diurnal temperature range is considerably high.(Lechner, 1991). In fact, the angle of sunlight, the amount of rain, The direction of the winds are different in every particular geography. Therefore, this parameter identifies the type of designs in vernacular architecture of hot-dry climate for acclimatization.

### **2.3.3 Impact of Topography in Hot-Dry Climate**

One of the environmental factors is topography, which is considered in the formation of vernacular context. The topographical and physical characteristics of the land have a direct effect on the design of buildings. The sea level identifies the divisions of the land. These are categorized into the highland, the mid land (hill lands), the flat land and the coastal land. (Ghobadian, 2006)

Stone is the preferred choice of material which is utilized in the high land because it is a readily available material in the mountains. Sand and timber are the materials for the coastal areas because it is abundant in the region and timber also has a high adaptability to the moisture of the weather. Earth is the material for mid land because of availability. (Ghobadian, 2006). Ghobadian 2006 stated that “lumps and dents of a land are called topography, which is the appearance of changes on the earth’s crust”. These changes on earth create different types of categories. In fact, some of the land makes hilly and mountainous areas where people prefer to settle. Some dents in the earth create oceans,

rivers and lakes which are the fundamental and initial staples for human life.(Ghobadian, 2006). Therefore, Vernacular architecture on flat land of hot-dry climates is constructed according to the nearest water source, the transportation to the settlements and by the amount of natural protection towards hostile attacks.

All these terms mentioned above demonstrate the importance of the topography with the help of the availability of materials and climatic conditions. As a result, topography has an effect on environmental factors that specifies the design of the vernacular architecture in different climates such as hot and dry.

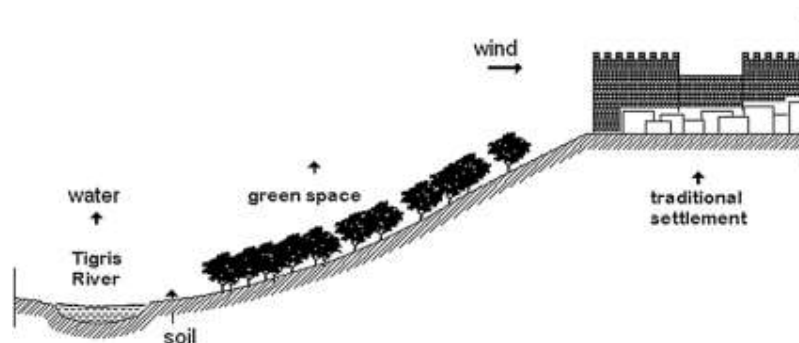


Figure 2: Topography of traditional settlements in Diyarbakir region (Baran, Yeldirim, & Yelmaz, 2010)

## 2.4 Utilization of Ventilation in Hot-Dry Climates

Szokolay (1980) defines ventilation as “the provision of fresh air and the removal of heat by mass transfer is the first of two tasks of ventilation” (Szokolay.S.V, 1980). In other words, ventilation is replacing warm building air with the cool air outside. This effect can be achieved with wind, stack effect and fans. The stack effect occurs when hot air rises because of its weight and is replaced by cool air below so ventilation causes the

heat to be removed from indoor spaces of the building and creates a cool indoor space for users.(Zandi, 2006)

The movement of the air may be produced either by active means or by passive means. Passive way is the process of using natural forces, which lead to natural ventilation while active ways is the process of using mechanical systems to ventilate the air which is not considered in this study. Natural ventilation exhausts the hot air from the building and replaces the fresh air with a lower temperature to gain the indoor comfort level. (Zandi, 2006)

The ventilation strategy, whether it be natural or mechanical it is essential for health, comfort and positive energy which has been considered in the recent years. On one hand, “the appropriate ventilation strategy should be utilized in relation to comfort and health, and on the other hand, it should be energy-efficient”. However, inadequate ventilation provides poor internal air quality. (Goulding, 1992)

Long summers with high temperature fluctuations between day and nights and low relative humidity and low rainfall are the characteristic of hot-dry climates. Therefore, the evaporation rates are greater in comparison with other climates. Humidification, natural ventilation and the provision of shading should be considered in order to achieve the thermal comfort level in the design of the buildings.(Zandi, 2006)

There are different cooling and ventilation strategies in hot-dry climates. These strategies are categorized in; Nocturnal cooling, convective cooling (cross-ventilation)

and evaporative cooling. Nocturnal cooling occurs at nighttime with the radiation of heat from a building to the sky so, the masonry surfaces and the mass of the building is naturally cooled. The heat is absorbed by the cooled masonry surfaces and the building mass during the daytime. The convective cooling method is also produced in two modes at nighttimes. The first one is that the cool air travels down from the roof into the courtyard, and the second one is by the utilization of wind catchers and wall openings in hot-dry climates such as the Yazd region which is equipped with wind catchers. Evaporative cooling is the “exchange of sensible heat in the air for the latent heat of water droplets of wet surfaces”. (Zandi, 2006). By locating pools of water around buildings, these processes will be better functioning. In hot-dry climates such as Yazd, ventilation would be produced by the utilization of wind catchers when the humidity is considerably low, particularly in the evenings.(Zandi, 2006)

#### **2.4.1 Convective Cooling**

As mentioned, convective cooling operates in two ways at night in hot-dry climates. During the night, cool air is produced on the roof of buildings because of the long infrared radiation from the sky. So the cool air travels down in to the court yard and removes the hot air. The parapet at the outer edge of the roof transfers the cool air in the courtyard and prevents the daring of the cool air to the outside of the building. Consequently, the lower parts of the building and the massive buildings structures would be cooled down by the penetrating cool air mass.(Aksugür, 1988)

On the other hand, the prevailing winds caught by the wind catcher in some hot-dry climates or the wall openings which are located on the sides of the courtyard, enter the inner spaces and removes the heat from the building during the night. As a result, during



the daytime, the heat from the air would be absorbed by the cooled structure of the house which leads to decrease of air temperature that is at a comfortable level for inhabitants.

(Aksugür, 1988)

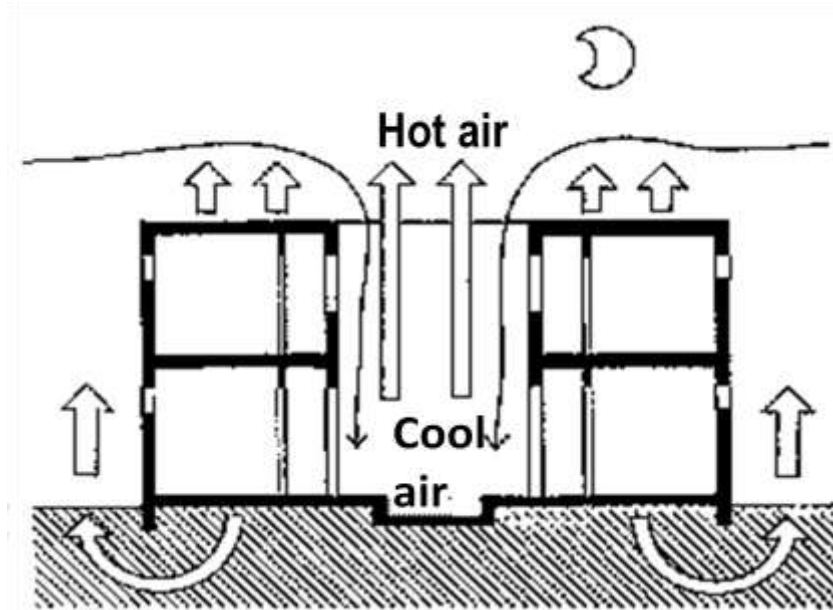


Figure3: Convective cooling (URL1)

#### 2.4.2 Evaporative Cooling

Evaporative cooling is another cooling strategy which brings the comfort to occupants in arid zones or hot-dry climates. It relies on the humidification of the air by the evaporation of water molecules to decrease the indoor air temperature and distribute the cooled air according to the convective cooling principles. This type of cooling brings the feeling of comfort to the occupant in areas that are under hot conditions such as hot-dry climates or arid zones.(Zandi, 2006)

The evaporative cooling system generates two modules. One is produced by passing the air over the pool or any other source of water around the building. The hot air decreases

the temperature by passing the air over the pool and provides cool air to its surrounding which is sufficient for hot-dry climates.

According to Goulding, whenever the vapor pressure of water in the form of droplets or wetted surface is higher than the partial pressure of the water vapor in the atmosphere, the evaporation system will occur. The stage change of water from liquid to vapor is accompanied by removing heat from its surroundings and other adjacent surfaces. The surface temperature will be reduced by the evaporation on the internal surface of a sealed container such as a tube. In other words, the indirect evaporative cooling occurs when adjacent air outside the container is also cooled but without any rise of humidity. (Goulding, 1992)

The second procedure occurs by wind catchers in two ways. Firstly, the mud inside the shaft absorbs the humidity of the air, which comes from the prevailing winds and decreases its temperature. The cool air then travels inside the shaft and enters the building. Secondly, the type of the evaporative cooling operation of the wind catchers happens after passing the air under the chamber and when the air passes over the pool surface, it cools its environment. In other words, in some hot-dry climates such as Yazd, there is a small pool or an underground water network around the wind catchers, so the high velocity air passes over the shaft and over the pool which increases the evaporation rate. The temperature decreases and causes the cooling of the environment to provide natural ventilation. In some houses, there is a floor opening which is connected to the basement under the shaft of wind catcher. The prevailing winds travel down to the basement and pass the Ghanat or pool which creates an evaporative system and cools the

air in the basement. The cool air then travels to the courtyard through the openings thus, provide a comfortable environment in the courtyard. (Zandi, 2006)

There is another evaporation method for inhabitants who are related to the interaction of their body and the environment. The evaporation from the skins of the inhabitants is accelerated by passing the air movement over their body causing them to feel cool and comfortable increasing heat loss and thermal comfort. (Zandi, 2006)

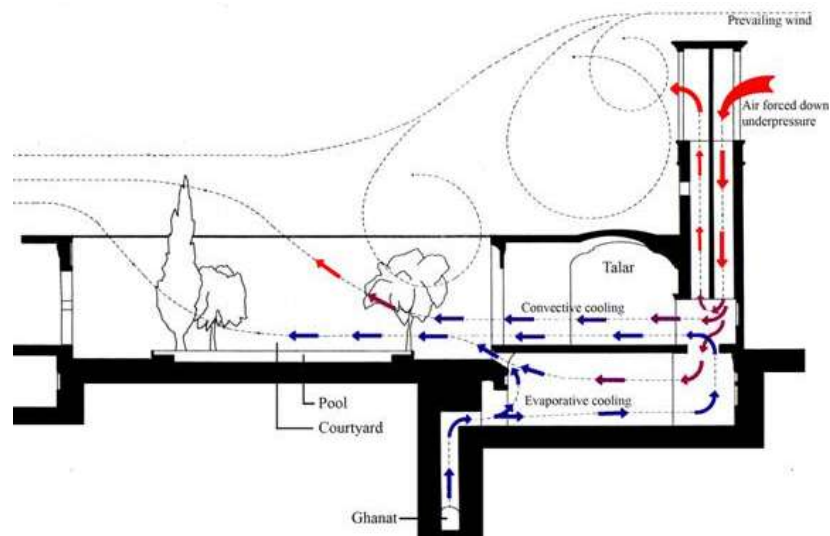


Figure 4: Convective and evaporative cooling by wind (Iranian heritage culture, 2006)

### 2.4.3 Wind Catchers in Hot-Dry Climate

Badgir (wind-catcher) is one of the more unique and traditional elements of vernacular architectures of hot-dry climates. The height of this element is between 2m and 22m and some unique designs reach up to 31 m in the Yazd region. The materials involved in the construction of wind catchers are adapted to the climate. Different types of wind towers according to their opening have been identified in Yazd region.(Zandi, 2006)

Wind towers with one side open face the north to catch the prevailing northerly winds of the Yazd region. There is no waffle wall inside the vertical divisions of this type of wind tower. This type of wind tower acts as a chimney and pushes the air forward. These kinds of wind towers are utilized in water reservoirs. There are four wind towers which are open on one side but in different directions due to the different directions of the prevailing winds in water reservoirs. The second type of wind towers are the ones with two sided opening. This kind of wind towers are used in housings. The third type of wind towers are the ones that are four sided and there is a waffle wall in the middle which divides the wind tower into four equal spaces that increase the evaporation rate and controls the wind pressure. This kind of wind tower is rectangular or square in shape. The last type of wind towers are twin wind towers. This type of wind tower includes all characteristics of the previous wind towers, but contains two separate wind catchers within each other and two openings on each side inside shafts which are divided by waffle walls. This kind of wind catcher has more advantages than the others because it could catch the wind from all directions and at different heights. As a result, more wind could go inside the houses and be even cooler than the other types of wind catchers. The polyngual wind tower type is utilized in the top of water reservoirs because of the diferent ventilationsall different directions.The heighest one is situated in Dolat abd Garden that is 33.8 meters. It is one of the heighest polygan windcatchers in the middle east. Moreover, there are 6 polygan windcatchers in one of the water reservoirs in theYazd region.It is known as the six wincatcher waterreservoir.(Zandi, 2006)

	Types of Badgir ( wind-tower) plans at the vent part	View of Badgir (wind-tower)
One sided		
Two sided		
Twin and four sided		
Polygonal sided		

Figure 5: The typology of badgirs in Yazd region(Iranian heritage culture,2006)

The wind catcher is divided into three main parts, which are symbolic. “The vent on the top of the tower is divided by vertical openings on one, two or on all sides, catches the prevailing wind from different directions “(Zandi, 2006). Vent transfers the wind and decreases the turbulence inside the shaft.

The main part of the wind catcher is known as the shaft. The cross sectional area and the configuration of the shaft influence the total ventilation performance. Diagonal wood supports the shaft, which is repeated at 0.5 m intervals on top of each other, and there are four equal spaces in the shaft by mud walls (baffle walls). These supports are considered to increase the strength of the wind tower. The last part of the wind catcher is known as the chamber, which is the connection between the talar and the wind catcher.

It has a direct connection to the basement through the hole in the floor in some cases. Consequently, the wind which was caught by the vent goes into the chamber or the basement with a high velocity and provides a cooling space for users. (Pooya, 1993)

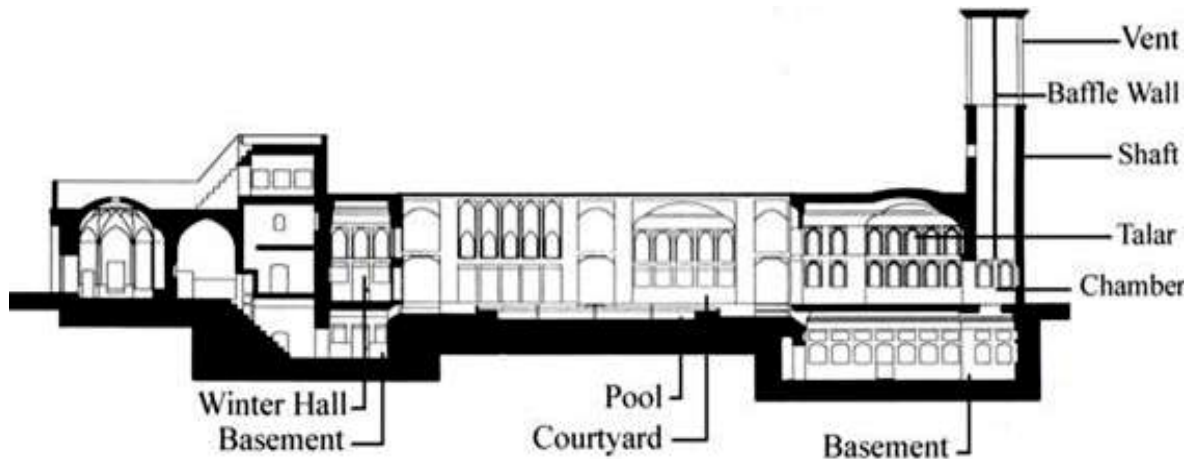


Figure 6: Section of courtyard Yazd house (Iranian heritage culture, 2006)

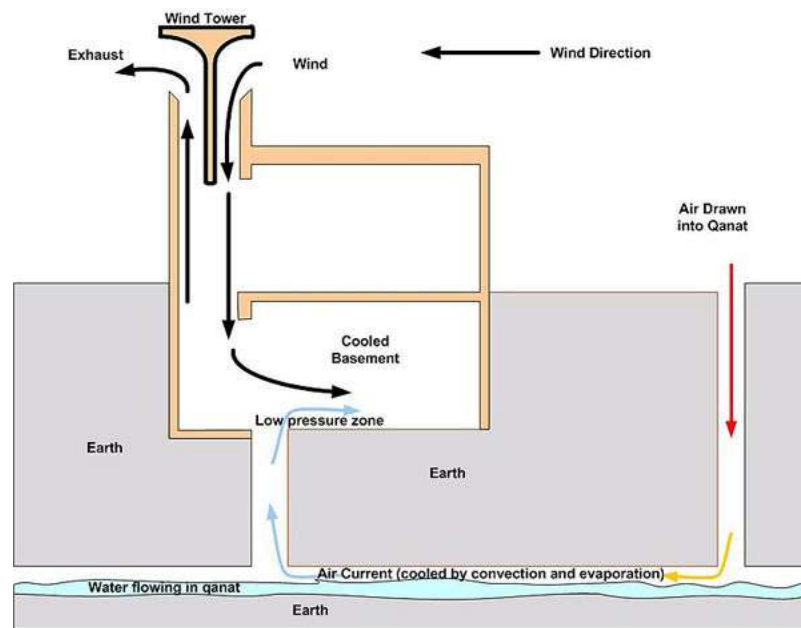


Figure 7: The relationship between wind tower and basement (URL 2)



Figure 8: The view of wind catchers from the bottom of the chamber (Zandi, 2006)

The size, shape, height, proportion, side openings, and vent decorations of wind catchers are classified according to two major criteria; “its acclimatization function and symbolic functions”. Furthermore, due to the architectural point of view, the height, the side openings and the proportion have a direct effect on the velocity of the wind inside the wind catcher and from a symbolic point of view; the decoration, height and the proportion of wind catchers demonstrate the economic situation of the people who reside in the houses. (Zandi, 2006)

#### **2.4.4 Opening Position and Size**

Openings are the connections between the outdoors and the indoors. This connection provides ventilation for indoor spaces so the design of the opening is a fundamental issue which should be considered, particularly in hot-dry climates because creating an indoor comfort is a major priority for inhabitants.(Zandi, 2006). The direction of the opening is completely effected in regards to its efficiency. The intensity and angle of the

sunlight is different all directions in different seasons in the northern hemisphere region such as Yazd and Diyarbakir. The angle of the sunlight in winter times in the south direction is more direct than other seasons so a large opening with large windows could invite more sunlight into indoor spaces for increasing thermal in northern direction. Sunlight coming from the north in the summer time is very intense and has a short angle of approach, so providing shading devices for openings such like shutters or louvers could be an adequate solution for protection from sunlight for indoor spaces that are faced in a southern direction.

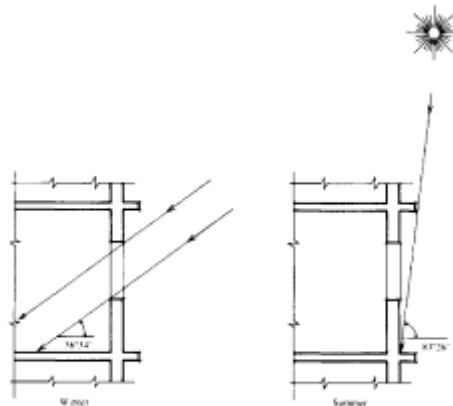


Figure 9: Different solar angle between winter and summer seasons (URL 3)

Due to the positive and negative pressure zones in the windward sidewalls and leeward sides, surface of the building must be towards the wind. (Goulding, 1992). In other words, the utilization of the prevailing wind is another factor, which should be considered in the design of the openings. Therefore, openings should be faced towards the prevailing winds to have the most efficient beneficial from of natural ventilation for indoor spaces.

In this respect, the building will achieve a cross ventilation if two openings are situated exactly in front of each other. In fact, cross ventilation is the most effective ventilation



strategy which is utilized in all climates based on the conditions of prevailing winds and it happens by crossing air flow through the inlet and the outlets of openings of the room in order to cool the space and extract the pollution from inside the room. “The best cross-ventilation occurs in a room with three adjacent walls when the wind direction shifts to the oblique direction”. (Zandi, 2006). Consequently, this type of arrangement of the openings creates the maximum benefit of natural ventilation by the pressure on the windward and suction on the sidewalls and leeward sides.

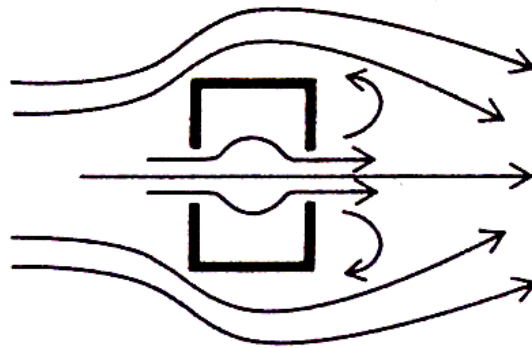


Figure 10: Air flow patterns in cross-ventilation (Bassler, 2000)

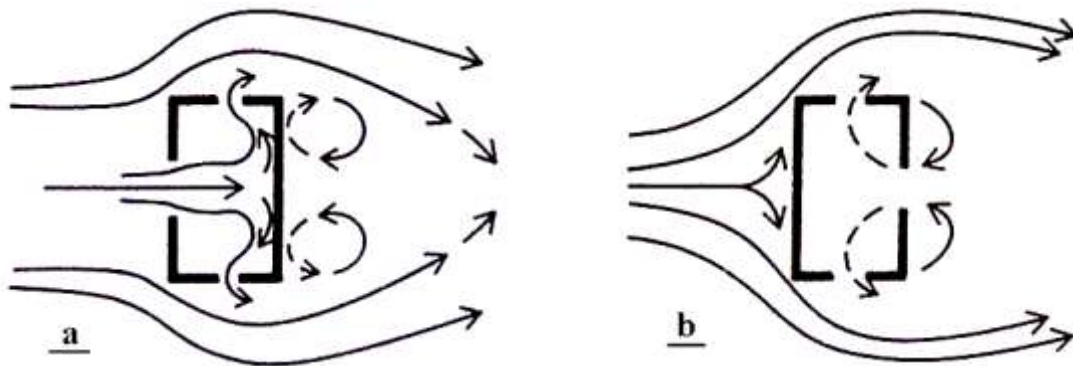


Figure 11: Air flow patterns in cross-ventilation (Bassler, 2000)

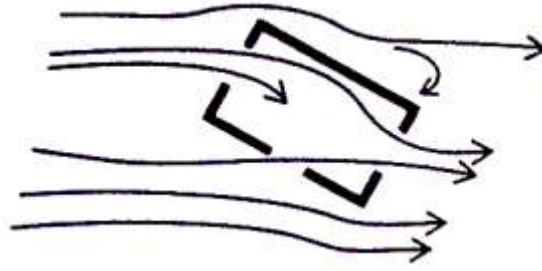


Figure 12: Air flow pattern in cross-ventilation by shifted wind direction (Bassler, 2000)

## 2.5 Iranian vernacular architecture in hot-dry climate

According to Parastoo's thesis, the vernacular architecture in Iran is categorized according to the impact of the climate, so every climate has specific characteristics that illustrate the vernacular architecture of every region. In fact, the climate of every region has a direct effect on urban textures, form, material and orientation of the buildings besides the impact of cultural factors. (Pourvahidi, 2010)

Socio cultural factors formed the vernacular architecture as well as the impact of the climate. The effect of the Islam religion could be visible in the design of Iranian vernacular architecture in hot-dry climates. Designing the house towards Mecca, not having any openings towards the street, no vision of the interior of houses from the streets are the effects on the design of traditional houses in hot-dry climates of Iran.

Hot and dry regions mostly include semi equatorial regions. Wind which travels from south-west and north-west to the equatorial regions makes the weather too dry. Minimum rain, low humidity, herbal cover and lack of clouds make huge fluctuations of temperature during the day and night in hot-dry climates. The largest region of Iran are

blocked by high hills which are located in central a plateau that house hot and dry summers with cold winters. These regions are categorized into two states: Desert climate and semi desert climate. (Pourvahidi, 2010)

An independent zone with a mild climate which is affected by the mountain is the result of a semi desert climate. Meanwhile, desert dry weather is included in the central low plateaus of the east and south east of Iran which is identified as an unknown region because of the absence of a meteorological station. A huge difference between the temperatures between the day and the night with the lowest relative humidity is the main characteristic of these regions with this kind of climatic meteorological station. One of the characteristics of such a climate is the temperature fluctuations between the day and the night times in summer. Lout plain, which is the hottest region in Iran, has the lowest relative humidity. Regions such as Yazd, Kerman and Zahedan are located in a desert climate. (Pourvahidi, 2010)

Shortage of water for agriculture and daily consumption in hot and dry regions, the undesirable wind and sand storms are the leading causes of trouble for inhabitants. (Ghobadian, 2006). However, in spite of these problems, Iranian traditional architecture overcomes the climatic troubles. Generally, in this region, most of the buildings are constructed with the use of local materials with high thermal capacity. Due to the extreme hot and dry climate conditions, most of the buildings are situated in the hills or underground which help control the temperature. Majority of the outer walls are painted white to decrease the absorption of heat. Few windows in the buildings exist, and most of them are located at the top of the walls which are not exposed to direct sunlight.

