

Sustainability Indicators of Iranian Vernacular Architecture: The Case of Yazd

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ABSTRACT

In this research, case study of Yazd city is analyzed in terms of the following environmental sustainability factors: climate, renewable energy usage, water consumption, open space and greeneries, reducing waste and sustainable building materials. The environmental sustainability factors that have been utilized up until now in the city of Yazd, as well as the analysis of the proper use of such methods along with the developments of technology.

In chapter one, the issue of sustainability in architecture, Yazd city as a case study for demonstrating the characteristics of vernacular architecture and where this city stands now, under influence of architectural components of Iranian architecture, are explained briefly in the introduction section. Subsequently, the problem statement, aims and objectives, research methodology, limitation and significance of the study have been explained. In chapter two, the dissertation explores the characteristic of sustainability in architecture, what is the definition of environmental sustainability and what are the aspects and issues in relation to environmental sustainability in architecture.

In sequence, chapter three analyses the general environment and geography of city of Yazd including precipitation, wind and sand storm issues. Afterwards the general urban pattern of Yazd city, in relation to the specific periods in the history of development of Yazd city is visualized by investigating the urban pattern. Therefore, the urban texture is discussed including following issues: structure of the city, compactness, dense texture, narrow, Irregular Street and covered streets. Moreover main spatial component of the vernacular houses of Yazd are analysed.

In chapter four, the information retrieved from chapter two and three are combined and also discussed. Therefore, Yazd city is evaluated according to environmental sustainability factors, environmental sustainability components, and environmental indicator of Yazd architecture and spatial organization of Yazd. Conclusion section is followed by some recommendations.

In sustainable architecture, the main issue is the productive usage of the environmental conditions and the architectural components. Historically, human beings have always strived to build dwellings that are in harmony with the surrounding environment in order to be able to feel safe and comfortable. In this respect, it is said that geography and weather conditions are directly related to the formations of residences. Due to the fact that Yazd's main concern during the contemporary time is the lack of respect for environmental aspects and having a hot and dry climate, the city has been chosen for further analysis in order to oversee the problems of the environment and the ways they solve the problems and how they reflect on the vernacular architectural components of that region.

Keywords: Sustainable architecture, vernacular architecture, Iranian traditional architecture, Environmental Sustainability, Yazd.

ÖZ

Bu arařtırmada, Yezd řehri için iklimi, yenilenebilir enerji kullanımı, su tüketimi, açık ve yeřil alan kullanımı, atıkların azaltılması ve çevreci yapı malzemesi kullanımı gibi çevresel sürdürülebilirlik faktörleri incelenmiştir. Ařamalı olarak yapılan incelemede Yezd řehrinde bugüne kadar uygulanmış olan çevresel sürdürülebilirlik ve gelişen teknolojiyle uygulanan metotların ne derece doğru uygulandığı arařtırılmıştır.

Çalışmanın giriş kısmında, çalışmanın konusu olan Yezd řehrinin geleneksel İran Mimarisini yansıtan yapılarından bahsedilmiştir. Sonra sırasıyla çalışmanın konusu, amacı, kapsamı, arařtırma yöntemi, genel çerçevesi ve arařtırmanın önemi açıklanmıştır. İkinci bölümde, mimaride sürdürülebilirlik özellikleri, çevresel sürdürülebilirliğin tanımı ve kullanılan yöntemler ile problemlerden bahsedilmiştir. Üçüncü bölümde, Yezd řehrini, yağış miktarı, rüzgar ve kum fırtınası gibi çevresel özellikleri incelemekte ve Yezd'in tarihsel şehirleşme süreci detaylı bir biçimde ele almaktadır. Özellikle evlerin geleneksel mimarisi, řehrin yapısı, yoğunluğu, řehrin dokusu, tartışılmıştır. Dördüncü bölümde, önceki bölümlerdeki sunulan bilgilerin ışığında Yezd řehri ve mekansal düzenlemesi; çevresel sürdürülebilirlik faktörleri, bileşenleri ve çevresel göstergelere göre değerlendirilmiştir. Sonuç bölümünde ise, tartışma ve öneriler kısmı yer almaktadır.

Sürdürülebilir mimaride, esas sorun çevresel koşulların ve mimari bileşenlerin etkin bir biçimde kullanılmasıdır. Tarih boyunca insanlar çevreleriyle uyumlu rahat edebilecekleri evler, mekanlar inşa etmişlerdir. Bu bağlamda, coğrafya ve hava koşullarının mekanların inşasında doğrudan alakalı olduğu söylenebilir. Yezd řehri

düşünüldüğünde esas sorunun şehrin sıcak ve kuru ikliminin getirdiği çevresel problemler olduğunu ve bunların bölgenin geleneksel mimarisini nasıl tehdit ettiğini incelemek ve çözüm üretmek gerekmektedir.

Anahtar Kelimeler: Sürdürülebilir mimari, verneküler mimari, geleneksel İran mimarisi, çevresel sürdürülebilirlik, Yezd.

To My Parents

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Chapter 1

INTRODUCTION

From the commencement of time, humans have attempted to inhabit the mother earth harmonically. In contrast, the unpredictability of nature holds them back to a number of activities because of the inability of adjusting to the speedily changing conditions and different environment. People try to emulate these barriers in order to survive a range of environment and climatic conditions. Throughout history, humans have been developing homes in order to attain a climatic comfort in a range of environmental conditions. Thus, the utilization of environment characteristic in vernacular houses has constantly been acknowledged even in older times.

Vernacular houses in vernacular architecture are good examples due to the fact that they offer comfortable and sustainable living spaces that are adequately adapted to the environment. Environmental sustainability items are widespread in vernacular houses and such factors have impacted the design characteristics for obtaining comforts indoors (Zandi, 2006).

Moreover, in sustainable design a lot of different sustainable environmental factors such as; Climate, renewable energy usage, water consumption, Sustainable building material, waste reduction and Open space are considered during the progression of architecture in regards to each particular region and climate. The climate of Iranian geography differs from region to region. The differing weather conditions has the

biggest influence on the building forms in Iran and that is the reason why the concept of sustainable environmental design must be looked at in order to understand the full extent of the Iranian Vernacular architecture.

For achieving a sustainable architecture, buildings must be designed with all the factors considered in order for them to have the least amount of adverse effects on the environment (Design integrated with Nature). The vernacular Iranian architecture obeys the rules of sustainable environmental architecture. This research focuses on how vernacular architectural components of Iranian architecture within the city of Yazd have been adapted with environmental factors.

This research will demonstrate the characteristics of the vernacular architecture that is impacted by the hot-dry climate conditions of the City of Yazd in terms of environmentally sustainable architecture. Yazd city is located at the centre of Iran. The weather conditions are harsh, hot and dry. Maximum temperature during the summer period is around 50 degrees Celsius with the temperature dropping to around 15 degrees during the night. The environmental feature of Yazd city is that it supplies a shading area for passages. Consequently, Yazd city has a dense environment where all the buildings would tightly bound together. The roads are sheltered with curvatures (sabaat). Therefore, protect the pedestrians by natural shading (Pourvahidi, 2010).

1.1 Background of the Study

This research focuses on the centre of Iran, Yazd city. This region's weather is hot-dry and the superlative temperature in the heat of summer reaches 50 degrees centigrade with a relative minimum temperature at night in summer that reaches 15

degrees centigrade which shows the high fluctuation of temperature between the daytime and the night time. The urban features of the city of Yazd supply a shading area for travellers. The city has a compressed urban form where all the buildings are adjoined. The Narrow Streets are covered by arches, which supply shading area for travellers (Mashhadi, 2012).

In spite of the harsh weather conditions in the city of Yazd with little to no rainfall annually, it upholds a reasonable comfort level for the people by circulating the air without consuming high amounts of energy (Zandi, 2006).

In this thesis, sustainable architecture is mentioning the characteristic of environmental sustainability and its components which have some parameters and can be used in different areas. According to the research done in Yazd city, these environmental sustainability factors such as climate, Renewable Energy usage, Sustainable building Material, Waste, Open space and Greeneries the environmental profit of a green space is vast. According to this research and how environmental sustainability is related to vernacular architecture, the components of vernacular architecture are briefly explained and they're transitions to today's architecture.

1.2 Problem Statement

Yazd city has been one of the most well know ancient cities with extremely harsh weather conditions. However, with the increasing population and lack of space in the surrounding environment, the structure of the city has been reforming towards a more compact apartment oriented lifestyle. The sustainable features of vernacular architecture of the city of Yazd have been ignored and have gradually disappeared overtime (Pourvahidi, 2010).

Vernacular architecture in Yazd uses local solutions for gaining environmental sustainability. In other words, using environmental sustainability factors such as wind, sun, geothermal and energy to achieve a comfortable indoor living environment that considers the environmental aspects of the area in vernacular architecture is a key factor. In this thesis, a general overview of the Yazd region is provided from sources such as books and articles. What is not considered in the available resources is the surrounding environment. Moreover, Climate, renewable energy usage, water consumption, Sustainable building material, waste reduction, Open space and Greenery spaces are essential environmental factors that play a huge role in the design of vernacular houses in Yazd city.

Although, the concentration on modernism has had a direct influence on the decrease of the quality of sustainable houses, discovering such vernacular component houses such as courtyards, wind catcher, pools, fountain and converting them so they can be transmitted and also used in today's world. Studying such features could be an aid to the future of sustainability in the buildings of Yazd city and the development of modern vernacular architecture. This research has been prepared in order to answer to the following questions:

- What are the environmental sustainability indicators?
- What are the main vernacular features of residential houses in Yazd city?
- What are the environmental sustainability indicators of Yazd city's vernacular architecture?

1.3 Aims and Objective

Yazd city is built around the idea of protecting structures against harsh environmental factors and extending their life by controlling such features advantageously. This research highlights the architectural components of vernacular architecture, defines the environmental sustainability factors of the city of Yazd and compares their functions to the present use of architecture. Such information could be a huge assistance to the future constructions and renovations, taking place in such regions.

Investigated facts in relation to sustainability of the city of Yazd and its development up to now could visualize the problems, decisions and the solutions for such a particular region in order to slightly aid in conducting the rest of the process along with innovations and technological developments in the coming future of the city of Yazd or any similar regions.

1.4 Research Methodology

Qualitative methodology will be employed for the research of this thesis. The thesis is split into four sections which consist of Literature review, data collection, field survey and the evaluation, which is based on documents, Books, articles, journals, online resources and observations of sustainable architecture and environmental sustainability factors related to Yazd city. Therefore, in summary for the purpose these researches are done in four steps:

Literature Review

In literature review section sustainable architecture, environmental sustainability and vernacular residential house architecture are considered. The issues related to this topic and developments of the city of Yazd are explained.

However, the process of the thesis is categorized into environmental sustainability factors such as: climate, renewable energy usage, water consumption, sustainable building material, reducing waste, open space and greeneries. Therefore, vernacular architecture and the environmental sustainability factors that affect the design of traditional settlements will be determined by referring to reliable documents that focused on environmental sustainability and vernacular house architecture. Moreover, general information about Yazd will include the environment of the city of Yazd, general urban pattern of Yazd, general Yazd architecture within the framework of environmental sustainability and also the main spatial components of the vernacular houses in Yazd will be clarified.

Data Collection

Data collection process is according to the documents analysis such as sustainability, environmental sustainability and vernacular house architecture in Yazd city for achieving the academic structure. Reliable sources such as written and visual documents that are focused on environmental sustainability and vernacular architecture of Yazd city, official publications that are associated to the environmental sustainability have been used in this thesis.

Subsequently, the features of vernacular architecture, which functioned as the environmental sustainability factors of the city of Yazd as the field study were determined. In addition, general environment focused on precipitation, wind and sand storms, general urban pattern focused on how cities have been developed in different historical periods, the framework of Yazd architecture related to the environmental sustainability focused on the structure of the city, compactness, dense

texture, narrow, Irregular Street and covered street, main spatial components of vernacular houses of Yazd city will be focused upon, which are surveyed in this section.

Field Survey

Data collection and its analysis in this approach are related to the field survey. The city in a hot and dry climate part of Iran has been selected; Investigation on the city of Yazd and its settlements was done in the summer of 2011, by one travelling to the city to collect information such as photographs of streets, and typical vernacular buildings, videos specifically of traditional components of vernacular houses in Yazd city such as courtyards, Godal Baghcheh, Entrance (Hashti), Living room (Talar), Pool, Eivan, etc. Due to the fact that all of the houses have similar layouts, a single one has been selected (Gerami house) and will be analyzed.

The Gerami house was commissioned in the late Ghajar period (1785-1925 AD). According to a relative of the present owner of the house; a dated marble inscription existed above its portal, which indicated that its construction dates back between 110 and 120 years. This building is a large house comprising of two different parts, each of which possesses a central courtyard. These two courtyards are aligned and laid out along a northeast-southwest axis. The southern courtyard is slightly larger than the northern one and the spaces surrounding it are more substantial and more elaborate. The larger courtyard is encircled on all four sides by built areas, whereas the built areas of the smaller one occupy only its eastern and western sides. Although a room also exists on the southern side of this courtyard, this room is not related to it and belongs to a larger one. The closed walls of the northern and southern sides of this courtyard are covered with arcades. These arcades and their frames have transformed

the facades of these two sides into an elaborately carved surface, endowing the smaller courtyard with the atmosphere of the central courtyard.

Evaluation

The city of Yazd is analyzed in terms of the following Environmental sustainability factors: climate, Renewable energy usage, water consumption, Open space and Greeneries, Reducing Waste and Sustainable building Materials. Therefore, the environmental sustainability components in relation to each mentioned environmental sustainability factors are considered. Amongst these issues, the utilized factors in relation to environmental sustainability of the case study (Yazd city) are selected and put in to another table1, 7 and 8. Afterwards, each utilized environmental sustainability factor related to the city of Yazd is defined, explained and visualized to open up the research issues in detail. Moreover, also historical periods of Iran which have been used in this study that show the development of the urban pattern of Yazd city that have been analyzed from (Hatami Nejad, 2005) are selected and put in to table3.

1.5 Limitation

The limitation is briefly explaining the sustainable architecture of Yazd as the topic is restricted to the environmental sustainability factors such as Climate, Renewable Energy usage, Water consumption, Sustainable building Material, Reducing Waste, Open space and Greeneries, which lead to the history of the City of Yazd which then shift towards the urban settlement and the density of Yazd that is limited to the houses. After these features are determined, the study will focus on how the vernacular architecture such as traditional components of houses like wind catchers, ventilation, pools, fountains and also materials influence the environmental sustainability of the city of Yazd. The other limitation is specific details about

comparative between vernacular and modern architecture of Yazd city. Moreover the limitation is the vernacular houses which are referring to environmental sustainability.

1.6 Significance of the Study

This research considers the environmental factors and duplication of the environmental issues that are missing in today architecture. Furthermore in this research general information about Yazd which includes general urban patterns focused on historical developments, General Yazd architecture within the framework of environmental sustainability such as structure, compactness, density, irregularities, narrow streets and also main spatial components of the vernacular houses in Yazd has been observed. Unfortunately, the environmental factors and the impact on the environment are not considered in today's world. Moreover, it is essential for architects to be inspired by the architecture in Yazd due to the fact that all of the architecture from that time considers the environment in the design of the buildings since such issues have totally been phased out nowadays. New settlements compared to the old ones do not consider any of the environmental aspects like in the past.

Therefore, this research will hopefully bring up a new solution by incorporating the vernacular features in today's world. However, the significance of this study could be the role of vernacular characteristic of Yazd in the history of development of this city, and how such features could be combined with the innovation of technology in order to improve the modern sustainability and more importantly environmental sustainability of such cities in the near future. However, the specific environmental sustainability factors of this study were selected according to the findings of Balkema 1998, Salingaros 2000 and Madanipour 1996.

Chapter 2

AN OVERVIEW ON THE CONCEPT OF SUSTAINABLE ARCHITECTURE BY FOCUSING ON ENVIRONMENTAL SUSTAINABILITY

In this chapter, Sustainability architecture has been discussed many times since long ago by researchers. The concept of sustainability and sustainable architecture will be reviewed concurrently in order to have a better grasp of the importance of these concepts in the field of architecture and also briefly overview sustainability that has come about as an approach and the factors that lie within sustainable architecture.

The term sustainability is a multi-faceted concept as Webster's International Dictionary defines "**to sustain**" as; "to strengthen or cause to continue for an extended period or without interruption". Brundtland Commission has mentioned that sustainable architecture is assembling the current generation's demands without threatening the ability of upcoming generation's needs. Moreover, the process of preserving the state of buildings for the next generation in terms of physical longevity in order to create sustainable energy sources is called sustainability architecture (Shokouhian, 2007).

In the mid 70's, the word "**Sustainable**" was used for the first time and it was pronounced frequently, especially after the oil crisis in the Middle East around 1973. In the recent years, the concept of sustainable development became a major topic

around the world. The critical arguments about the topic began after the abovementioned crisis. In 1992, an international conference was held in Brazil entitled “**Global Meeting**” but later was renamed as the “**Rio Meeting**”. Ten years after the first official “**Rio Meeting**”, another was held in South Africa in 2002 among ministers from all over the world, which emphasized the topics discussed in the “**Rio**” conference (Kamran, 2003). Sustainable development is a term that was being used by the Brundtland Commission, which, has developed the idea of the most talked about definition of the term “**Sustainable Development**”, which was a development that “meets the needs of the present without compromising the ability of future generations to meet their own needs” (Charles, 1998).

The term sustainability as a multifarious notion fuses responsible planning and design concepts with nature. “Furthermore, sustainability is a concept that can give localities a constitution within which to approach many of the forward-looking processes they are already doing” (Ahmadi, 2003). Architecture alone cannot be sustainable, but must be used along with the developments in lifestyle, safety, environmental attributes as well as economic opportunities. Sustainable architecture utilizes its surroundings to maximize comfort for its users. In such an instance, architects use tools to clarify all aspects in order to avoid unexpected hiccups during the construction phase (Ibid, 2003).

Sustainable architecture pursues the means to ensure that the negative impacts of buildings are completely minimal and moderates the use of space, energy and development. “The idea of sustainability or ecological design is to ensure that our actions and decisions today do not inhibit the opportunities of future generations” (Doerr Architecture, 2011).

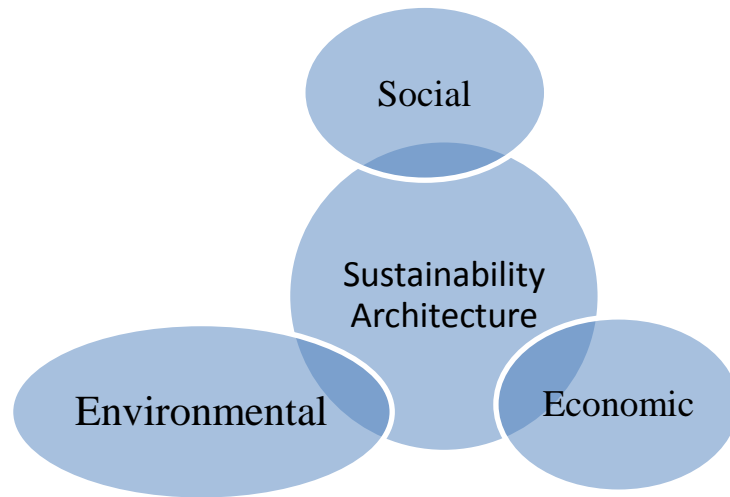


Figure 1: Three Factors of Sustainability architecture
(Ahmadi, 2003)

In this section, sustainable architecture will be reviewed briefly. Sustainable architecture needs to be considered from three main areas of influence. The three interconnected parts of sustainability are environmental, economic, and social aspects of our world. If all three aspects are observed and implemented, the development will have a solid foundation that considers all various problems that may arise. For example natural resources are considered for sustainable architecture, the environment would be protected, the economy will not be harmed, and the quality of life will be improved. Due to the connection between the three parts where the environmental considerations can be the beginning of such a situation, it is possible to classify it as **“Environmental Sustainability”**. If environmental sustainability is neglected then various negative outcomes would be inevitable. Building sector constructions and human actions such as energy consumptions, material utilizations and using up natural resources that creates a large amount of emissions, so sustainable architecture needs to be built up in order to achieve that are set by the international policy organizations (Weihong, 2011).

This furthermore suggests that sustainable architecture would stand for being the driving force of the reduced use of natural resources and fuels by consuming more solar energy through a more appropriate building design. The development of ideas has led to the current broad concept of “**Sustainable Architecture**” which is a term that elaborates ecological and conscious approaches to the surroundings while building (Ken Beattie, ND).Furthermore, the overview of sustainable architecture and environmental sustainability is going to be examined in this study.

2.1 Environmental Sustainability

Environmental sustainability is simply described as the thought of preserving Earth so it is in the same condition, if not better for generations to come. The actions of human beings can only be environmentally sustainable if their needs are met by avoiding the depletion of the natural resources that cannot be replaced. Below are some factors that can be linked to sustainable environment architecture:

- Minimal Resource consumption
- Consumed products are should be constructed from 100% recycled materials or even go as far as constructing materials from renewable sources.
- 100% recycling throughout
- Conservative measures taken for energy consumption and the energy supplies being totally renewable and pollutant free (Beer, 2002).

Over a decade later, the environmental part of sustainability has been seen as a humanistic subject, which has come to signify all things that are relevant to all occupants. The approaches of sustainable design have brought a larger connectivity between inhabitant’s welfare, environmental sustainability considerations, technological possibilities and nature itself, which is essential to a sustainable future (Adedeji and Aluko, 2009).

Environmental sustainability combines common practices that aim to abolish the negative impact of the construction of new structures within the environment. This means that it focuses on fully benefiting from renewable resources that use the sun through means of passive and active solar energy that utilize plants and trees in order for the decrease in rainwater run-off problems (Environmental Protection Agency, 2009).

Buildings are the reasons why energy, land, water and the environment issued up today. Statistics show that reducing pollution and using sustainable material is essential for future sustainability and the list below shows the different categories of environmental sustainability factors: (Balkema 1998, Salingaros, 2000).

- Climate
- Renewable Energy Usage
- Water Consumption
- Sustainable Building Material
- Reducing Waste
- Open Space and Greeneries

Below is the explanation of the above-mentioned parameters of environmental sustainability:

2.1.1 Climate

Climate is one of the mainly essential factors which are having affected the vernacular houses. In developing countries as they are referred to, climate is the leading priority for the Department for International Developments (DFIS's). In recent studies, it has been revealed that not a whole lot of effort went into ensuring that the changes in the climate would alter and effect the mainstream policy decisions. Currently, there are a few very good examples of projects offered to DFID who should consider steering away from discrete projects to establishing

comprehensive climate change programs (International Development Committee, 2009).

However, climate is an environmental aspect that plays a huge role in people's lives. Climate is referred to as a pattern of weather including its temperature, rain quantity and wind conditions. One of the most important features in climate is the air temperature. Air temperature is the effect of sun's variation and the effect of heating on water, land and forests. Climate change due to global warming can affect the design and structure of buildings. In order to create sustainable buildings, the integration of a sustainable climate concept is essential (Szokolay, 1980).

2.1.2 Renewable Energy Usage

The idea of using renewable energy has sprouted when the concerns about global warming and its negative effects as well as the rising cost of fuel is calculated. Plants accumulate the energy from the sun during photosynthesis, which in turn, is driven up the food chain to almost all organisms as a form of nourishment. Since the industrial revolution, fossil fuels, which are essentially fossilized plants containing energy from the sun has been a huge influence behind the technological advancements as well as the economic and political powers in the world (Goodall, 2007).

Natural energy resources have brought forward the concepts of environmental sustainable and renewable energy. In order to balance the environment, it is not adequate for resources to be solely renewable, but must also be sustainable as well. Continuity is not an indication of sustainability. Sustainability is only feasible if it is renewable. Thus energy systems must be sustainable, and energy resources renewable. Renewable energy is illustrated as "an energy resource which is present

the next day as it is within self-evolution of nature” (Uyar, 2009). Fossil fuels are not renewable as they are consumed from day to day and are not constantly replaced. An example of clean renewable energy sources are sun, water and wind which are utilized but never destroyed in the process of transferring energy (Ibid, 2009).

In other words, buildings are ought to be designed in such a way that they will be able to benefit from the climate as well as natural energy sources. Today, the World relies on fossil based energy. In the last 50 years, the amount of fuel needed has been increasing rapidly and compared to 50 years ago, the consumption rate has risen by more than 5 times. Fossil based fuels account for 85% of the world’s energy consumption. However, in the future, this number is expected to plummet due to the increase of the use of natural and renewable energy resources (Kuban, 2002).

The decreases in the dependency of fossil fuels in a building would make a very big impact in the reduction of carbon dioxide emissions. Decrease in energy rate used in buildings would make a considerable contribution to erase carbon dioxide emissions. If nothing is done, the remaining energy required would still be provided by burning fossil fuels but soon fall to its knees as there is only a limited amount of supply. There is a need to invest in alternative systems, which will provide energy from natural or renewable sources (Towers, 2005).

2.1.3 Water Consumption

Water is a vital and an important source of nourishment for the continued existence of human beings which must be protected. Due to environmental factors, water is unfortunately contaminated to some degree. In an urban culture, water waste/treatment plants are necessary in order to provide clean drinking water to the masses. Throughout the century, the consumption of water has doubled compared to

the increase of population. The fact is that more than a 1/3 of the world is situated in a country which is experiencing a drought to a degree, “i.e. where the use of freshwater is larger than 10% of renewable freshwater resources” (Uncsd, 1997).

Another issue is the rising sustenance requirements and economic developments which pose a risk to the ever-growing demand for fresh water and clean unpolluted air. Water shortages and pollution are a public health hazard that limits economic and agricultural developments as well as effectively destroying ecosystems. As perceived in developing countries, the lack of water management plans can negatively impact the shape of urban populations (Niemczynowicz, 1996).

Most developed countries have urban water systems that are somehow successful in collecting waste water and treating them to remove the pollutants. It is a necessity in these developed countries for water to be abundant and also be at a reasonable price. Whatever the positives are in such systems, they fail in numerous other aspects (Balkema, 1998).

2.1.4 Sustainable Building Material

Environmental sustainability has an effect in picking the materials for building. Nevertheless, the availability and the locality of materials also have an effect in selecting materials as well. The most important features of the materials should be recognized according to the critical seasonal periods in the region (Ghobadian, 2006). Therefore, in different environment, materials which can be adapted to environment should be considered. Generally building materials usually refer to lumber that is obtained from plant material such as straw and bamboo that comply with the forest standards, dimension stone, recycled stone, recycled metal, and other products that are non-toxic, reusable, renewable, and recyclable. An example of such

material is sheep wool, tress, paper flake panels, adobe, compressed earth, clay, cork, coconut, calcium sand stone and roman self-heating concrete among others (Jonkers, 2008).

The EPA (Environmental Protection Agency) recommends the use of using recycled industrial goods, such as foundry sand, and demolition debris in construction projects. They recommend that the materials be extracted and manufactured locally to minimize transportation costs which again utilize non-renewable energy. It is also recommended that the manufacturing of the materials should be assembled off-site to minimize waste, maximize recycling and the use of high quality products.

2.1.5 Reducing Waste

Waste also known as rubbish, trash, refuse or garbage is unwanted or useless materials collected from constructions. Waste is directly linked to public development. Sustainable architecture aims to reduce the energy consumption as well as water consumption while construction buildings. Well-designed constructions that are thought out with sustainable development in mind assist the decrease of water waste created by the inhabitants. Not only is water usage decreased but solutions that are created at the site (compost bins) reduce the waste that has to be transported to landfills. Many alternatives exist that can help reduce the pressure on water treatment plants as well as the local wells. Dishwashers and washing machines are a perfect way for subsurface irrigation. Better yet, if the water from the machines are treated, cars can be washed with the clean treated water and toilets can also be flushed with it. Rainwater collectors are also used for similar reasons (Adedeji and Aluko, 2009).

Construction waste is made up of undesirable material created either by accident or by the construction industry e.g. Nails, rebar, tree stumps, rubble, insulation and electrical wiring (Skoyles and Skoyles, 1987).

Waste water is water that is contaminated and its quality reduced due to human impact on the environment. Such contaminants comprise of liquid wastes that are discharged by domestic, commercial and industrial properties. It most commonly refers to the municipal wastewater that contains a broad spectrum of contaminants resulting from the mixing of wastewater from homes, businesses, industrial areas and often storm drains, especially in older sewer systems (Beychok and Milton, 1967).

2.1.6 Open Space and Greeneries

Open spaces and greeneries are a welcome sight, which is a valuable contribution to cities and neighborhoods due to the fact that they generally improve the quality of life by providing essential activities for people, and have certain pleasing aesthetical aspects. Green space or an open space reserve is a term used to describe areas of protected or conserved land or water on which development is indefinitely set aside (Berry, 1976).

The most common purpose of an open space reserve may be the preservation of the lands natural historic character for the sake of future generations or its aesthetical, ecological and environmental interests (Marilyn, 1975).

The environmental benefits of a green space are vast. Trees and shrubs help cool the air temperature in heavily trafficked streets and provide a natural shade while intercepting solar reflections and radiation from buildings and streets. Trees and shrubs also improve air quality by reducing pollution while producing oxygen. They

can directly influence a buildings overall energy use and CO2 emissions. “Trees provide carbon-storage capacity and lower the level of water run-off into drains, reducing flood problem” (Hargreaves, 2006).

In this section, sustainability and sustainable development are reviewed. However, in this case, the definition of sustainable has been explained. Furthermore, the aspect of environmental sustainability has different components, which are environmentally sustainable climate architecture, sustainable environmental energy, sustainable water, sustainable materials, waste minimization and green areas.

2.1.7 Summary

In this section, according to the research and study done about the environmental sustainability, the summary is that all the researches and studies done have come to more or less similar factors. However, referring to the aspect of environmental sustainability and its components which can be used in different regions, which in this thesis these environmental factors are being connected to Yazd city, explain these factors briefly by referring to the main sources of each one : climate is an environmental aspect that has a huge responsibility in inhibitions lives. Climate is referred to as a pattern of weather including its temperature, precipitation, rain quantity, humidity and ventilation (Szokolay, 1980).Renewable Energy usage the decrease in the dependency of fossil fuels in a building and environmental and also renewable energy including wind and sun (Kuban, 2002).

Water is vital and an important source of nourishment for the continued existence of human beings which must be protected. However water including drinking water, storm water, rain water, eliminates/treats waste, water store, wastewater, pools and fountain (Niemczynowicz, 1996). Sustainable building Material Generally building

materials typically refer to lumber that is obtained from plant material such as straw and bamboo that comply with the forest standards (Jonkers, 2008). Waste also known as rubbish, waste water, construction waste, trash, refuse or garbage is unwanted or useless materials collected from constructions (Beychok and Milton, 1967). Open space and Greeneries the environmental profit of a green space is vast. Trees and shrubs help cool the air temperature in heavily trafficked streets that effect the environment (Marilyn, 1975). Which are listed as follows and afterward summarized in the following table:

Table 1: Environment Sustainability Factors

Environmental Sustainability		
No	Environmental Sustainable Factors	Environmental Sustainability Component
1	Climate	<ul style="list-style-type: none"> ▪ Temperature ▪ Weather Condition ▪ Humidity ▪ Pressure ▪ Precipitation ▪ Ventilation
2	Renewable Energy Usage	<ul style="list-style-type: none"> ● Wind ● Sun
3	Water Consumption	<ul style="list-style-type: none"> ▪ Drinking Water ▪ Storm Water ▪ Rain Water ▪ Eliminates/Treats Waste Water ▪ Store Water ▪ Pool ▪ Fountain
4	Open Space and Greeneries	<ul style="list-style-type: none"> ▪ Open Space(Green Spaces) ▪ Outdoor Space ▪ Type of Greenery
5	Reducing Waste	<ul style="list-style-type: none"> ▪ Construction Waste ▪ Waste Water

Chapter 3

IDENTIFICATION OF VERNACULAR ARCHITECTURE IN YAZD

Since the concept of sustainable architecture has been explained and overviewed, it would help give some ideas of how to verify sustainability in the case study and according to what factors should the case study be evaluated against.

This chapter will explain the impact of environmental sustainability architecture on Vernacular architecture of Yazd, which has been discussed many times in the past by researches. There are a variety of viewpoints about this kind of architecture. Moreover, this chapter focuses on the general geographical information, urban pattern, General Architecture within the framework of environmental sustainability and specific components of a house that are related to environmental factors.

3.1 General Environment in Yazd

There is a certain thermal balance between a human body and its surroundings that plays an important role in the comfort factor. The elements that affect the thermal balance include Air temperature, sunlight, airflow and humidity, which are the key aspects that play a role in the desert architecture. Iran is mostly made up of a hot climate that is relatively dry throughout with minimal rainfall that causes sandstorms. There is also a great variance between the daytime and the nighttime in terms of temperature fluctuations, sand and dust storms as well as low rainfall which make it hard to adapt to the rapidly changing climate conditions. This prevents inhabitants

from being comfortable inside their living spaces, which is why they have to build houses according to the environmental sustainability factors. Architects have come to the conclusion that the less contact with the changing climate conditions, the more comfortable the houses will be to live in (Masoud Nasri, Rahele Hekmatpanah, 2010).

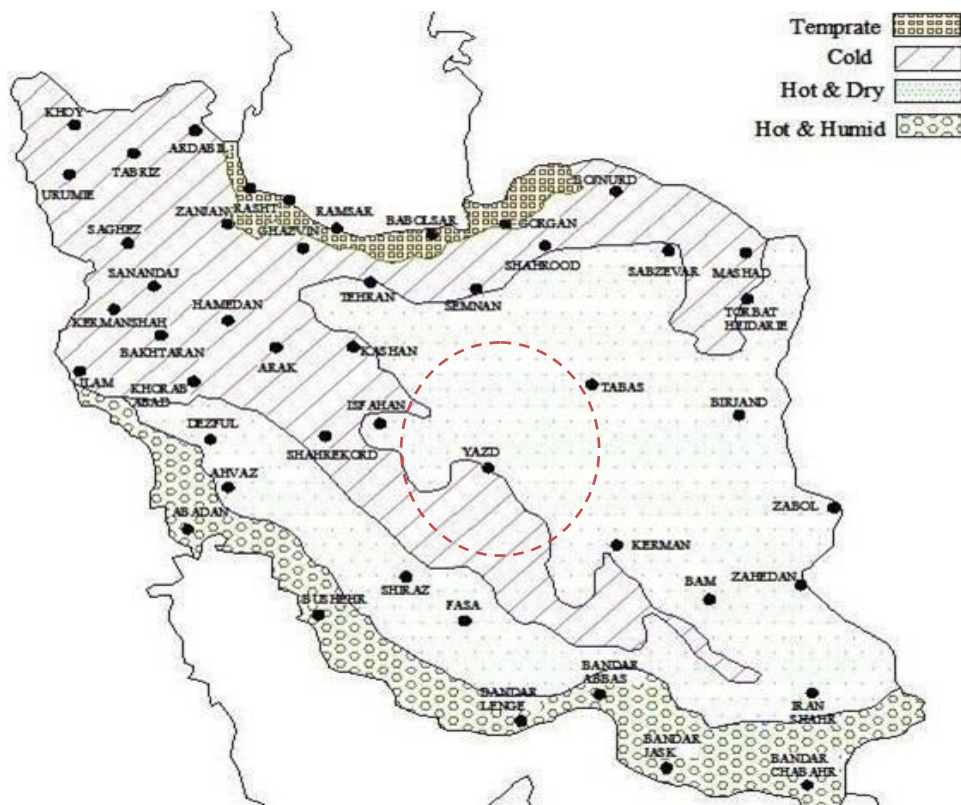


Figure 2: Climatic Regions of Iran (Delfani, 2010)

Due to the geographical setting of the city of Yazd, the weather condition is extremely dry; also the desert climate is dominant in this province. Because of little atmosphere precipitations, low relative humidity combined with extreme heat and fluctuations, the temperature of this province is turned to be deserted climate, and the average annual raining in this area is 50 millimetres. Yazd has severe temperature fluctuations in winter and summer as well as throughout the night and the day. The

temperature fluctuates between minus 20 to positive 40 degrees centigrade, whereas, the average annual temperature is approximately 18 to 20 degrees centigrade. Yazd also has severe winds, since it has plain deserts and mountains. The wind direction in the warm seasons is from North to North-East and in the cold seasons, the direction changes from South to South-West and this is the reason that houses have to be built in a way that inhabitants are kept safe from winds, sandstorms and also different temperature between daytime and night times in their indoor spaces (Ghobadian, 1982).

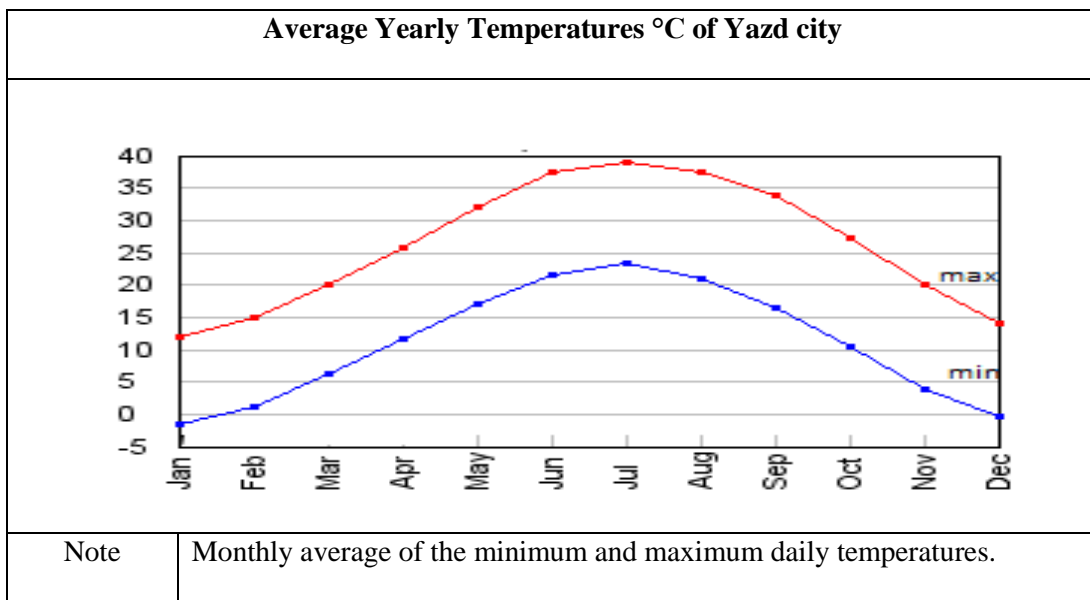


Figure 3: Yazd, Iran Average Annual Temperatures °C in 2012
(Source by: www.allmetsat.com)

The geographical condition of the Yazd province results in a dry and a desert-like climate condition. Yazd province is considered as one of the most deserted places in the world, because of low to average precipitations, severe evaporations, low relative humidity followed by hot weather and severe temperature fluctuations. The only place that has a positive effect on the weather condition of this province is the peak of Shir-Kooh (Mountains). The rainfall in the Yazd province fluctuates from a minimum of 50 millimeters near the Rige-Zarrin desert, Anjir and Miyan-Kooh

valleys to 350 millimeters in the heights of ShirKooch Mountain. The maximum rainfall pattern occurs in January for the desert areas and in March for the mountainous areas. In the Yazd region, the snow mostly falls in the ShirKooch heights, and it is visible until the end of spring (Ghobadiyan, 1982).

Yazd is divided into three regions from a weather condition perspective:

- 1- Cold and dry region, semiarid with short grass and high mountainous areas
- 2- Dry and deserted region, with mountainous and semi-mountainous areas
- 3- Hot and dry, severely deserted area for plain or deserted areas of the Yazd province (Ibid, 1982).



Figure 4: Administration Map of Regional in Iran (Zangeneh, 2009)

3.1.1 Precipitation

Precipitation plays a key role in architecture. There has to be enough information gathered in order to design a house with maximum comfort. According to the environmental sustainability factors such as climate and natural recourse the most

precipitation in Yazd is in the winter, spring and fall. The summer precipitations are very low in the deserted and high regions. The annual precipitation of various places in this province fluctuates and it increases by height. In some deserts like; Siyah kooh, Rig-e-Zarrin, Anjir and MiyanKooch valleys, the average annual precipitations rate is less than 5 millimeters. The average annual precipitation is approximately 10 millimeters in the precipitation line of the mountainsides and in between 13.50 mm and 15 mm heights. The areas with the highest precipitation in this province are; ShirKooch heights with approximately 3.50 millimeters rain and Bajegan with 3 millimeters. The average precipitation of Yazd city is approximately 7 millimeters, which is shown in the table below (Geographical culture in Yazd, 2000).