Moreover, orientation of the building is in the direction that decreases the sun radiation absorption. The plan should be designed in a way that heat absorption from northern and southern facades becomes equal to the heat absorption from eastern and western sides in the hottest season. (Kasmaee.M, 2003). Urban texture is compact in hot-dry regions of Iran in order to maximize sun protection and preventing the effect of sand storms. The borders of houses are not clear because of the common walls that are built between houses. There is an external surface between two adjoined buildings because of this combination. Consequently, each building could achieve maximum shading for its external surfaces by using this kind of construction also preventing the heat from penetrating indoor spaces in summer time as well as preventing the heat loss in winter. (Pourvahidi, 2010). A city situated in hot-dry climates is formed in the direction of desirable winds. Streets are narrow which are covered with arch roofs for creating shade for pedestrians. (Kasmaee.M, 2003)

There is a big veranda which can be used in the afternoon in a hot-dry with cold winter climates. The inhabitants irrigate the courtyards which provide cool outdoor spaces in the yard and veranda. In fact, the courtyard is the focal point in the vernacular architecture of hot-dry climates of Iran. It is a social space for inhabitants as well as the environmental solution needed in these kinds of regions. The high walls are abounded the courtyard which provide shade and the pool along with different types of trees provide comfort for acclimatization. There special courtyard which is called Godalbaghcheh in hot-dry regions of Iran. Site location and topography leads to construct houses around lower levels of the ground. Sunken yards are built in the middle of the central courtyard and another level is built underground because of the location of

the site and the topography of some areas of Yazd. Sunken yard provides bioclimatic spaces due to the lower levels of the ground by utilizing the moist air and the cool ground.(Azami, 2005)

Generally, the height of the buildings in the southern facade should be higher than northern facade because of solar radiation. Furthermore, the two-stories could act as a buffer zone for solar rays in summer as well as preventing the undesirable winds which come from south for winter. Additionally, adobe and sundry brick materials with one-meter thickness could be a good insulation for preventing the heat from penetrating the inside of buildings in this region. Two shielded dome roofs solve the problem for providing a cooling space because of good insulation. Some parts of the dome structures always are not exposed to the sunshine which is adaptable for hot-dry climates.(Azami, 2005)

Another reason for choosing dome a shape in such a climate is the shortage of wood due to minimal rain. The dome roof could be shaped with mud bricks as it is abundantly available in the region. The traditional elements in vernacular architecture of hot-dry climates of Iran are the wind towers. It provides cooling space for users by catching the prevailing wind through the vent at the top. According to Ghobadian's research, wind towers are known in central plateau regions such as Yazd, Kerman and also between the Bushehr and Bandar abbas city in the northern coast of the Persian Gulf because the summers in the region is extremely hot. There is a small pool with a fountain under the wind catchers in some regions. (Ghobadian, 2006)

As it is mentioned before, there are different types of wind towers in Iran; one sided, two sided, four sided and twin and octagonal wind towers. Central parts of Iran such as Ardakan, Bam, and specially Meybod have one sided wind towers. Their openings would be built towards prevailing winds. Common types of wind towers are four sided which are appropriated for cities such as Kerman, Esfahan and Shiraz without sand storms. Octagonal wind towers are ordinary in Yazd region and are located on top of water reservoirs. (Ghobadian, 2009)

Old houses in hot and dry climates are called four seasons' houses.(Ghobadian, 2009). In other words, every part of house is appropriated for a particular season. As a result, there is a horizontal movement for occupants in all seasons. There is also a vertical movement in summer parts of the older houses that are related to the different times throughout the day.

Consequently, Iranian vernacular architecture in hot-dry climates gains indoor thermal comfort with less energy consumption and without using expensive and polluting mechanical systems. Using wind towers, basements, semi open spaces, pools of water, central courtyards, thick and high walls, shading elements such as louvers, suitable windows and appropriate materials for roof, wall and storage loggias and separate seasonal rooms are innovative and environmental solutions that are achieved in vernacular architectures of hot-dry climates of Iran.

### 2.5.1 Vernacular and Traditional Architectures in Yazd Region

Yazd is located in the central part of Iran. This region is completely immersed in the hot and dry climate of the Kavir Desert .So, one of the most important problems is the lack of water resources and harsh natural conditions.



Figure 13: Map of Iran (memarian, 2003)

In spite of the harsh climate and some restrictions for providing initial living condition, the existing potential is considered for comfort of the occupants in this region. Indigenous courtyards are the focal point in of vernacular architecture of the Yazd region. There are some environmental and cultural reasons to why there is a courtyard in every house and it is so that all of the functions are surrounded courtyard. Courtyards are considered in order to prevent sunlight penetration during hot days. Walls create the shade which in turn, creates a comfortable area for its users. Moreover, a courtyard plan with thick walls designed for protection from visual contact with passersby. Also, there is a big pool and some vegetation in the middle of a courtyard. These elements create natural ventilation and shading for occupants as sun protection is an essential part of the

comfort of an occupant. All of the spaces which are surrounded courtyards are divided according to solar protection and solar gain guidelines. In other words, each different direction of a house is considered for particular season.(Foruzanmehr, 2008)



Figure 14: Courtyard

Wind-tower is the unique element which is appropriated in vernacular architecture of this region. The heights of wind towers from the roof are between 2 and 9 meters. The height and the amount of wind towers have a direct effect on the wind velocity, so the consequences of this element is providing natural ventilation and comfort for a particular living situation. There are semi open spaces in every house. One of aforementioned semi open space is called aTalar and is located exactly under the exhaust of the shaft of the wind tower. It is situated in the southern part of the courtyard, which is the coolest place for inhabitants to reside in.





Figure 15: Wind-tower and semi-open space

Underground is another innovative design for vernacular architecture of this region. The height of the underground is 6 meters from the yard with some windows to allow the day light in and for circulation purposes. There is a residence entitled Sardab which is equipped with a small pool that is connected to an underground water network. In fact, underground is the coolest place, especially during the hot summer days. It is a suitable place for keeping food and resting during hot days. (Foruzanmehr, 2008)

The materials used for construction of the houses are all local, such as massive adobe and mud roofs and walls; one of the characteristics of this material is the high capacity for dispersing heat for long hours so, capacitive insulation helps daily heat peaks to be reduced. Moreover, the straw in mud bricks can absorb the humidity during the day and disperse it to the indoor spaces during the night. (Kasmaee, 2003)

A mix of flat and dome roofs create a comfortable situation for sleeping at night during the hot days. Dome roofs are considerable for protection from sand storms as well as helping decrease the sun absorption and shading on each other. Consequently, Yazd vernacular architecture is quite possibly the best example for sustainable living spaces.

As a result, environmental and socio-cultural factors are the two main factors which have considerable effects on the design of vernacular architecture. They will be introduced in detail in this part of the study.

#### **2.5.1.1 Impact of Environmental Factors in Yazd Vernacular Architecture**

Oliver stated that “All vernacular cultures exist within, largely depend on and are partially shaped by the environmental contexts”.(Oliver, 1997). In general, the available material from the surroundings has been collected by individuals in order to prepare and use it in the formation process with the help of simple tools. This is one of the most important issues which should be considered and adapt the house with the existing environmental conditions of the region. This can be the concept for vernacular societies as a whole throughout the world. (Oktay M. , 2006)

In this manner, the vernacular architecture of Yazd region is shaped in response to the environmental conditions by considering their way of life, needs and experiences. As a result, the environmental factors such as climate features, geographical and topographical contexts with consideration to the available materials have formed Yazd regions vernacular architecture.

##### **2.5.1.1.1 Geographical Context**

“The latitude of Yazd 31° 53' 50" N while the longitude of it is 54° 22' 3" E between the Shirkooh Mountain and salt central Kavir”.(Kasmaee.M, 2003). It is apparent that the lack of water resources in this area is due to the fact that the location is in a dry and desert climate, so the agriculture has not thrived in this area. As it is mentioned, the

shortage of water resources was one of the more severe issues in this region. Therefore, local people tried to find a solution for this kind of problem. Usage of underground water networks to convey water to the location where water reservoirs are built in order to preserve the water which was an innovative solution in this region. Appropriating at least 4 wind catchers in every underground water reservoir for keeping cool water was another pioneering solution. One of the arts that Yazd people have created is the ability to live in regions with climatic and resource limitations. (Semsaryazdi, 2010)

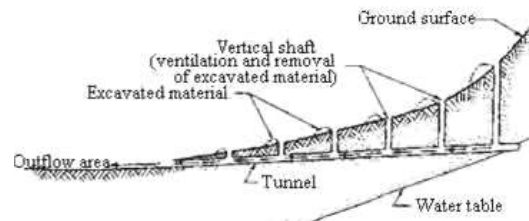


Figure 16: Aerial view and the section of Ghanat, Yazd (Iranian culture heritage, 2006)

#### 2.5.1.1.2 Topographical Context

The ecological textures have introduced the Old houses. Courtyard housing is the focal point and the main solution for protection from sand storms and heavy sunlight. Ghobadian (2009) mentioned that in this city, urban compactness and adjoined buildings have some advantages. Firstly, enclosure of urban spaces can help the city combat the harsh climatic factors since the enclosure of urban spaces can create comfortable environments for residents of this city. Secondly, outside surfaces of the buildings would be less exposed to the outdoor harsh conditions. Therefore, less heat is transferred from the buildings during the winter time. In addition, buildings can lose less heat. Urban spaces and streets had to be close to each other for protection from sand storms. On the

other hand, narrow streets which are covered with arches provide shade for travelers. (Ghobadian, 2009)

### 2.5.1.1.3 Climatic Data

Yazd is located in the latitude of 31° 53' 50" N where diurnal temperature difference can reach up to 28°C in a day. The summer in this region is too hot. The daily temperature reaches 40° centigrade. The winter and the summer periods are longer than spring and autumn seasons. The temperature changes between winter and summer are wide-ranging, from anywhere between -5°C to +40°C. (Pourvahidi, 2010)

The average annual rainfall is low. The rainfall is in September which is nearly 58 Mm. So, inhabitants were faced with the shortage of water resources throughout the year. Most of the day is sunny during the year. The average annual sunny day is 250 Hrs per month. Therefore, old settlements were designed with the consideration of solar protection. (Pourvahidi, 2010)

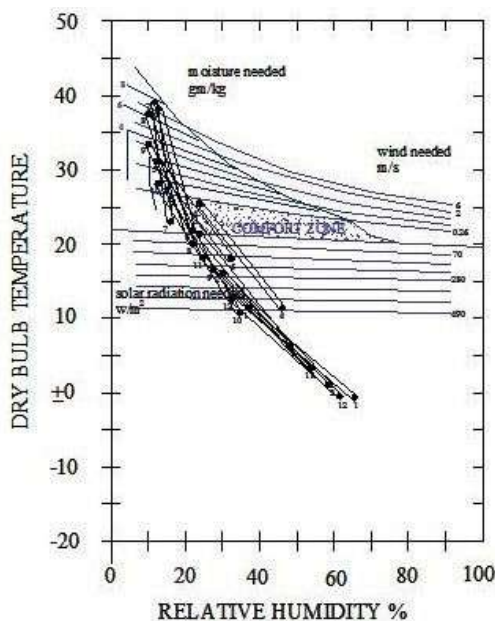


Figure 17: Bioclimatic chart of Yazd city (Pourvahidi, 2010)

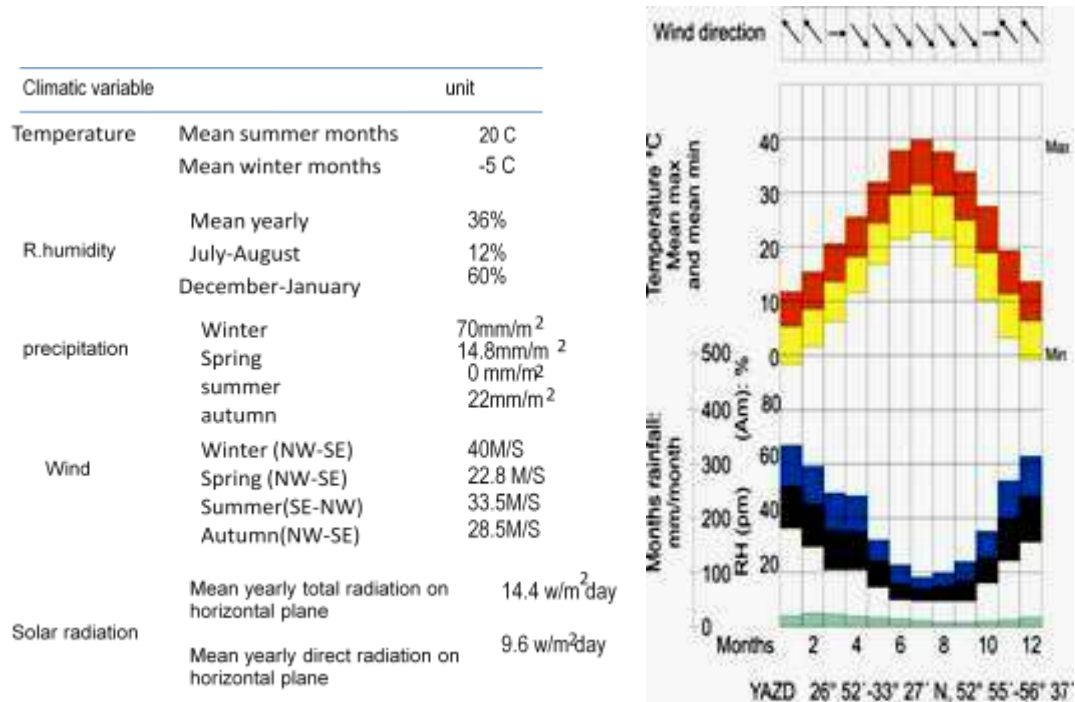


Figure 18: Climatic data of Yazd region (Kasmayee,2003)

#### 2.5.1.1.4 Impact of Climate in Yazd Vernacular Architecture

Climate has a direct effect on the form, materials and the orientation of the houses. In fact, climatic issues such as wind direction, sun direction, humidity, air pressure, temperature and rainfall identified the form and material and direction of the houses.

The angle of solar radiation is different in winter and summer. Therefore, the south part of the courtyard which faces north needs some shading for protection from the summer sun rays. On the contrary, the north sides of the houses which face the south part do not need any shading elements. According to the climate in this region, summer parts which are located in the south side of the courtyard is two stories with semi open spaces to prevent sunlight and overheating during the hot days and vice versa for the winter parts

which are located in the north side of the courtyard which are single story for absorbing the sunlight in cold days. (Kasmayee, 2003)

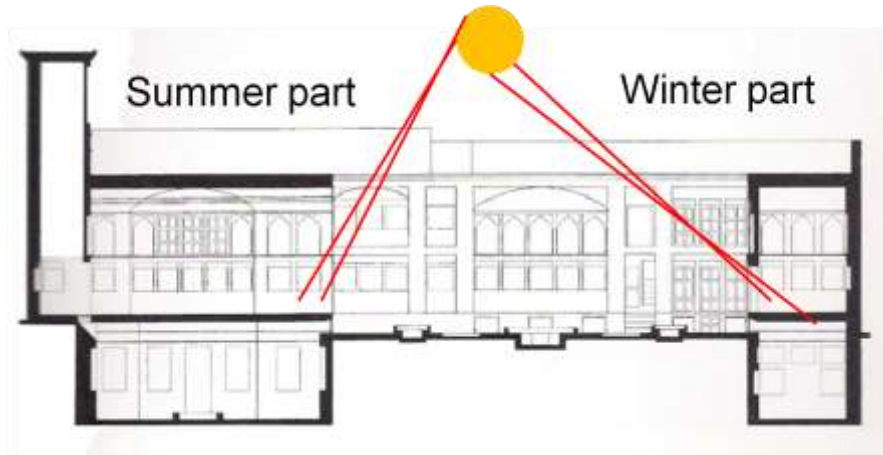


Figure 19: Different sunlight in winter and summer part (Iranian Cultural Heritage, 2005)

Wind direction is from North-west to South-East in this area. Most of the wind catchers are located in the south part with south-west vents. Natural ventilation comes to the courtyard and passes the pool and goes inside of the houses through the wind catchers, so this creates indoor environment comfort during the hot days for occupants.

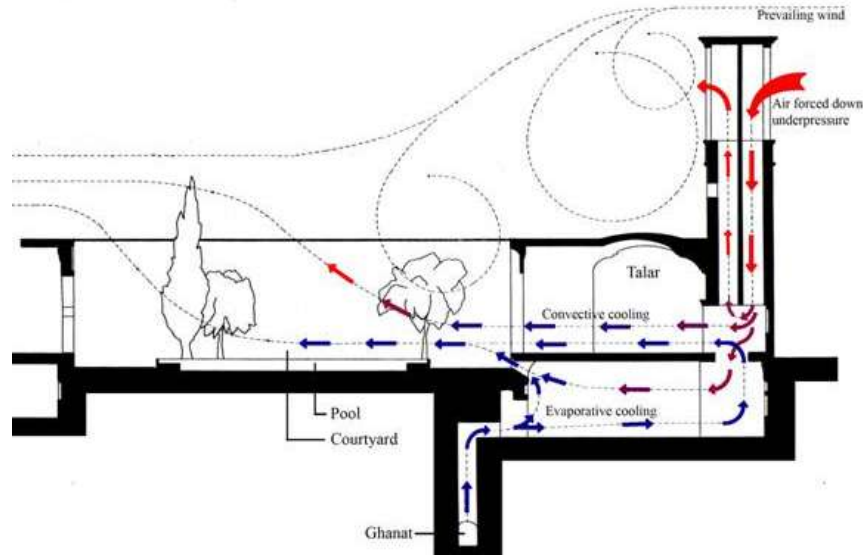


Figure 20: Natural ventilation by wind tower (Iranian Cultural Heritage, 2004)

Climate affects the orientation of the houses. All houses are aligned in a north-south direction with the courtyard plan in order to protect from sun light. Moreover, the climate has an effect on material. However, adobe is the available and local material in this region. It could be a good alternative for the construction of the building. This material has low thermal conductivity and high heat capacity. Using fiber inside the adobe improves the thermal capacity. It also absorbs the humidity of the air, acting as a desiccant material, then the air temperature decreases and the relative humidity increases at night. (Zandi, 2006)

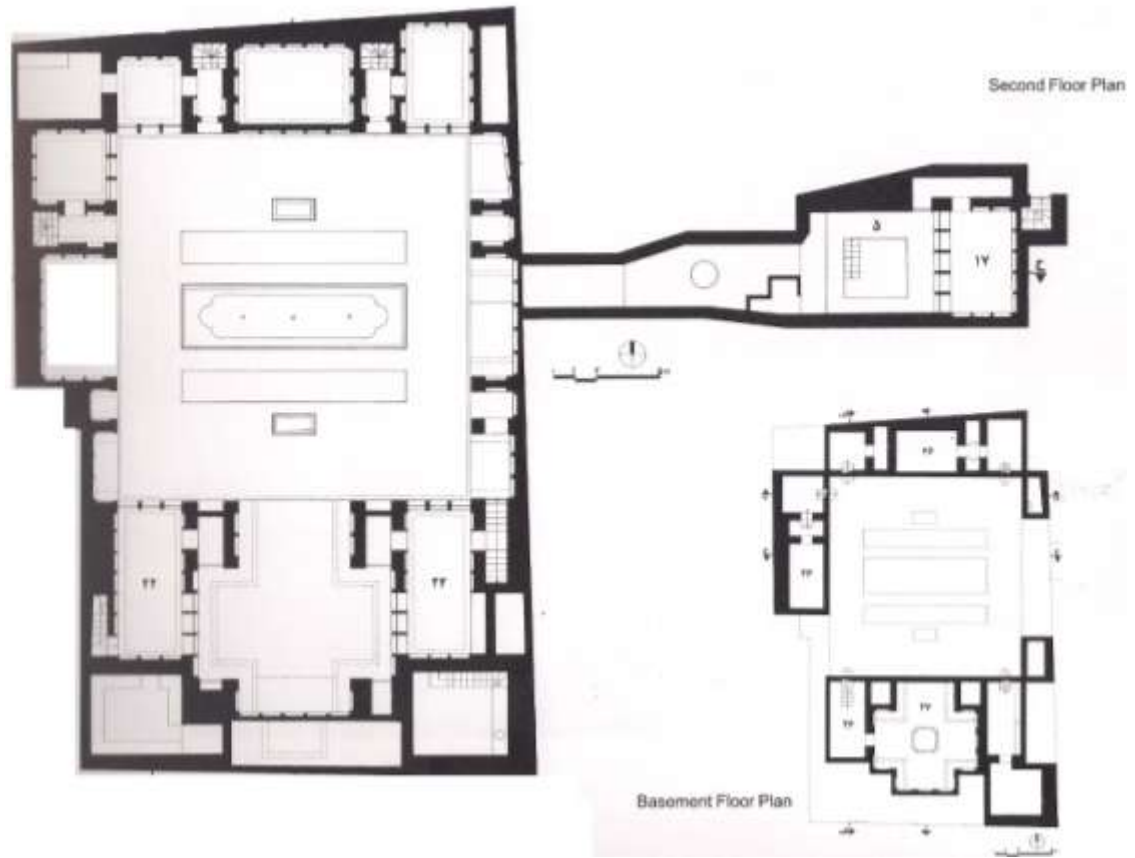


Figure 21: Plan of traditional houses in Yazd region (Ghasemi, 2005)

## 2.6 Turkish Vernacular Architecture in Hot-Dry Climate

The hot dry regions are located in the central and south-eastern part of Turkey. Turkish government commenced irrigation and an agriculture project in south-eastern part of Turkey. This project includes some provinces of the regions such as Diyarbakir, Mardin, Sunliurfa which have been commercial and cultural centers from the third or fourth million BC. Nowadays, many tourists come to visit these cities in spite of only a few monumental buildings being left in these regions. (Demirbilek, 1984)

Ozdeniz (1991) said, these kinds of climates are temperate climates with hot-dry summer periods. “The minimum highest air temperature reaches 40 degree centigrade in



summer. There is a wide diurnal air temperature range”.(Ozdeniz, 1991). Mardin, Diyarbakir and Sunliurfa are located in hot arid zones of Turkey. Diyarbakir and Sunliurfa are similar in design characteristics. There are differences between daytime heating and cooling in the three cities. In hot seasons, Mardin has the lower temperature of all the three cities. Sunliurfa has the highest air temperature during the summer. Therefore, solar gain in winter in Mardin and protection from sunlight in summer become the most important consideration in the design of the vernacular and traditional houses in these regions. (Demirbilek, 1984)

Diyarbakir and Sanliurfa are placed on plateaus which benefits from the night-time cool air pools, while Mardin is located in a sloped topography. The slope creates advantages and disadvantages in a circulation system. The east-west connection is easier than north-south connection. In fact, some stairs should be considered for vertical access. All vernacular houses are double stories. The upper one for summer and the ground floor for winter use. Roof of lower level rooms act as terraces for the upper levels. (Demirbilek, 1984)

Although it can not be completely proven that only climate has an effect on the formation of vernacular and traditional houses. There are socio-cultural issues which formed the houses as well. For example, Turkish people are Muslim, so they tend to build their houses with the main facade facing toward “qibla” which is a direction that overlooks Mecca, the holly place for Muslims. Furthermore, there are no windows which face the outside of the houses because of religious beliefs. In other words, a high wall which is surrounding the houses and separates the entrance without any direct

visual contact to the inside of the houses is the priority in the design of vernacular or traditional houses in these regions. Consequently, the climatic factors and Islamic cultures play an essential role in the formation of vernacular and traditional houses in hot-dry regions. The dominant architecture style of houses can be pointed out in two headings. City scale and building scale:

The urban textures of these regions are Compact, dense and have a shaded layout. The vernacular houses are adjoined to each other and are surrounded by high and thick walls. Narrow streets and the bridge-like passage joins the building to each other creating shading and a comfortable environment for passengers. All roofs are flat which is built with high heat capacity materials that increase the time-lag effect. Double enveloped roofs and adequate insulations prevent transmission of hot air to inside spaces. Moreover, flat roof enables the occupants of these regions to sleep outside during the night times in the summer time. The stone walls with the thickness between 0.50-0.60 meters provide a good thermal insulation and a suitable thermal lag. (Demirbilek, 1984)

Turkish traditional houses are designed with a protection from sunlight in hot arid climates. Therefore, the courtyard plans with thick and high walls are the solution for preserving the harsh climate of this region. In fact, a courtyard plan with a pool in the middle and a diversity of plants create a comfortable environment by means evaporative and convective cooling systems. All spaces surround the courtyard with varying functions. Every facade is constituted according to the solar radiation and solar gain in different seasons. Most traditional houses have a ground and basement floor. Semi open spaces which are called Eyvan are covered with vaults are a mutual and a cool place in

all regions. Artificial waterfalls are considered at Eyvan and the basement floor which provides air cooling by means of evaporative cooling system. (Suzen & Gedik, 2007)

### **2.6.1 Vernacular and Traditional Architectures in Diyarbakir Region**

Diyarbakir is located in the southern part of Turkey. The old settlement of this region is surrounded by walls and is divided in to four major parts by the location of street on NS and EW axis. Vernacular architecture of Diyarbakir and its traditional houses is the best example of an adapted city to a hot and dry climate.(Baran, Yeldirim, & Yelmaz, 2010)



Figure 22: The map of Turkey (Baran, Yeldirim, & Yelmaz, 2010)

Courtyard plan is one of the solutions for adaption to this climate of this region besides cultural reasons. These kinds of plans with high walls that are surrounded create shading for occupants since it is a fundamental factor for occupants to avoid the sun light especially during hot days. Furthermore, it was a religious belief in the traditional Middle Eastern culture to protect the house against outsiders. (Al-Kodmany, 1999). There is the small pool in the middle of a courtyard with the diversity of plants, so occupants could have a beneficial form of natural ventilation which is created by the evaporation of water.



Figure 23: Courtyard (Tuncer, 1999)

There are semi-open spaces that are covered by vaults, which are called Eyvan. It is one of the coolest places in the evening and nights. The hot air after passing the pool will decrease the temperature. Therefore, the cool and pleasant air will arrive at the semi open spaces and create a comfortable environment. There is another space which is called Serdap. It is located in the basement with the pool in the middle of this space which is overlooking the north side of the court yard. Designing the ground floor five or six stones higher from the courtyard creates the natural ventilation and lighting for the basement floor. It is a convenient place for resting and keeping food. Flat roofs in vernacular architecture of houses give an opportunity for the occupants to sleep outside during hot summer nights. The materials for construction of the houses are local materials such as basalt stone. Thick walls enable the temperature to be kept outside longer rather than reflecting the heat to the inner surfaces in a short period. Therefore, the hot air does not travel inside easily. (Baran, M., Yildrin,M. , Yilmaz,A, 2010)

Plans are based on sun protection, so every house is oriented between the northeast - south west axis and the north- south axis in order to provide protection from sun light.

The spaces on the north side have no shading elements to benefit from sunlight during the cold days. By contrast, the spaces in south side are covered with louvers and shading elements for protection from sun light during the hot days. In other words, researchers call this kind of house a seasonal house. In fact, each part of the houses are appropriated for particular seasons.(Baran, M., Yildrin,M. , Yilmaz,A, 2010)

Consequently, vernacular architecture of Diyarbakir regions are the best examples of ecological architecture which showcase optimum solutions for different stages of building, environmental protection and respect for materials by using low energy consumptions. Environmental and socio-cultural factors are the main factors, which have a direct impact on vernacular architecture.

#### **2.6.1.1 Impact of Environmental Factors in Diyarbakir Vernacular Architecture**

To sustain life, a design that considers the environment is fundamental. The environmental factors such as climatic features which include solar radiation, wind, temperatures, precipitation, topographical and geographical issues have shaped the Diyarbakir vernacular architecture. The effect of environmental factors on vernacular architecture has been discussed for many years.