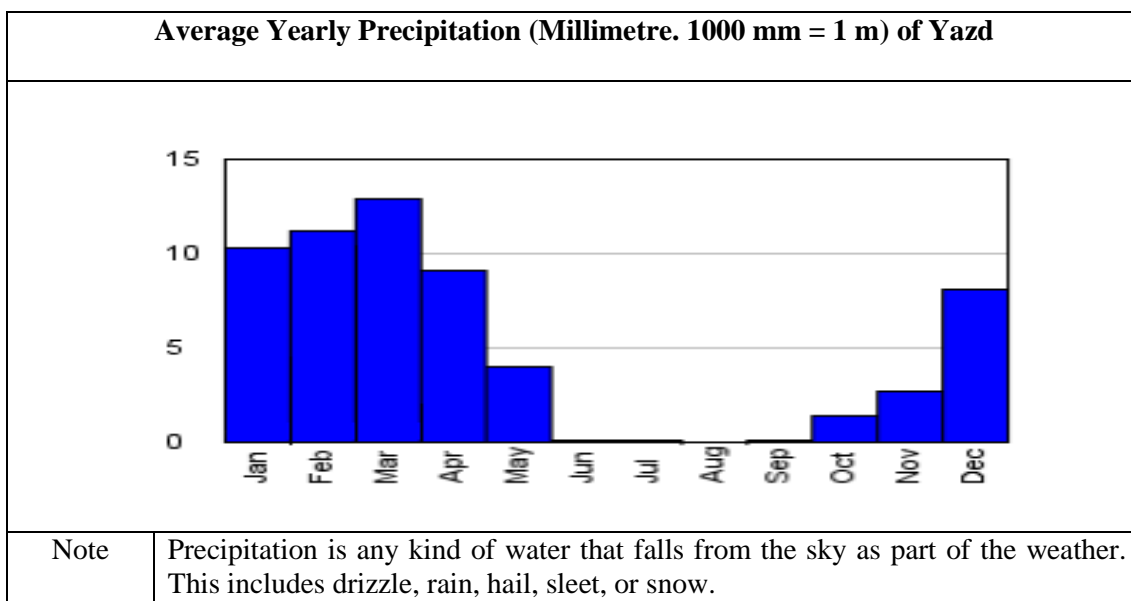


Figure 5: Yazd, Iran Average Yearly Precipitation (mm) in 2012
(Source by: www.allmetsat.com)

3.1.2 Winds and Sand Storms

Yazd region has severe winds since there is no tree coverage. The number of stormy days is between 40 and 60, which is somewhat similar compared to the other regions of the central plateau. The worst sandstorms start at March and last until late June, early July. It's possible to say that the calmest season of the year is fall in this region,

whereas the restive season is spring. The speed of the winds in this area can reach up to 90 kilometers per hour and on some severe occasions, up to 120 kilometers per hour. The direction of the wind is usually from north, Northeast in the hot seasons and from Southwest in the cold seasons. Esfahan wind is the wind that originates and blows from Esfahan to the city of Yazd, which plays an important role in the city. It is named as the “black storm”. The wind carries high amounts of sand and dust with the help of severe storms that originate from Esfahan and end up in the city of Yazd in the springtime. However, the wind that blows from Esfahan is not always ferocious. Other seasons of the year, there is a calm wind blowing from Esfahan. Kerman wind is the calm breeze that blows from Kerman with no dust present. However, it is hot and in the summer season and hot dry in the winter. Wind is one of the famous winds of this region. It is a high speed circulating wind; the speed of the winds reach 200 meters (Ghobadian, 1982).

3.2 General Urban Pattern of Yazd

Historical development hashed an impact on environmental sustainability in such a way that inhabitants are able to access all parts of the city due to the compactness of the city, which allowed people protection from the harsh climatic situations such as the sun and the wind as well as recurring sand storms.

Moreover, the historical background of Yazd indicates the primary identities of Iran in terms of its origins and values. Yazd is one of the most ancient settlements of Iran, since it possesses a rich heritage of ancient culture and civilization with over 3,000 years of history. Yazd city was founded by Alexander the great, (339-421 AD), after building a prison where it is located. They argue that the city was established and named as “Yazdangerd” by the command of Yazdgerd in the Sassanid era. However

the term "Yazd" means “clean and sacred” and "Yazdgerd" means “divine” in Persian. The city of Yazd signifies ‘God's City and Holy Land', and the name Yazd, has been derived from its meaning of sacred, auspicious and creditable (Modarres, 2006).

There are many villages located in the province of Yazd. Unfortunately, not all of these villages stand today. Some have been the victims of destruction but nonetheless their memories live on within the land (Ibid, 2006). However, The Yazd region is divided into ten small cities, according to the latest administrative divisions of the country. These small cities are Maybod, Mehriz, Taft, Ardekan, Bafgh, AbarKuh, Sadugh, Marvast, Tabas and Yazd. In this respect, the city of Yazd is going to be the main focus of this study.

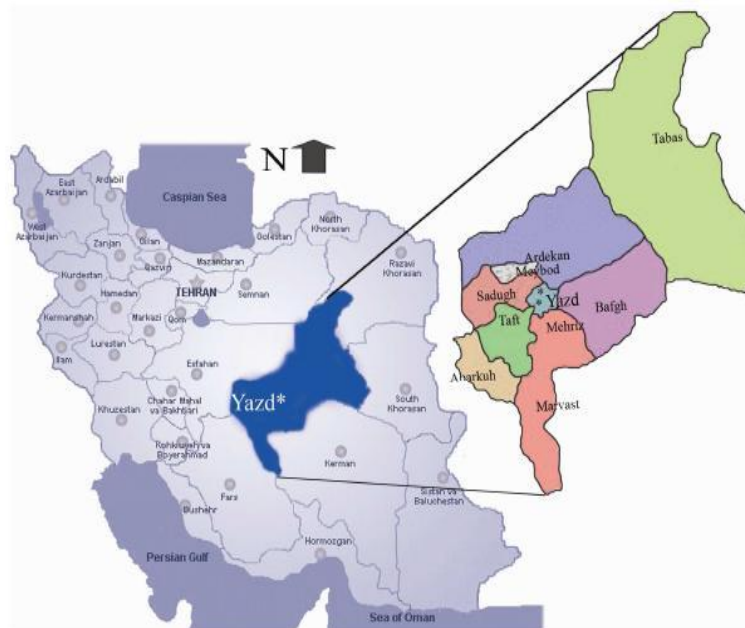


Figure 6: View of Geography Yazd City
(Hatami nejad, 2005)

The provincial capital of Yazd region is the Yazd city. As a result Yazd is one of the most populated cities of the province. Yazd province is located in the middle of the

mountainous area of Iran. This region includes different geographical formations such as plains, deserts, and sandy hills (Khademzadeh, 2007).

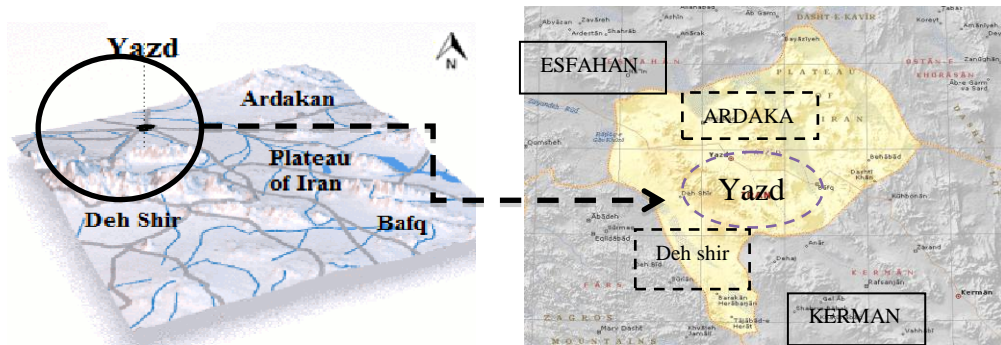


Figure 7: View of Yazd City
(Hatami nejad, 2005)

Yazd city consists of several districts: Fahedan Area, Shaikh dad Area, Dolat abad Area, Gadal-e-mosalah Area, six wind catcher (shish Badgir) Area, Gozargah Area and Gonbad-e-Sabz Area. The historical territory of Yazd has continuously changed, especially in the last century. The changes in the city are obvious. City was ruled by many different dynasties which are explained below (Mirrazavi, 2011).

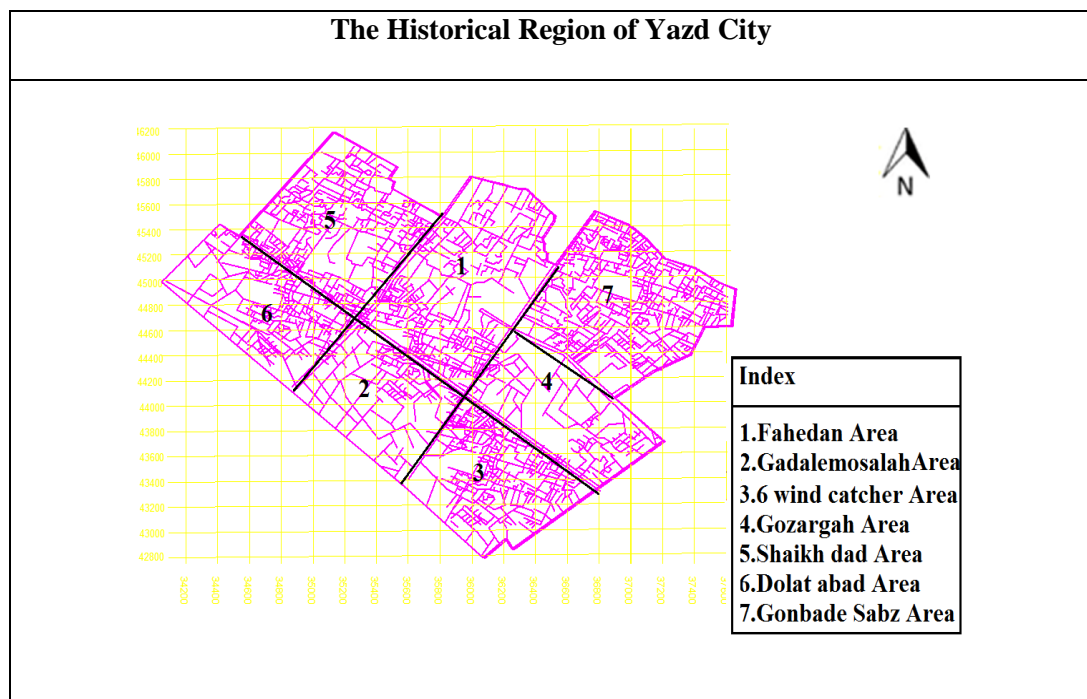


Figure 8: The Historical Region of Yazd
(Hatami nejad, 2005)

3.2.1 Historical Period of Iran (549 BC - present)

The historical period of Iran from 549 BC to present some of the periods that had a large influence in history of Yazd are selected in our research. These periods show the development of Yazd city how the inhabitants have development which are living spaces according to the environmental sustainability factors to be kept safe from natural disasters . The table below show the historical period of Iran between 549BC until present time (Hatami nejad, 2005).

Table 2: Historical Period of Iran (549 BC - Present)

1	Mad (549-728 BC)	19	Sarbdaran (1332-1386 AD)
2	Achaemenid (330- 550 BC)	20	Gorkani (1370-1506 AD)
3	Solukanian (63-312 BC)	21	Mareshian (1359-1582 AD)
4	Parthia (224BC-274 AD)	22	Kiyaian (1371-1374AD)
5	Sassanid (224-651 AD)	23	Ghaghoronlo (1375-1468 AD)
6	Amoyan (660-750 AD)	24	Aghghouonlo (1378-1508 AD)
7	Abasian (753-520 AD)	25	Hezar aspian (1148-1424 AD)
8	Taherian (821 – 873 AD)	26	Safaviad (1507-1722 AD)
9	Safarian (873-874 AD)	27	Afsharids (1736-1796 AD)
10	Ziyarian (874-1004 AD)	28	Zandia (1757-1794 AD)
11	Al-e-buye (980-990 AD)	29	Ghajar (1785-1925 AD)
12	Ghaznavian (990-1187 AD)	30	Pahlavi (1925-1975 AD)
13	Saljoghian (1037-1194 AD)	31	Islamic Republic (present time) (1975-2013 AD)
14	Kharazmshahan (1098-1219 AD)		
15	Ilkhanate (1156-1225 AD)		
16	Atabakan (1228-1332 AD)		
17	Jalairian (1335-1432 AD)		
18	Chopanian (1320-1380 AD)		

The following items are select important periods for Yazd:

1. Sassanid Period (224-651 AD)
2. Al-e-buye Period (980-990 AD)
3. Atabakan Period (1228-1332 AD)
4. Gorkani Period (1370-1506 AD)
5. Safavid Period (1507-1722 AD)
6. Zandia Period (1757-1794 AD)
7. Pahlavi Period (1925-1975 AD)
8. Islamic Republic (1975-2013 AD)

The most influential eras that affected the development of the Yazd city is discussed thoroughly in this section (Hatami neja, 2005).

3.2.1.1 Sassanid Period

During Sassanid Period (224-651 AD), when Sassanid rulers entered the city of Yazd, the main part of the city was located along Ray-Kerman route (fig8); Yazd had a strategically important situation in terms of its proximity to the central cultural and economic routes (Hatami Nejad, 2005).

Moreover, the city walls of Yazd were one of the most expressive examples of protective architecture in Central Iran, including fortified villages, road outposts, provincial castles, imperial citadels and ramparts. Junctions of both inter city and regional trade routes; Yazd has predictably been a fortified settlement since its inception in the Sassanid era (Ibid, 2005).

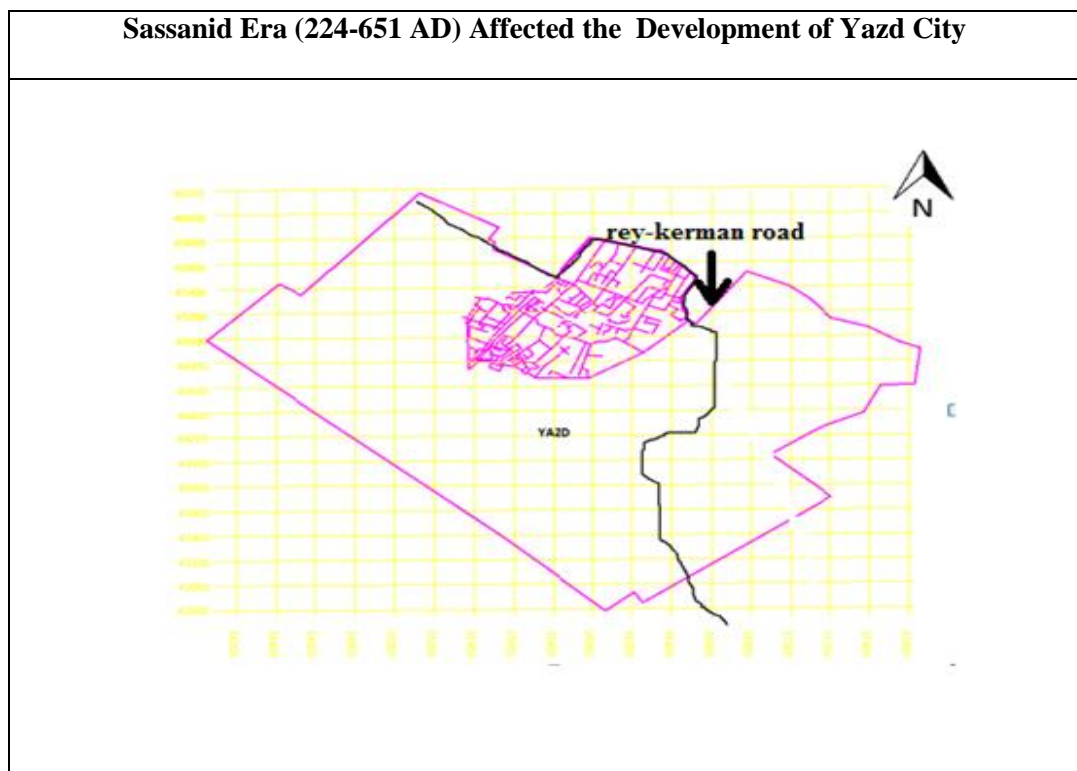


Figure 8: Yazd period before Islam
(Hatami Nejad, 2005)

3.2.1.2 Al-e-buye Period

The Al-e-buye Period (980-990 AD) started at the end of the seventh century and continued until the eighth century, this period ended by the migration of the Arab tribes into the Fahadan area. In this period, the city was developed towards the South-East direction. All Dulleh and Al-e-buye kings built the walls around the city. Moreover, four new gates were built around Yazd. Which are called Mahri-jerd door, Malmir door, Shahi-door and Kohkeno door (Jafari, 1958).

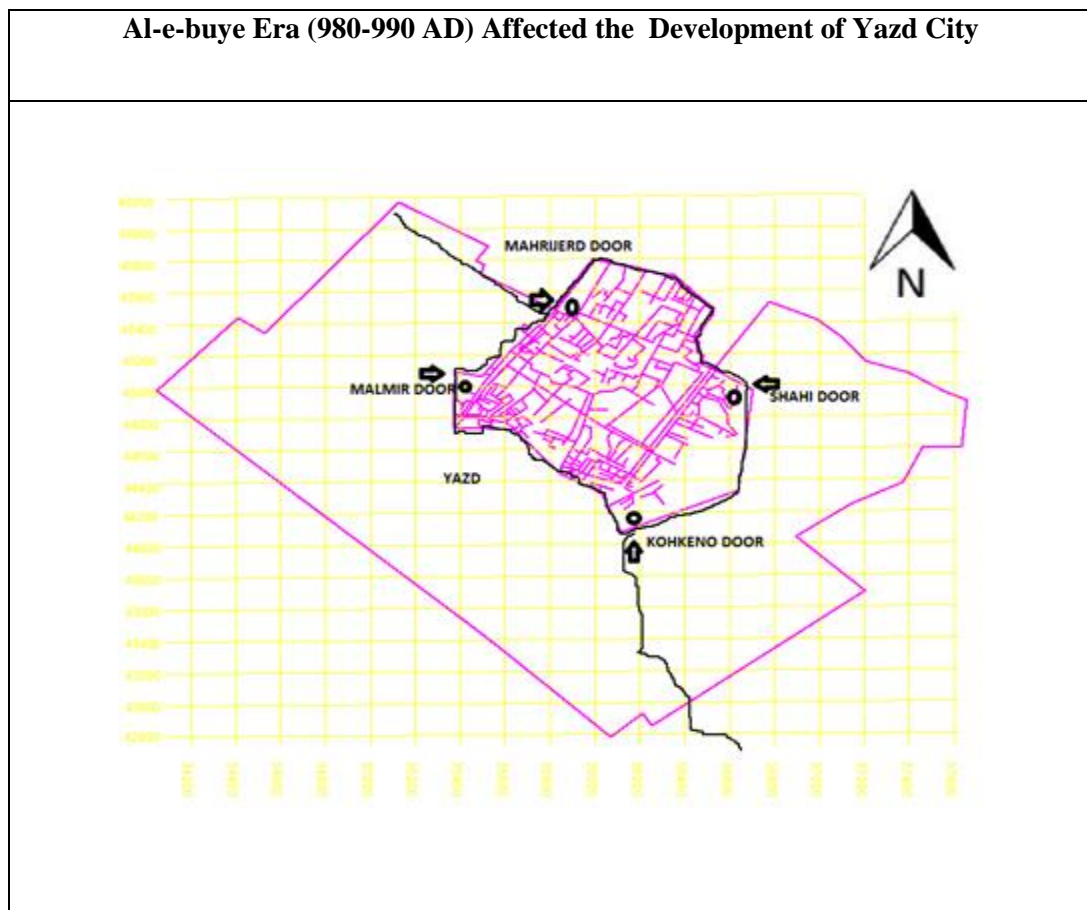


Figure 9: Al-e-buye Era
(Hatami Nejad, 2005)

3.2.1.3 Atabakan Period

During the ruling Period of Atabakan (1228-1332 AD) in the fourteenth century, main developments were facing towards the East and the West sides of the city. Developments reached the suburbs and had an impact on culture and commerce (Toosli, 1981).

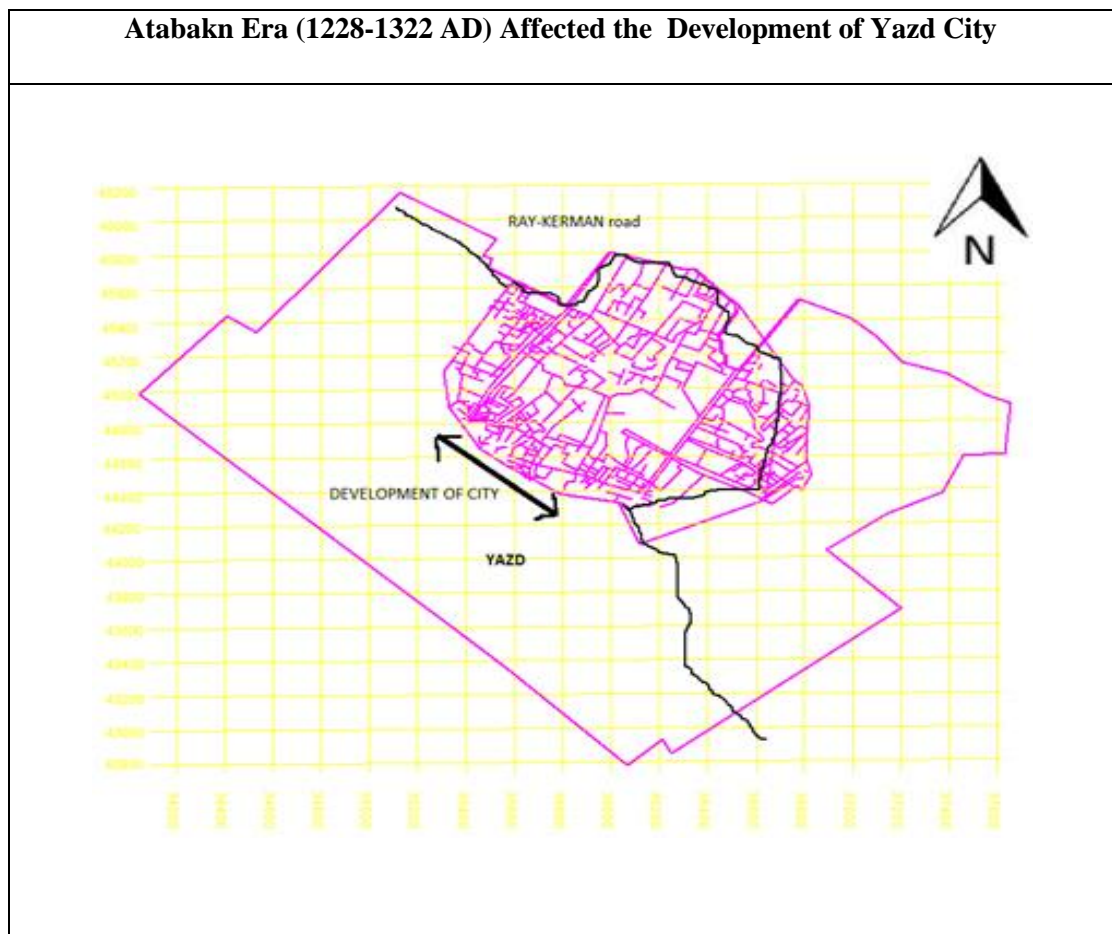


Figure 10: Yazd Atabakan Era
(Hatami Nejad, 2005)

3.2.1.4 Gorkani Period

In this Gorkani Period (1370-1506 AD), Yazd was developed towards the South, new buildings types and artifacts such as great mosques, schools, baths, underground

resources like Qantas (water system), water reservoirs and some governmental buildings were established around the eastern borders. During this major transformational process of the city, Yazd mosque, Rig mosque and Amir-Chakmagh square, which were nearing the Mehri-jerd gate (door), formed the fundamental components of the developments in the city center (Kaateb, 1956).

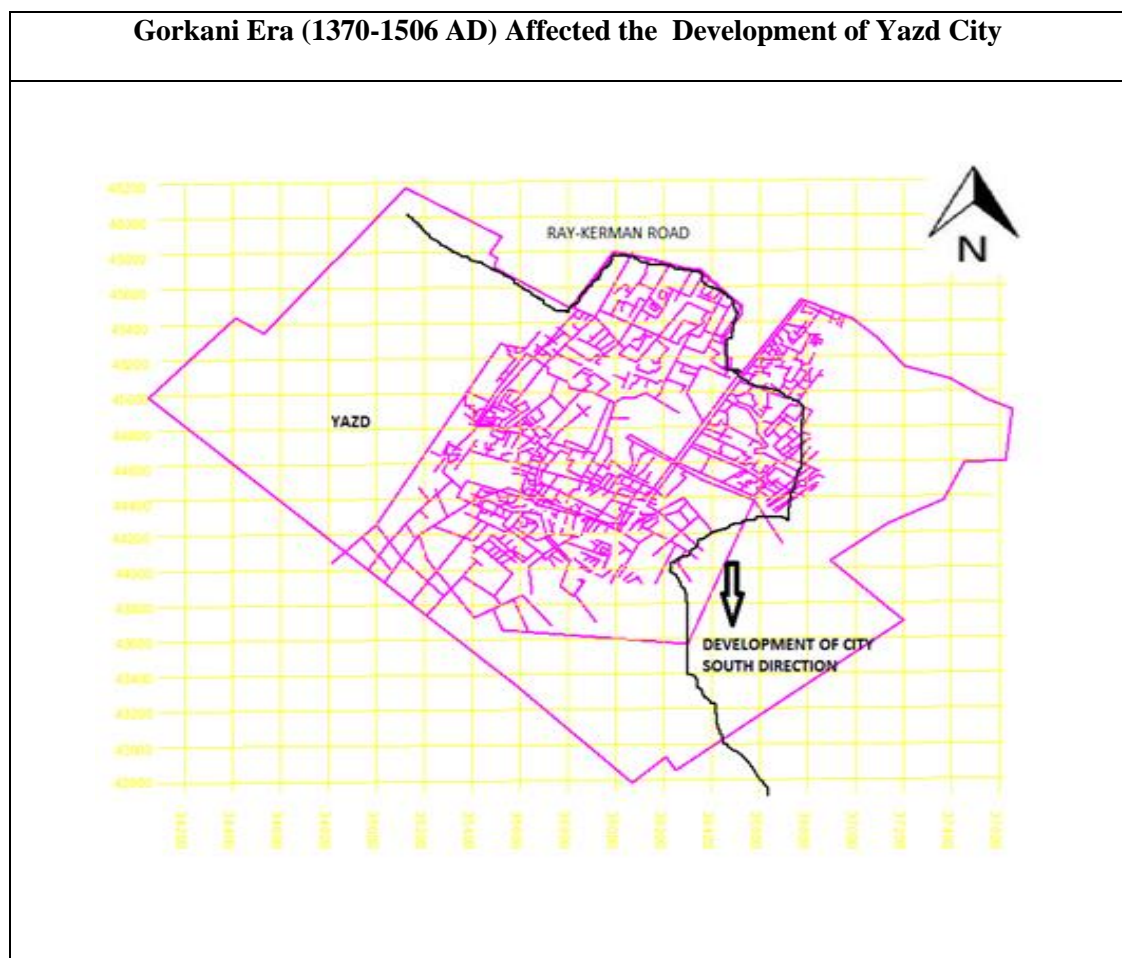


Figure 11: Yazd Gorkani Era
(Hatami Nejad, 2005)

3.2.1.5 Safavid Period

This Safavid Period (1507-1722 AD) began in the sixteenth century during the Safavid period. Two prominent complexes were built. The first one is Shah

Tahmasb complex, which included a mosque, a school and a bazaar. The other one is a commercial market, which was located in the main square between Amir Chakhmagh and Shah Tahmasb squares (Toosli, 1981).

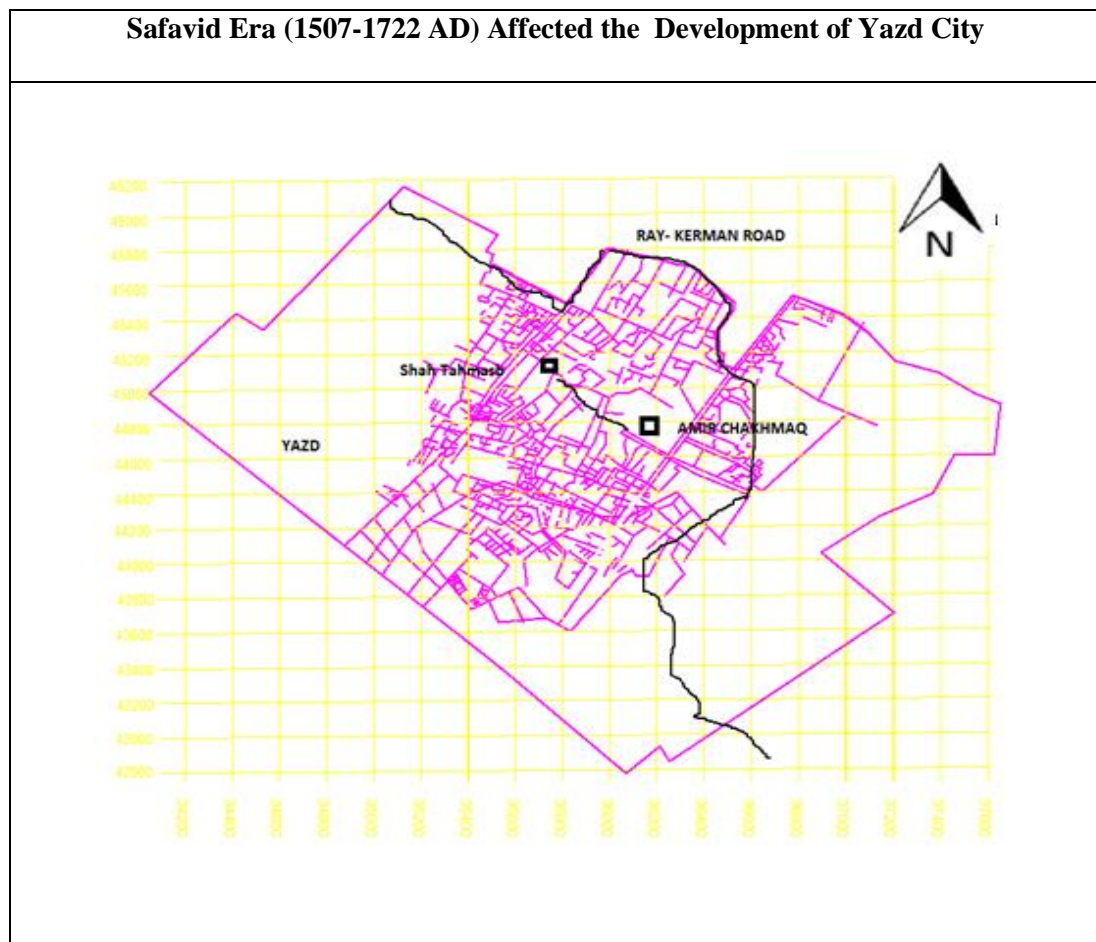


Figure 12: Yazd Safaviyeh Era
(Hatami Nejad, 2005)

3.2.1.6 Zandia Period

During the Zandieh Period (1757-1794 AD), developments took place towards the South and the Southeastern parts. New developments such as bazaar-e-khan,

Gheysariyeh and Meydane-Khan were built close to the existing parts of the city (Hatami Nejad, 2005).

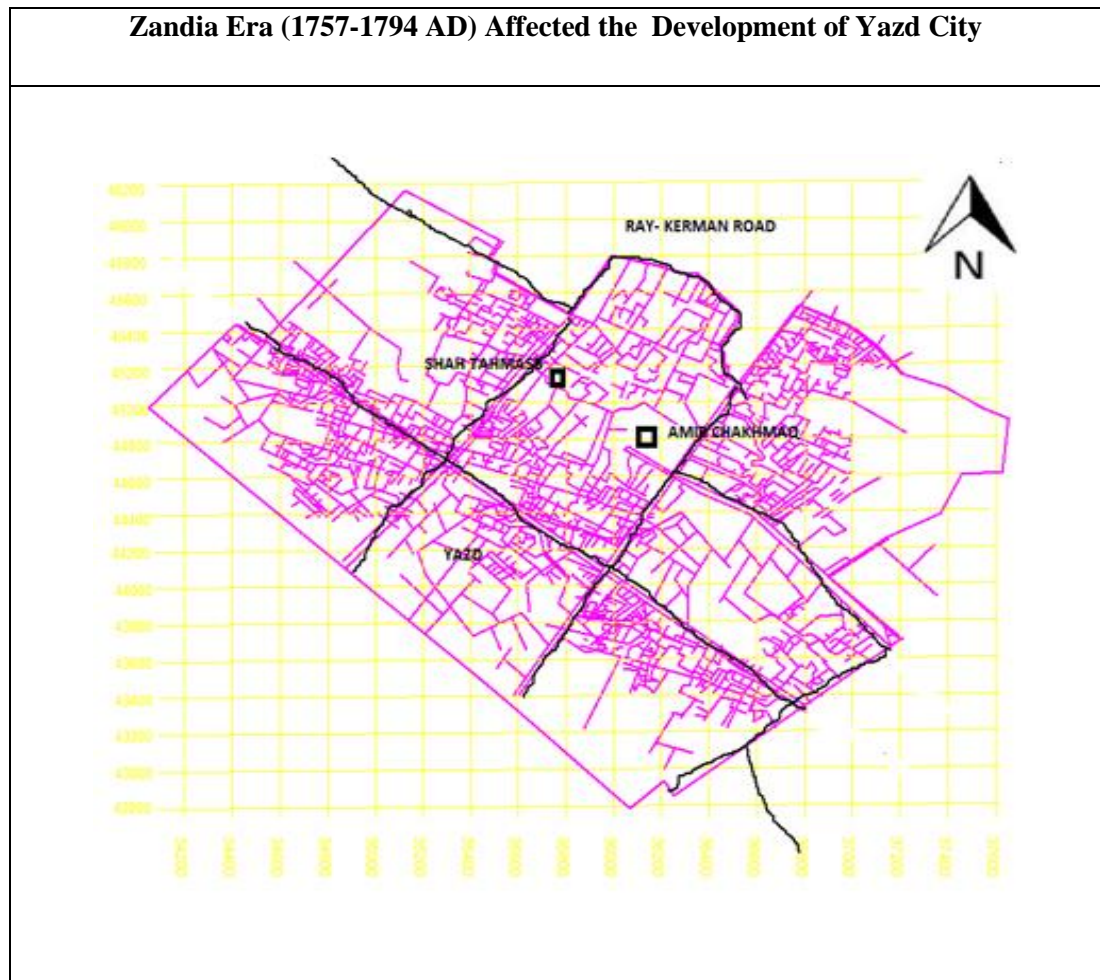


Figure 13: Yazd Zandigh Era
(Hatami Nejad, 2005)

3.2.1.7 Pahlavi Period (Before Revolution)

During Pahlavi Period (1925-1975 AD), the construction of new avenues transformed the city structure from what it was (originally created in the Reza Shah era). The following avenues played an important role in these changes: Fahadan,

Godal-Mossala, Sheh-Bafgir, Gajar-Gah, Dollat-Abad and Gonbad-e-Sabz (Kalantari Khalil-Abaad, 1999).

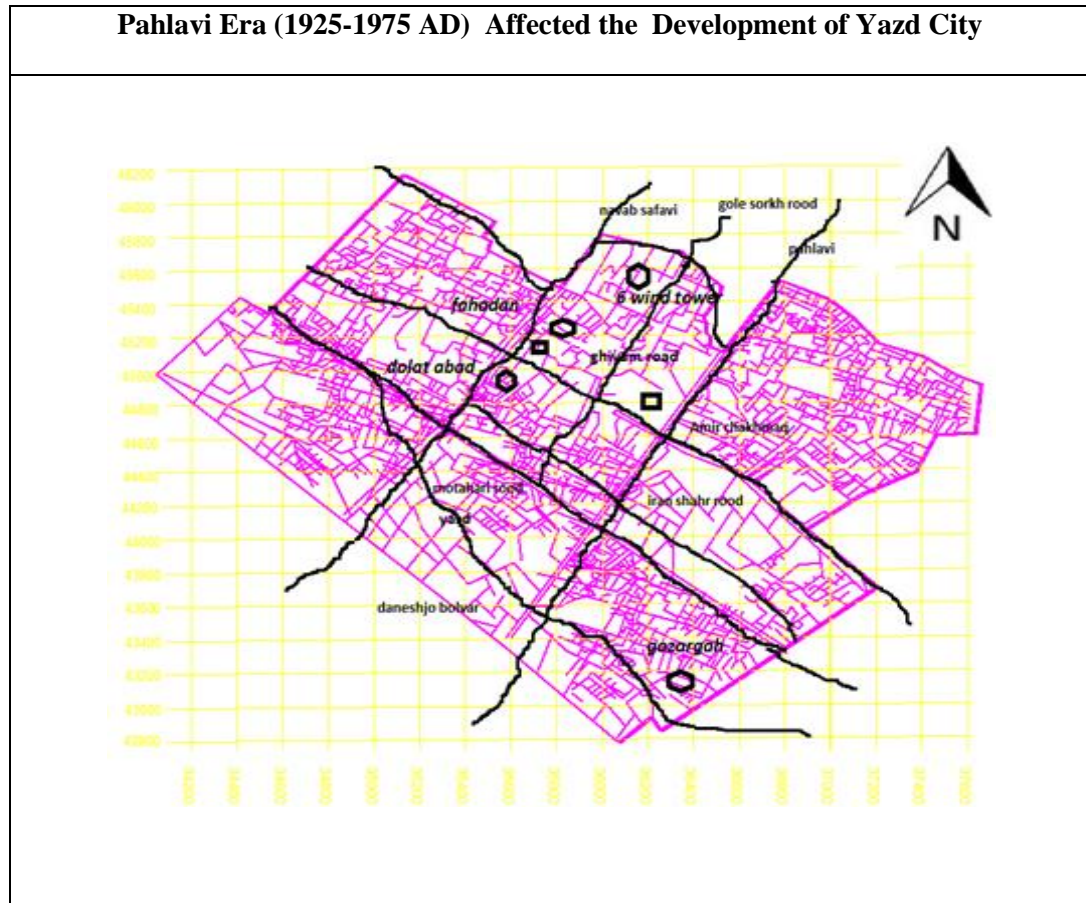


Figure 14: Yazd Pahlavi Era
(Hatami Nejad, 2005)

3.2.1.8 Islamic Republic (Present Time)

During Islamic Republic (1975-2013 AD), the black highlight illustrate the fact that new developments haven't had major influences on the settlement and the urban pattern of the streets in the city of Yazd, rather impacting the development of public places such as: hospital, school, mosque, and new buildings around Ghiyam Street. These changes can be seen in the following figure (Kalantari Khalil Abaad, 1999).

Islamic Era (1975-2013 AD) Affected the Development of Yazd City

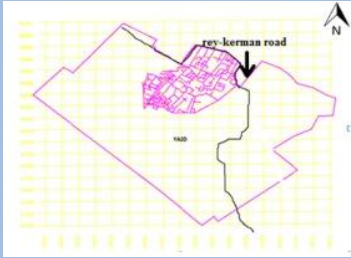

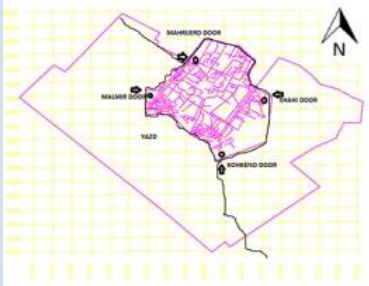

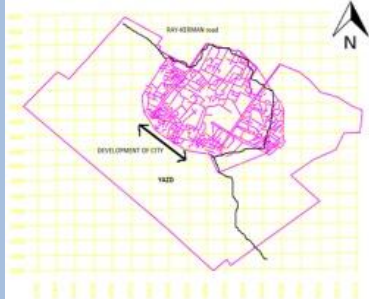





Figure 15: Islamic Era
(Hatami Nejad, 2005)

3.2.2 Summary

According to Iran's historical background, the most important periods that Yazd's urban has changed massively in these periods has been explained. These developments show how Yazd city has been developed and formed. Moreover, the inhabitants have built this city according to the experiences they have gained through these developments to be safe and protected from the environmental factors that could harm them. The table below shows the history of the developments achieved at different eras in the city of Yazd (Kalantari Khalil Abaad, 1999, Kaateb, 1956, Toosli, 1981, Jafari, 1958 and Hatami Neja, 2005).

Table 3: History Periods of Yazd City Maps

NO	Map History Periods of Yazd City	NO	Map History Periods of Yazd City
1	 <p data-bbox="453 600 804 629">Sassanid Period (224-651 AD)</p>	5	 <p data-bbox="995 600 1358 629">Safavid Period (1507-1722 AD)</p>
2	 <p data-bbox="448 1039 807 1068">Al-e-buye Period (980-990 AD)</p>	6	 <p data-bbox="995 1039 1358 1068">Zandieh Period (1757-1794 AD)</p>
3	 <p data-bbox="435 1464 820 1494">Atabakan Period (1228-1332 AD)</p>	7	 <p data-bbox="995 1451 1358 1480">Pahlavi Period (1925-1975 AD)</p>
4	 <p data-bbox="443 1861 812 1890">Gorkani Period (1370-1506 AD)</p>	8	 <p data-bbox="995 1868 1358 1928">Islamic Republic (Present Time) (1975-2013 AD)</p>

3.3 General Yazd Architecture within Framework of Environmental Sustainability

This section will focused on architecture in framework current sustainable factors such as Structure of the City, Compactness, Dense Texture, Narrow, Irregular Street, Covered Streets and how they have affected environmental factors which include Climate , Renewable Energy and Water consumption in the Yazd city.

Therefore, the architecture of Yazd has some unique characteristics. The yards, pathways of structures are generously shielded from any weather changes such as undesirable winds and sunlight. The houses are very tightly wound together to make use of each other's shadings. The borders of the houses are not easily recognizable due to them being so cluttered together but the cluttered state of the houses means that only a minimal amount of walls are directly facing the external space which saves a tremendous amount of energy (Ahmadkhani Maleki, 2005).



Figure 16: Dense texture of Yazd city
(A'zami and A. Salehipoor, 2005)

High walled arch roofs cast shadows on the nearing houses that help reduce the wind coming from the desert. The city is structured in a way that the pathways of the city are open on one end, which allows for the attractive winds to flow through while blocking the harsh undesirable winds from entering. The climatic challenges are met by harmonizing the city with the environmental sustainability factors that are present in the urban texture.

The form of Yazd city is simple, understandable and has social unity, spatial connection, is colorless, balanced and harmonized. Spaces in the city are designed to balance any accumulation.

The significant aspects of urban texture that refers to environmental sustainability are as follows: (Ahmadkhani Maleki, 2005, Ghobadian, 1998, A'zami, 2005, Tavasoli, 1987, karimi, 1997, Soltanzadeh, 1998).