##### **2.6.1.1.1 Geographical Context**

“Diyarbakir (37\_550N, 40\_120E) is situated on a wide plateau between Karacadag Mountain and the Tigris River in the Mesopotamia region which is also known as El Cezire, in the southeastern part of Turkey”. The maintenance of Diyarbakir has been important throughout history since the location of this region is an area where various civilizations are flourishing in the Upper Mesopotamia which have met and has interacted. “The thick walls that are 5 km in length and 6e8 m height which bounded city

where whole of the settlement were completely within the wall until 1950”.(Elizabeth, 2011). New settlements were later formed outside the wall, and the old texture began to deteriorate. Since the settlement area within the city wall is restricted, its cultivated areas are limited as well. On the contrary, the southeast and west sides of the city contain productive fields called “Hevsel gardens”, which are irrigated by the Tigris River. (Baran, Yeldirim, & Yelmaz, 2010)

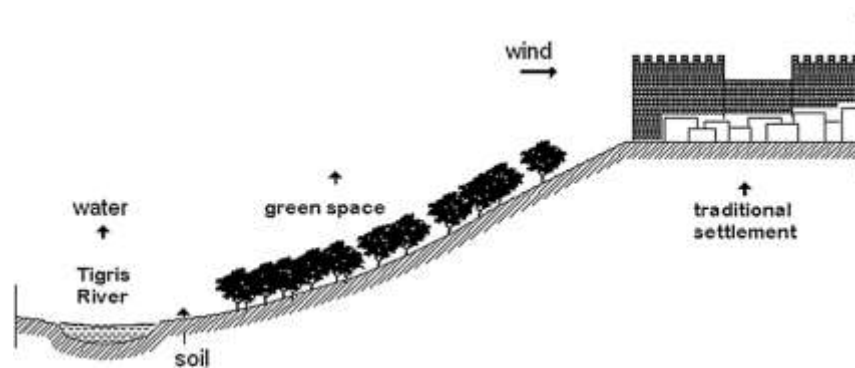


Figure 24: Settlement of the old city(Baran, Yeldirim, & Yelmaz, 2010)

#### **2.6.1.1.2 Topographical context**

Diyarbakir is situated in an area that has harmony with ecological textures, including water, soil, air and green spaces. This ecological texture has determined the settlement of the old city. Organic forms of the houses with indigenous courtyards institutes the old settlement. Since, the wall is bounded the city where there is limited area for urbanization. Narrow streets and short distances between old settlements are the major characteristic of urban texture. The dwellings shade each other, pedestrians and the streets, so they create an environmental comfort by providing protection sunlight and reducing solar gain.

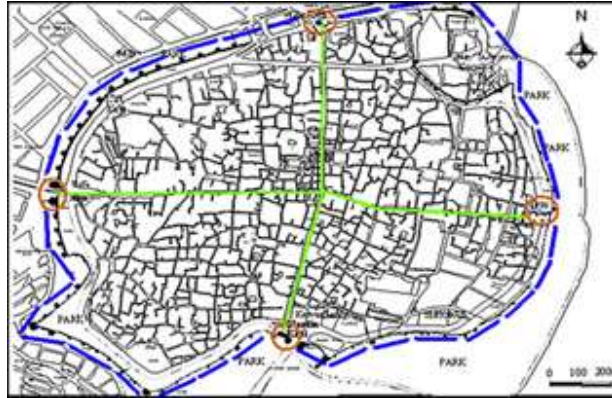


Figure 25: Old settlement of Diyarbakir (Baran, Yeldirim, & Yelmaz, 2010)

### **2.6.1.1.3 Climatic data**

As it is mentioned, Diyarbakir is located in the southern part of the Turkey. Therefore, the climate is considered as a temperate climate with hot-dry summer periods and the Min Highest Air Temperature in summer reaches 40 °C. (Ozdeniz, 1991). The humidity is low in this region. The hot seasons are longer than the cold seasons. The maximum rainfall is 71.4 Mm.(Baran, Yeldirim, & Yelmaz, 2010). As a result, the hot period conditions should be considered in the design of the buildings.

Climatic data for Diyarbakir, latitude: 37°55' North, longitude: 40°12' east

Climatic variable		Unit
Temperature	Mean summer months	30.5 °C
	Mean winter months	3.7 °C
R. humidity	Mean yearly	53%
	July-August	24(min)%
	December-January	77(max)%
Precipitation	Winter	71.4 mm/m <sup>2</sup>
	Spring	59.8 mm/m <sup>2</sup>
	Summer	3.9 mm/m <sup>2</sup>
	Autumn	28.3 mm/m <sup>2</sup>
Wind	Winter (S-NW)	33.8 m/s
	Spring (W-NW)	21.6 m/s
	Summer (SW-NW)	23.1 m/s
	Autumn (NW)	20.6 m/s
Solar radiation	Mean yearly total radiation on horizontal plane	16 MJ/m <sup>2</sup> day
	Mean yearly direct radiation on horizontal plane	10.4 MJ/m <sup>2</sup> day

Figure 26: Climatic data for Diyarbakir (Baran, Yeldirim, & Yelmaz, 2010)

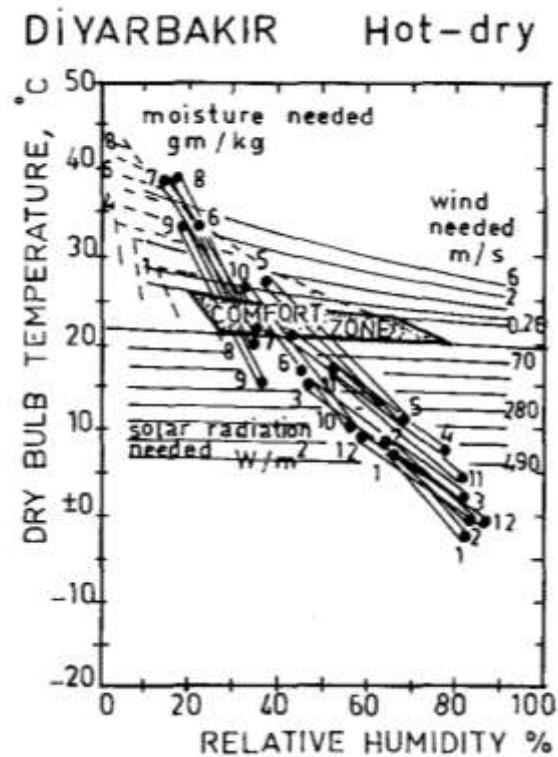


Figure 27: Bioclimatic data(Ozdeniz, 1991)



#### **2.6.1.1.4 Impact of Climate in Diyarbakir Vernacular Architectures**

The impact of climate as a main environmental factor should be considered on vernacular architecture. There are several factors which effect building formation, location and direction in climatic issues, they are classified as: Wind direction, sun direction, humidity air pressure, temperature and rain fall. (Yaldiz, 2009). The angle of solar radiation is different in winter and summer. Therefore, in the south part of the courtyard which is faces north needs some shading for protection from the summer sun.

On the contrary, at the north sides of the houses which face south do not need any shading elements. Wind direction is from north-west to south-west in this area. All the blocks are located in this direction with large windows and openings which invite natural ventilation inside of the houses and create a comfortable indoor environment during the hot days. According to the kind of climate in this region, summer parts which are located on the south side of the courtyard is two stories tall with semi open spaces to prevent the sunlight from penetrating and overheating during the hot days. During the winters with the winter sides that are located in north side of the courtyard is single story for absorbing the sunlight in cold days.

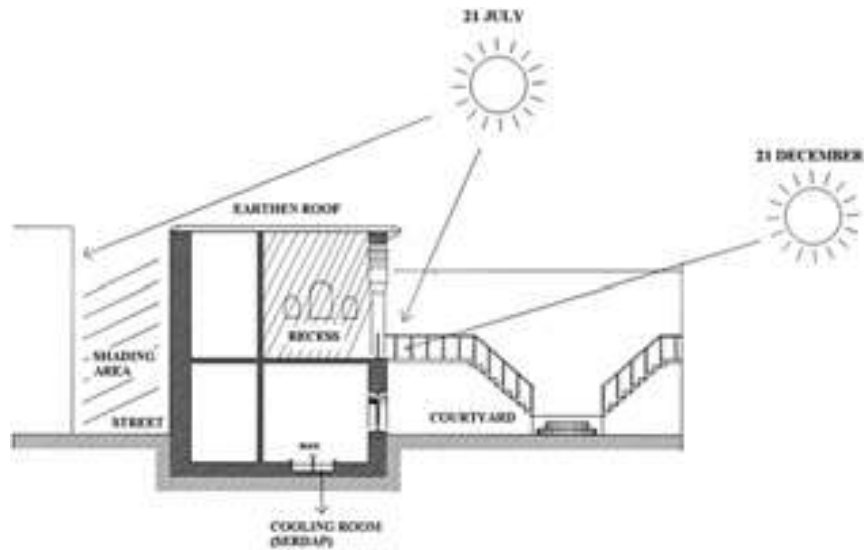


Figure 28: Different solar radiation in summer and winter times(Baran, Yeldirim, & Yelmaz, 2010)

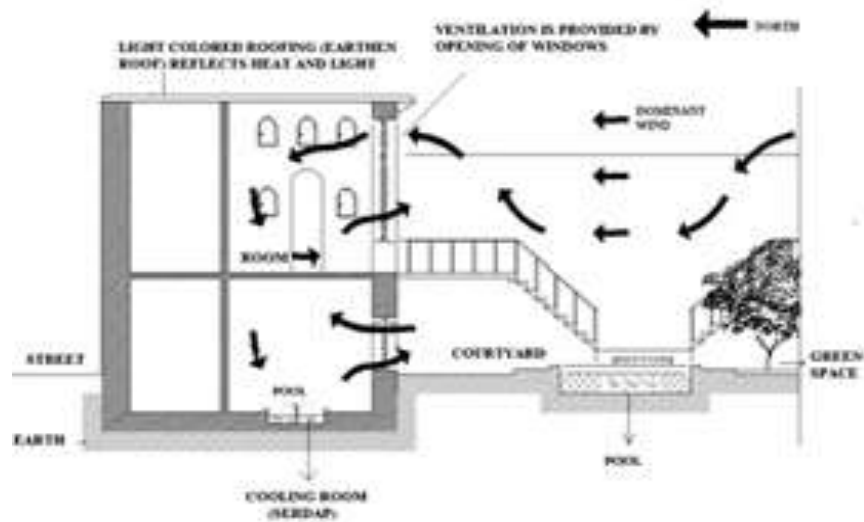


Figure 29: Ventilation in old houses(Baran, Yeldirim, & Yelmaz, 2010)

For achieving proper microclimates of spaces, orientation of the houses is one of the main aspects. Old houses in Diyarbakir are predominantly aligned towards the north-south direction to protect from sunlight since the shading is an important issue in this

climate. Old houses are formed with a courtyard (square, rectangle, and trapezoid plan type) which are surrounded by buildings.

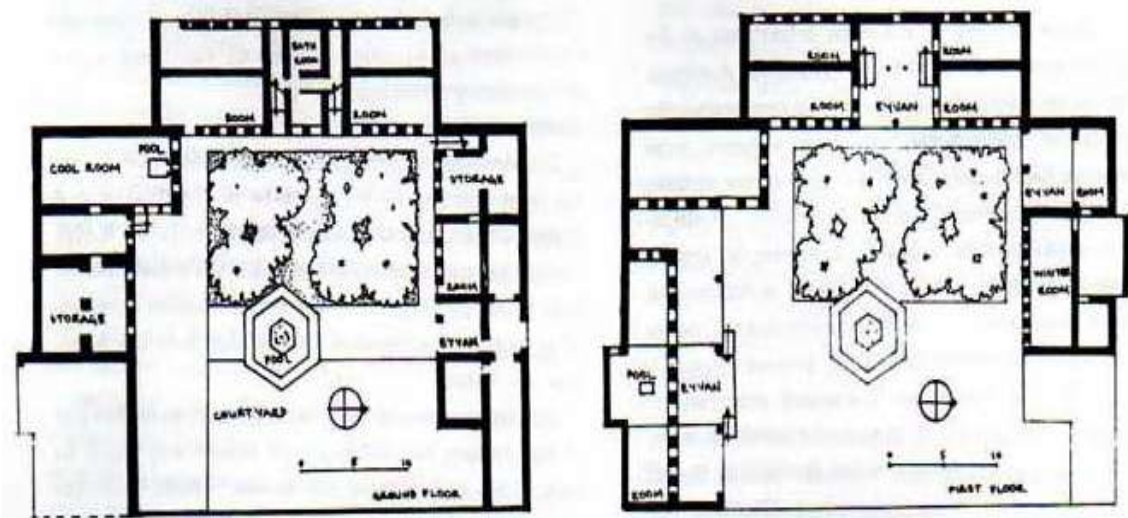


Figure 30: North-south orientation in Diyarbakir traditional houses (Tuncer, 1999)

## **Chapter 3**

# **COMPARISION OF YAZD AND DIYARBAKIR TRADITIONAL ARCHITECURES**

There are similarities and differences between Yazd and Diyarbakir in terms of design characteristics and cultural issues. As it was mentioned before, the climate of both regions are hot-dry. Therefore, there are main issues such as urban textures, use of spaces, building forms, plan types, facades, site locations, building envelopes and materials which should be compared in both of the traditional houses in the regions. Also, the effect of socio-cultural factors in the old settlements of both regions should be compared as well.

### **3.1 Urban Textures**

The city of Yazd has been a commercial center for caravans traveling across the desert throughout history, which helped the economy of Yazd at a high level. Because of that, people of Yazd were able to build complex and luxurious houses. Its location and harsh natural conditions helped the citizens to be safe from the destruction of wars. On the other hand, the harsh conditions have created the compactness and enclosed urban spaces in the region. Therefore, all the streets are narrow and are covered with shading elements for protection from sunlight. In other words, the distance between two houses in front of each other is very short which leads to narrow streets and gains shading for passengers which it is essential in hot-dry climates to keep out the direct sunlight.

Thick city walls are abounded in the old settlement of Diyarbakir. In addition, the urban texture is compact because of the limitation of the area for urbanization (city wall) and the harsh climate. Clustered courtyard buildings and alleys constitute to organic planning because of the location of the streets on principal axis with full twists and turns. The distance of the dwellings are very close to each other and are located on narrow streets. These characteristics cause dwellings to shade each other, pedestrians and the streets also creating thermal comfort by reducing solar heat gain in Diyarbakir.(Baran, Yeldirim, & Yelmaz, 2010)

As a result, the similarities between two regions are the narrow streets, the compactness and the enclosed urban spaces due to the harsh climate that protects from sand storms. With these kinds of urban morphologies in both regions and a limited area for urbanization in Diyarbakir city because of the city walls, provides a shade street for pedestrians in order protection them from sunlight that are very similar in both regions. There is difference in the structure for providing shade in every region. In Diyarbakir, the exposed structure of the traditional houses provides shade for passengers. The traditional structures in Yazd do not project to the street. Therefore, there are vaults that are covered between two walls of the houses in front of each other in order to provide shading for passengers as well as the arches that can tolerate the load of the adobe walls in front of each other. The other reason is that there are no windows on the outer walls which face the street in the Yazd region so the presence of these elements with different heights could add beauty to a simple alley. There are some windows which are facing

towards the alley in Diyarbakir and the exposed structure of the traditional settlements creates a beauty within the alley.



Figure 31: Narrow Streets in Yazd region

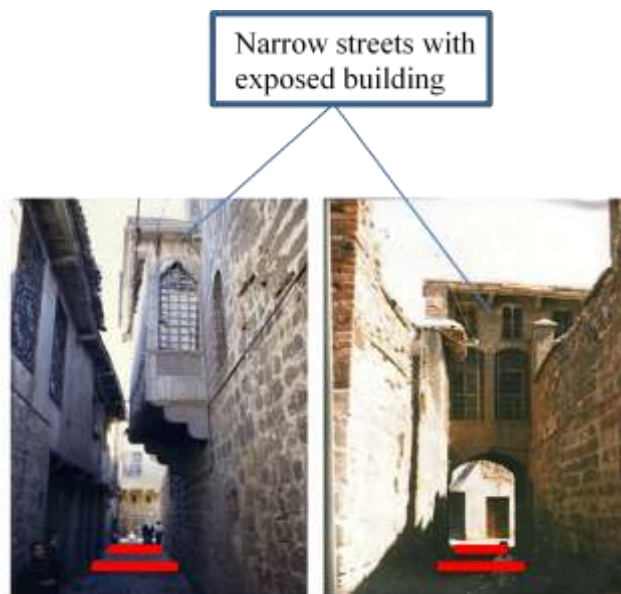


Figure 32: Narrow streets in Diyarbakir region(Baran, Yeldirim, & Yelmaz, 2010)

Compactness, courtyard plans and inward houses are the similarities between two regions. Firstly, inward houses with high walls around them preserve the occupants from direct visual interaction with strangers because of the dominance of the Islam religion in

both regions. Secondly, courtyards which are surrounded with thick, high walls and diversity of plants with a big pool in the middle create shading and decrease the air temperature during the hot days by means of evaporative and convective cooling systems. In fact, hot air passes the pool in the middle of courtyard and decreases the temperature by evaporative cooling, so the cool air created in the yard removes the hot air by means of convective systems. These walls also provide privacy for its users. As a result, by opening the windows that are facing the courtyard, the occupants benefit from natural cooling ventilation. Thirdly, compact urban is the solution for sand storms and the intensity of solar radiation during hot days. The adjoined buildings with the courtyard plans are the greatest solution for protection from sunlight and the limited areas that are available for urbanization due to the city walls in each region. As a result, these three characteristics are common in Diyarbakir and Yazd vernacular architectures because of the impact of the Islamic culture for achieving indoor environment comfort for its users.



Figure 33: Urban form of Yazd (URL4)    Figure 34: Urban form of Diyarbakir (URL5)

However, roofs are different in two regions. The roofs in Diyarbakir traditional houses are flat. These kinds of roofs provide occupants an opportunity to sleep at night on the roofs and benefit from natural ventilation during the night times of summer. On the

contrary, mixture of flat and dome roofs are apparent in Yazd traditional houses. Domed roofs create shading and prevent sandstorms from affecting its occupants. Likewise, dome shaped feature is a good structure to withstands and storms because this kind of storms includes a lot of dust, so it could easily pass domed shape roofs instead of penetrating the inner spaces. Because, there are no sand storms in the Diyarbakir region, so the shape of roofs are different in both regions. Additionally, two domed roofs besides each other create shading for one and other. On the other hand, Azami (2005) said “from a geometric point of view, the area of an over arch is approximately three times bigger than its base area”.(Azami, 2005). As a result, the round part has received the lower intensity of the sunshine rather than other areas. Therefore, the lower part of the domed roof would be affected the least amount from the temperature. Furthermore, the one part of the domed shape is always in the shade during the day which causes the inside of the building to be constantly cool. Consequently, domed forms are also suitable for decreasing the temperature and prevent sand storms in Yazd vernacular architecture. Double envelope domed roofs which are insulated with adequate materials lead to the internal cooling, especially during the night, which is a huge similarity between the two different traditional settlements. The colors of roofs in both regions are light colored material due to the hot climate and which do not absorb the sunlight and is a fundamental characteristic for this kind of climate.

The difference between the roof forms in each region is related to the wind storms that occur in the Yazd region. Dome roof is a suitable shape for protection from this kind of storm and its usage of available materials besides providing cool air due to its form. In



spite of different forms of roofs in every region, the functions and purposes of both them are similar as they are both using it as a cool space in the summer.

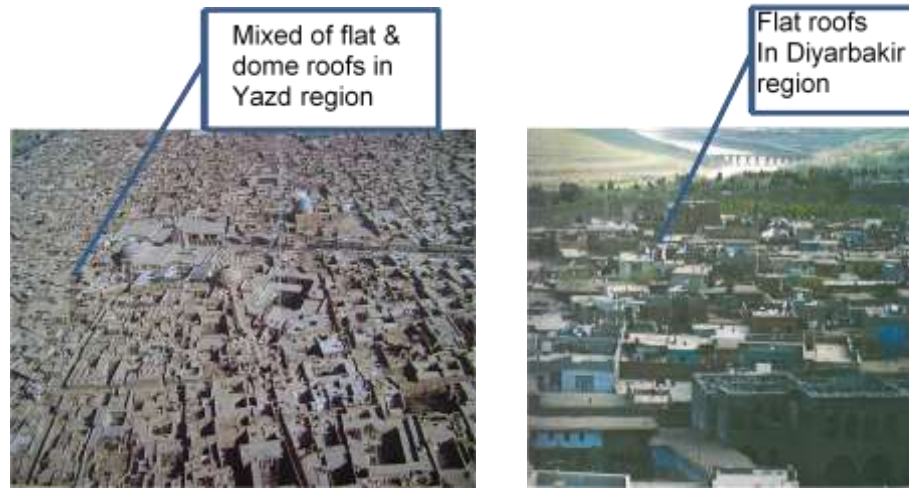


Figure 35: Different roofs in Yazd and Diyarbakir region (Pourvahidi, 2010) (Tuncer, 1999)

Wind catchers and underground water reservoirs are the two main factors and innovative solutions used in the Yazd region. However, in the Diyarbakir region, there are no such elements used. The reasons are that the situation of Yazd located between the Dasht-e Kavir desert and the Dasht-e Lut desert so has a lack of drinking water which is one of the most important problems in this kind of climate because of the geographic situation. Yazd people tried to solve the shortage of fresh water by benefiting from water network systems (qanats). “In other words, the qanat is an underground gallery that conveys water from an aquifer or a water source to less elevated fields. In practice, a qanat consist of vertical shaft in sloping ground, interconnected at the bottom by a tunnel with a gradient flatter than that of the ground. The water reservoir is an underground structure, constructed to store freshwater for domestic use. The reservoir was fed from a nearby shallow qanat”. (Semsaryazdi, 2010). All of the water reservoirs had storage

tanks where the dimensions depend on the amount of qanat discharge and the demand for water. Most of the water storage tank roofs are dome-shaped or conic. There are between two to six wind catchers at the top of domed roofs of water reservoirs to circulate the air and to evaporate the water to create a cooling effect. The ornamental portal of the water reservoir demonstrates the wisdom and talent of Iranian architecture. Meanwhile, there are no underground water reservoir systems in Diyarbakir's vernacular architecture. The reason is that the geographic situation of the city is located near the river. Therefore, all of the old houses were fed by this river and there was never a shortage of water in the Diyarbakir region.

Wind catchers are unique element of traditional architecture. According to Memarian, wind catchers are categorized in two types. 1) Functional elements which are visible in ordinary houses of the Yazd region. 2) Functional and symbolized elements that demonstrate the importance of the owner and his economic situation. (Memarian, 2006). Another categorization of wind catchers are according to Maziar's thesis, their openings: One side opening, two sided openings, four sided openings, twin wind catchers and octagonal wind catchers. Wind catchers are located in the south part of the majority of Yazd traditional houses at the top of a semi open space (Talar). This vertical element creates cooling natural ventilation in summer parts of traditional houses. In fact, Convective cooling and evaporative cooling are being used by wind catchers for creating comfortable indoor environments. Convective cooling happens during the night times, when the prevailing winds come inside the wind catcher and the wall openings which are located on the sides of the courtyard that passes through the indoor spaces and removes heat from the building. Therefore, during the daytime, according to the laws of

physics prove that the cooled structure of the house absorbs more heat from the air and by decreasing the air temperature, achieve comfortable environment for the inhabitants. (Zandi, 2006)

The evaporative cooling system of the wind catcher acts in two ways. The mud material inside the shaft absorbs the moisture, while the wind passes down over the shaft. Under the shaft of the wind catcher, “temperature could be dropped between 1 to 3 °C. In some of examples, the temperature difference can be up to 6 °C from top to the bottom of the shaft.” The second type of evaporative cooling operation of the wind catcher takes place through the chamber in two ways. In the beginning, the temperature of the dry air is decreased by the evaporation of the water from the pools or underground water reservoir. The second way enables the air movement that is passing over the body so, the evaporation from the skin of the users is accelerated.(Zandi, 2006)

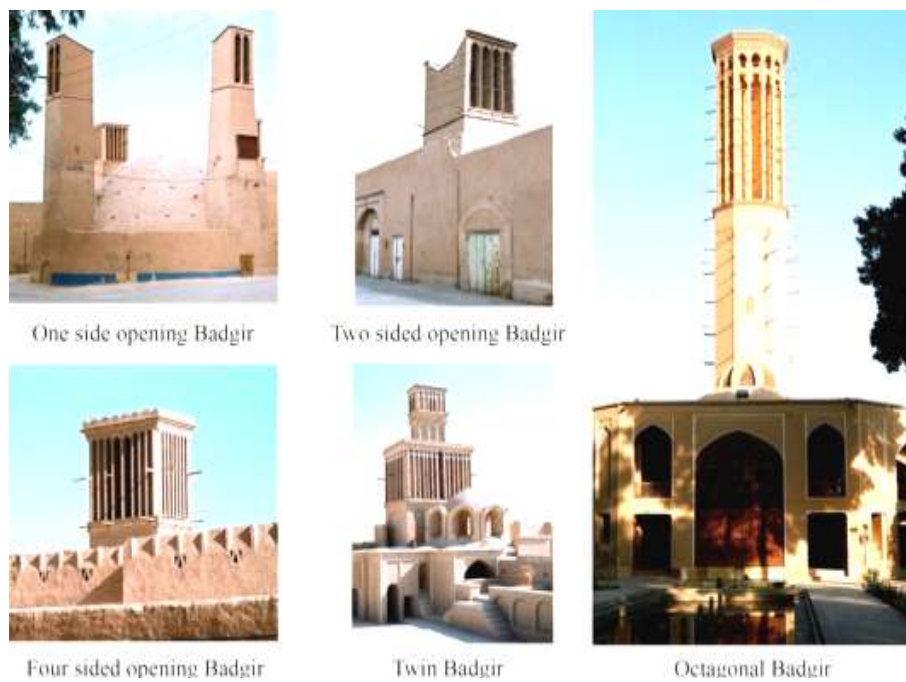












Figure 36: Different types of wind catchers in Yazd region (Zandi, 2006)

Consequently, water reservoirs and wind catchers have been a symbolic element and great solutions for Iranian architectures in hot-dry climate such as the Yazd region since long ago which were not visible in Diyarbakir region because it was only an innovative solution that solved the lack of water problem in the Yazd region.