- Structure of the City
- Compactness
- Dense Texture
- Narrow, Irregular Street
- Covered Streets

The Yazd desert is very uncomfortable. Therefore, people tend to stay within the city walls. The city is very well protected from common problems such as gusts of wind. The alleys are covered with tall walls and the pathways are zigzagged to cut the harsh winds. Alleys are only wide enough for no more than a couple of people to

pass through. Such design allows for more shading throughout the year (Ahmadkhani Maleki, 2005).



Figure 17: Urban fabric of Yazd city
(Ahmdkhani Maleki, 2005)

3.3.1 Structure of City

A common rule is observed when analyzing the city of Yazd. The rule being that in all of the towns within the city, the Bazaars act as the linear shape that everything else branches off which continues towards the gates of town. The alleys always branch off the main bazaar road (Karimi, 1997).

The center of the neighborhood is a public space that houses a water reservoir, mosque, a public bath as well as being spacious enough to be used for religious ceremonies (Soltanzadeh, 1998).

Two differing kinds of Bazaars exist (Bazaar and Bazaarcheh) in Yazd which are; (Tavakoli, 2009).

3.3.1.1 Bazaar and Bazaarcheh (The Small Bazaar)

These small Bazaars usually form the center of the urban neighborhoods and the scope of the activities of these small Bazaars is the neighborhood and they include between one and a few small workshops, traditional apothecaries, a mosque and an underground water reservoir (Ibid, 2009).

The network of Yazd's old Bazaars is an extensive urban architectural complex located at the south of the city and includes several Bazaar passages, trade compounds and houses, mosques, squares, schools, underground water reservoirs, caravanserais and workshops.

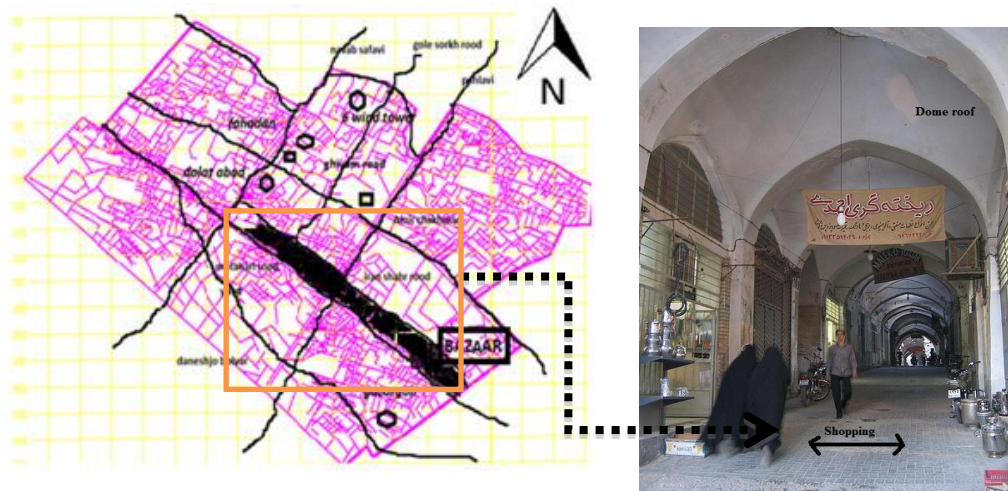


Figure 18: Map of Yazd City with Bazaar (Hatami Nejad, 2005)

The neighborhood center is connected to a semi-private open space that is a part of several houses that divide into several other passageways. Social interactions were carried out in the shared space and everyone had a sense of belonging there. The

semi-private opening is linked to other houses with their own passageways (Tavassoli, 1983).

Such a feature is also present in each and every house. The entrance planning of a house is very important in the City of Yazd and the houses are mostly single floor with thick high surrounding walls. Passersby cannot see the private quarters of the house. Window openings are small and are above eye level. The heavy doors are placed in a way so that when it is open, the quarters cannot be seen. Its place therefore is accurately calculated and in some cases, it was placed entirely away from the courtyard (Soltanzadeh, 2004).

All public and private spaces are enclosed to decrease the effect of the heat and wind. According to this, a community in Yazd named Kheir-abad was chosen for analysis on how this specific part has formed (Khademzade, 2007).



Figure 19: Kheir-abad Neighborhood Enclosure (Khademzade, 2007)

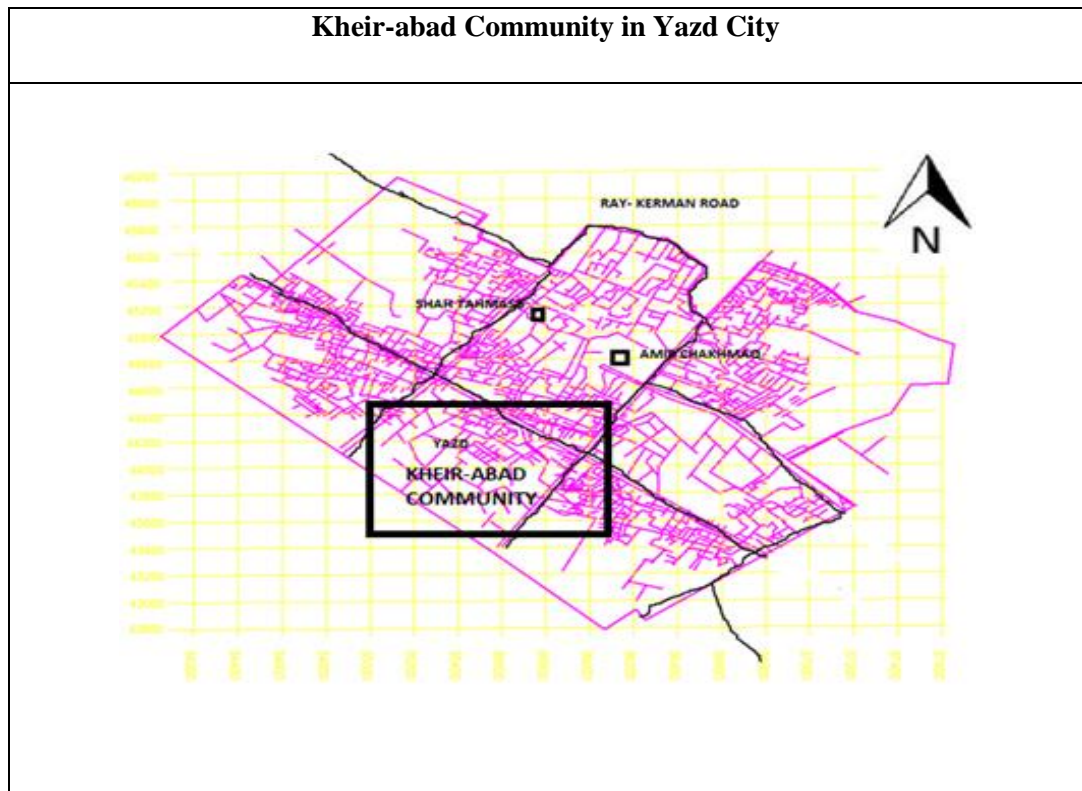


Figure 20: Kheir-abad Community
(Hatami nejad, 2005)

According to the local sources, it is called a kheir-abad because of its good weather, vibrancy and prosperity. It joined the Yazd city urban fabric a few decades ago. According to the geographic coordinates of this community and its notable structures, it seems essential to conduct further studies in order to find out its formatting in time. The most important historical structure is the Kheir-abad castle, which has recently been converted to a sports complex. The Islamic culture and their interactive coexistence is another important feature of this community. According to the local researches, most residents of this community were involved with agriculture and animal farming. This is still practiced by today's occupants (Khademzade, 2007).Able environmental structures of this community are as follows:

- | | |
|---------------------|-------------------------------|
| 1-Kheir-abad Castle | 3-Kolah-douz Water Storage |
| 2-Kolah-douz Mosque | 4-Water Storage of Kheir-abad |

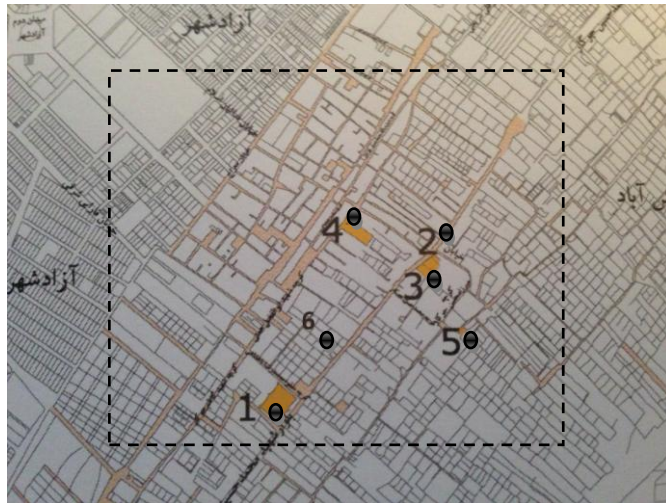


Figure 21: Neighbourhood Main Elements
(Khademzadeh, 2007)

3.3.2 Compactness

The compactness of the urban structure of Yazd city which is connected to environmental sustainability, with thousands of historic residential buildings and a large number of traditional structures contains the largest uninterrupted, historic and sustainable urban fabric in Iran. Adjoined buildings and urban compactness in Yazd have some advantages. First of all, sheltered urban areas protect the city from the harsh climate that fashions a comfortable living space for the occupants. Secondly, in order to make sure less heat is lost through the walls, not many of the building walls are facing outside. Such a structured way of construction enabled less heat loss in winter and cooler days in summer (Ghobadian, 2009).

The biggest problem in the City of Yazd is the sand storms that frequently occur. In order to protect the city and its occupants, openings were made in such a way that the buildings would be protected from the harsh desert winds but not block the cool

summer breeze from the mountainside. By arranging the urban space and orienting it towards the south meant that it would benefit from the rays of the sun during the winter period (Ibid, 2009).

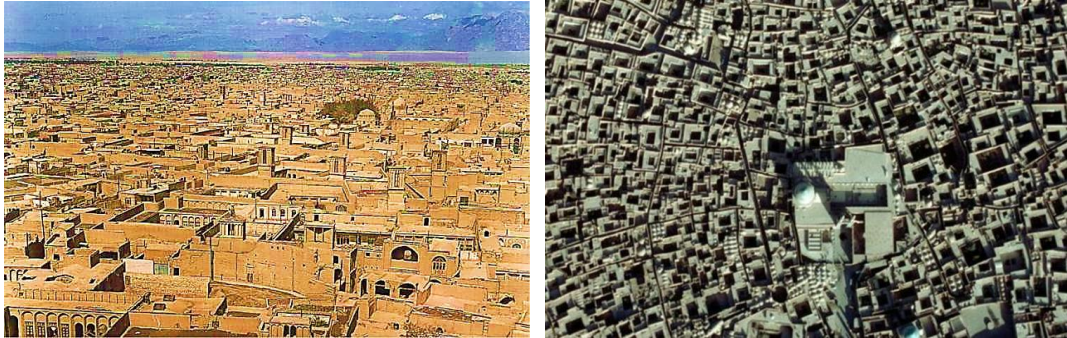


Figure 22: The urban in Yazd City is Compact (Ganjnameh, 2004)

3.3.3 Dense Texture

The dense texture of Yazd city which is considered in environmental sustainability, however the majority of the structures are semi-detached in the city of Yazd, which means that the settlement plan is semi-open in a sub-climatic region. The specific climate is actually a mix of both the heat and the humidity that comes from the south coast and the hot and dry that comes from the central plateau (Ghobadian, 2009).

As you can see in the accompanying photos; Yazd has linked buildings and covered bazaars. So that in an overall overview you can see it as a single roof with holes (courtyards), and some alleys cut in this roof. Neutral color and the same material ensure this feeling is present. This worked as a protection against both the harsh weather and enemies who attacked city in the past (Ahmadkhani Maleki, 2005).

Revised flickers of the sun and high temperatures in summer, daily temperature changes, seasonal changes, dry hot summers, cold and dry winters, additionally low

humidity, limited water resources and dusty winds were the essential factors in shaping the city of Yazd (Ghobadian, 1998).

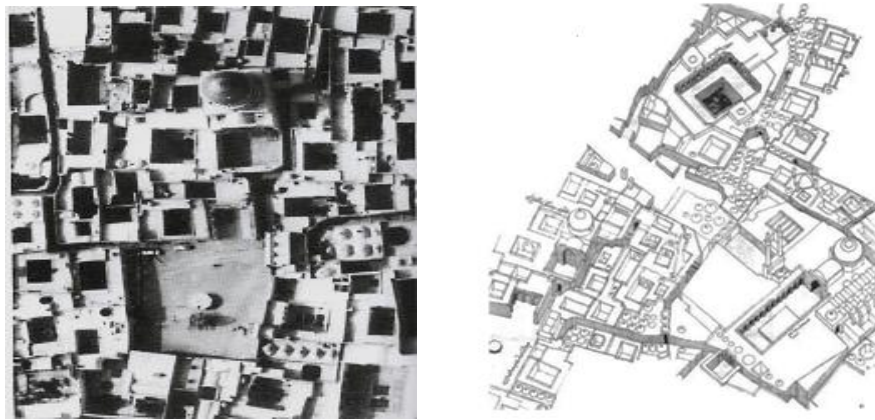


Figure 23: Dense Texture
(Construction in Arid and Hot Zones, 2002)

3.3.4 Narrow, Irregular Streets

The narrow, irregular streets of the urban structure of Yazd city which are related to environmental sustainability that protected from harsh winds and the blazing sun, alleys are built not straight, but rather zig zagged (crinkle) with high walls and extending roofs to provide shading to the pedestrians. Pathways are very tight surrounded by tall buildings. They can be partly covered or fully covered, sometimes with the help of the second stories of structures. This allows for daylight to enter the street spaces, but keeps the daylight to a minimum as it can be harsh when direct (Hindrichs, 2007).



Figure 24: Semi Covered Alleys in Kheir abad – Yazd

3.3.5 Covered Street

The street coverage also focused on environmental sustainability system which is the result of two different requirements. From one side, the need for extra space for buildings, mostly housing was the reason why the Sabaat (the roofed lane) was created (to make a covered lane for entrance space for houses) which is a room spanning the street. It's usually long enough to create a spacious room; however it could be a series of rooms creating a continuous coverage and a tunnel effect over the street. Secondly, there is a need to consider pedestrians which require coverage and protection from the sun (Francesca De Filippi, 2006).



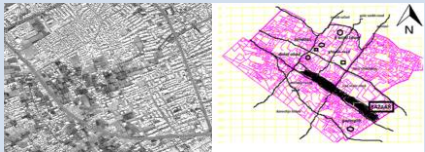

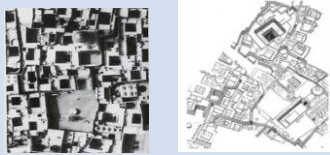


Figure 25: Covered Street in Yazd, a Sabaat in Yazd

3.3.6 Summary

According to the general Yazd Architecture within framework of environmental sustainability discussion the significant aspects of urban texture that refers to environmental sustainability are as follows: Structure of the City (which circulates around the Bazaar in order for people to have easy access to everywhere), Compactness, Dense Texture, Narrow, Irregular Street and Covered Streets.

In order to protect the city and its occupants, openings were made in such a way that the buildings would be protected from the harsh desert winds but not block the cool summer breeze from the mountainside. These factors have been developed according to the environmental factors especially wind, sun and sand storms that the city and the orientation of the houses have been designed accordingly. However, due to the experiments people have gained for maximum comfort in living spaces the city has developed and living spaces have been formed. According to these traditional developments and these environmental factors we have to develop their experiments (Ahmadkhani Maleki, 2005 and Ghobadian, 1998).

Table 4: General Yazd Architecture in framework environmental sustainability

General Yazd Architecture within Framework of Environmental Sustainability		
NO	The Significant Aspects of Urban Texture that Refers to Environmental Sustainability	Picture of General Yazd Architecture within Framework of Environmental Sustainability
1	Structure of City	
2	Compactness	
3	Dance texture	
4	Narrow, Irregular Street	
5	Covered Street	

3.4 Main Spatial Components of the Vernacular Houses of Yazd

The components of vernacular houses in Yazd city which is related to environmental sustainability which explains The city space is shaped by the wind catchers, the most prominent element of a system that organizes the dwellings. All of the housing elements as well as the way of living are designed accordingly. The system drives in

fresh air into the dwellings through a series of courtyards connected to the wind catcher. The rooms are then connected to the courtyards that become the main circulation and these organizations are to provide maximum comfort for people living in these spaces (Memarian, 2004).

The vernacular Iranian house is the grouping of several different open and closed spaces that were designed to combine the nature and life space together. This combination, by concentrating on the spatial figures and the ability of movement and circulation, tried to create a practical space for users matching with environmental sustainability (Dehghani and Mohd Zin Kandar, 2012).

Iranian people's beliefs consider valuing private life and its purity; this fact has made the Iranian architecture, to some extent, introverted. Introversion is a concept, which has existed in the Iranian architecture as a principle and is apparent in various forms. In the hot and dry climate of Iran, this Introversion has shown itself in terms of more than a few environmental sustainability factors (Memarian, G, 2004).

Their architectural style consists of two parts in the houses located in Yazd, which are the indoor and the outdoor. Each house had an independent courtyard, Godal Baghcheh and Narejestan also had complete units such as a saloon, three-doors, five-doors, flanks as well as a kitchen, a storage room, toilet and a bathroom with similar circumstances (Tavassoli, 2008).

Due to the fact that almost all of the houses are typically the same, the Gerami house has been chosen in particular. The Gerami house's components are briefly explained

and how they are oriented in each organization of the house. These organizations are based on the comfort level of the inhabitants according to the environment. The entrance of the building, located on the western side of the ensemble, is connected on one side to the smaller courtyard and on the other to the corner of the larger courtyard. Therefore, the two courtyards of the house are independent of one another and neither of them function as the others forecourt. Nevertheless, they are not entirely unrelated and directly and closely connected via a short corridor located east of the main courtyards northern Panj Dari (five doors room); but this corridor is designed so that it obstructs the direct view between the two courtyards. The two courtyards also have a common area. The following items are selected as the main spatial components of the vernacular houses of Yazd:

- Courtyard
- Entrance (Hashti)
- Corridor (Tarme or Dalan)
- Pool and Garden (Hoz & Baghche)
- Living Room (Saloon)
- Eivan
- Three Doors Room (Seh Dari)
- Five Doors Room (Panj Dari)
- Wind Catcher (Badgir)
- Basement(Sardab,shabestan)

3.4.1 Courtyard

Yazd is known as a traditional urban city that is completely focused on its inner appearances. Urban texture is dense and compact within the city. Surely, the orientation and relation with the environment had been one of the most important dimensions in the planning of the city. The people of the hot and dry regions had found solutions for their climatic problems through their buildings (Tavassoli, 2002).

Courtyard is one of the main components of the vernacular buildings in Yazd the courtyard is surrounded by buildings. The places built around these spaces were designed to maximize the potential heat of the building in winter when sun was directly facing the rooms that directly focus on environmental sustainability factors (Ghobadian, 1998).

Significantly, in the city of Yazd, almost all structures are hidden away that have room openings pointed towards the courtyard. The change between the central yard in this weather and that in a hot and dry climate is that it is not entirely closed off. Openings are high and wide and the porches are wide and overlook the lane spaces on the second and the third floor. If both the windows and doors are open which face the courtyard and the outside respectively, it creates a natural two-sided flow of air that cools the interior of the rooms.

Moreover, another difference in the architecture is apparent in the hot and humid regions where the central square is smaller due to the fact that people like to plant tall trees around to facilitate shadows throughout the hot days. Usually wealthy homeowners have two courtyards that have two different purposes. One courtyard is completely private. Only reserved for family members and the other is used for the friends and relatives that are not as close as the immediate family of the homeowner. In some occasions, in even larger homes, there is a service and facilities rooms present (Shohouhian and Soflaee, 2005).

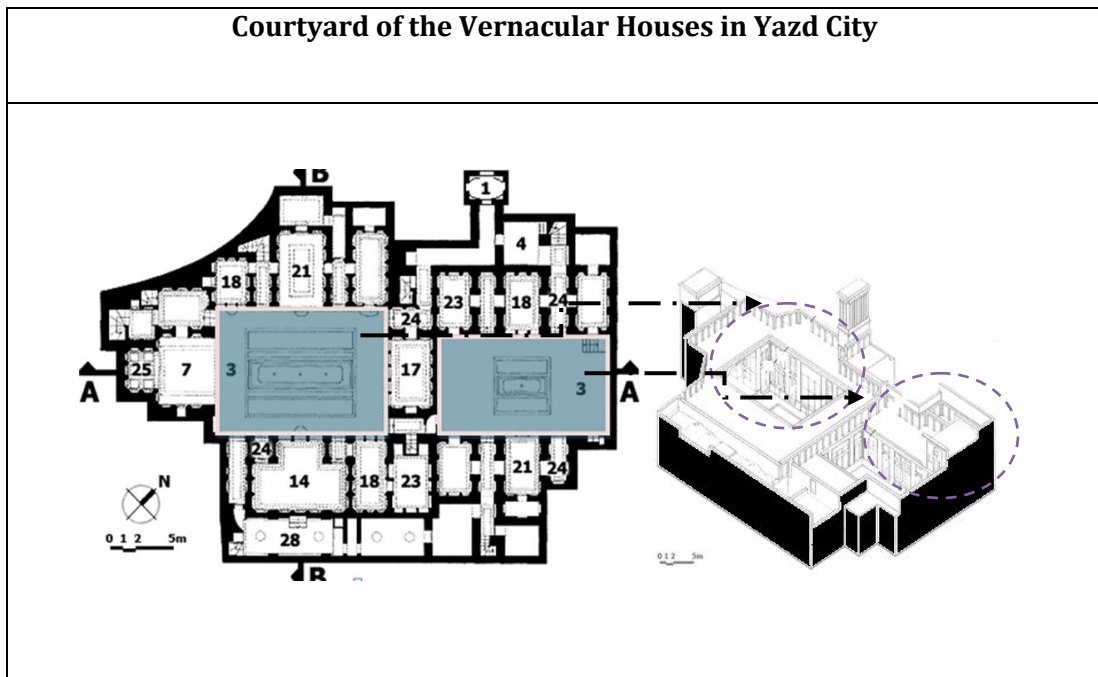


Figure 26: Main Courtyard of Gerami House
(Ganjnameh, 2004)

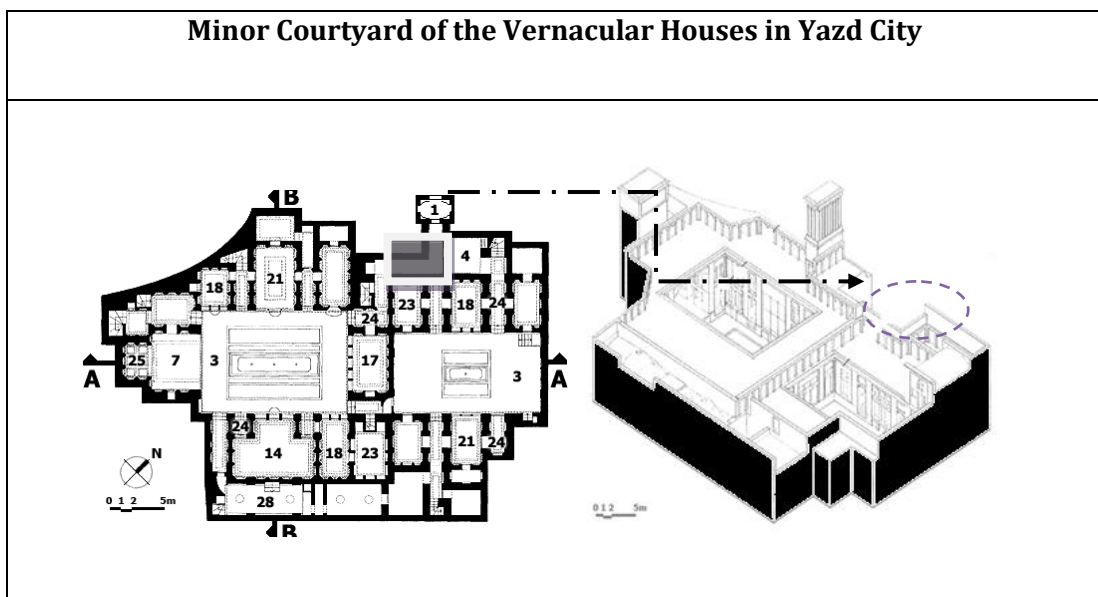


Figure 27: Minor Courtyard of Gerami House
(Ganjnameh, 2004)

3.4.2 Godal Baghcheh in House Yard

The Godal Baghcheh of vernacular houses in Yazd city which is related to environmental sustainability to explain Godal-Baghcheh or alternatively referred to

as Padua is a type of yard. Qanat (water systems) are present in the city of Yazd and the courtyards are well above the standard depth level to be able to utilize these Qanat water systems for irrigation purposes. They are given such names due to their functionality, which is to keep the courtyards cool and breezy when trees and plants are watered (Due to evaporation). The cool fresh air travels to the upper floors keeping them cool and refreshed as well. Square bricks are used to pave the floors of the courtyard to provide more contact surface for maximum evaporation. The creases, bumps and crannies in the bricks create a larger surface area instead of a smooth surface, which has minimum surface area properties. Houses are built within a pile of soil as much as possible to create an efficient building that has minimal heat exchange between the indoors and the outdoors for more comfortable during nighttime and daytime (Ahmadkhani Malek, 2005).

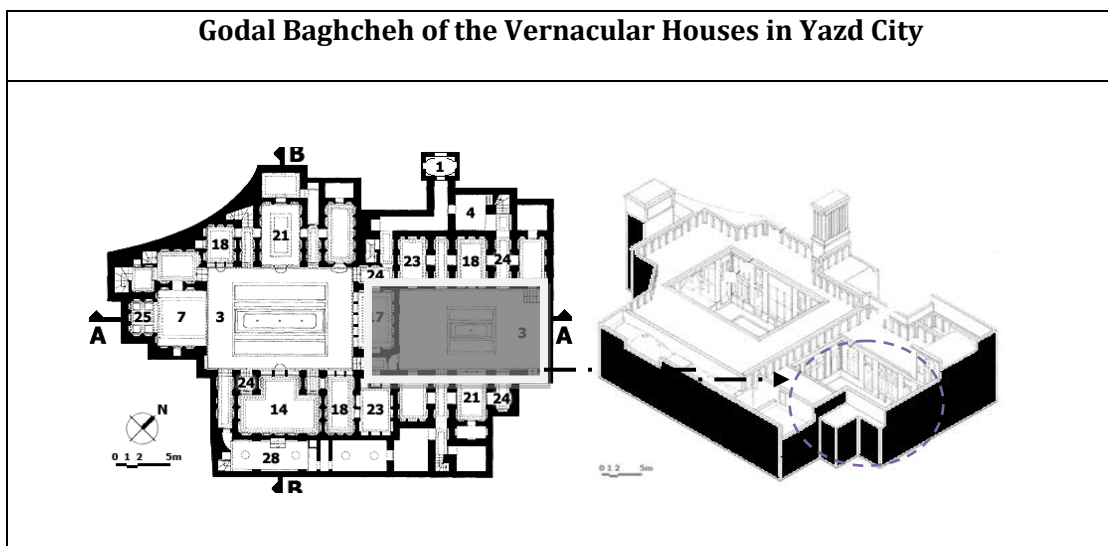


Figure 28: Godal Baghcheh of Gerami House
(Ganjnameh, 2004)

3.4.3 External Courtyard (Bironi)

It is a square or alternatively, a rectangle formed yard. There is a circle, octagonal or a star shaped pond in the centre of the yard. The yard is often referred to as an External courtyard (Bironi). It is luxurious and is

designated for guests. A small garden is apparent on all sides of the pond that is decorated with fruit trees. The outer yard is styled for greeting guests.

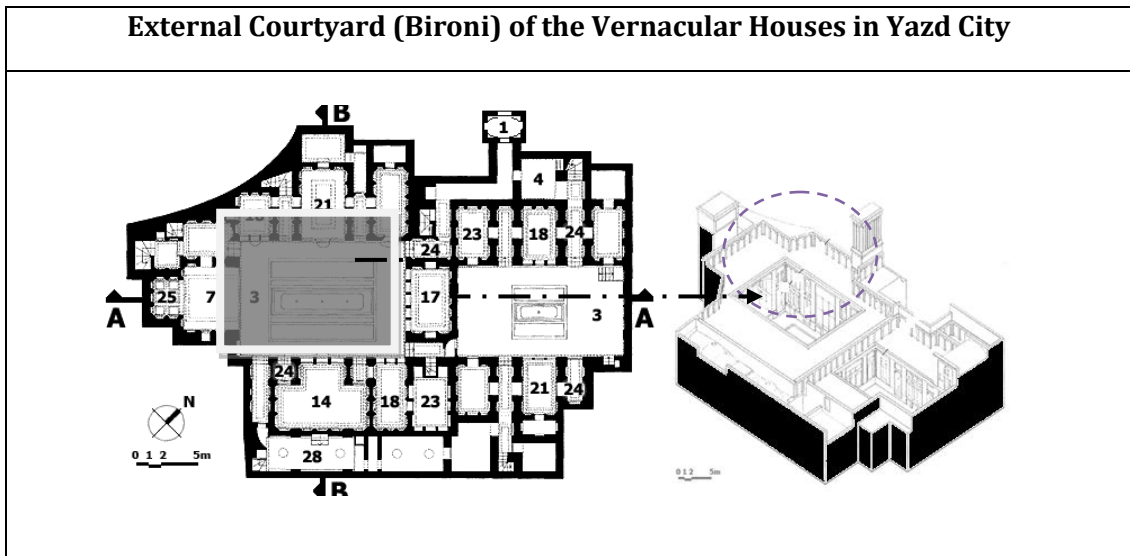


Figure 29: External Courtyard (Bironi) of Gerami House (Ganjnameh, 2004)

3.4.4 Internal Courtyard (Andaroni)

Vernacular houses in Yazd are usually constructed with an internal courtyard (Andaroni), which is private and includes a kitchen and bedrooms. It is an extended yard that is suitable for rooms that have relevant dimensions with the yard.

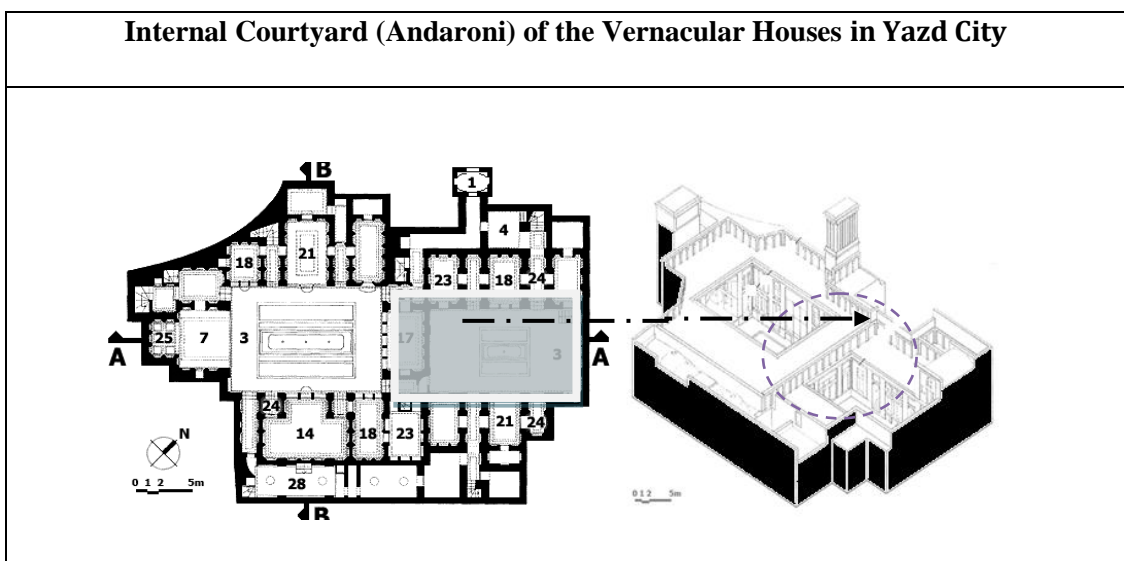


Figure 30: Internal Courtyard (Andaroni) of Gerami House (Ganjnameh, 2004)

3.4.5 Entrance (Hashti)

Main entrance access doors are wooden and have door knocks that have been installed on a pair of rings. The doorknockers are designed so that when women knock, there is very little noise but men use the hammer on the knock to emit a louder noise for differentiation between the sexes (Nosratpour, 2012).

Entrance (Hashti) is a traditional element in the Iranian architecture. Such elements are not apparent in modern built houses. Vestibules in houses of Yazd play the filter role. The function of vestibule entrance into the house is apparent in order to keep the privacy of the house, as this was often paramount. Vestibule is more often than not octagonal or semi-octagonal shaped and sometimes even square. Short roofs and a porch with openings for lighting as well as domed platforms are usually designed so occupants can sit on them. Porch is often separated with one side being for women and the other being for men (Ghasemi, 2004).

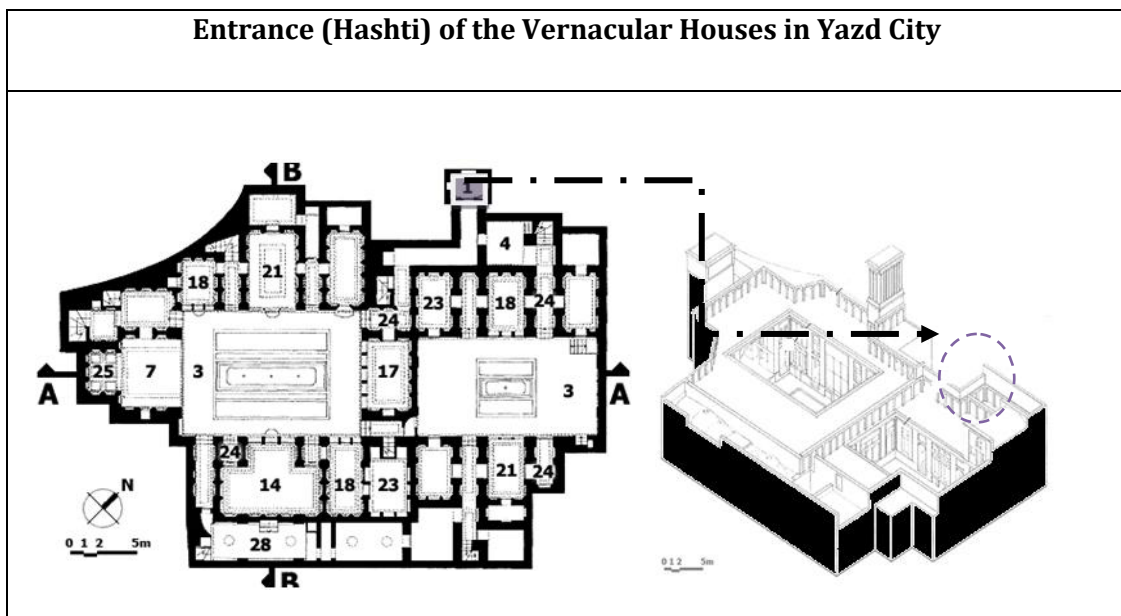


Figure31: Entrance hashtiof Gerami House
(Ganjnameh, 2004)

3.4.6 Corridor (Dalan or Tarme)

It is a narrow corridor that guides the entrant from the porch to the yard. This maze corridor creates privacy and never gives an immediate understanding to the activities that are ongoing in the house. However, Spire of the corridor (Dalan or Tarme) is there purely for the respect of the family so that no person can enter this area of the corridor, which is strictly for the family only (gender separation is not emphasized in this area (Nosratpour, 2012).

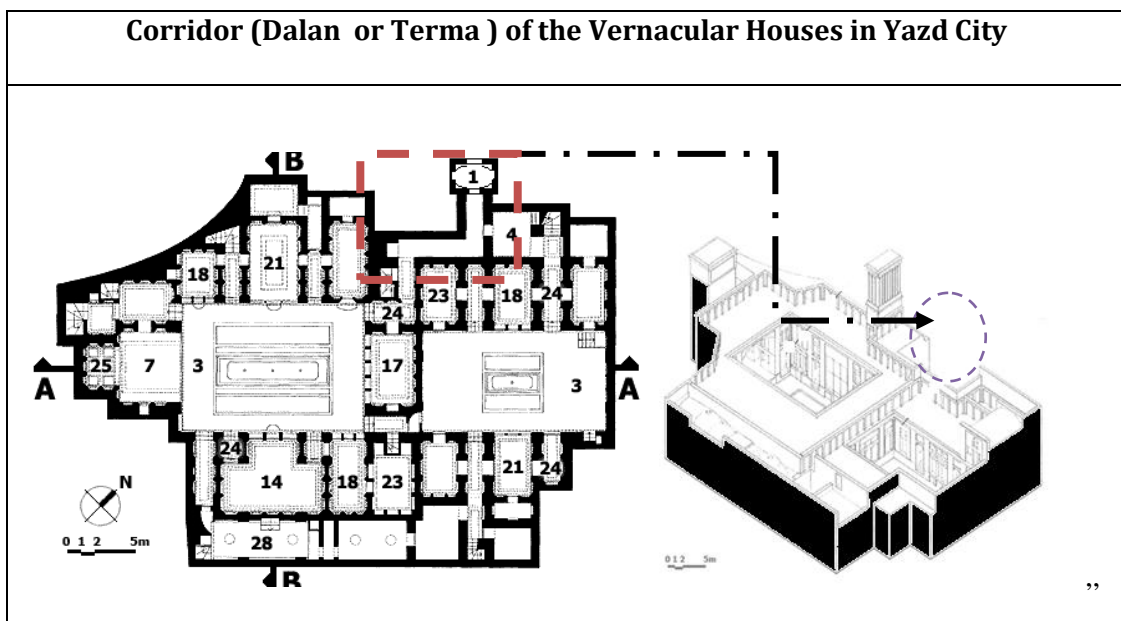


Figure 32: Corridor (Dalan or Tarme) of Gerami House (Ganjnameh, 2004)

3.4.7 Pool and Garden (Huzva Baghcheh)

The pool and garden of vernacular houses in Yazd city which is interrelated to environmental sustainability which explains the courtyards in the vernacular houses of Yazd contain pools and gardens, which are an important element within the houses. Depending on various conditions such as the characteristics of people, cultural, and also environmental factors the pool and the garden is constructed in different forms.

3.4.8 Living Room (Talar)

The Talar is a three-sided wall space directed towards the northeast. The walls, the roof and the walls keep cool and reflect the cool throughout the day. A room is built for public and crowded meetings that is used during the summer and is built towards the Northeast corner. This room is directly connected to the outdoor spaces or courtyards. Next to the Talar or salon, there is a big corridor, which contains a staircase at the end of it that is connected to the basement and the Bala Khane (upper house). In large houses, there is a cross shaped room entitled Tonbi (Place for resting and Sleeping) behind the Talar, near the wind catchers (Pirniya, 1992).

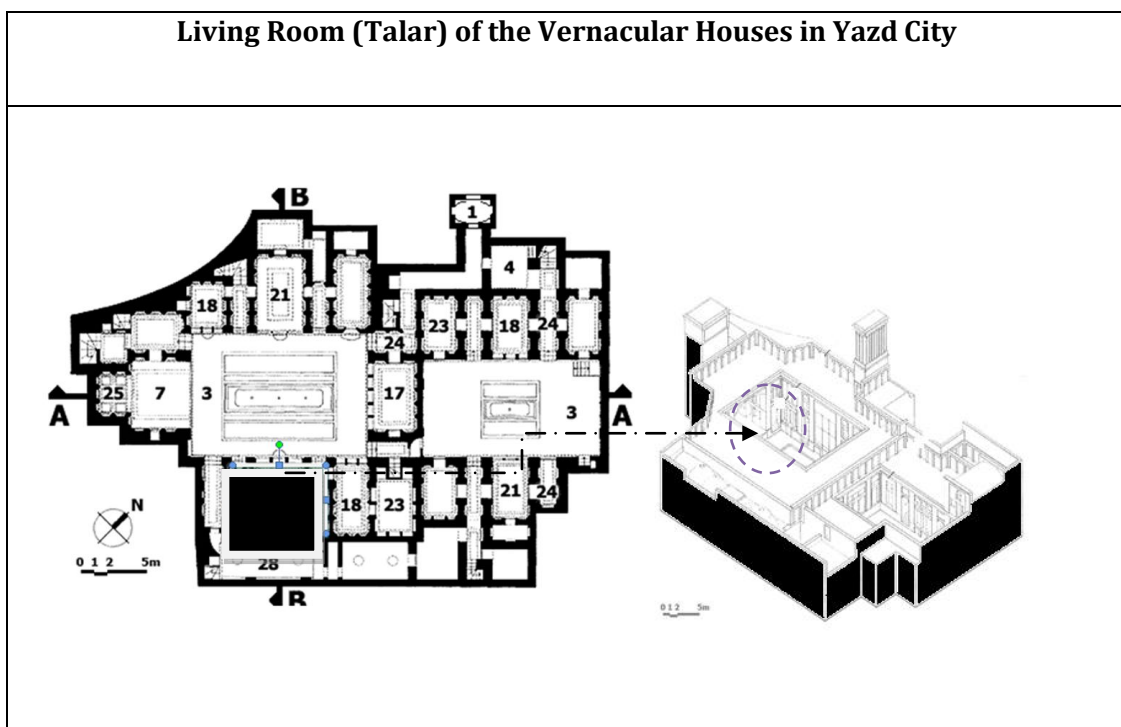


Figure 33: Living Room (Talar) of Gerami House
(Ganjnameh, 2004)

3.4.9 Eivan

Eivan is a half-roofed area surrounded by the courtyard and is regarded as an indoor space between the courtyard and the main building. Patio has an

effect on the spatial hierarchy of the main building from a climatic aspect (Nosratpour, 2012).