Figure 37: Water reservoir & wind catchers in Yazd city

Table 1: Differences and similarities in urban textures of Yazd & Diyarbakir region

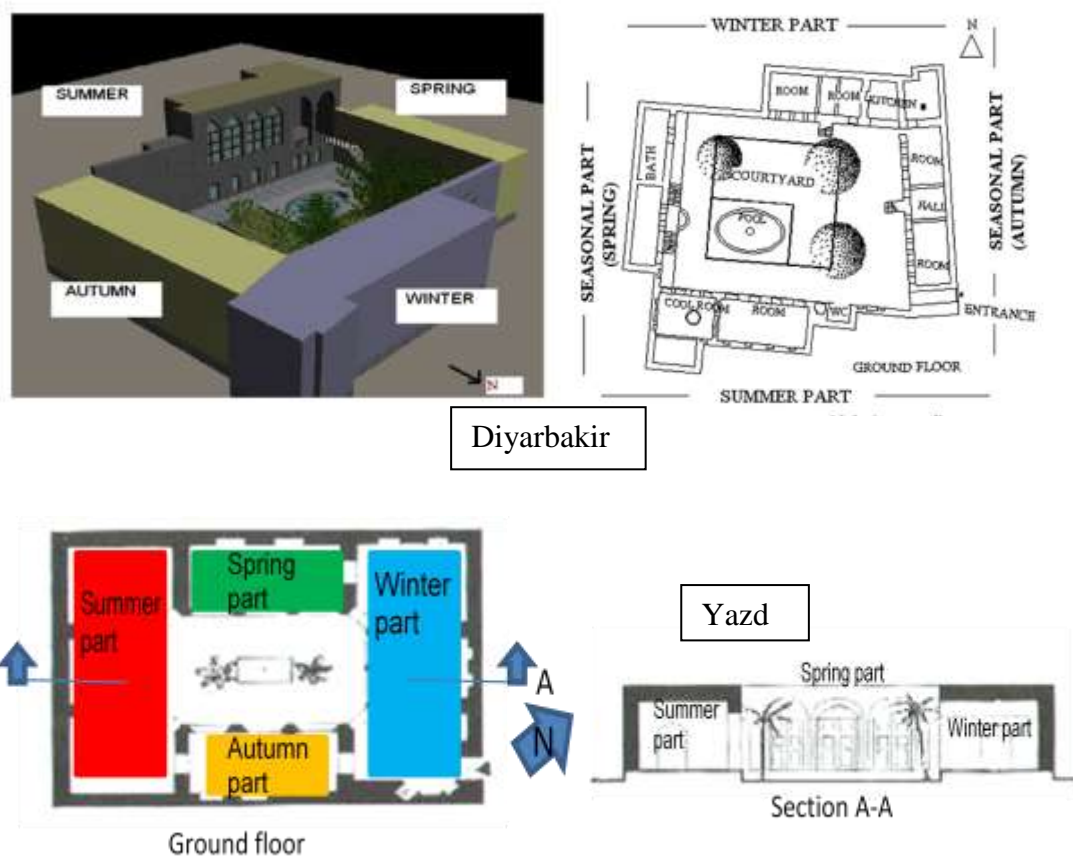
<b>Differences and similarities in vernacular architectures in hot-dry climates</b>						
<b>Urban textures</b>	<b>Roofs</b>	<b>streets</b>	<b>Compactness and inward house</b>	<b>Urban spaces</b>	<b>Wind catchers</b>	<b>Underground water networks&amp; water reservoir</b>
<b>Diyarbakir region</b>	<p>Flat</p> 	<p>Narrow with expose house cover</p> 	<p>Yes</p> 	<p>enclosed</p> 	<p>No</p>	<p>No</p>
<b>Yazd region</b>	<p>Mixture of flat&amp; dome roofs</p> 	<p>Narrow with vault cover</p> 	<p>Yes</p> 	<p>enclosed</p> 	<p>Yes</p> 	<p>Yes</p> 
<b>Conclusion</b>	<p>Different in shape but similar in function in order to create indoor cool air</p>	<p>Similar in width &amp; different in providing shade because of different styles of traditional houses in every region</p>	<p>Similar because of solar protection and restrictions in urbanizations</p>	<p>Similar for providing shade in both regions</p>	<p>Different because shortage of water in Yazd region and an innovative solution for gaining natural ventilation</p>	<p>Different because of geographical situation of Yazd and lack of water</p>

### **3.2 Use of Spaces**

The traditional houses of Diyarbakir and Yazd region are the best examples of buildings that are adapted to a hot-dry climate. In other words, the traditional houses of two regions are a living organism that decrease energy consumption, use natural resources and provide comfortable, healthier and more sustainable living spaces that are harmonized with the hot-dry climate.

The aim of the design in both regions is to protect inhabitants from sunlight and to create natural ventilation as well as house the cultural features. The important similarities of using the spaces between the two traditional houses are the different regional function rooms, which are known as seasonal rooms. In fact, the functions in traditional houses surround the courtyard in both regions. The rooms facing the south and east directions are allocated for summer and autumn seasons because of the solar intensity in these directions is lower than towards other directions. On the contrary, winter rooms are located in the north and west directions because of benefits of the solar radiation during the winter. U type plan of Diyarbakir traditional houses includes spring units. This unit could be located in the east or west of the courtyard only for the wealth families' of the Diyarbakir region. However, seasonal rooms in are located in all houses in the Yazd region. Winter rooms are single story and are facing south for protection from the cold winds of the north in both regions. Small floor areas with tiny windows decrease the heat loss and air movement indoors in both regions. Furthermore, the angle of the sunlight in winter times in the Northern hemisphere regions such as Diyarbakir and

Yazd is direct and even small windows without shading devices could invite sunlight to indoor spaces. By contrary, shading devices in the summer parts which face north in both regions should be taken into consideration. Consequently, the use of spaces and locations are according to the sun protection and solar gain in different seasons which are similar in traditional houses of the two regions. This is due to the fact that the climates are situated in the northern hemisphere and the same solar angle is present every season. In other words, there is a horizontal movement in the courtyard for users in both regions due to the similarities of the seasons.



Diyarbakir

Yazd

Figure 38: Seasonal spaces in Diyarbakir and Yazd region (Baran, Yeldirim, & Yelmez, 2010) (Memarian, 2006)

### 3.2.1 Cooling Spaces

Semi open spaces (talar or eyvan), cellars (underground) and courtyards are cooling spaces in both traditional houses of two regions. The functions of these spaces are similar in both regions but the differences are in the forms of these spaces.

#### 3.2.1.1 Cellars ( Sardab or serdap)

There is more than one underground room in the traditional houses of Yazd region in that function to keep the foods and protect them from sunlight during the summer period. As a result, cellars are one of the coolest places which are convenient for resting during hot days. In some of Yazd traditional housings such as Tehrani's house, there is a small pool in underground which is connected to the underground water network. This space is called "Sardab" in Persian. Therefore, the underground with pool in the middle connects to water networks that create a comfortable indoor temperature for users, particularly during the hot days where they can escape from the warm outdoors in the Yazd region. In Diyarbakir, the same space is not connected with an underground water network. The reason could be that there is no underground water system in Diyarbakir, or if there is, they did not need to use it because of adequate domestic water that was fed by the river near the city.



Figure 39: Cellar in Yazd old houses



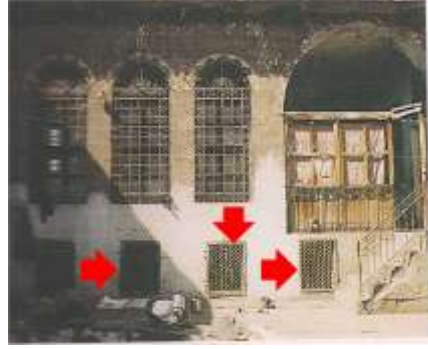


Figure 40: Cellar in Diyarbakir traditional houses (Tuncer, 1999)

The ceilings of the basement spaces in Yazd traditional houses are approximately 70 cm above the courtyard. The windows are located between the courtyard and the basement which are allocated for natural daylight and ventilation. The height of the basement ceiling in Yazd traditional houses are nearly 2.5 m. However, cooling space that is called “Serdap” in Diyarbakir traditional houses are located approximately 80-100 cm below the ground. The difference of height of the ceilings between the two regions is due to the fact that Yazd region has access to an underground water network. In fact, for solving the lack of water problem in Yazd region, designers excavated the ground to access water and make sure that it was usable in traditional houses for domestic purposes. The similarities are the small windows on the top of the walls of the basement spaces in Diyarbakir traditional houses, which create natural ventilation and daylight. This process is also apparent in the Yazd traditional houses since in both the regions the cellars need to provide light and ventilation to both food and its occupants during hot days. Another similarity is a small pool in both basements of the two regions. The reason for this is to achieve a convenient place during hot days that provides protection from sunlight. Moreover, occupants keep their foods in this cooling space in both regions, so basement spaces in both traditional houses act as a storage spaces as well.



Yazd



Diyarbakir

Figure 41: Windows in basement spaces of Yazd and Diyarbakir region (Tuncer,1999)

One of the differences is the hole in the ceiling of basement spaces which is directly located under the chamber of the wind tower in Yazd regions traditional houses, so the natural ventilation comes down through the vertical chamber of wind catcher and passes the pool and creates cool air by means of evaporation cooling in the cellar. While, there is no hole in the ceiling of the basement spaces in Diyarbakir traditional houses, it is due to the fact that there are no wind catchers available in the old houses to convey the wind into the basement spaces.



Figure 42: Hole in the ceiling of basement spaces in Yazd traditional houses

### 3.2.1.2 Semi Open Spaces (Talar&Eyvan)

Semi open space is another cooling space which is visible in both traditional houses of two regions. The similarity is the semi open spaces in both regions are in the south part of the courtyard which is covered with a vault for solar protection as protection from sunlight in this kind of climate is a priority for designers. The solution was the semi open space that was covered with a vault. This kind of place gives an opportunity for users to sit out during the evening without being disturbed by the sunlight. Moreover, by irrigating the yard in the evenings in both regions, this place could be a convenient place for resting evenings until night times during hot days. The differences in Yazd houses is the wind catchers at the top of the semi open spaces where natural ventilation comes down through the vertical shafts of the wind tower to provide cooler air than the ones seen in the traditional houses in Diyarbakir region.

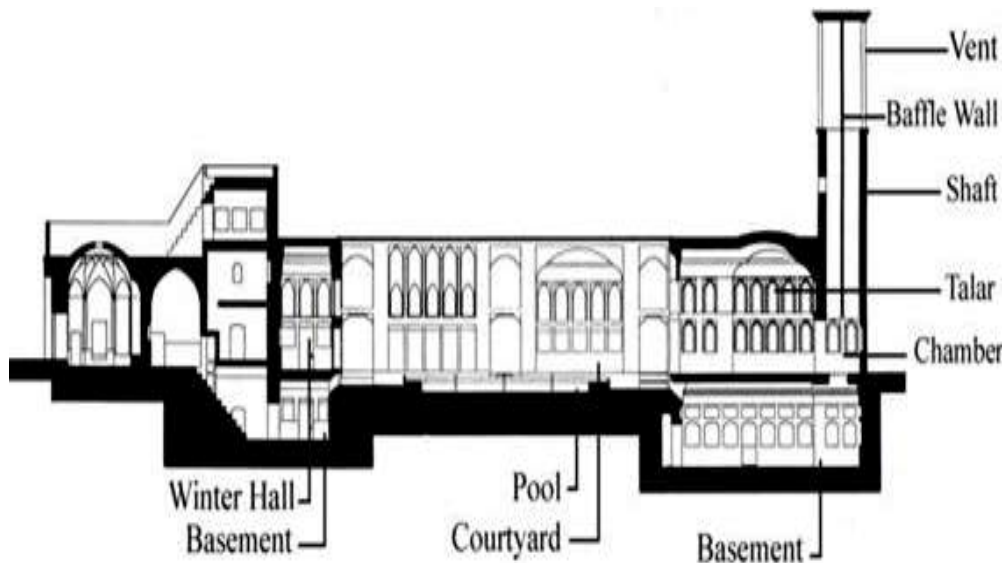


Figure 43: The relation between Talar and Wind catcher in Yazd traditional houses (Iranian Cultural heritage, 2005)

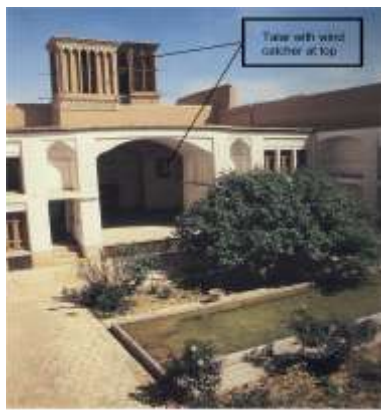


Yazd



Diyarbakir

Figure 44: Semi open spaces in Yazd and Diyarbakir traditional houses (Iranian Cultural Heritage, 2005), (Tuncer, 1999)



Yazd

Diyarbakir



Figure 45: Semi open spaces in Yazd and Diyarbakir traditional houses.(Ghasemi, 2005), (Tuncer, 1999)

Consequently, semi open spaces are different in both structures of the two regions due to the use of wind catchers in Yazd traditional houses and the different materials which are used in every house for resistance of the vault. In fact, in Yazd traditional houses, this structure should tolerate the weight of the adobe materials so one arch in the middle could withstand the resistance of the load of the adobe material. However, in Diyarbakir traditional houses, the stone material should only be able to tolerate the structure with the

help of a double arch. It is the reason for the two different structures in both traditional houses in Diyarbakir and Yazd regions.

### **3.2.1.3 Courtyard**

Courtyard is the focal point of the houses and one of the best cooling spaces in Yazd and Diyarbakir traditional houses. All houses have an abundance of a courtyard which has different functions according to the acclimatization. In fact, a courtyard is a solution for protection from not only sunlight in both regions but also sand storms in the Yazd region. The high walls around the courtyard in both regions provide shady spaces for inhabitants as well as prevent strong dusty winds from penetrating the courtyard. There is religious reason for designing the courtyard plan in both regions the way they are and that's because the Muslim religion dictates that the inside of houses should not be visible from the outside. In fact, thick walls are abounded the courtyard which act as a buffer from any visual contact between the inside and the outside of each house. There are different types of traditional houses that use courtyards in both regions. Houses with one courtyard, two courtyards or in some cases, more than two courtyards are apparent. The traditional houses with two or more courtyards usually belong to rich families in both regions.

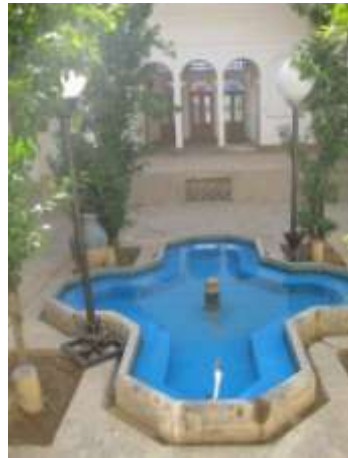
There are three different courtyards with different purposes in some of the houses located in Yazd which are related to rich families. They are categorized into outdoor courtyards, indoor courtyards and orangery courtyards. The outdoor courtyard is the courtyard that is nearest to the entrance, which is allocated for guests and strangers. Women are not allowed to go to the outdoor courtyard without their outfit and veil because of religious beliefs. Indoor courtyard is a private space for inhabitants. Women

perform many activities such as preparing food and weaving carpets freely in this house because men cannot enter the indoor courtyard without permission. The orangery courtyard is a small courtyard in the inward sections that provides light for surrounding rooms which make it possible to cultivate plants that are sensitive to the winter frost of the desert area. However, in Diyarbakir traditional houses, there are a few houses with two or more courtyards that are used for different purposes. They are called harem and selamikpart. Heram part of a courtyard is allocated for females and the selamik part is appropriated for male guests. Two separate entrances are used, one is for males and the other is for females to enter. A door connects these two parts.

Consequently, different courtyards in traditional houses are similar between two regions because of the effect of the Islamic culture in both regions. However, there are differences in the design characteristics, the positioning of the yard and the entrances in both regions. In fact, some traditional houses with one yard in Diyarbakir have two different entrances, which lead the same yard. They are classified into the visitor entrance and the service entrance. The different entrances in some of Yazd regions in traditional houses lead to different courtyards. In fact, it is one of the most important differences between the two traditional houses in different regions. As a result, male and female are separated and have private spaces which are the main similarities between the two regions affected by Islamic culture. However, there are differences in the design of the private spaces such as the courtyards due to the fact that they are in different regions with different cultures.



Yazd



Yazd



Diyarbakir

Figure 46: Different courtyard in Yazd and Diyarbakir traditional houses (Tuncer, 1999)

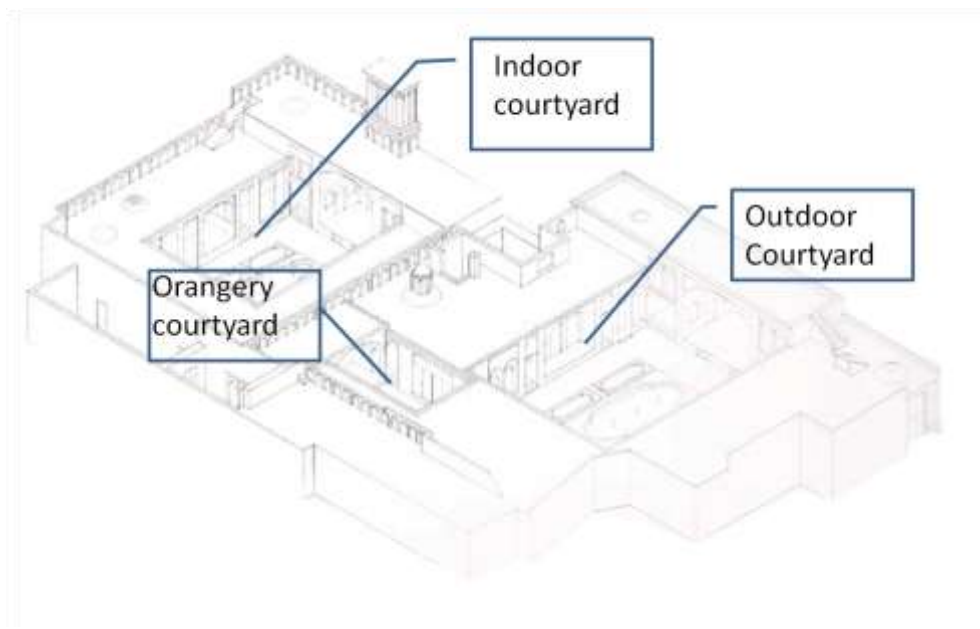


Figure 47: Different courtyards in Yazd traditional houses (Ghasemi, 2005)



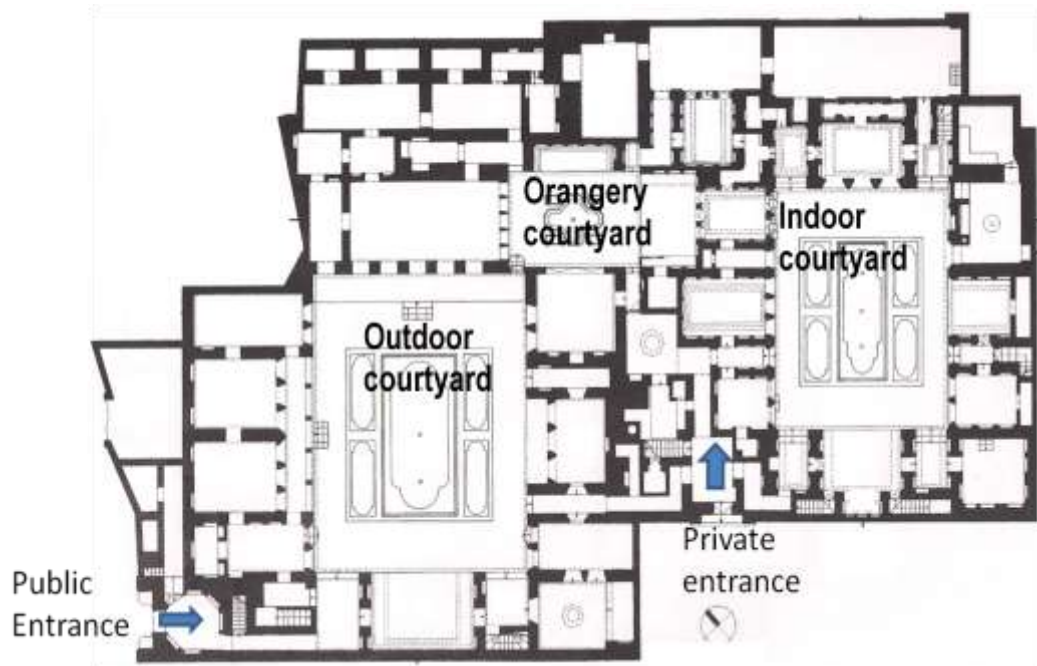


Figure 48: Different entrances with different courtyards in Yazd traditional houses (Ghasemi, 2005)

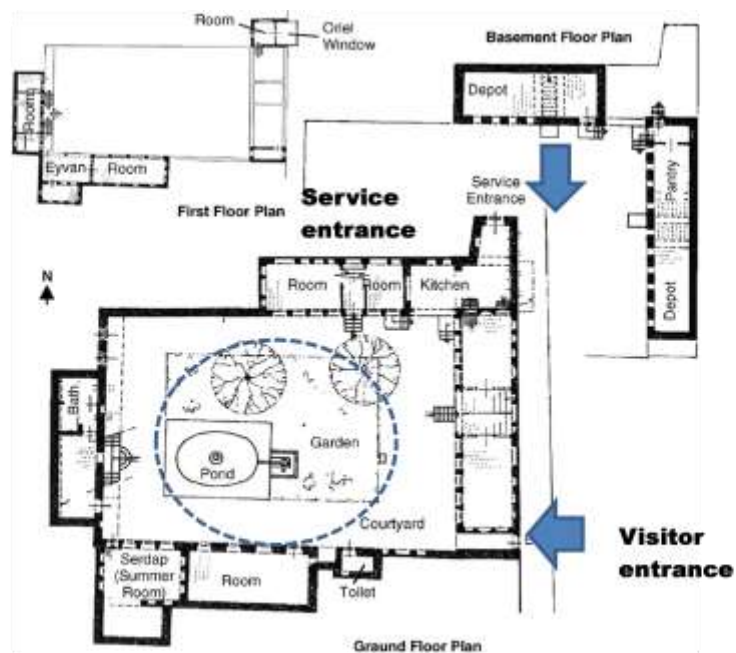


Figure 49: One courtyard with separate entrances in Diyarbakir traditional houses (Suzen & Gedik, 2008)



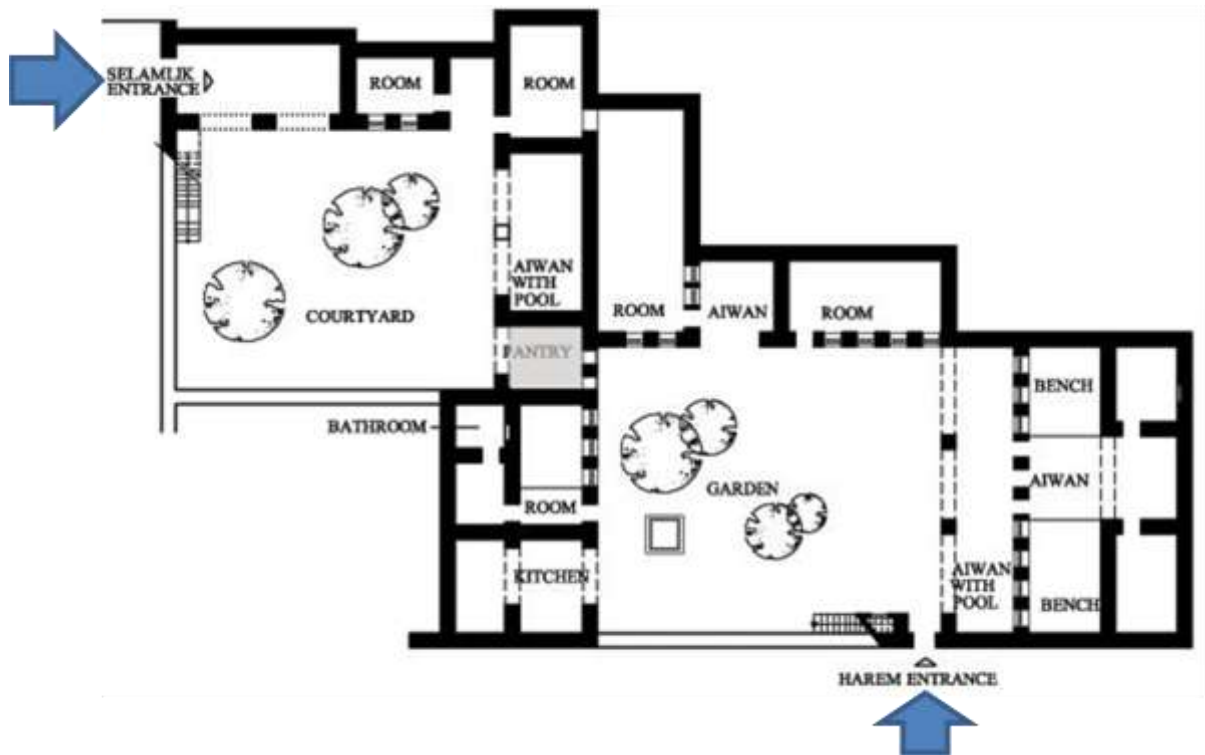


Figure 50: Two courtyards with two separate entrances in Yazd and Diyarbakir traditional houses (Sari, sen, Khya, & Sagsoz, 2011)

Furthermore, sunken yards or “godalbaghcheh” is another type of courtyard that is well known in some parts of the Yazd region. This kind of yard was built in the middle of a central courtyard with one level underground because of the site location and the topography in some areas of Yazd. Sunken courtyards provide bioclimatic spaces due to the lower leveling of the ground by using moist air and cool ground. However, this kind of courtyard is not apparent in Diyarbakir traditional houses because of the similarity of the topography throughout the city.