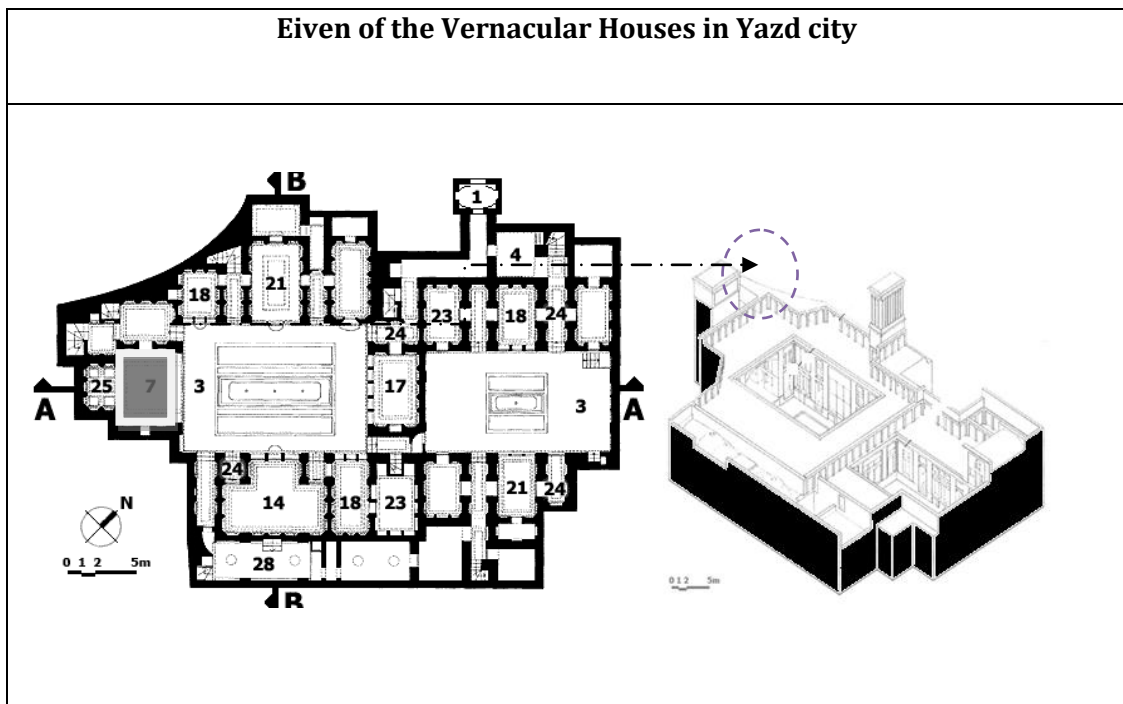


Figure 34: Eiven of Gerami House
(Ganjnameh, 2004)

3.4.10 Seh Dari (Three-Door Room)

This room functions as the bedroom of the house. The idea of the design for such rooms came from the golden ratio, and with these proportions, they achieved more depth and the room is able to absorb more sunlight. One of the main points in the design of these rooms is that the entrances of these rooms are not directly accessible from the outside but instead, they are accessed through corridors. The rooms that are higher from the ground are designated for older people and guests, entitled shah-neshin (King-set room) (Pirniya, 1992).

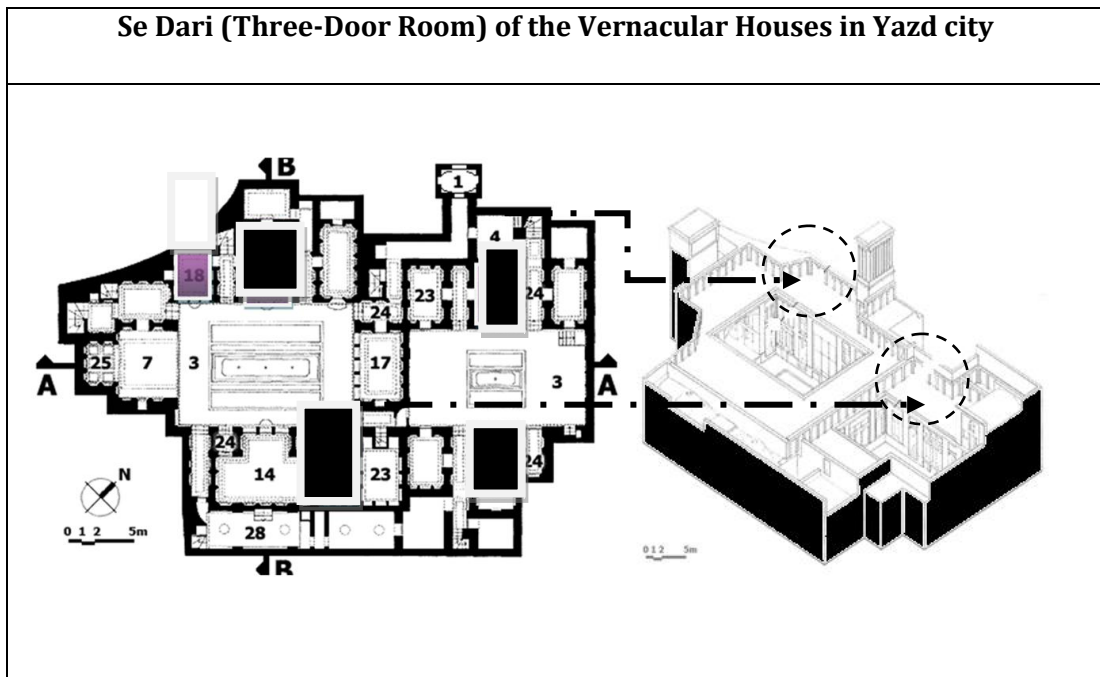


Figure35: Se Dari (Three-Door Room) of Gerami House (Ganjnameh, 2004)

3.4.11 Panj Dari (Five-Door Room)

Panj Dari is mainly used as a guest room but can sometimes be occupied by the house owners in smaller houses. Both sides of this room are facing corridors, which connect the room to the other parts of the house (Ibid, 1992).

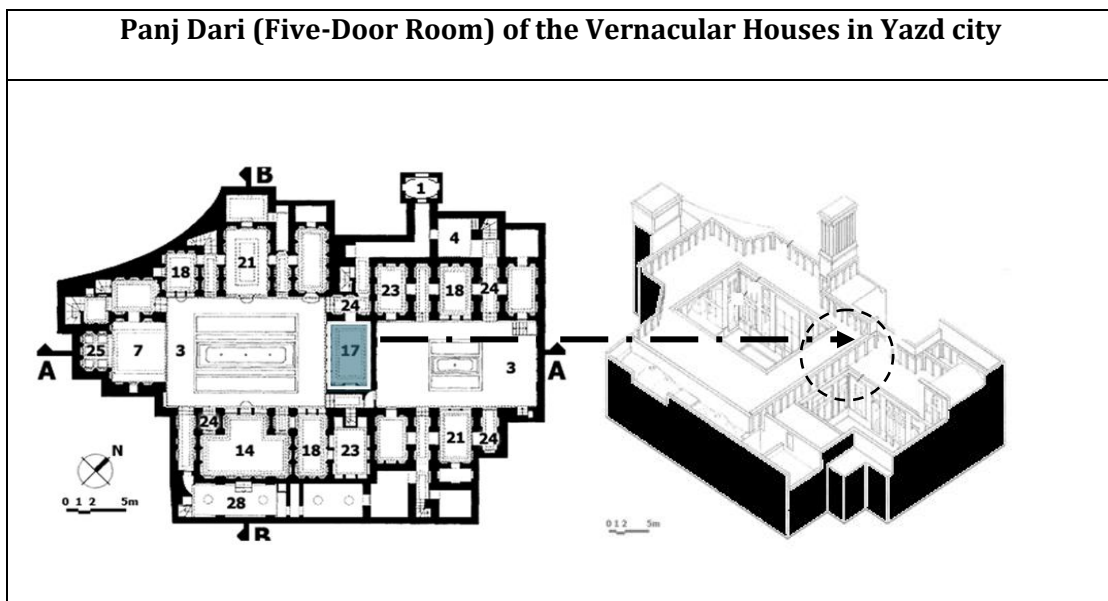


Figure 36: Panj Dari (Five-Door Room) of Gerami House (Ganjnameh, 2004)

3.4.12 Wind Catcher Room (Badgir)

Wind catcher is a facility that helps the air flow through the house. There is one difference between a fan and a wind catcher. A fan creates wind by using electricity but a wind catcher can redirect the already flowing wind through the house. Wind catchers are designed specifically for each family's needs and uses. Without a doubt, the wind volume is related to the entry dimensions, and more height means more wind flowing through the house (Ghasemi, 2004).

It is possible to consider traditional wind catchers as an example of an architecture art. They provide cold internal weather when outside weather is very hot without any energy consumption.

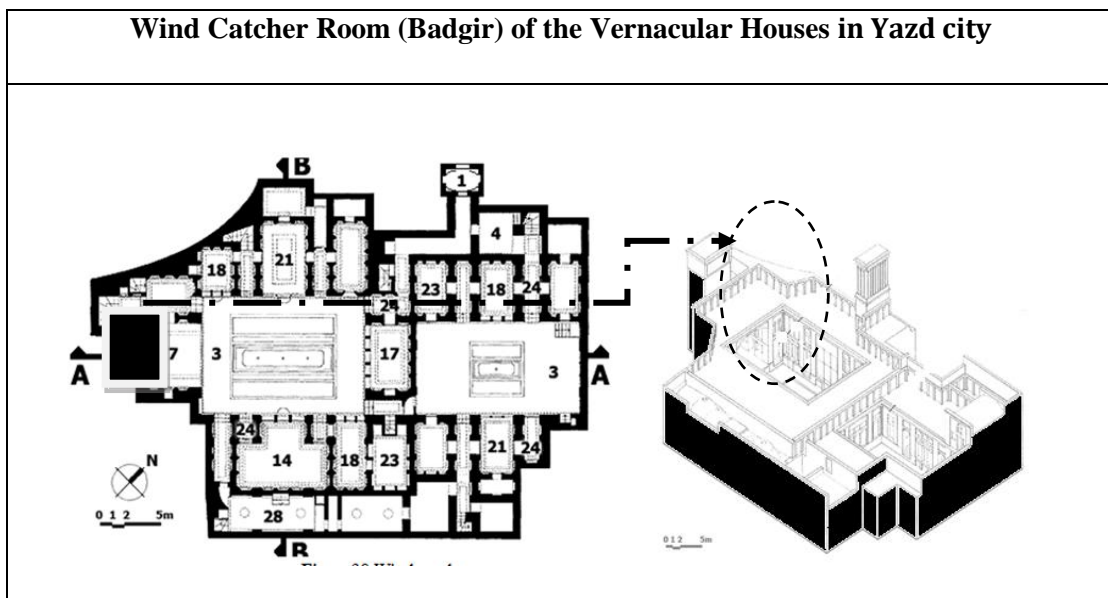


Figure 37: Wind Catcher Room of Gerami House
(Ganjnameh, 2004)

3.4.13 Basement (Sardab and Shabestan)

The basement (Sardab) floor is a multi-functioning room where the Qanat underwater system passes through. It is approximately 60 meters below the surface of the ground. Since the water that passes through it is relatively cold, the basement also becomes cold. The cold air is utilized by attaching an air duct which leads the air to the upper floors. If the temperature were to be examined within the earth wolf, it would be apparent that it is much cooler than that of the earth's surface. It is possible to demonstrate that within a depth of 5 or 6 meters below the earth's surface, the temperature fluctuations during the year is constant. It is possible to use this feature for underground designs. In the past, the architects of Yazd connected wind catchers to the underground rooms in order to circulate the cool air within the house. Moreover, the cool weather underground is distributed by two methods. First, with the help of the heat transfer by replacing cold weather and secondly, heat transfer by the help of distributing the air through the cold walls of the underground (Ghasemi, 2004).

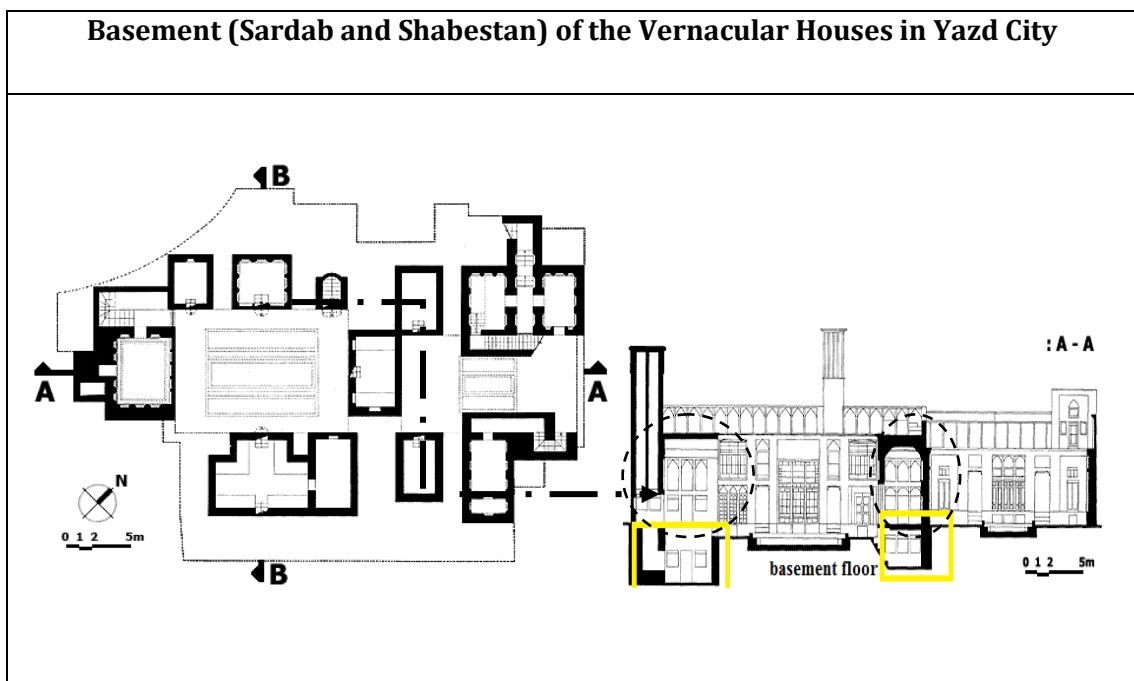







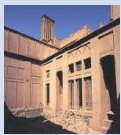








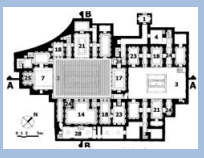
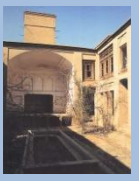
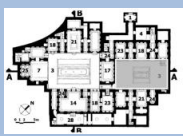

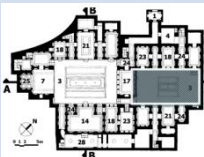

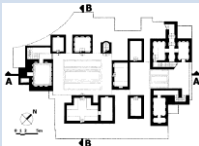



Figure 38: Basement Floor Plan (Sardab) of Gerami House (Ganjnameh, 2004)

3.4.14 Summary

According to the described paragraphs, all the elements of the house have to have a connection and a harmony to the environmental factors of the specific region. Due to the experiences gained by the inhabitants living in this region, the Main Spatial Components of the Vernacular Houses of Yazd have been designed to live in comfortable spaces in spite of the harsh climatic factors. According to the details of the components of the vernacular houses, Entrance door and Entrance (Hashti), Corridor (Dalan), Pool and garden (Huz and Baghche), Living room (Saloon), Eivan, Three door room (Seh Dari), Five door room (Panj Dari), Wind catcher (Badgir), Basement (Sardab, Shabestan) and according to their organization, these spaces have been designed for corresponding and being in harmony with the environmental factors. According to the experiences from the past and the modernism in today's world, improvements have to be made in the design of houses to follow in their footsteps and further develop their innovations. The table below shows the spatial components of the vernacular houses of Yazd (Ganjnameh, 2004).

Table 5: Spatial Components of the Vernacular Houses of Yazd

no	Components of the Vernacular Houses of Yazd	Special Components	Picture of Spatial Components	no	Components of the Vernacular Houses of Yazd	Special components	Picture of Spatial Components
1	Entrance & Hashti			7	Courtyard		
2	Corridors			8	Talar (Saloon)		
3	Se Dari (Three-Door Room)			9	Eivan		
4	Panj Dari (Five-Door Room)			10	Wind Catcher Room		
5	External Courtyard (Bironi)			11	Godal Baghcheh		
6	Internal Courtyard (Andaroni)			12	Basement		

Chapter 4

ENVIRONMENTAL SUSTAINABILITY

ARCHITECTURE OF YAZD

In this chapter, the influence of the environmental sustainability factors of vernacular architecture of Yazd city is explained and how vernacular architecture of Yazd city can be transmitted into today's architecture. However, Sustainable environmental architecture searches to find different ways about the special effects of human effects on the environment. Therefore, Yazd's architecture has many examples, which utilize existing materials within time and defend against the worst conditions while maintaining necessary functionality, good organization, comfort and safety. In many areas of Yazd, the urban and the architectural characteristics point to the specific life approach of particular urban plans (Maeiya, 2009).

4.1 Special Organization of Environmental Sustainable Architecture of Yazd

In Yazd City, traditional builders have considered a sequence of logically different solutions for human comfort many years ago even though it is in a hot and dry climatic zone. While energy use is not taken into consideration in today's world, Yazd example architecture principles and characteristics have demonstrated number of passive design processes by taking into consideration the climatic factors and the characteristics of the weather conditions in the area. Yazd architecture is heavily dependent on the subject of sustainability environment and its compatibility of the

building with its surrounding environment and the community (Movahed, 2009). The following table below is created in order to visualize the analysed issues in relation to environmental sustainability of Yazd city. In this table, Yazd city is analysed in terms of the following environmental sustainability factors: climate, renewable energy usage, water consumption, open space and greeneries, reducing waste and sustainable building materials. For this purpose, the environmental sustainability components in relation to each mentioned environmental sustainability factors are considered. Afterwards, among them, the utilized factors in relation to environmental sustainability of the case study (Yazd city) are selected and put in to this table. In order to explain the reason behind the selection of these particular environmental sustainability factors of Yazd city amongst other factors, each specific factor has been explained and visualized to open up the research issue in detail. Moreover, the spatial organization environmental of Yazd is considered according to the environmental sustainability factors and components itself. It is demonstrated in every space that is related to environmental sustainability. Finally, it is categorized according to special organization and vernacular components of architecture to the case of Yazd city and one by one are being explained for being utilized in the present time. Therefore, the following items are selected as the main spatial organization of environmental sustainability architecture of Yazd city (Movahed, 2009, Maeiya, 2009, Balkema, 1998, Salingaros, 2000, Madanipour, 1996, Jonkers, 2008).

- Type of Plan
- Air Circulation
- Wind Catcher
- Roof
- Pool
- Fountain
- Greenery in Side of Courtyard
- Thickness of Wall

Table 6: Spatial organization of Environmental Sustainability Yazd

Environmental sustainability				
No	Environmental Sustainability Factors	Environmental Sustainability Component	Environmental Sustainability Indicator of Vernacular Houses in Yazd	Spatial Organization of Vernacular Houses in Yazd
1	climate	<ul style="list-style-type: none"> ▪ Temperature ▪ Weather condition ▪ Humidity ▪ Pressure ▪ Precipitation ▪ Ventilation 	<ul style="list-style-type: none"> ▪ Weather Condition ▪ Precipitation ▪ Ventilation 	<ul style="list-style-type: none"> • Type of Plan • Air Circulation
2	Renewable Energy Usage	<ul style="list-style-type: none"> • Wind • Sun 	<ul style="list-style-type: none"> ▪ Wind ▪ Sun 	<ul style="list-style-type: none"> • Wind Catcher • Roof
3	Water Consumption	<ul style="list-style-type: none"> ▪ Drinking Water ▪ Storm Water ▪ Rain Water ▪ Eliminates/Treats Waste Water ▪ Store w\Water ▪ Pools ▪ Fountain 	<ul style="list-style-type: none"> ▪ Store Water ▪ Pool ▪ Fountain 	<ul style="list-style-type: none"> • Pool (HUZ) • Fountain
4	Open Space and Greeneries	<ul style="list-style-type: none"> ▪ Open Space(Green Spaces) ▪ Outdoor Space ▪ Type of Greenery 	<ul style="list-style-type: none"> ▪ Open space ▪ Greenery in Side of Courtyard ▪ Type of Greenery 	<ul style="list-style-type: none"> • Greenery in side of Courtyard
6	Sustainable Building Materials	<ul style="list-style-type: none"> ▪ Type of Material ▪ Easy Transport Material ▪ Thickness of Material 	<ul style="list-style-type: none"> ▪ Vernacular Material ▪ Thickness of Material 	<ul style="list-style-type: none"> • Thickness of Material

4.1.1 Type of Plan

In this plan the vernacular house of Yazd region is being shown. The environmental state has an effect on the design of the vernacular houses of Yazd region. However, the extent and complexities are different according to owner's financial state, environmental influences according climate, renewable energy, and water utilization, Greeneries, decreasing waste and building material verify the sustainability of the house (Khorsand Mashhadi, 2012). Furthermore, The Houses are shaped around courtyards. In central courtyard plan, winter part is positioned in the north direction, summer part in the southern direction and the seasonal part in west and east direction. However, the plan type is categorized according to the courtyard and has thick walls and a minimum of openings. They are built close to one another, shielding environmental factors such as solar radiation and sandstorms. The walls are structurally independent; nonetheless collectively offer thermal shelter from the severe desert sun (Memarian, 2005).