Figure 51: Sunken yard in Yazd traditional houses

Moreover, adobe materials of thick walls around the courtyards in Yazd traditional housings absorb the humidity of the air during the night so it gives back to the environment during the day and cools the air. On the other hand, the stone materials of the thick walls around the courtyard in Diyarbakir traditional houses have a high capacity to store heat for a long time and provide it to the surrounding environment during the night. Therefore, both the different walls and materials create indoor environment comfort for occupants in each region. Additionally, the high walls create shading for occupants during the hot days in both regions. There is also a shallow pool in the middle of a courtyard with a diversity of plants such as pomegranate trees and grape vines. This vegetation is highly suitable for the climate of Diyarbakir and Yazd and provides natural ventilation and decreases the air temperature. Therefore, the courtyard is a convenient place for inhabitants during the evenings and a suitable place for children to play. In addition, occupants sleep in the courtyard during the summer nights. As a result, In spite of the same climate and similar religions, the courtyards in two traditional houses of Diyarbakir and Yazd region have differences which are apparent when looked into because of the different traditional styles of the traditional architectures in each region that are inspired from Turkish and Iranian cultures.

However, the aim of the courtyard in both regions is to provide privacy and achieve a comfortable environment for inhabitants.



Figure 52: Courtyard in Yazd and Diyarbakir traditional houses (Tuncer, 1999)

One of the similarities in two different courtyards of the regions is using the same plants. Pomegranate, fig and mulberry are the same plants used in Diyarbakir and Yazd houses. These kinds of plants are adaptable to the hot-dry climates and create shading and prevent noise pollution for inhabitants in both regions.

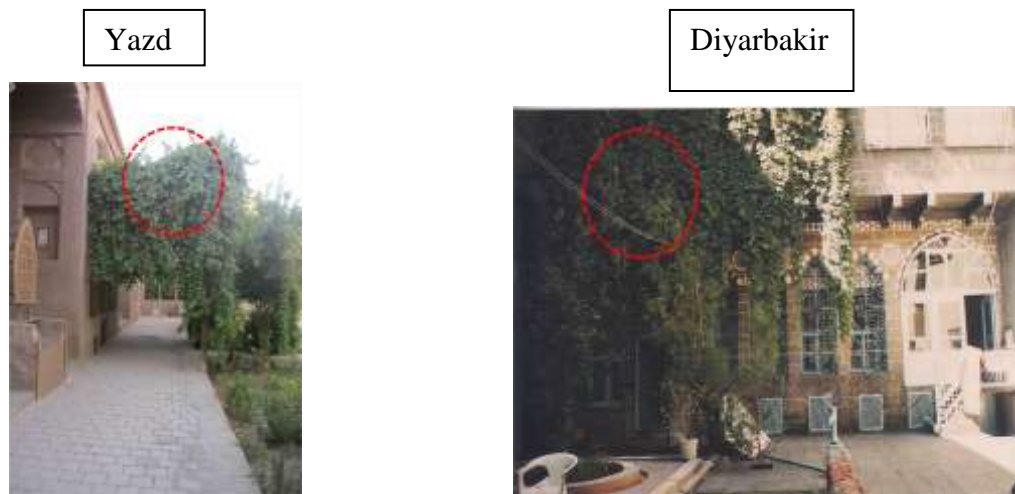


Figure 53: Fig trees in Diyarbakir and Yazd old houses(Tuncer,1999)

One of the differences is placing the bed in the shallow pool in Yazd traditional houses for resting at nights. The reason for this is that there is a type of spider called a tarantula, which lives in the desert climate. They are really dangerous and poisonous. Therefore, occupants place their bed in a shallow pool for resting during the night and keeping themselves safe from this type of spider, as they cannot swim. There are no tarantulas in the Diyarbakir region, so the occupants of Diyarbakir region can sleep outdoors or on the ground without any dangers from this type of spider.



Figure 54: Sleeping area in Yazd old houses



Figure 55: Location of sleeping area in Diyarbakir old houses (Tuncer,1999)

Table 2: Differences and similarities in cooling spaces in Diyarbakir and Yazd traditional houses

<b>Differences and similarities in cooling spaces of traditional houses in hot-dry climates</b>			
<b>Use of spaces</b>	<b>Cellars</b>	<b>Courtyards</b>	<b>semi open spaces</b>
<b>Diyarbakir region</b>	<p>No water network connection inside</p> <p>Windows face to yard</p> <p>Keeping the food</p> <p>Resting during the hot day</p> <p>Pool in the middle</p>  	<p>Diversity plants such wide leaf fruit Trees (pomegranate &amp; grape ) and pool in the middle</p> <p>Courtyard is Islamic culture</p> <p>Two different entrances to one courtyard for men and women or two different courtyards with two entrance</p> <p>Stone materials walls around the courtyard</p> <p>Convenient place for children and sleeping at summer nights</p> 	<p>In the south direction</p> <p>Summer use</p> <p>Two arched ceilings</p> <p>Double story</p> <p>Stone material</p> 
<b>Yazd region</b>	<p>Connect to water network</p> <p>Hole in the ceiling</p> <p>Windows face to yard</p> <p>Pool in the middle</p> <p>Keeping the food</p> <p>Resting during hot days</p>  	<p>Diversity plants such wide leaf fruit Trees (pomegranate &amp; grape ) and pool in the middle</p> <p>Court yard is Islamic culture</p> <p>Indoor courtyard (For women)</p> <p>Outdoor courtyard (For men)</p> <p>Orangery courtyard</p> <p>Two courtyards with one entrance and three courtyards with two entrances</p> <p>sunken courtyard (Topographical situation)</p> <p>Adobe material walls around the courtyard</p> <p>Convenient place for children and sleeping at summer night</p> 	<p>In the south direction</p> <p>Summer use</p> <p>Cover with vault</p> <p>Wind catcher at top</p> <p>Double story</p> <p>Adobe material</p>  
<b>Conclusion</b>	<p>Similar function but different in connecting to water network and hole in the ceiling because of underground water resources and wind catcher</p>	<p>Same plants because of adaptability with hot-dry climate, different courtyards for different purposes and different walls material according to availability</p>	<p>In the same directions but different shapes and materials because of availability materials and different traditional styles of architectures</p>

### **3.2.2 Service spaces**

Entrances, kitchens, toilets and bathrooms are the service spaces which have similarities and differences in the traditional architecture of Yazd and Diyarbakir regions. Entrance is an important space which is constructed according to the cultural aspects and the traditional architecture of every region.

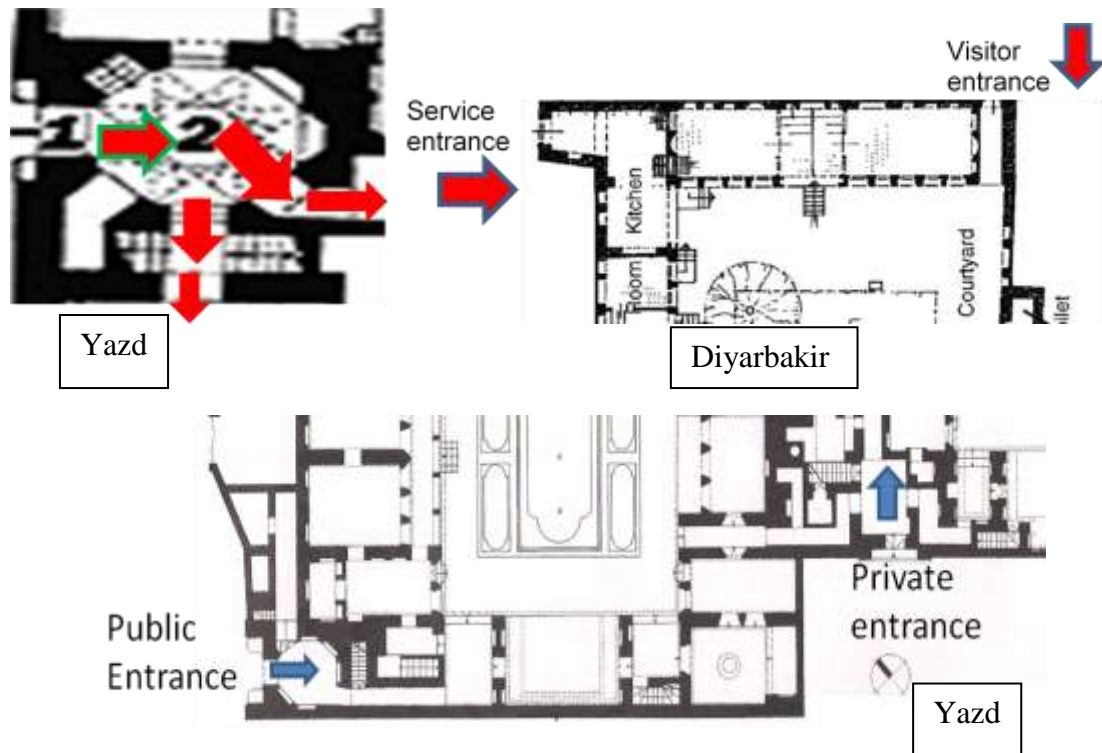
#### **3.2.2.1 Entrances**

Entrance is one of the most important service spaces in Yazd traditional houses. The eight Polygons for entrances with special doors and two different handles for distinguishing the males from the females is called a Vestibule or “Hashty” in Persian. Yazd people are religious and women are expected to cover themselves in front of strangers. Vestibule is a traditional element in the Iranian architecture. This space is a buffer zone between the outside and the inside of a house. This space is divided into two corridors, which lead to a private space (indoor courtyard) for the owners and a public space (outdoor courtyard) for the strangers and guests. The size of the entrances is different according to the size of the houses. Additionally, there is no direct vision between the entrance and the inside of the houses because of the Islamic culture in Yazd traditional houses. In Diyarbakir traditional houses, two different entrances lead to one yard or two separate yards for cultural reasons. One of the entrances is for inhabitants and female guest and the other is for strangers and male guests which is the same as Yazd traditional houses.

However, in Diyarbakir, traditional house separate entrances lead to a single yard while in Yazd, traditional house separate entrances lead to different courtyards. The plan of the entrance is rectangular in Diyarbakir old houses. There is no visual contact between the



outside and the inside of the houses and the same goes for the Yazd region because they are Muslims and believe that their women should preserve themselves only for their husbands. Therefore, Islamic culture has a direct impact on the entrances in the two regions but in different forms because of the different styles of Iranian and Turkish traditional architectures in Yazd and Diyarbakir.



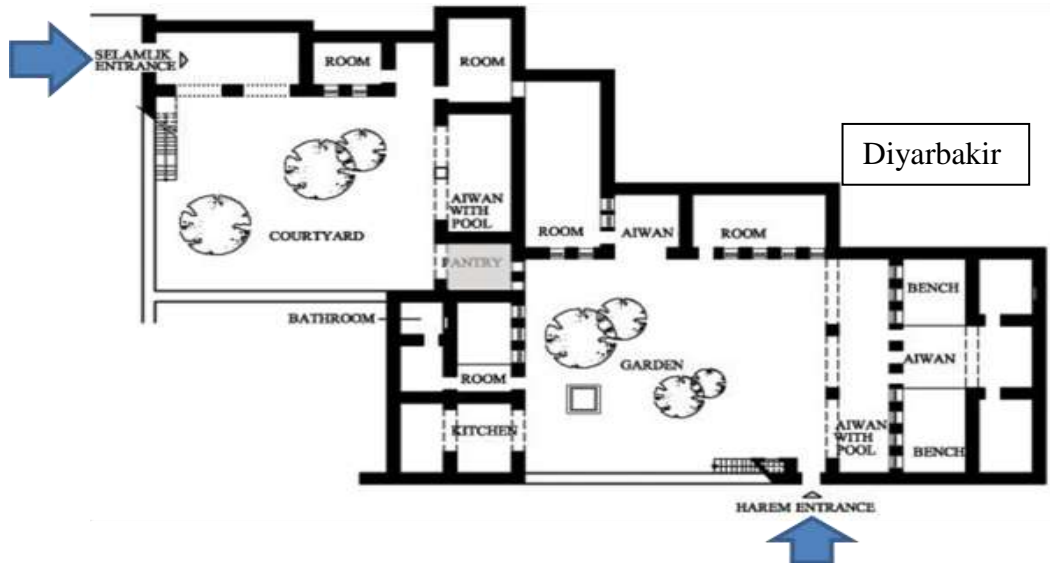


Figure 56: Plans of entrances in Diyarbakir and Yazd traditional houses (Bekleyen&Dalkiliç,2011), (Memarian, 2005)

Consequently, the similarities between the two entrance halls are providing the privacy measures for occupants. In other words, it is not possible to visit the courtyard when the street doors is opened in both Diyarbakir and Yazd traditional houses because of the way they are built in both regions to keeping women away from direct visual contact with strangers.



Figure 57: Different views from street to inside of the Yazd and Diyarbakir traditional houses (Tuncer,2011), (Memarian, 2005)

As it was mentioned before, the doors of Yazd traditional houses have separate handles for identifying the sex of a person behind the door due to the religious facts. In some of



Diyarbakir traditional houses, considering two separate entrances for inhabitants and strangers is a solution for identifying the sex of person outside of the door.

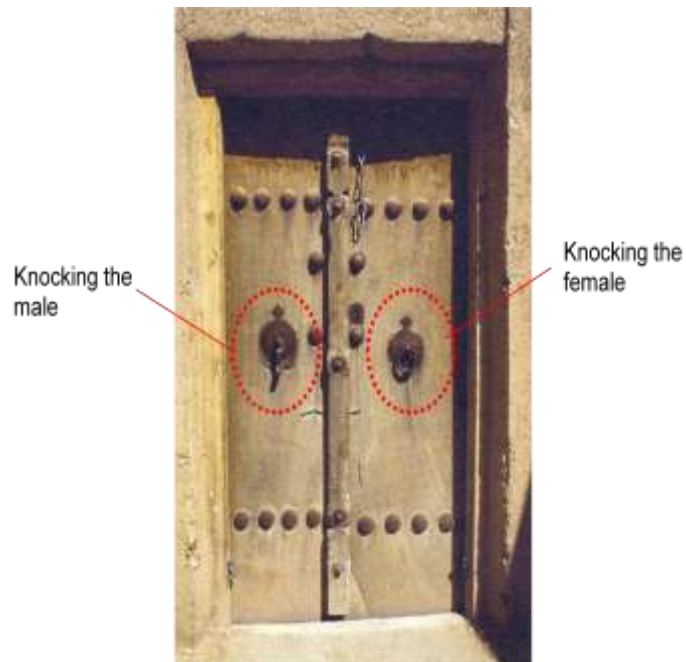


Figure 58: Entrance gate in Yazd traditional houses (Ghasemi, 2005)



Figure 59: Entrance door in Diyarbakir traditional house(Tuncer,1999)

### 3.2.2.2 Toilets, Bathrooms and Kitchens

Because of the shortage of water in Yazd city, there were no bathrooms inside of the houses in most traditional houses. Some big houses had bathrooms inside the houses so

most inhabitants used public bathrooms that were located in the center of the city. However, there was a toilet that was located near the entrance for easy connection to the main disposal systems. On the other hand, there is a bath and a barn in some big houses of Diyarbakir region, although there are public baths in the city for citizens. The reason is the limited area for settlement because of the city wall, so only the big houses could integrate baths. Toilets are situated in the courtyard near the entrance gate to avoid unwanted odors seeping into the indoor environments. Dovecotes are located at the inner wall surfaces of the courtyard. Besides being nature indicators, barns and dovecotes supply the fertilizer required for the courtyard garden, so they are economic indicators. The situation of toilets in both regions is similar where they are located near the entrance to keep the indoor environment healthier and cleaner. Moreover, public baths in the city is one of the similarities in both regions because of the lack of water resources in Yazd region and the limited area for houses due to city walls in Diyarbakir region.

Since the women in Yazd region were housewives, kitchen was one of the most important spaces for women. It is a big space which is located in the north part (winter part) of most homes. It contributes to its thermal performance in this direction. As the inhabitants are religious, the kitchen has no windows and no direct visual contact to the outside including the courtyard. In fact, they believe women should not have any visual stimulation during the cooking and preparation process. In addition, in some traditional houses of Yazd, this place is located in the indoor courtyard for protection from visual contact of outside strangers or even male guests.

Kitchens are located in the north side of the courtyard near the winter section in order to act as a thermal enhancer and are fitted with equipment made of reusable materials like copper, wood and earth in Diyarbakir traditional houses. Consequently, the kitchens in both traditional houses of the two regions are situated in the north part (winter part) of courtyard that increases indoor thermal air quality.

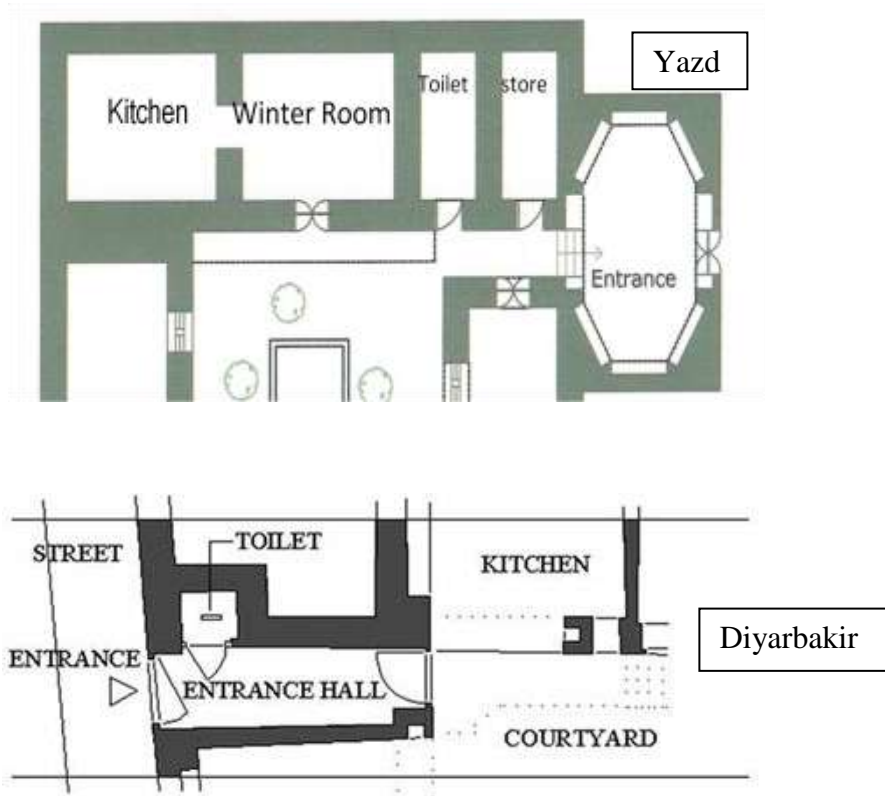
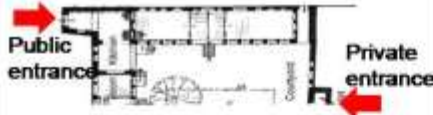
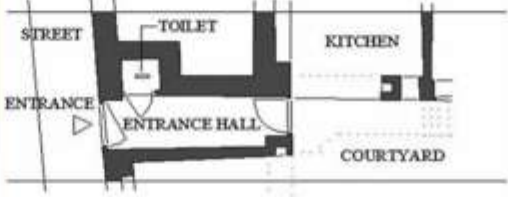

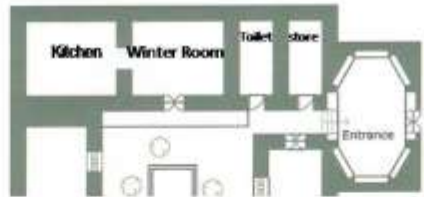


Figure 60: The location of service spaces in Yazd and Diyarbakir regions (Bekleyen & Dalkilic, 2011)

Table 3: Differences and similarities in service spaces of Yazd and Diyarbakir

Differences and similarities in service spaces of traditional houses in hot-dry climates			
Use of spaces	Entrances	kitchens	Toilets and baths
<b>Diyarbakir region</b>	<p>Rectangle plan</p> <p>Two different entrances (private and public use)</p> <p>No direct vision to court yard (Islamic culture)</p> 	<p>In North direction (winter part)</p> <p>Near the entrance</p> 	<p>Near the entrance</p> <p>No baths in some of the houses</p> <p>Public bath in the city</p>
<b>Yazd region</b>	<p>Vestibule</p> <p>Traditional element</p> <p>Has two different corridors for public and private use</p>  <p>Special ceiling accordance with Iranian traditional architecture</p> <p>Two different handles on the door for indentifying men and women (Islamic culture)</p> <p>Different size according the big of the house</p>	<p>In north direction (winter part)</p> <p>Indoor court yard (no visual connection to other space because of religious belief)</p> 	<p>Near the entrance</p> <p>No bath in some of the houses</p> <p>Public bath in the city</p>
<b>Conclusion</b>	<p>Different types of plan according to different traditional architectures styles, similar function because of same Islamic culture (no vision between outside and inside)</p>	<p>In similar direction for increasing indoor thermal</p>	<p>In the same direction and near the entrance for healthier indoor environment</p>

### **3.2.3 Winter Rooms and Summer Rooms**

The spaces around the courtyard are constructed appropriately for seasonal usage in both regions. The spaces in the south part of the courtyard is appropriate for summer because they face north and are not exposed to direct sunlight which is protected from sunlight in hot-dry climates which is an important issue that was considered in design of traditional houses. However, the forms and ornaments of these rooms are different in every region.

Summer rooms in Yazd region are located in the southern part of the courtyard. Semi open spaces (talar and veranda), cellars (sardab), courtyards and vent rooms are very important summer spaces in Yazd traditional houses. While, semi open spaces (eiwan), cellars (sardab) and courtyards are summer rooms in Diyarbakir traditional houses which are located in south direction, the same as Yazd region because of the sun's path in this direction being minimal in this direction. Moreover, roofs are other spaces that are used in summer nights and evenings for sleeping and resting by inhabitants in both the traditional houses of two regions. The similarities between two traditional houses in different regions are a vertical movement type where inhabitants move vertically during the day-night periods depending on where it is the coolers. In fact, in the mornings and evenings, they use semi open spaces and during the day, they go downstairs to avoid direct sunlight and at night, they travel upstairs and sleep at roofs in both traditional houses in hot days.



Figure 61: Vertical movement of inhabitant in summer parts of Diyarbakir and Yazd traditional houses (Tuncer,1999)

The layout of the carved stucco decoration in summer spaces of Yazd houses, particularly at the top of the walls, openings and windows inspired from Iranian traditional architecture in Yazd houses. The wind catchers in most Yazd traditional houses are placed in the summer sections on top of the semi open spaces (Talar). There is a room under the vertical shaft of wind catchers titled “vent room” in some of the traditional houses in Yazd. In fact, there is a sash- window which is facing to courtyard that can be opened during the night and evening to benefit from natural ventilation in some of the traditional houses in Yazd(south section). The vertical shaft of wind catchers is directly connected to this space with sash-windows, so this space is completely cooled by the prevailing winds that travel through the wind catcher. Likewise, there is an upper window close to the ceiling in the summer rooms to help remove the indoor air in Diyarbakir traditional houses and there is no wind catcher in the summer part because it is not available like it was traditionally and symbolically for Iranian architecture. Therefore, using passive environmental control in Yazd traditional houses were achieved by utilizing wind catchers.

The other differences are the double arches in semi open spaces in the summer parts of Diyarbakir which is inspired from the Turkish traditional architecture. On the contrary, the single arch in the middle and two spaces beside it for creating a symmetrical form is an important characteristic for Iranian traditional architectures that is visible in Yazd traditional and vernacular architectures.



Figure 62: Different forms of semi open spaces in Diyarbakir and Yazd regions (Tuncer,1999)

There are rooms on the second floor and the windows are facing towards the semi open space and the courtyard in both different houses. There is a eiwan between the summer rooms and the courtyard in both different houses. Nevertheless, in Yazd houses, there is one big semi open gap beside the summer rooms. Summer parts of the two different houses have various different shapes in spite of the same functions that protect from sunlight and provide cool ventilation for inhabitants.



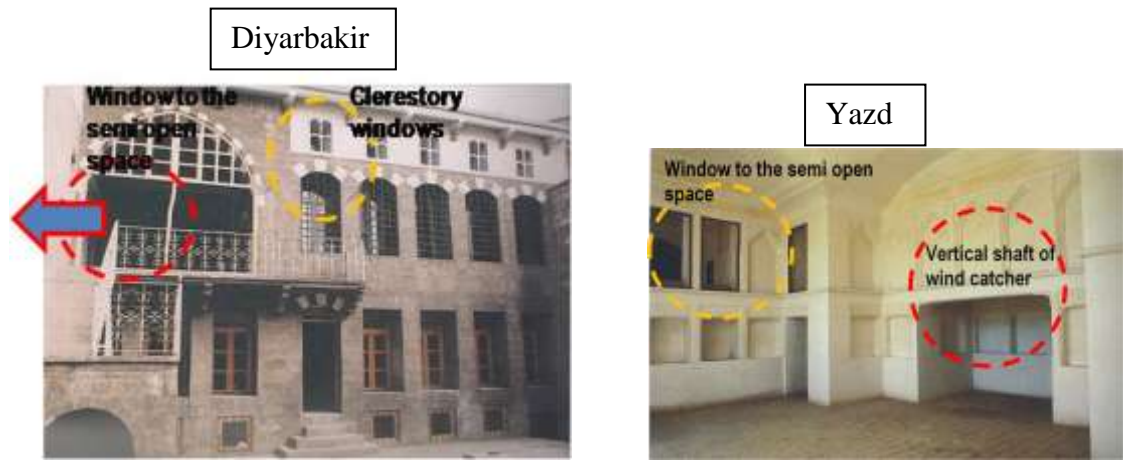


Figure 63: Windows of summer part in Diyarbakir and Yazd traditional houses (Tuncer,1999), (Ghasemi,2005)

Summer parts in both traditional houses of these regions are two stories due to the solar protection capabilities and barriers to the north winds which decrease the heat loss for the single story winter sections. Movable windows for inviting the wind during the evenings and nights are similar characteristic in both different houses.

The summer rooms have a high ceiling, large walls and many clerestory windows facing the north direction in Diyarbakir traditional houses. The similarities between Yazd and Diyarbakir are the high ceilings and the large walls for solar protection. The differences is clerestory windows in Diyarbakir region which give an opportunity to ventilate the hot air while in Yazd traditional houses sash-windows and movable windows are the solutions used for removing hot air and providing natural ventilation. The reason could relate to the different kinds of traditional architectures in order to create a comfortable indoor environment as a priority. Using the frame inside the window recesses in both different houses does not allow sunlight entry to indoor spaces.





Figure 64: Summer rooms in Diyarbakir and Yazd traditional houses(Tuncer, 1999), (Ghasemi, 2005)

Most of winter rooms in both regions have short ceilings and are situated in the northern part of the courtyard to provide an indoor thermal control. In Diyarbakir and Yazd traditional houses, the winter rooms in some houses are situated in the eastern side and the western side because of the sun's path in these directions in both regions which increase the solar absorption towards these directions in the winter times. However, the summer rooms are always situated in south in both regions. 15-45 degrees west of south with a southern orientation being the optimum position for effective solar gains, window opening are similarly between two different houses in different regions. Low ceilings, small floor area, single story and big windows facing the courtyard for maximum sunlight in order to increase the thermal control in winter times are the similarities between the regions. The reason behind it is that in the cold winters, houses in both regions need some passive thermal control and by using natural energy such as sunlight in houses, it is provided for in both regions.

One of the differences between winter rooms in every house is the type of opening in every traditional house because of the different traditional architectures. In Yazd traditional houses, the main section of winter rooms consists of a set of spaces including “Sedari” (a room with three doors),”Panjdari” (a room with five doors) which are inspired by the Iranian traditional architecture. However, in Diyarbakir traditional houses, the frames outside and the provisional sunlight and the heat losses from the window openings in the winter rooms are retrieved by the window recesses in the middle. Indoor materials of the winter rooms in Diyarbakir houses are covered with wood which help increase the thermal temperature while the indoor material of Yazd traditional houses are covered with stucco that act as a suitable thermal insulation for the heat loss in winter times.

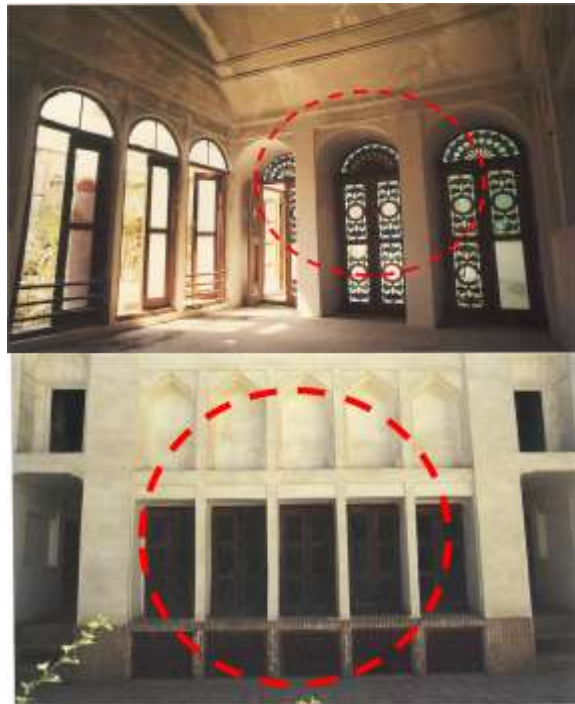


Figure 65: A room with three and five doors in winter part of Yazd traditional house (Ghasemi, 2005)

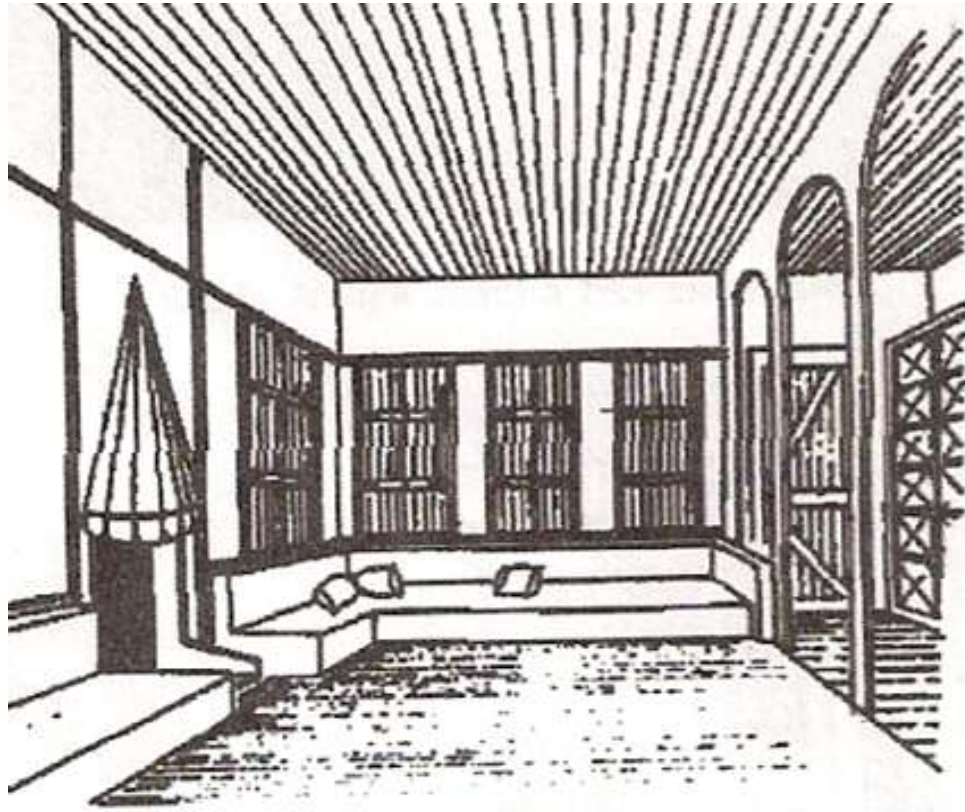


Figure 66: Winter room in Diyarbakir house (Suzen & Gedik, 2007)

Table 4: Differences and similarities between summer rooms in Diyarbakir and Yazd traditional houses

<b>Differences and similarities in summer and winter rooms of traditional houses in hot-dry climates</b>		
<b>Use of spaces</b>	<b>Summer rooms</b>	<b>Winter rooms</b>
<b>Diyarbakir region</b>	<ul style="list-style-type: none"> <li>•South part of court yard for type of solar radiation in this direction</li> <li>•Include semi open space, cellar and rooms</li> <li>•Yard and roof as an outdoor spaces for evening and nights summers</li> <li>•Upper windows in summer rooms for removing the indoor hot air</li> <li>•High ceiling and large area with recess windows frames for protection from sunlight</li> <li>•Stone decoration adapts with Turkish architecture style</li> <li>•Double story act as barrier to the north winds decrease the heat losses for the single story of winter part.</li> <li>•Windows are facing to the semi open space and court yard with shading elements</li> <li>•Vertical movement in summer part during the day for runaway from direct sunlight</li> </ul>	<p>Single story for solar absorption</p> <p>Low ceiling, small area and a few windows for decreasing the heat loss</p> <p>In north direction because of climatic issues</p> <p>Indoor spaces are covered with wood material for increase thermal air</p>
<b>Yazd region</b>	<ul style="list-style-type: none"> <li>•South part of court yard for protection from sunlight</li> <li>•Include semi open space, cellar and rooms</li> <li>• yard and roof as an outdoor places in summer evenings and nights</li> <li>•Wind catcher at top of this part</li> <li>•Vent room in some house with direct connection to the wind catcher</li> <li>•Double story act as a buffer for insufficient wind in winter times</li> <li>•High ceiling with and windows with frame side act as a shading element</li> <li>•carved stucco decoration is related to Iranian architecture style</li> <li>•Windows are facing to court yard and semi open space with the shutter for protection from sunlight</li> <li>•Vertical movement in summer part during the day for runaway from direct sunlight</li> </ul>	<ul style="list-style-type: none"> <li>•A room with three doors(sehdary) and a room with 5 doors(panjdary)</li> <li>•Single story for solar absorption</li> <li>•Low ceiling, small area and big windows without shutter for gaining more sunlight</li> <li>•In north direction because of climatic issues</li> <li>•Indoor spaces are covered with stucco for decreasing the heat loss</li> </ul>
<b>Conclusion</b>	<p>Similar in creating cooling space for occupants and vertical movement in summer rooms and horizontal movement depends on the seasons, Different in gaining natural ventilation because of different styles of architecture. similar story because of pretending unsuitable wind which comes from south part for winter times</p>	<p>Similar function and similar story in order to achieve more sunlight for indoor spaces, different in opening and form which is related to traditional architecture of every region ,different indoor material with the similar function for increasing indoor thermal air</p>

### 3.3 Plan Types

There are different types of plans in traditional houses of Diyarbakir and Yazd regions. The environmental conditions have an impact on the design of the houses in both traditional architectures of two regions. The similarities and the common elements in all of them are the courtyards and inward plans to protect the inhabitants from both the extreme heat in hot days and any disturbances caused by outsiders. Their size and complexities are varied according to owner's financial situation, social status, and building site, design features, bioclimatic, ecological and environmental influences determine the sustainability of the houses.

There are three different plans according to the courtyards in Diyarbakir traditional houses. Outer, inner and central courtyard in Diyarbakir traditional houses. L type, U type and a mix of both which are the different types of plans of the outer courtyards. In L types, summer rooms are always located in the southern part and the winter rooms are located in the western and the eastern part.

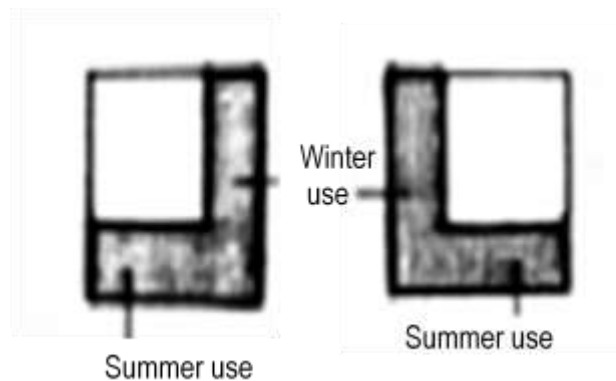


Figure 67: L types plan in Diyarbakir traditional houses (Bekleyen & Dalkilic, 2011)

In the U type houses, summer rooms are located in southern part of the courtyard and winter rooms are located in northern part of courtyard.

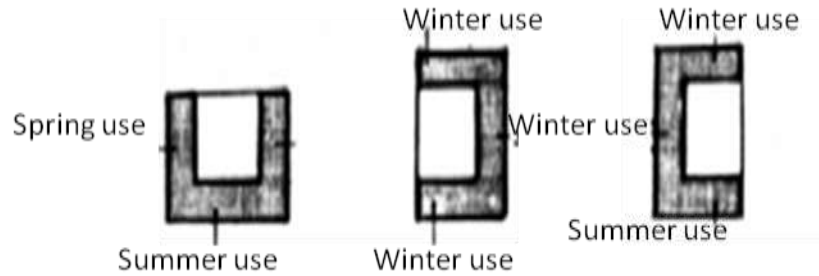


Figure 68: U types plan in Diyarbakir traditional houses(Bekleyen&Dalkiliç,2011)

In a mixed type, summer rooms are located in the southern part and winter rooms are situated in the west and the eastern part.

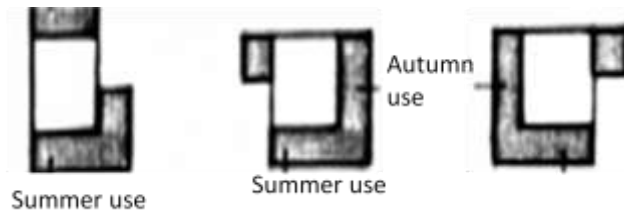


Figure 69: Mixed types plan in Diyarbakir traditional houses (Bekleyen&Dalkiliç,2011)

In an inner courtyard plan, winter section is located in the north direction and summer part is located in the south direction.

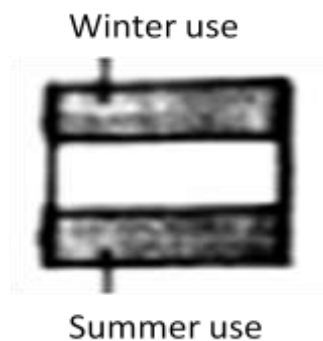




Figure 70: Inner courtyard plan in Diyarbakir traditional houses (Bekleyen & Dalkiliç, 2011)

In a central courtyard plan, winter part is located in the north direction, summer part in the southern direction and the seasonal part in west or east direction. The most important similarities of different types of Diyarbakir traditional houses is the location of summer sections in the southern direction and winter sections in any other directions except southern. The reason is that the hot-dry climate of the region coupled with the placement of the northern hemisphere, the sun protection is a high priority for designers and a southerly direction of a courtyard plan is the solution.

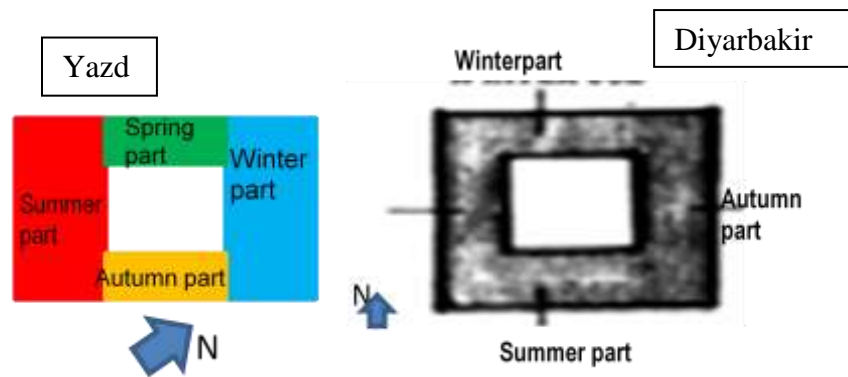


Figure 71: Central courtyard in Yazd and Diyarbakir traditional houses (Memarian, 2003) (Bekleyen&Dalkiliç,2011)

Types of plans in the Yazd traditional houses are categorized according to the courtyard much like the Diyarbakir houses. The influence of the Islamic culture in Yazd houses is causing the division of indoor courtyards and the outdoor courtyards for public use and private use. However, the effect of Islamic culture leads to having different entrances to a single courtyard or two courtyards in Diyarbakir traditional houses. Different entrances in some Yazd traditional houses almost always lead to separate courtyards.

1. One-courtyard house: There is one yard in this type of plan which is located in the southern part of Yazd's traditional houses. This type of plan is categorized according to semi open spaces and the spaces beside it. One-courtyard plan is what most typical traditional houses use in the Yazd region.

1.1 One semi open space (Talar)

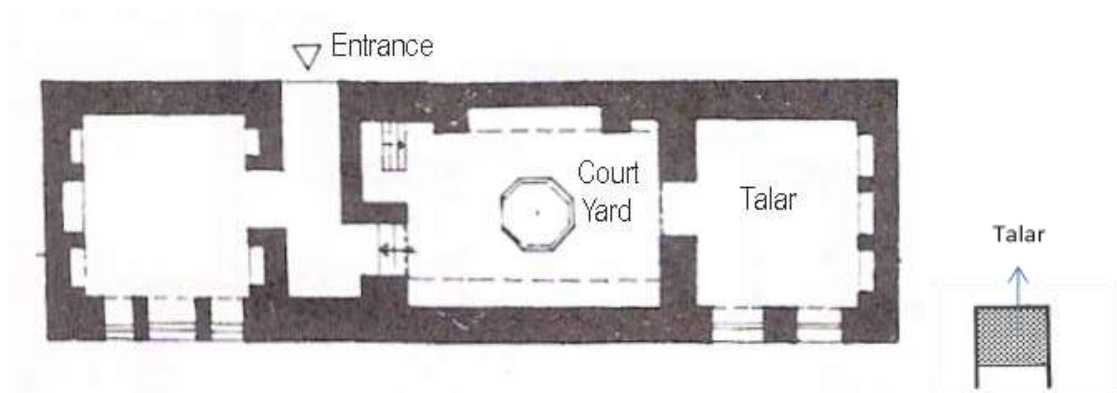


Figure 72: Plan of Talar in Yazd traditional houses(Memarian,2005)

1.1. One semi-open space (Talar) + one space beside it; There is one space beside the Talar in this type of plan which is used in summer times.

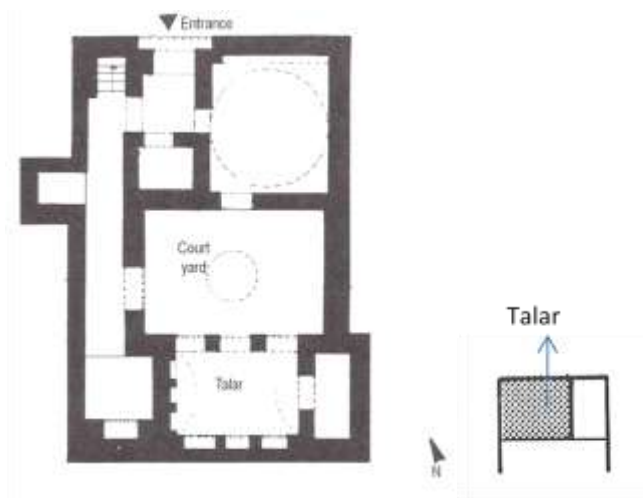




Figure 73: Plan of Talar and other spaces in Yazd old houses (Memarian,2005)

1.3. One semi-open (Talar) space between two spaces: Two spaces between the Talar create the symmetry in the design of the houses.

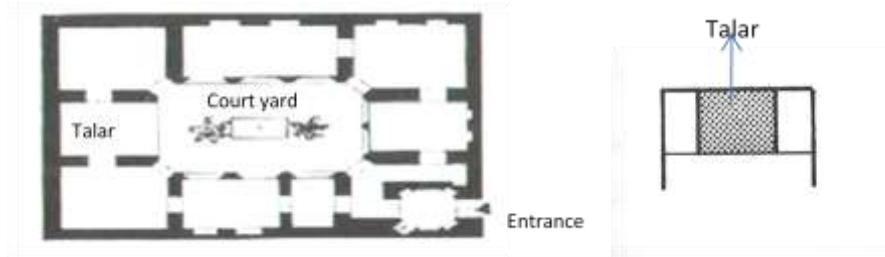


Figure 74: Plan of Talar and other spaces in Yazd old houses (Memarian,2005)

1. One semi-open space(Talar) between 4 spaces: It is visible in traditional and big houses.

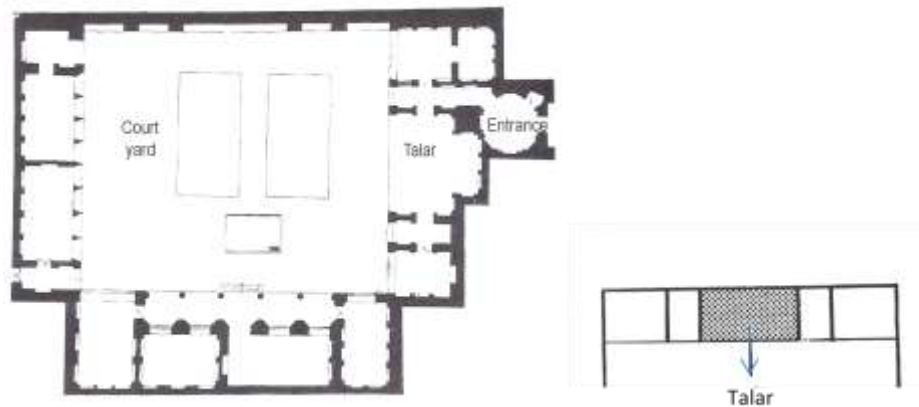
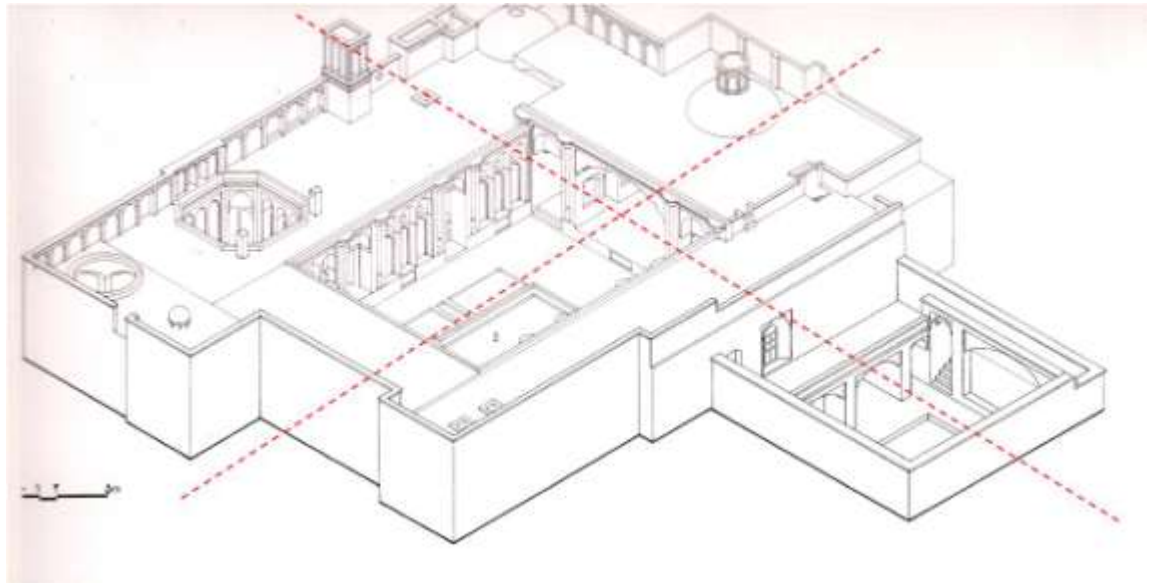
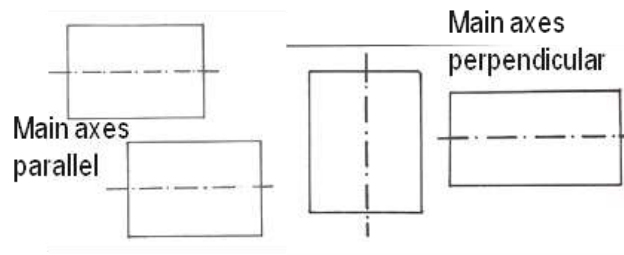


Figure 75: Plan of talar and other spaces in Yazd traditional houses (Memarian,2005)

2. Multiple Yard houses are categorized according to the situation of the interactions of the yards with each other

2.1 Main perpendicular: In this type of plan, two main axes of both yards are parallel

2.2 Main axes parallel: In this type of plan, two main axes of both yard cross each other.



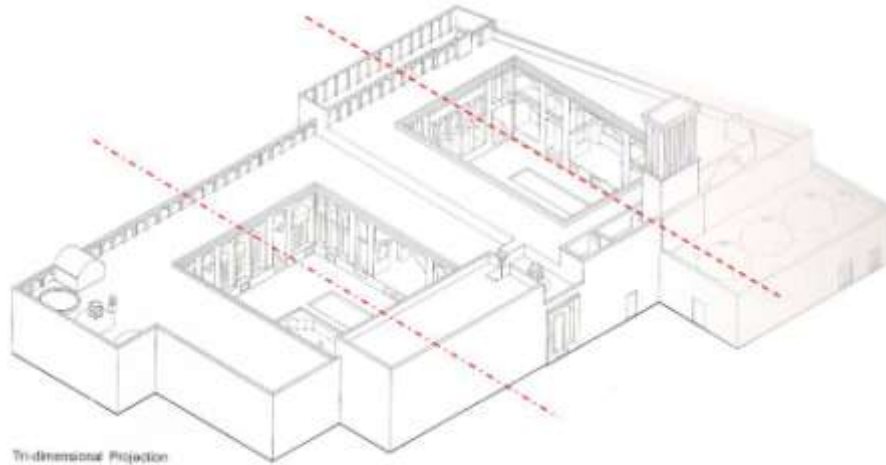


Figure 76: Different positions of courtyard in Yazd traditional houses (Memarian,2005)

Consequently, the type of plans between Yazd traditional houses and Diyarbakir traditional houses are different due to the fact that Iranian and Turkish traditional architectures are different although they have similar functions. In fact, there are spaces which are considered for winter and summer uses in both regions in similar directions for protecting from or gaining sunlight in different seasons. Moreover, most of the plans in both regions are oriented in a north-south direction because it is the best orientation for having harmony between the hot-dry climate and the northern hemisphere such as the Diyarbakir and Yazd regions pertain.

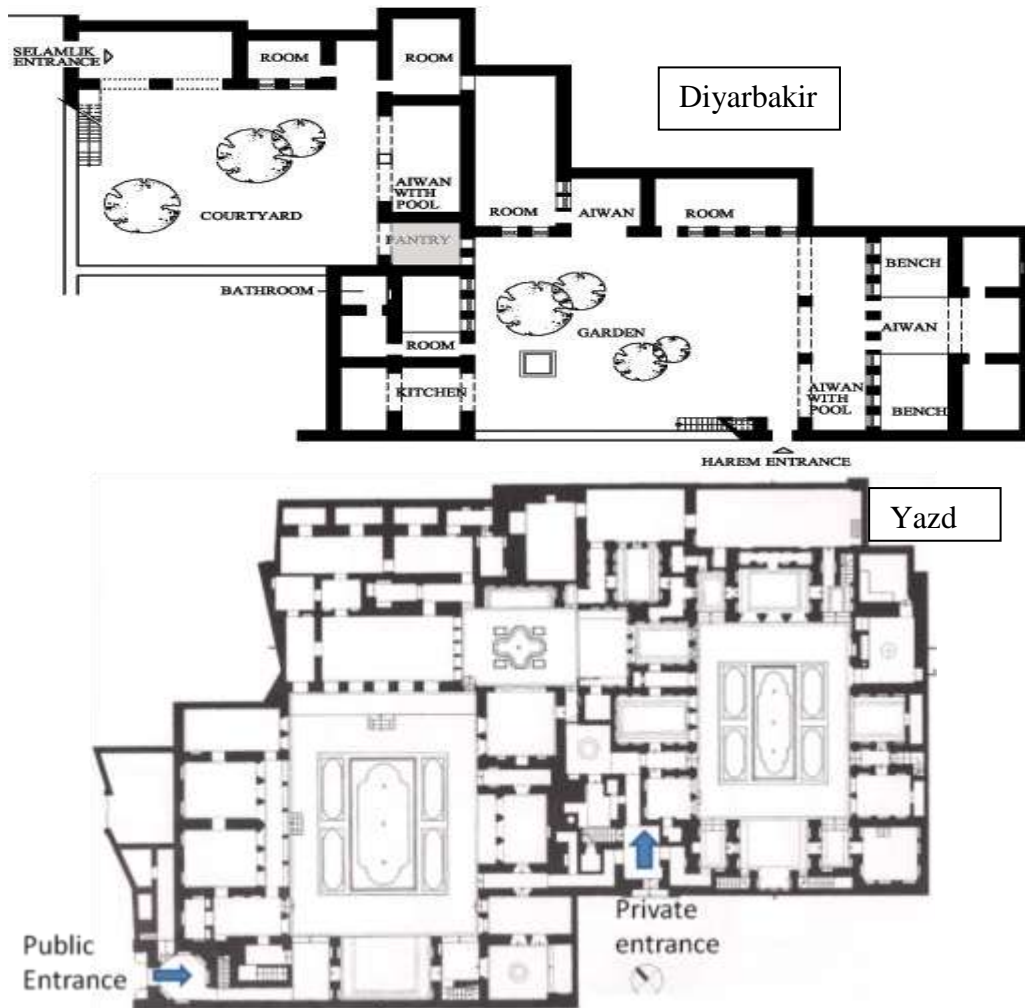


Figure 77: Different types of plans with one and two entrances in traditional houses of two regions (Memarian,2003), (Tuncer,2009)

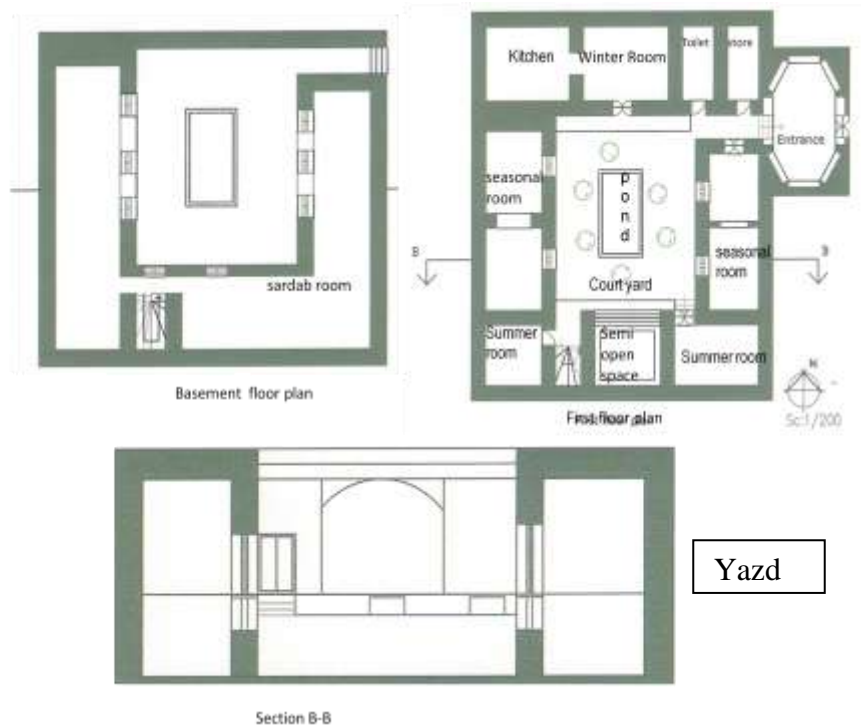
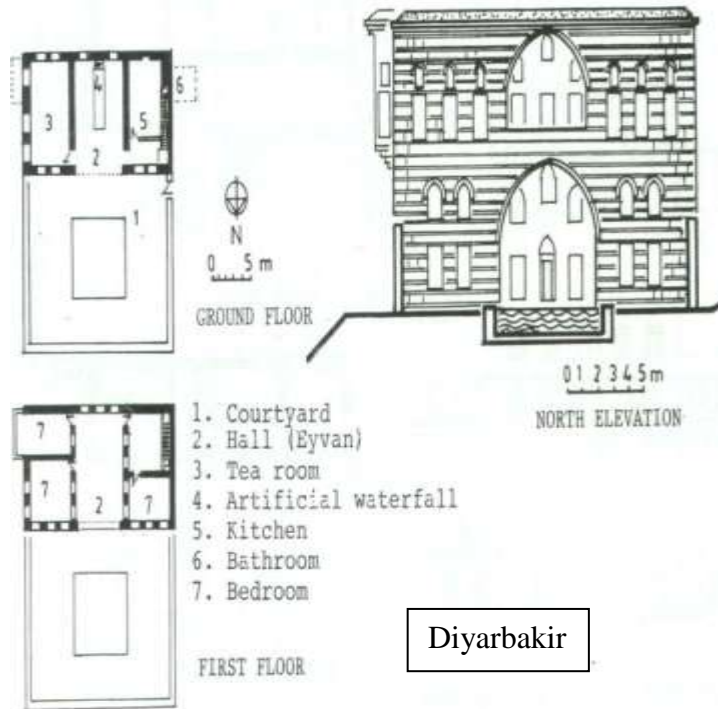


Figure 78: Plans and sections of different traditional houses in both regions (Ozdeniz,1991)

Table 5: Differences and similarities in plan types of Yazd and

Differences and similarities in traditional houses of hot-dry climates		
Plan types	Types	Descriptions
<b>Diyarbakir region</b>	<ul style="list-style-type: none"> <li>Outer court yard: L type</li> <li>Outer court yard: U type</li> <li>Outer court yard :Mix type</li> <li>Inner court yard</li> <li>Central court yard</li> <li>Multiple courtyard</li> </ul>	<p>The diagram shows six rows of courtyard plans, each with a 2D floor plan, a 3D perspective view, and a cross-section. The rows are labeled 'OUTER COURTYARD' and 'INNER COURTYARD'. The plans illustrate different orientations and placements of seasonal blinds around the courtyard perimeter.</p>
<b>Yazd region</b>	<ul style="list-style-type: none"> <li>Different plans are categorized according to the court yard</li> <li>One courtyard</li> <li>Multiple courtyard</li> </ul>	<p><b>Plan Types</b></p> <p><b>One yard plan</b></p> <ul style="list-style-type: none"> <li>Rectangle Plan Talar+space beside</li> <li>Rectangle plan Talar without any spaces beside</li> <li>Rectangle plan Talar between two spaces</li> <li>Rectangle plan Talar between 4 spaces</li> </ul> <p><b>Multiple yard</b></p> <ul style="list-style-type: none"> <li>Main axes parallel</li> <li>Main axes perpendicular</li> </ul> <p>The diagrams illustrate different configurations of Talar (windcatchers) in Yazd houses. For 'One yard plan', it shows a Talar on the side, a Talar without spaces, a Talar between two spaces, and a Talar between four spaces. For 'Multiple yard', it shows two main axes: one parallel and one perpendicular to the courtyard walls.</p>
<b>conclusion</b>	Similar orientation because of same climate, different types of plans because of different conceptions which inspire from traditional architecture of every region	

### **3.4 Buildings forms**

Building forms in traditional houses of two regions are according to environmental factors and cultural features. From the cultural point of view, “in traditional Middle Eastern Islamic culture, it was very important to separate males and females and to protect the house against outsiders” (Al-Kodmany, 1999). Protection from visual contact between sexes by creating spaces separately for male and female is one of the desired effects in Diyarbakir and Yazd traditional houses. The privacy issue is another factor which has influenced traditional houses in both regions. Consequently, the courtyard is formed with thick walls all round in each house which is the best solution for achieving privacy and environmental comfort for the users.

There are some Similarities and differences between Yazd houses and Diyarbakir houses in the forms of the buildings. Courtyards and inward forms are the most important similarities between them because the climate of the both regions are hot and dry, so the courtyard form could be an innovative solution in order not to be exposed to direct sunlight and have privacy control in both regions. Moreover, each side of a house has a particular form in order to repel or absorb the sunlight in different seasons. Summer parts are located in south directions with double stories in both different regions. While, north parts of the houses are allocated for winter spaces with single story forms in Diyarbakir traditional houses due to the fact that the double story summer sections act as a buffer to cut the harsh south winds in Diyarbakir so the winter parts are not exposed to such winds. All sides of the Yazd traditional houses are double stories in order to achieve a symmetrical form which was the aim of the designers in the Yazd region.

There is a vertical element for creating natural ventilation which is called a wind tower that is common in Yazd traditional houses. This element has been observed in the south section of the courtyard at the top of semi open spaces of traditional houses. As a result, the forms of semi open spaces in both regions are different because of the addition of a wind tower as a traditional, symbolic and environmental control element in the Yazd region. In fact, wind tower is one of the focal points in traditional Yazd houses, which is not visible in traditional Diyarbakir houses because of the different solutions used and various styles of traditional architecture for achieving natural ventilation of indoor spaces in every region.

Also, the symmetrical form demonstrates the Iranian traditional architecture in Yazd traditional houses. However, an unsymmetrical form demonstrates Turkish traditional architecture in Diyarbakir region.

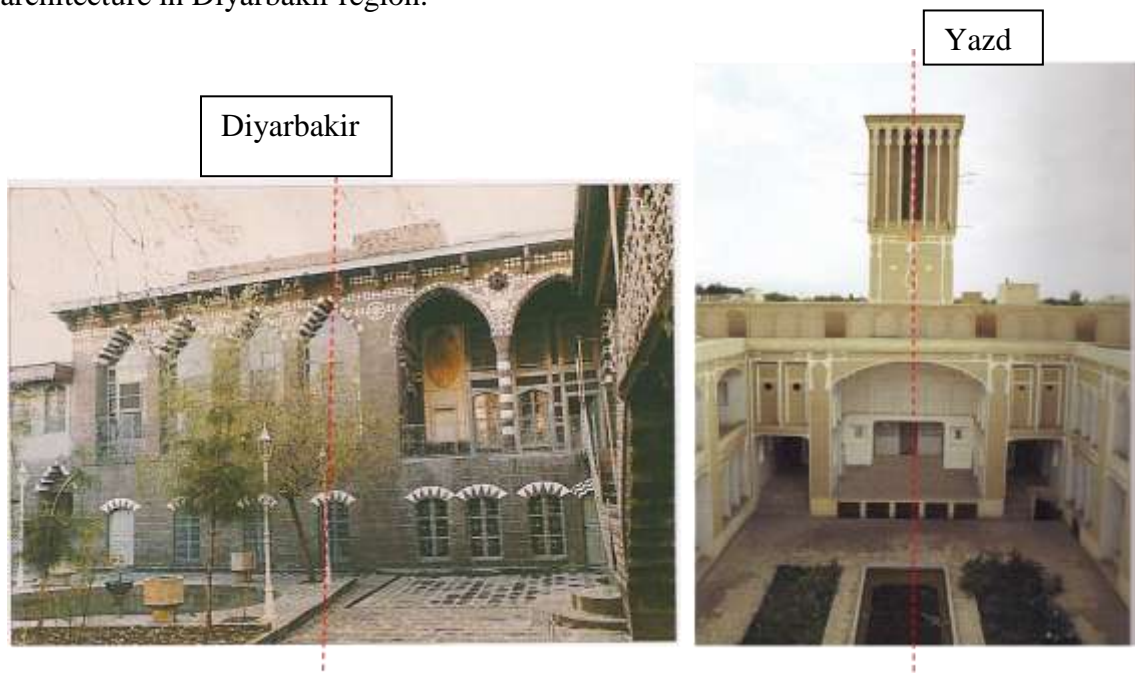


Figure 79: Symmetrical and unsymmetrical forms in south directions of Diyarbakir and Yazd traditional houses (Ghasemi, 2005), (Tuncer,1999)



The other difference in both traditional houses is the form of the entrance. Entrance is in a cubic form in Yazd old houses. It is a mixed rectangle and comprises of eight polygons with different spaces which are covered by a domed roof form. It is an important space in Islamic culture and is designed with the consideration to not having any visual contact with the outside world and the decoration illustrates the importance of this space in traditional Yazd houses. In Diyarbakir houses, entrance is in a cubical form with a flat roof. The reason for this difference is related to the various styles of architectures in every region. However, the aim of both entrances is to control inside spaces from visual contact of strangers in the street. Even if a stranger opens the door of the entrance, they will be unable to see the indoor space of the house due to the effect of the Islamic culture considerations in the design of both traditional houses in different regions.

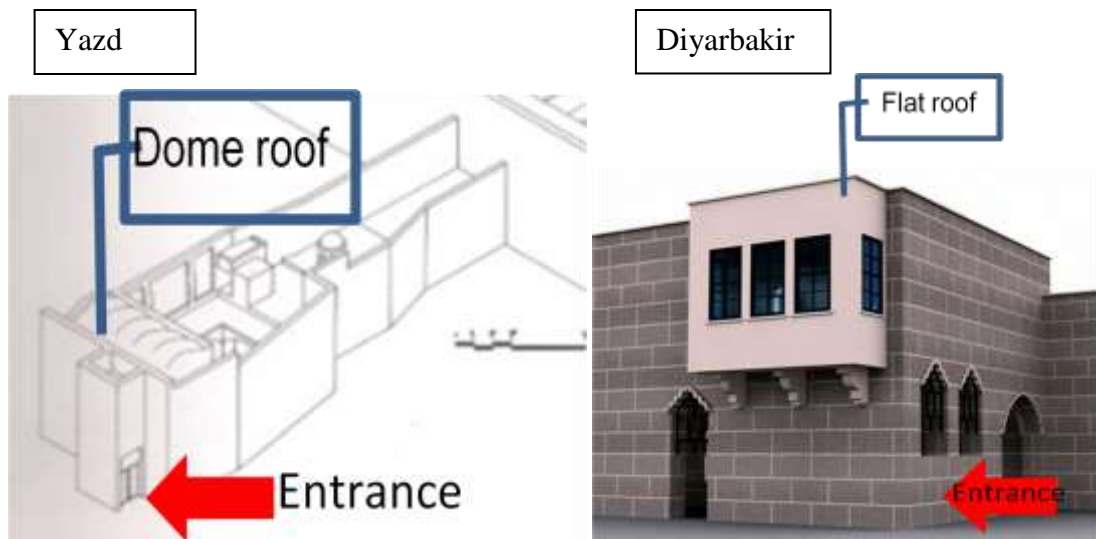
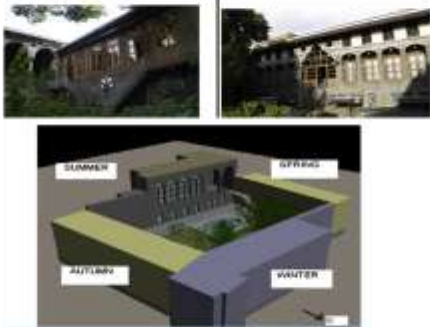


Figure 80: Different entrances with dome and flat roofs in Yazd and Diyarbakir traditional houses (Ghasemi, 2005), (Tuncer,1999)

Table 6: Differences and similarities in building forms of Yazd and Diyarbakir

Differences and similarities of traditional houses in hot-dry climates		
Building forms	Descriptions	Descriptions
<b>Diyarbakir region</b>	<ul style="list-style-type: none"> <li>•Inward form with flat roof for sleeping at summer nights</li> <li>•Different forms for every season for environmental control</li> <li>•Mixed double and single stories for preventing the harsh north wind to winter part and gain more sunlight in winter part</li> <li>•Cubic entrance form with flat roof inspires from traditional architecture</li> <li>•Unsymmetrical form accordance with Turkish traditional architecture</li> <li>•North-south orientation form for make adaption to hot-dry climate</li> </ul>	
<b>Yazd region</b>	<ul style="list-style-type: none"> <li>•Inward form with mixed flat &amp; dome roof because of windy storms in this region and act as a buffer</li> <li>•Different forms for every seasons because of make adaption to hot-dry climate</li> <li>•Double stories because of harmony form</li> <li>•Wind catcher as traditional and symbolic element in the form</li> <li>•Cubic entrance form and stretched plan with flat roof form</li> <li>•Symmetrical form accordance with Iranian traditional architecture</li> <li>•North-south orientation form because of climatic values</li> </ul>	
<b>Conclusion</b>	<p>Similar inward forms and North-south orientation because of hot-dry climates and protection from sunlight through the inward and this orientation form, Different forms of entrance because of different styles of traditional architectures, Different in roof forms and symmetrical form because of various styles of traditional architectures and environmental conditions such as windy storms in Yazd</p>	

### 3.5 Facades

Although the function of facades in both regions is to protect from sunlight and gain more sunlight depending on the season, facades in Diyarbakir's old houses differ from houses in Yazd. South facades in Yazd traditional houses are equipped with wind catchers. There are no wind catchers in Diyarbakir's south facades because wind catchers are the environmental and traditional elements for Yazd vernacular architecture. There are semi-open spaces in both houses of two regions but with different elevations. The semi-open space in Yazd region is an arched form and with two spaces beside it which creates the symmetrical form in south facade.

There are two arched forms in some south facades of Diyarbakir old houses because two arched structures divide the weight of the stone materials in order to be able to tolerate the loads of the stones easily.



Figure 81: South facades in Yazd and Diyarbakir traditional houses (Baran, Yeldirim, & Yelmaz, 2010)

Moreover, the original Diyarbakir windows overlooking the courtyard were movable. They could be taken out in summer and returned to their place in winter. Therefore, the moisture air of the courtyard could be taken inside. Clerestory windows were another

type of window designed for removing the hot indoor air in Diyarbakir traditional houses. The windows in the south facade of Yazd old houses were not movable and there were no top windows in most Yazd old houses because there were sash-windows with vertical openings in the South facade of Yazd old settlements. Therefore, indoor spaces benefit from natural ventilation by opening the sash windows in the south facades. Furthermore, the wind catcher at the top of the south facade created passive ventilation conditions.

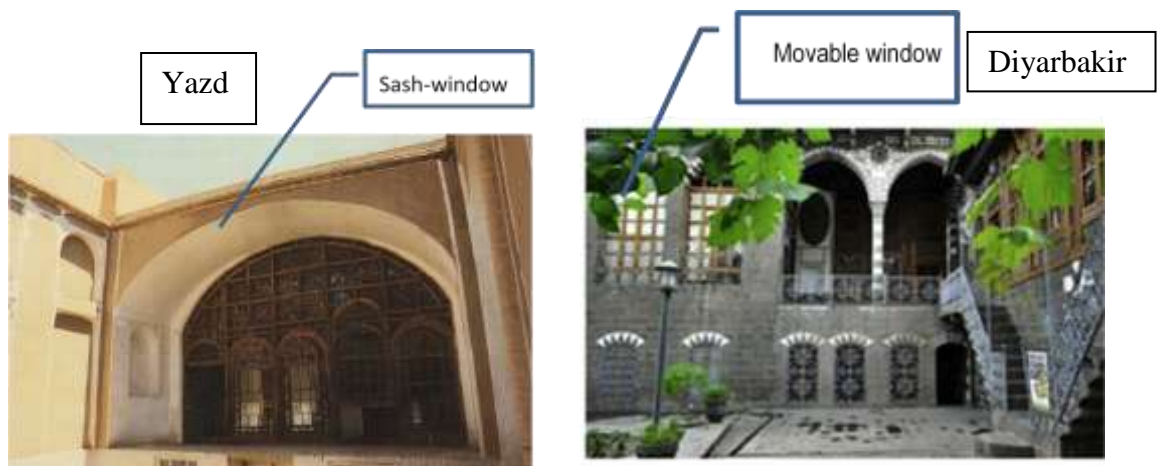


Figure 82: Different windows in south facades of Yazd and Diyarbakir traditional houses (Baran, Yeldirim, & Yelmaz, 2010)

In the north facade of Yazd old settlements, there is a room with three to five doors which faces to the courtyard and is called a “sehdary” and “pangdary” respectively in Persian. Openings are vertical. In fact, it is similar to a sash-window. Almost the same as Diyarbakir old houses but the moist and cool air of the courtyard could be overcome by opening these sash windows in the evenings and nights because there is no wind catcher in the north facade of Yazd houses. Moreover, locating the window frames outside or in the middle of the window recess provides an effective usage of the illumination of the sun and reduces heat loss in Yazd traditional houses.

North facade in Diyarbakir has upper windows close to ceilings for ventilating the hot air. Moreover, the large windows provide sunlight for indoor spaces besides increasing the thermal control for inhabitants. Also, the height of the ceiling in the north facade is lower than the south facade in order to decrease the overall size of the rooms in Diyarbakir traditional houses. The height of the ceiling in the north facade and the south facade is the same in Yazd traditional houses. Consequently, the type of windows in the north facade that is facing the courtyard of different houses in each region is different but function in much the same way in order to increase indoor thermal for occupants in winter times. Moreover, the symmetrical north elevation is the similarity between two traditional houses in Diyarbakir and Yazd for achieving the similar sunlight in all the winter rooms.



Figure 83: North facades in Yazd & Diyarbakir old houses (Ghasemi, 2005), (Ozdeniz,1991)

Orusi is used in Yazd traditional architecture in order to achieve privacy on the windows. On the other hand, they provide shading to keep the indoor area cool. Mixture of colorful small pieces of glass and wood ties invite color and life into the building. Chemical substances of these colored windows keep some insects away such as the common mosquitoes. There are no windows in Diyarbakir traditional houses because it demonstrates Iranian traditional architecture and not the other way around. The large and

movable windows with iron and wooden frames in Diyarbakir traditional facades provide natural ventilation in summer times by opening and taking out the windows to increase thermal comfort by inviting sunlight inside of the building in the winter times. The summer rooms have a window sash which is fixed on the stonewall with a hook in Diyarbakir houses. Therefore, overheating can be prevented by opening sash windows in summer days. The most of clerestory windows in Diyarbakir traditional houses are fixed sash and stained-glass with a hole for ventilation.

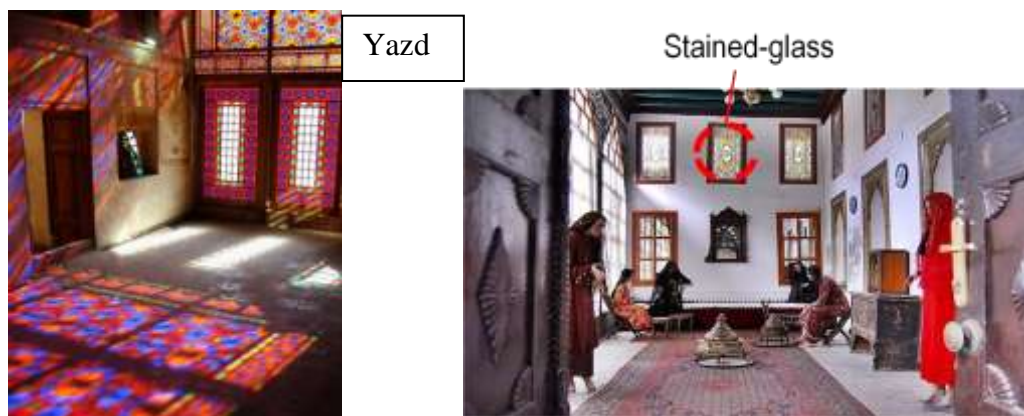


Figure 84: Orusi and clerestory windows in facades of Diyarbakir and Yazd traditional houses (Iranian heritage culture, 2006) ,(Tuncer,1999)

East and west facades in both houses of two regions are appropriated for autumn and spring seasons. However, in some of the traditional houses, these two facades have been allocated for winter times as well because of the intensity of sunlight and solar gain in these directions. Big windows are decorated with wooden frames and veranda in east elevations of Yazd traditional houses much the same as Diyarbakir’s east elevation to expose more solar radiation in the winter and autumn seasons. The west windows in Diyarbakir and Yazd old houses are big windows which have ornamented wooden frames in and a mixture of wooden and iron frames in Diyarbakir old settlements with upper windows for removing the indoor hot air in the spring season.





Figure 85: East facades in Yazd & Diyarbakir old houses (Baran, Yeldirim, & Yelmaz, 2010)



Yazd



Diyarbakir

Figure 86: West facades in Yazd & Diyarbakir traditional houses

There are no windows in facades of the outer walls which are facing the street in Yazd traditional houses because of the Islamic culture and no visual contact to the inside of the houses from the outside. However, small windows related to the toilet and kitchen space in outer walls do face the streets. The positions of these windows are quite high in order to prevent curious eyes of passengers in the street. In some of the houses, there is a room with windows looking outside, which is referred to as a cumba (oriel) in the upper floor above eye level so that pedestrians cannot see the inside of the room. For providing privacy, the windows of this room are facing the street and they are not looking to a neighbor's house. These spaces create shading in the street because it is fundamental design in hot-dry climates to keep solar radiation out. Consequently, the difference between the two outer facades facing towards the streets in two different houses of the




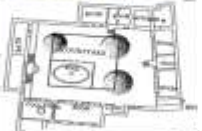









regions is to place a small window in the upper rooms in Diyarbakir old houses. However, providing privacy as referred to in the Islamic culture is considered in the design of both different outer facades in the traditional houses of Diyarbakir and Yazd regions.



Figure 87: Different windows looking outwards in Yazd & Diyarbakir traditional houses (Tuncer,1999)



Table 7: Similarities and differences in facades of Yazd and Diyarbakir traditional

Similarities and differences of traditional houses in hot-dry climates		
Facades	descriptions	descriptions
<b>Diyarbakir region</b>	<p>North elevation faces to courtyard: One big windows with different windows beside</p> <p>South elevation faces to courtyard: clerestory windows with and movable windows, window sash with a hook for opening, veranda with two arched forms</p> <p>West elevation faces to courtyard: Big windows and mixture of wooden and iron frame</p> <p>East elevation faces to courtyard: Double story and big windows</p> <p>Movable and Mixture of wooden and iron frame windows</p> <p>White glasses with frame for protection sunlight</p> <p>Outer facades: Small windows in high height and room with windows to pedestrian passage for providing the neighbors privacy and shading</p>	<p>North Elevation</p>   <p>South Elevation</p>     <p>Outer windows looking outside</p>
<b>Yazd region</b>	<p>North Elevation: Three windows in the middle and 2 doors besides</p> <p>South Elevation: Veranda in the middle with one arched form and two spaces beside with wind catcher at top, sash- window (orouzi) with vertical opening and colorful glasses</p> <p>West Elevation: big windows with wooden frame</p> <p>East Elevation: big windows with wooden frame and veranda</p> <p>Wooden frames for windows</p> <p>Colorful glasses pretend sunlight to come inside, providing privacy for inhabitants and keep away insects</p> <p>Outer facades: No windows because of the structure of traditional houses and providing privacy for inhabitants</p>	<p>North Elevation</p>    <p>South Elevation</p>     <p>Outer facades looking outside</p>
<b>Conclusion</b>	<p>Different in types of windows &amp; colors and frame materials because of different style of traditional architecture, similar in function in order to protect from sunlight in south part by using shading elements and different types of windows such as color windows in Yazd houses and gaining more sunlight in winter part by using the big windows in both different houses. Different in the windows looking outside because of different structures in the old houses of every region by Considering the privacy control</p>	

### **3.6 Buildings Envelopes and Materials**

Buildings envelopes and materials in both regions are used according to the climate and the availability because both regions are located in hot-dry climates, so the materials should be adapted to the climate to create a comfortable indoor environment. Earth is the most plentiful resource in Yazd region, so sun-dried or fired mud bricks (also known as adobe) are the materials used in the construction of Yazd buildings. These materials are locally available. Moreover, it was a good idea to use light color materials for constructing the building because of the hot-dry climate. It is made of earth mixed with gravel, clay, water and especially straw, grass or hair of livestock which were categorized as binder. “Straw increases the adhesion of the mud, by acting as a reinforcement agent, and eliminates cracks on the plaster” (Izadpanah & Husseini, 2011)

This new material has lower thermal conductivity and a high heat capacity. Using fiber inside the adobe improves the thermal capacity. It also absorbs the humidity of the air, acting as a desiccant material, then the air temperature decreases and the relative humidity increases at night. Maziar (2006) said when the dry bulb temperature goes up during the daytime due to the intense solar radiation, relative humidity drops, the moisture has been absorbed by the straw mixed mud evaporates, and the building structure disperses heat with this evaporation process and its temperature decreases. The brick is another material used in Yazd old houses. It was used in some parts of the exterior walls, ceilings of the domes, stairs and covered the ground for protection from sunlight and sand storms. Vault is a structural system which is developed to cover the

roof in Yazd houses. In fact, vault system has some advantages of good transfer of roof loads to vertical walls. (Zandi, 2006)

Basalt stone is a local material that was used in the construction of old Diyarbakir houses. Basalt stone has a high thermal conductivity so it could keep the hot air for a long time and then transferred it back to the environment. The basalt stones are categorized into two forms: male stone (massive basalts) which is used in columns, pool sides and sometimes in walls, and female stone (porous basalts) which is used in walls and as floor covering materials. Wall thickness should be kept between 0.5 and .08 meters with a maximum time lag and a minimum decrement factor.(Suzen & Gedik, 2008)

Baran (2010) stated that coefficient of heat transmission of basalt stone is  $0.5\text{W/m K}$ . The transmission time of outside temperature to inner surface temperature of the walls is long because of the thick walls and consequently stable temperatures that are present indoors in Diyarbakir traditional houses. For decreasing sound transmissions between houses, thick and high walls of the buildings and courtyards are considered. In addition, courtyard walls and trees sometimes provide an obstacle for sound transmission.(Baran, M., Yildrin,M. , Yilmaz,A, 2010). Consequently, different materials were used in Diyarbakir and Yazd old settlements due their specific availability and locality. The similarities between the two materials are providing indoor environment comfort for occupants of Yazd and Diyarbakir. However, adobe does not have a high thermal conductivity unlike basalt stone but by adding fiber, we could improve this characteristic in Yazd old houses as well.

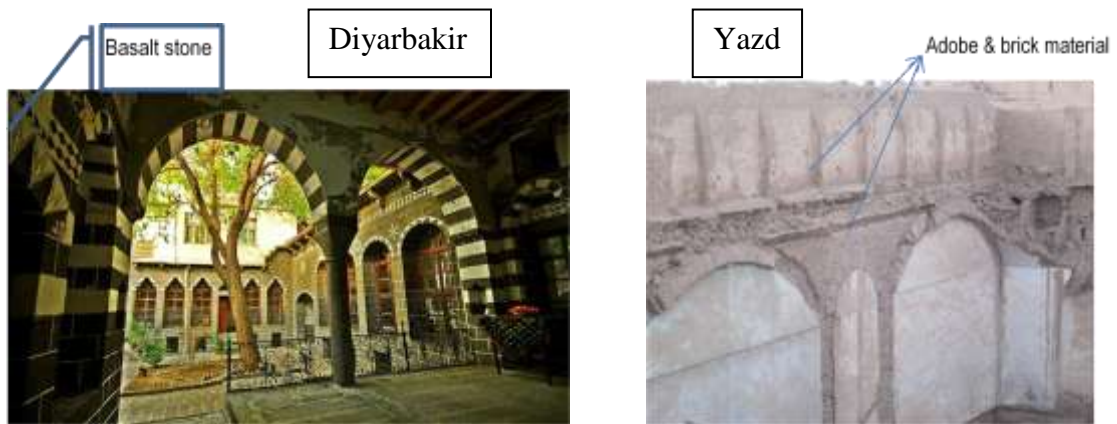


Figure 88: Different material in Yazd & Diyarbakir traditional houses (Iranian Cultural Heritage, 2005), (Tuncer, 1999)

The double envelopes in the roof of semi open spaces act as a great insulation and they do not allow warm air to enter inside easily in Yazd traditional houses. On the other hand, the light colors of the Yazd roofs do not absorb the sunlight, so it is convenient for this climate.

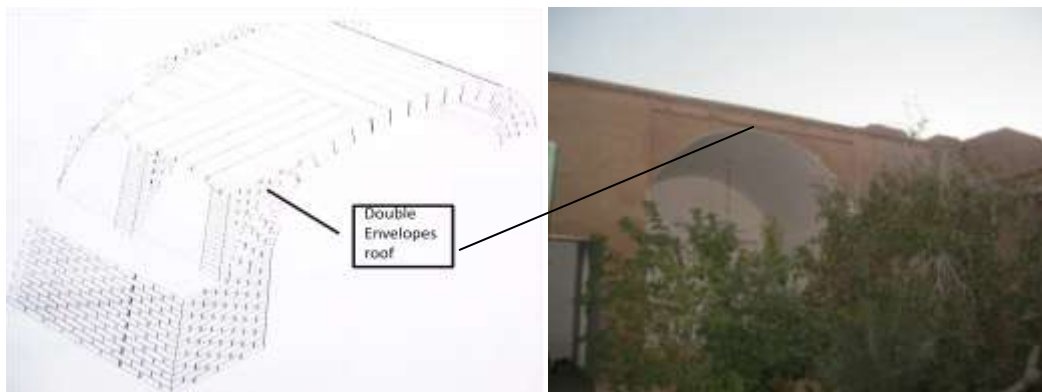


Figure 89: Structure of the roofs in Yazd old houses (Ghobadian, 2006)

Most parts of Yazd old houses are located inside the earth and thickness of the wall is between 0.80 and 1.00 meters, so thermal conductivity is reduced between the outside and the inside. One of the reasons for thick walls is to support the heavy dead loads of

these vaults and domes. However, “the outer walls of Diyarbakir traditional houses have a thickness between 0.5 and 0.8m made of porous stone. The transmission time of outside temperature to inside is too long because of thick walls” (Suzen & Gedik, 2007). So, life is spent indoors in cold days without any noise interaction because of these thick and massive walls in both regions. On the contrary, outdoor life occurs in the summer times in hot days particularly in the evening and nights without any noise pollution because of porous stone and adobe materials as well as plants in the courtyards of both regions. In fact, masonry walls act as a very good thermal mass and minimize the day and night temperature fluctuations between the indoor and outdoor parts of the buildings in Yazd and Diyarbakir traditional houses. Diversity of trees and thick walls provide obstacle for transmission of sound effects in both traditional houses of every region.

“A flat earth covered roof with the thickness of 0.30-0.50 m provide good thermal insulation and suitable time lag in Diyarbakir traditional houses”. (Ozdeniz,1991). Details of a typical roof are given in Figure 90. High heat storage and increased time lag are the most important characteristics of this feature in Diyarbakir old houses. Consequently, flat roofs with high insulation have been covered with material of traditional dwellings in Diyarbakir to provide the indoor environment comfort during hot days. The double enveloped roofs in Yazd and Diyarbakir houses act as an adequate insulation that does not allow the hot air to travel inside the house. Thick and high walls in both regions create healthy indoor environments for occupants by modifying the heating effect of the sunlight.

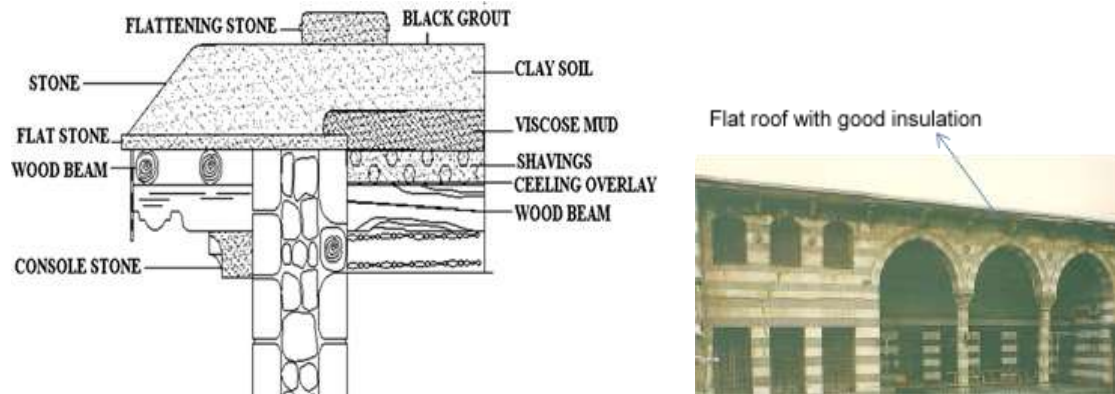


Figure 90: Detail of the roof in Diyarbakir traditional houses (Tuncer,1999), (Baran, Yeldirim, & Yelmaz, 2010)

The windows in Yazd old houses are double-glazed for achieving comfortable sound levels indoors and they are colorful with wooden frames for protection from sunlight. The colorful windows provide privacy and life for the occupants whilst the chemical substances of the color glasses do not allow insects to enter the indoor spaces. The windows are opening in vertical or horizontal directions, so by opening them during the evening in the summer days, they could have the benefit of natural ventilation through the trees and pool in the courtyard by means of evaporative cooling systems.

Pertaining sunlight to indoors specially in a south direction is achieved by placing the window frames inside the window recess in Diyarbakir old settlements. The window sash keeps the stone wall with the hook in some summer spaces of Diyarbakir region. Therefore, the overheating could be removed by opening this window sash in hot days. Moreover, exterior movable windows shade in much the same way as shutters. In fact, the original windows overlooking the courtyards are movable in Diyarbakir's old settlements. They could be taken out in summer and refitted in winter. As a result, the moist and cool air of the courtyard could be transferred inside and create comfort for

occupants. The clerestory windows with stained glass and a hole in the middle has been used for venting and removing the indoor hot air during hot periods.

Consequently, in spite of different types of windows in Yazd and Diyarbakir traditional houses, the purpose of them is to achieve a comfortable level of thermal adjustment and a healthier indoor environment by using double glazing, clerestory, and colorful windows with shutters or frames inside the window recess in all traditional houses.



Figure 91: Colorful windows and strained glass in Yazd & Diyarbakir old houses







(Tuncer,1999)



Figure 92: Clerestory windows in Yazd & Diyarbakir traditional



Table 8: Differences & similarities of building envelope in traditional houses of both regions

<b>Differences and similarities of traditional houses in hot-dry climates</b>				
<b>Building envelopes</b>	Materials	Roofs	walls	windows
<b>Diyarbakir region</b>	<p>Basalt stone</p> <p>High thermal conductivity</p> <p>High heat capacity</p> 	<p>Flat roof</p> <p>Double envelopes roof</p> <p>Good insulation</p> 	Thick & high walls	<p>Mixture of small and big windows depends on the directions and solar ray in every direction</p> <p>Movable</p> <p>White and stained glass</p> <p>Mixed of wooden &amp; iron frames</p> 
<b>Yazd region</b>	<p>Adobe and brick materials</p> <p>Low thermal conductivity</p> <p>High heat capacity</p> 	<p>Double envelopes roof</p> <p>Mixture of dome and flat roofs</p> <p>Good insulation</p> 	Thick & high walls	<p>Mixture of small and big windows depend on the directions and solar ray in every direction</p> <p>Movable</p> <p>Colorful glasses</p> <p>Wooden frame</p> <p>Double glazing</p> 
<b>Conclusion</b>	Different because of separate available material of every region	Similar in good insulation because of the climate of two region	Similar for gaining indoor environment comfort	Different in types because of different traditional styles of architectures, similar in the comfort of indoor spaces for users by protection element such as shutter, color windows or ventilation by upper windows and removable windows



## 5.6 Socio-Cultural Features

“Islam is a men's world. Women in Muslim societies are segregated from daily life”. They should keep themselves by wearing the veil to avoid direct visual contact of strangers. As a result, they have introverted living. (Erpi, 1991)

Bioclimatic features and social structures have played a major role in the forms of the interior and exterior spaces of the traditional Diyarbakir and Yazd houses. Since the majority of people in both regions believe in Islam and are religious people, so they protect their houses against outsiders. In other words, Islamic culture is one of the important factors that are considered in the design of traditional Diyarbakir and Yazd houses. Cultural environments which demonstrate socio-cultural factors such as religion have a drastic effect on the form of traditional houses in both regions. The form is one of the many important components of culture which has affected the building and its environment. (Rapoport A. , 1969)

Diyarbakir has been occupied by the Kurdish people for many years. They are Family oriented which is a common belief of Kurds. Leadership of tribes passed down from one generation to the next. However, personal qualities include being generous, honest and skillful which are the main characteristics for choosing accomplished leaders as well. Moreover, the Kurdish language is the same as the Persian language of Farsi. Some of the words in this language have been borrowed from the Arabic language as well. Yazd region has been occupied by Iranians for many years. They speak Farsi which is the same as Kurdish people in Diyarbakir. So, both the Kurds and the Iranian people

practice Islam. Therefore, the common religion and language is a similarity between the two regions.

Segregating males and females to prevent direct visual contact from outside of the houses are embedded in the Islamic culture that affects the design of traditional houses in both regions. So, providing privacy for inhabitants is the dominant feature of the Islamic culture in traditional houses of both regions. The Diyarbakir old houses and Yazd old houses demonstrate introverted livings.

In other words, courtyard plans and inward houses in both regions provide privacy as needed by the religion of Islam. Furthermore, separate entrances for guests and service in some Yazd and Diyarbakir traditional houses are a perfect solution for comfort and elimination of direct visual contact. The entrances of Yazd traditional houses is a polygon plan with a particular door with two different handles on the entrance gate for knocking the door separately for men and women. Moreover, the entrance has two corridors which lead to the different courtyards for men and women due to the effects of the Islamic culture in the Yazd region. The entrance of the traditional Diyarbakir house is a rectangle plan and which houses two separate entrances for guests as well as for service. Therefore, separate entrances, which lead to separate courtyards in some of the Yazd and Diyarbakir traditional houses, reflect the same culture in both regions and their solutions to the problems. In fact, in Diyarbakir traditional houses, there is a door between two courtyards and a cupboard between two spaces to serve the food without seeing each other. In other words, the food, which is prepared by women in the heramlik section, is put on the cupboard and they spin it and the men from selamlik part could

take their food without ever establishing visual contact. The other similarity, which shows the effect of Islamic culture in both regions, is the position of service spaces such as toilets in traditional houses of two regions. In fact, the toilet bowl should be located on the east-west axis which reflects the Islamic belief that “when you sit in the toilet, do not turn your front and back towards Mecca.” (Sari, sen, Khya, & Sagsoz, 2011)

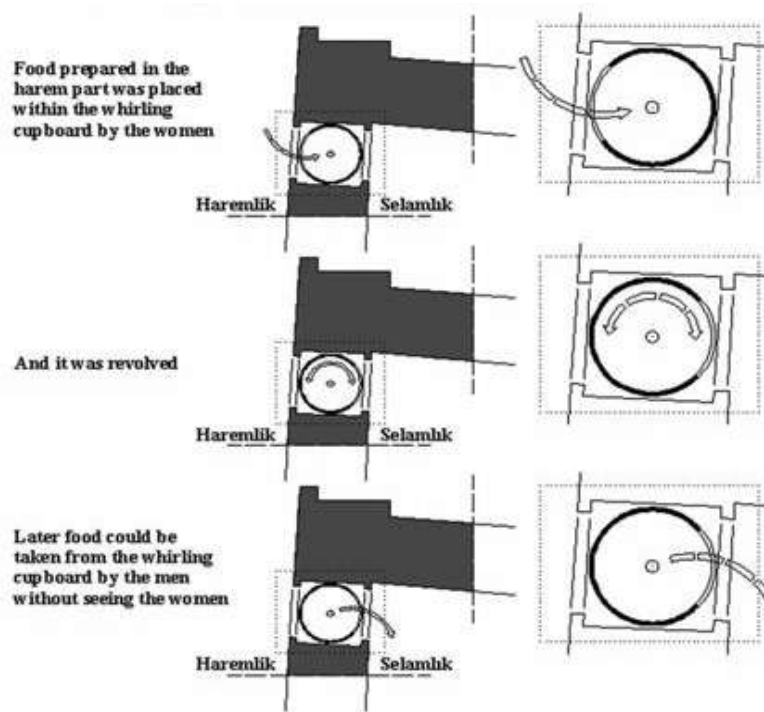


Figure 93: The cupboard between selamlık and heramlık for serving the food in Diyarbakir old houses (Bekleyen & Dalkilic, 2011)

The other similarity in Yazd and Diyarbakir are the positions of the openings and the height of living spaces in order to avoid visual contact from the outside of the house. High walls without or with small windows overlooking the streets are abounded which is true for the courtyard as well for privacy purposes. In Diyarbakir, there are small windows which are high enough so that passengers are not able to see the inside of the

houses. In fact, there are some rooms in Diyarbakir traditional houses which are constructed on top of the street. The windows of these rooms have iron bars or screens for controlling the privacy of the inhabitants. For providing privacy from the neighbors, these rooms are looking towards the streets and not the neighbor's house. In Yazd, the outdoor walls have no windows because the type of the traditional architecture is different from the Diyarbakir region. However, the aim of both of them is to create privacy for the inhabitants. Moreover, the heights of the entrance doors are 1.70 m in both regions. So, to entering the house, one has to bend slightly which demonstrates the respect to the inhabitants of the house (this is inspired from the Islamic culture in both regions).

The dimension of houses in each region depends on the economic situation of the owners. In fact, big houses with more spaces are allocated for rich and wealthy families in both regions. Moreover, there is no agriculture in Yazd region because of the lack of water in this area. So, most rich people had to resort to trading with different parts of the country. There is an important space in every traditional house which is appropriated for women to weave carpets and create other handicrafts such as bags or shoes in the Yazd region. Farming and livestock breeding are the major sources of income in Diyarbakir region. The region's farmland is watered by the Tigris River via the network. Diyarbakir had strong economic ties with the cities in Iran. Cotton textiles, leather products, and trade of grain, mohair, and wool are the handicrafts of the Diyarbakir people.

Style of living in Yazd was determined according to the economics of the family which varied immensely. Sometimes more than three families lived in a household with lower economic situation. In fact, parents with children and brides and grooms lived together.

The best rooms were allocated for elderly people and the other rooms were allocated according to age. In rich families, there were many rooms which were appropriated for the people who worked for the owner such as a waiter or a waitress. Also a polygynous family-husband with two or more core wives and their progeny were common amongst rich families of the Yazd region. Kurds always married Kurds. They believe that the first cousins should marry each other. It is obligatory in their culture. Couples usually live with each other's family after they get married. However, they had separate rooms and housekeeping arrangements. Cooperative works are ordinary in their culture. In other words, both men and women work hard in the field.

Vicinity relation is an important tradition in Yazd and Diyarbakir regions. All people in the same neighborhood know each other and have good relationships in both regions. The reason to this is the small city and the limited population of both regions. They even invite each other to their house for different ceremonies and provide the food as a cooperative workforce in each region.

Consequently, socio-cultural factors such as the Islamic culture and the economic situation of the inhabitants are very important issues which have an effect on the design of the traditional houses in both regions.

Table 8: Differences and similarities in socio-cultural factors in Yazd & Diyarbakir

<b>Differences and similarities in socio-cultural factors in Diyarbakir &amp; Yazd region</b>					
<b>Socio-cultural factors</b>	<b>Religion &amp; nationality</b>	<b>Language</b>	<b>Traditions and beliefs</b>	<b>Living type</b>	<b>Nationality</b>
<b>Diyarbakir region</b>	Islam & Kurds	Farsi	Religious people  So, division according to the structure of family (Harem, Selamlık)  religious structures (providing privacy)	Group life  Different space for different family  Family marriage	Kurds
<b>Yazd region</b>	Islam & Iranian	Farsi	Religious people  So, division according to the structure of family (Indoorcourtyard for female and outdoorcourtyard for male)  religious structures (providing privacy)	Group life  Different space for different family  a polygynous family-husband with two or more core wives and their progeny in rich family	Iranian

## **Chapter 4**

### **CONCLUSION**

Environmental factors and socio-cultural features have an effect on the design of traditional houses in hot-dry climates. Climate, geography and topography are the environmental factors which have an impact on the design of the traditional architecture. Therefore, the climate is a major factor which affects material, structure, form and orientation of traditional houses. The most important issue in the design of traditional houses is using natural resources such as wind, sun and rain to adapt to the climate

Yazd and Diyarbakir traditional houses are a good example of ecological architectures which have adapted to the harsh conditions of the surrounding arid climate. Different innovative solutions for acclimatization and environmental physics such as religion cause similarities and differences in vernacular architectures of traditional houses between the two regions.

The similarities between the design characteristics of the two regions are accorded with the same climate and Islamic domain values in both regions. In fact, similar hot-dry conditions of climates in both regions enable the designers to take into consideration the impact of the climate in urban textures and traditional houses in order to achieve

comfort for users. Furthermore, environmental physics such as the Islamic culture in both regions affected the design of the traditional houses. As a result, the most important similarities of design characteristic in both regions are related to the same climates and protection from sunlight and dominant Islamic cultures.

Narrow streets, compact and enclosed urban spaces, courtyard plans, double enveloped roofs, light coloured roofs, cooling spaces, semi open spaces, winter sections, summer sections, vertical movements in summer sections, horizontal movements in different seasons in courtyards, situation of some spaces with the same functions (seasonal rooms), high ceiling and large walls of summer parts, low ceilings and small walls of winter parts, pools in the middle of courtyards and basement spaces, north-south orientations forms and appropriate materials in constructions are the similarities in traditional architectures of the two regions that provide natural ventilation, shading areas and indoor environment comfort for inhabitants. Moreover, courtyard plans, separate entrances and no visual or direct contact between the outside of the houses and courtyards, same direction of some service spaces such as toilets, different courtyards for service and visitors, no vision availability to neighbour's houses, no more than double stories and no windows or small windows in outer walls of the houses that are influenced by the Islamic culture in order to control privacy measures which are essential in both regions. However, there are some important reasons for the differences in the design characteristics of traditional architectures in both regions. The lack of water and the hot and dryness of Yazd city forced its people to provide conditions beneficial conditions of natural ventilation as well as solving the problem of the shortage of the water. Innovations such as wind catchers and underground water reservoirs satisfied their needs. These two



functional elements are one of the differences between the two regions. The reason for some of these reasons is the possibility of Diyarbakir being near the Tigris River. Therefore, they had an abundance of water resources for domestic use. As it has been mentioned before, in order to solve the shortage of water resources, they used underground water networks and underground water reservoirs in each area of the Yazd region. Some of basement spaces were connected to water network systems directly, but there are no underground water network systems in the Diyarbakir regions. Moreover, Yazd region is located in the desert region of Iran, so there are a lot of sand storms in this region. Mixture of flat and domed roofs are one of the solutions applied in the Yazd region which was a big difference between the two regions to prevent the sand storms from affecting indoors.

One of the main reasons for the differences in both regions are related to the different traditional architecture styles in regions. One being inspired by Turkish architecture and the other being inspired by Iranian Architecture. Plan types and layouts, symmetrical and unsymmetrical forms, entrance forms, orsi windows, colorful glass, ornamentations, seh dar and panjdary, outer walls and the types of windows are the differences in the traditional houses of the two regions due to the differing styles of the Iranian and Turkish architectures. Moreover, different materials in the construction of traditional houses in both regions are adjusted according to the availability and locality of materials which lead to different types of structures in every region. Consequently, it could be said the different materials, traditional styles, climatic situations and geography are the main features which make a difference in the design characteristics of traditional architecture of both regions.

Finally, traditional architectures of the two regions and the features which have an effect on the design characteristics for using natural energy sources and acclimatization could be good patterns to travel towards for contemporary architecture. Windcatchers, basement spaces, semi open spaces, courtyard plans, sun protection elements, appropriate forms and natural materials are the substantial characteristics needed in hot-dry climates for acclimatization and comfortable indoor spaces. Since people do not feel comfortable in modern buildings without using mechanical equipment, these two regions could demonstrate the utilization of natural passive cooling methods, natural daylighting and the utilization of material to achieve comfort for inhabitants in the design of houses as well as considering cultural contexts which are missing in most aspects of the contemporary architecture today.

<b>The Differences&amp; reasons in design characteristics of both region</b>	
<b>Differences in design characteristics</b>	<b>The reasons</b>
Plan types Lay outs Symmetrical and unsymmetrical forms Entrance forms Orusi windows Colorful glass Ornamentations She dary & panjdary Outer walls and types of windows	Different styles of Iranian & Turkish traditional architecture in every region
Wind catchers Underground water reservoir	Locating Yazd region in desert area & shortage of the water in this region
Style of structures	Different materials according to the availability
Different roofs	sand storms in Yazd

<b>The similarities &amp; reasons in design characteristics of both region</b>	
<b>Similarities in design characteristics</b>	<b>The reasons</b>
<ul style="list-style-type: none"> <li>•Narrow streets</li> <li>•Compact and enclosed urban</li> <li>•semi open spaces</li> <li>•winter sections</li> <li>•summer sections</li> <li>•horizontal movement in different seasons</li> <li>•Vertical movement in different seasons in courtyards</li> <li>•Situation of seasonal rooms with same functions</li> <li>•North south orientations forms</li> <li>•Appropriate materials for construction</li> </ul>	same climates
<ul style="list-style-type: none"> <li>•Courtyard plan</li> <li>•Separate entrances</li> <li>•No visual or direct contact between outside of the houses &amp; courtyard</li> <li>•Same direction for houses toward Mecca</li> <li>•Different courtyard for male &amp; female</li> <li>•No vision availability to neighbor's house</li> <li>•No more than double stories</li> <li>•No windows or small windows in outer walls</li> </ul>	Islamic culture

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## **APPENDIX**

## Appendix A: List of Foreign Phrases

Godal baghcheh	The court yard in the middle of central courtyard and one level underground, sunken courtyard
Talar	Semi open space which is located in south part of courtyard
Eyvan	Veranda
Sardab or Serdab	Basement spaces which are equipped with small pool in the middle
Seh-dari	Large room with three large adjoining windows
Panj-dari	Large room with five large adjoining windows
Vent room	The room at summer part of Yazd houses which is directly connected to wind catcher
Orusi	Colorful small pieces of glass between the beautiful wood ties
qanat	Underground water network
Hashty	Vestibule
Badgir	Wind catcher
Ab anbar	Underground water reservoir in Yazd region
Haremlik entrance	Female entrance
Selamlk entrance	Male entrance
Cumba	Oriel