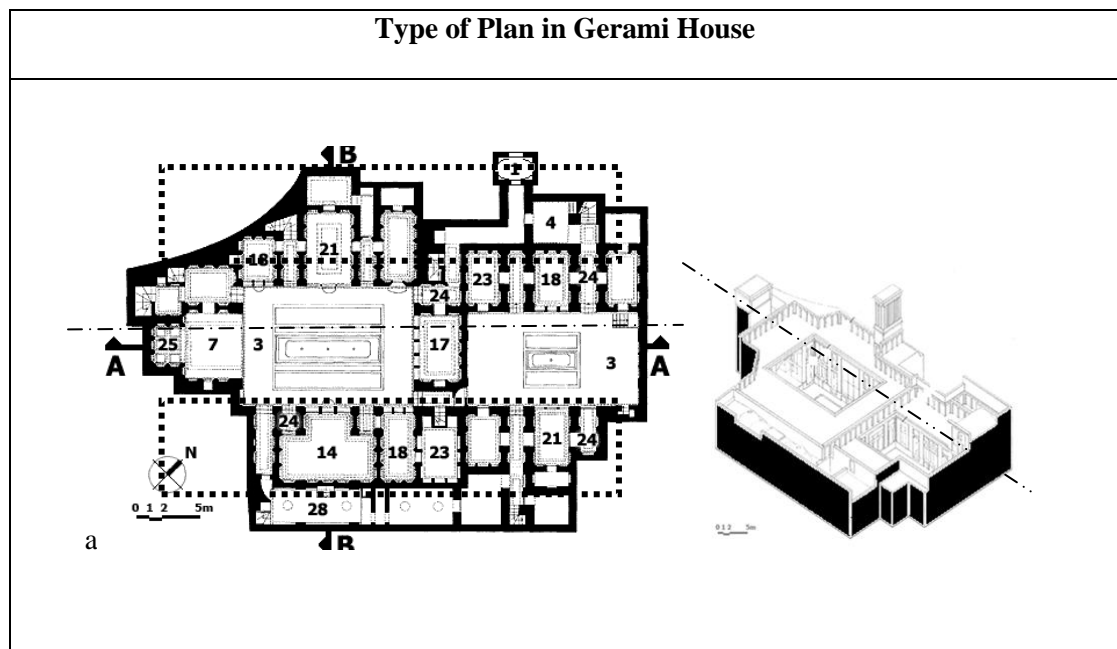


Figure 39: Central Courtyard in Yazd Vernacular House
(Memarian, 2005)

4.1.2 Air Circulation

The air circulation of vernacular houses in Yazd city which is related to environmental sustainability to explain Circulation of air is the function of natural cooling and ventilation elements in a vernacular house in Yazd. The hot and dry air is caught by the high adobe wind catchers and is led into the house. On its way through the long adobe chimney and with the help of the evaporation principle, the air becomes moist and cool. Through the adobe wind canals inside the house, a part of the air is led into the basement and the other part into the summer residence and the courtyard. The first part passes through the basement's adobe wind canals under the courtyard and absorbs moisture from the canal walls. Accordingly, it blows out through the small openings on the surface of the courtyard. The evaporation and the air circulation process cause a more comfortable climate inside the building in the courtyard (Karizi, 2011).

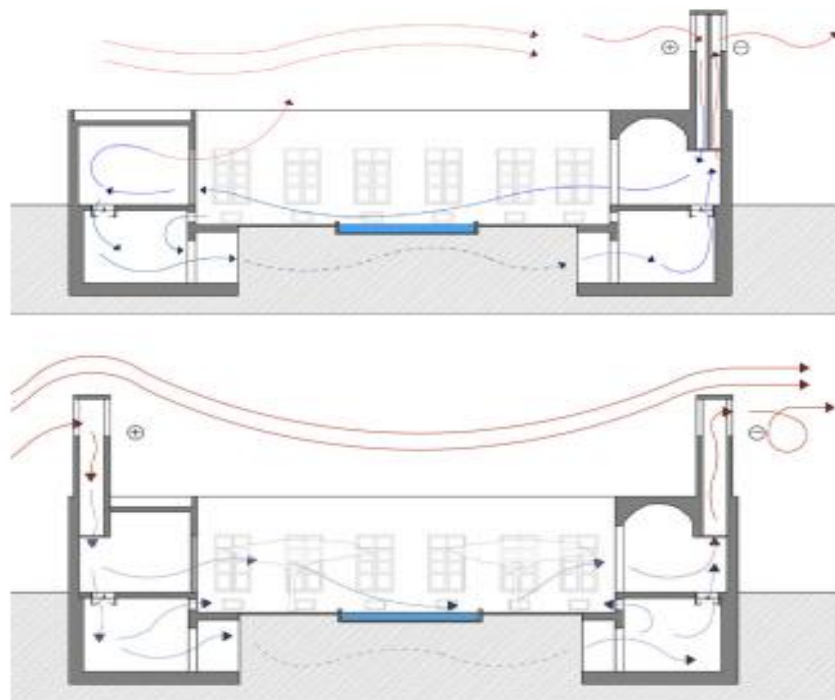


Figure 40: Operation of Two Different Types of Wind Catchers (Karizi, 2011)

The trees in the yard are also an element of the natural cooling system. They provide a better air quality and more shadow in the courtyard. Furthermore, their roots keep the basement's wind canals moist. This fact increases the evaporation process on the air flow in the basement (Karizi, 2011).

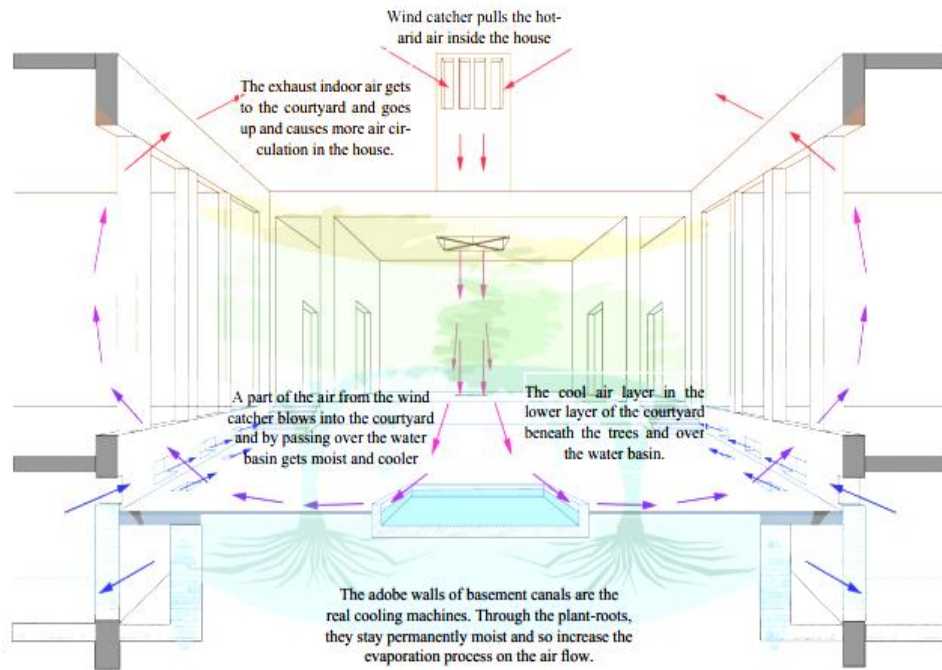


Figure 41: Function of Different Natural Cooling and Ventilation Elements (Karizi, 2011)

4.1.3 Wind-Catcher

The wind catcher of vernacular element in Yazd city which is connected to environmental sustainability to clarify the orientation of the wind tower generally means that the position of the wind tower flank is based on the four main geographical directions. It is determined by its purpose, use of wind power and the desired direction in which the wind blows. There are one-directional wind towers in Yazd which are facing the desired wind direction and in some cases, one directional wind towers draw air and the air flow is reverted back towards the wind to create a negative air pressure to ensure that warm air in interior is blown out of the house. The desired wind direction in Yazd is from the northwest. The long sides of wind

towers are therefore oriented towards the northwest for maximum usage of the wind to provide cooling for buildings (Maleki, 2011).

Moreover, Wind-catchers are environmentally and sustainable energy systems which traditionally have been used in the Yazd city for air circulation and cooling purposes. They are only relying on natural air force to supply comfort and fresh air (A'zami, 2005).

Wind-catchers have been used for four major motives (Roaf, 2005, A'zami, 2005):

1. Air circulation and fresh air for indoor area.
2. Convective cooling in the buildings where the temperature of indoor area is Between: 25-35° C.
3. Evaporative cooling in hot-dry region where the indoor temperatures are upper than 35°C.
4. Providing nighttime cooling.

On the other hand, as the wind-catcher originally was considered in hot area, applying contemporary wind-catchers in supplementary type of climatic situation creates some problems such as heat lost, cold draught in winter and disorganization of the system in hotter times and during time when the wind speed is not enough to run the system (Elmualim, 2003).

Consequently, in designers and engineers are not confident enough to apply wind-catcher in the buildings. The significance of applying wind catchers on the one hand and its limitations in different climatic condition on the other hand reveals the

requirement of further studies in this field. It is attempted in this study to introduce a wind catcher which can be transmitting today's architecture (Ibid, 2003).

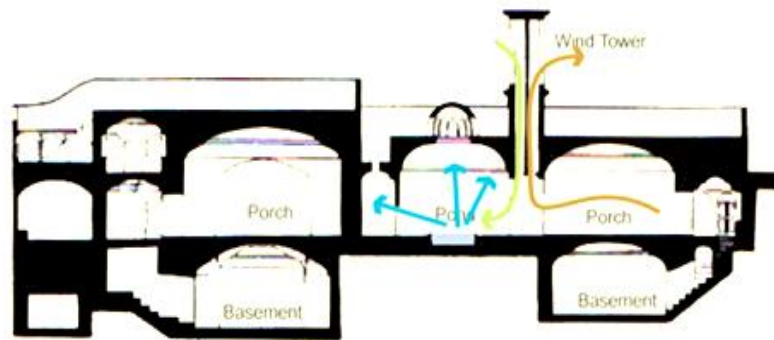


Figure 42: Show Simple Manner in an Air Wind-Catcher Day and Night Time (Bahadori Nejad, 2007)

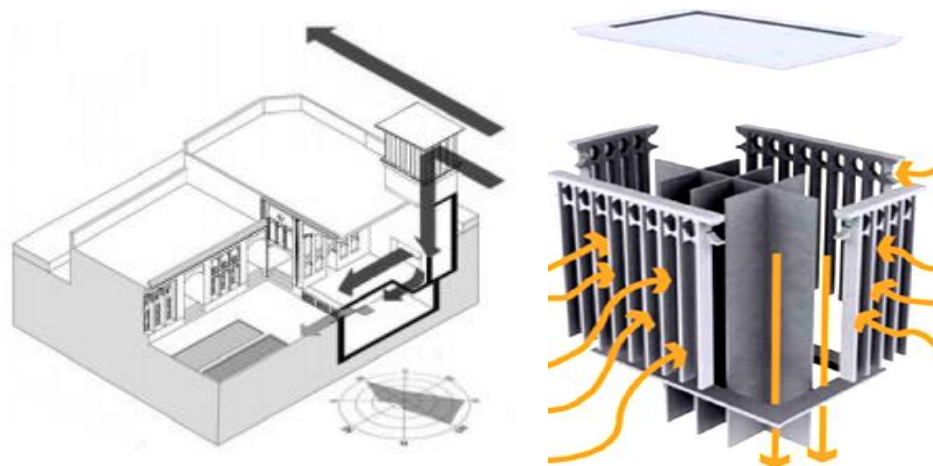


Figure 43: Wind-Catcher (Nasri, 2010)

4.1.3.1 Types of Wind-Catcher

Wind-catchers have several different external shapes and are divided into several categories. Single faced wind-catchers are the simplest kind. They are small and are built over an opening on the roof. It faces the pleasant breeze and cold winds with all other sides being closed off (Bahadori Nejad, 2007).

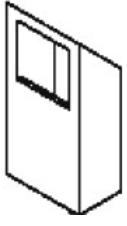

One direction Wind-Catcher	
Interpretation of One Direction Wind-Catcher	Plan of One Direction Wind-Catcher
	

Figure 44: One Faced Wind-Catcher Plan
(Nasri, 2010)

These kinds of catchers are mainly built to protect the building from heavy storms and it is mostly seen in System and in some parts of Yazd. The second type is the two faced wind-catchers. The openings, in this type are in two opposite directions and built with long and narrow windows (Hekmatpanah, 2010).

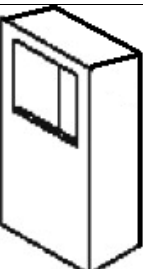
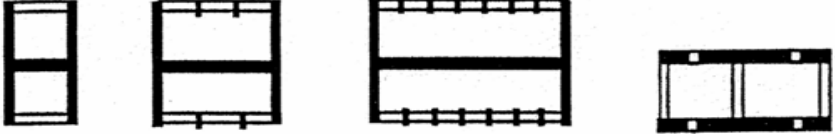
Two direction Wind-Catcher	
Interpretation of Two Direction Wind-Catcher Plan	Plan of Two Direction Wind-Catcher
	

Figure 45: Two Faced Wind-Catcher Plan
(Hekmatpanah, 2010)

The third type, trihedral, is very rarely used. The design of this kind is more complete than those designs of the others. The inside channels are made of small rows of bricks or plaster divided into several parts. In some cases, at the bottom of

the catchers, there is a big pool that decreases the overall temperature and absorbs dust, which provides a graceful condition for the occupants. These types of catchers are mainly built in Yazd (Bahadori Nejad, 2007).


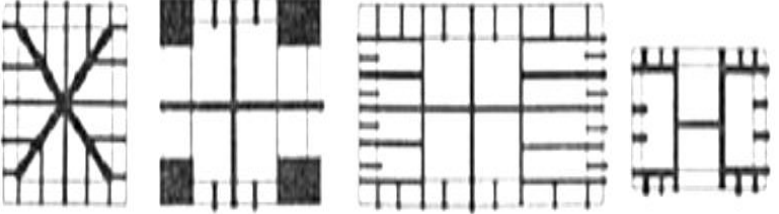
Tetragonal Direction Wind- Catcher	
Interpretation of Tetragonal Direction Wind-Catcher	Plan of Tetragonal Direction Wind- Catcher
	

Figure 46: Tetragonal Wind- Catcher Plan
(Hekmatpanah, 2010)

Consequently, Mechanical cooling systems in buildings are the major manufacturers of carbon dioxide productions, which have negative forces on environment and increase universal warming, mainly in hot-dry environment. Due to the lack of energy supply, wind catchers can be used as an environmental sustainable challenge for cooling and air circulation reasons.

4.1.4 Roof

Flat roofed buildings are constructed in this region and arched roofs are not considered. The reason is that it is a common tradition to utilize the roof by sleeping on it where cool winds always blow. There are of course some safety measures that are put into place to avoid onlookers from seeing the occupants lying on the roof.

Shelters and walls are constructed that have grid-type openings to minimize obstructions and maximize privacy. The roof of semi open areas acts as a vast insulation and they don't permit warm air to come inside effortlessly in Yazd vernacular houses. (Ghobadian, 2006). Roof is covered with flat clay shaped like an arch. This is achieved by laying wooden beams on either side of the wall approximately thirty cm from each other then they are covered with mats. After the lengthy process, they are all coated with clay plaster. The wooden beam must be smooth as possible and should be treated against bugs, termites and other pests that are attracted to wood. There is a major problem with such structures, which is the fact that they are not earthquake resistant which can be a safety concern (Shohouhian and Soflaee, 2005).

For water reservoirs, bazaars and mosques, dome shaped roofing is used. It is effective in dispersing heat due to its convex shape. The shape alone naturally causes there to be an unbalanced surface on the roof, which is a perfect way to create a constant shade on a part of the roof throughout the day. That is the reason to why a dome-shaped roof is a very effective type of roofing to use for bazaars, mosques and reservoirs. As mentioned above, when flat roofs are constructed, they are usually square brick paved to alleviate the suns radiation intensity and the angle (B. Ahmadkhani, 2005).

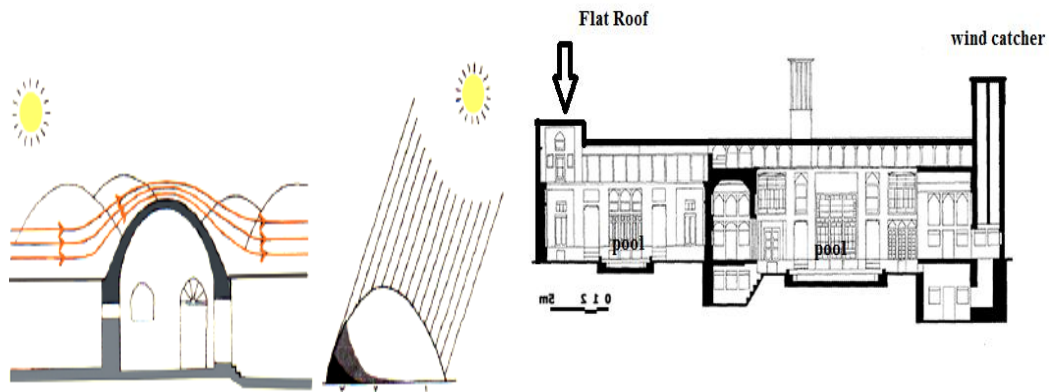


Figure 47: The Domes Roof and Flat Roof
(Ahmadkhani, 2005)



Figure 48: Theses Rooms Using Arch Roof and Flat Roof
(Ganjnameh, 2004)

4.1.5 Pool (Hoz)

Pool (Hoz) is a kind of pool unlike its western counterparts. The characteristic of Hoz is Persian tradition design for ventilation and decoration that shows the quality of life of house owner. The pool has to be built at the center of courtyard must be designed indirection of the summer wind. Pool has a main Persian tradition characteristic and due to the limitation of water, the occupants can also use it to store ground water for temporary usage. A huge central water pool and resistant trees such as pomegranates and grapes keep the atmosphere moist and calm.

Moreover, the courtyard is a great place for human interactions with nature and its elements such as water. In cases where the subterranean canal is not passing too deep underground, other patterns appear. Occupants place pools in the middle of their houses; it is often thought of as the symbol of Heaven on earth. The still and stagnant water pools reflect the sky and it's a place where the depths and beauties of the infinite sky are displayed on the ground. The still and resting water omits the boundaries between the sky and the ground. The reflective silence and the still gathering of water in these pools have ambiguous secrets like a meditative spirit has penetrated them from the nature (Mor, 2002).

These pools are often shallow so that they can be extended and their water surface increased without too much water. Pools often almost occupy the biggest area of the courtyard. In some cases, pools divide the direct route to the main porch (porch) of the construction into two indirect lateral and side routes. In the warm climates, pools are often made in two sections and which reside in the inbound and the outbound routes so that the wind passing above the water of these pools may provide a cool and a desired condition for the residents in warm summer days (Nayebi, 2002).

Plan and Section of Pool in Gerami House

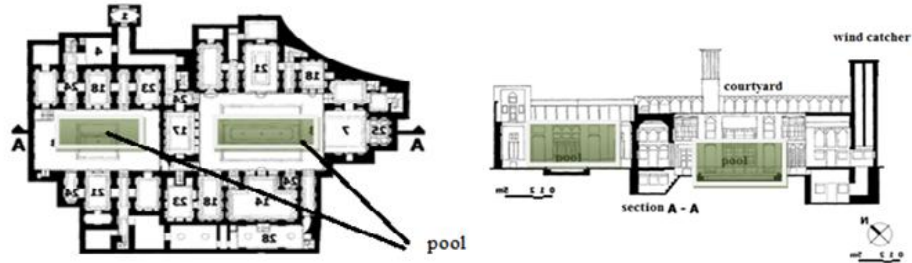


Figure 49: Pool in Gerami House
(Ganjnameh, 2004)

4.1.6 Fountain

Fountains have three main rules and functions in Yazd courtyards. Firstly, they have an effect on the static building characteristic, for instance, as a decorative element. Secondly, they can convert the summer wind into a cool wind briefly with the combination of the water spray caused by the fountain. It is particularly useful to place a fountain under a wind catcher. The breeze will ventilate and circulate within the indoor spaces to help decrease the overall temperature of the building. However, most fountains are usually located at the edge of the courtyard so this way the dimensions may be doubled. In the vernacular houses, fountains were constructed proportionally with the dimensions of the courtyard. Fountain in the vernacular houses had various shapes and forms (Tofan, 2006).

The function of a wind catcher is basically a method of utilizing the wind to flow in through the building and suck out the hot and polluted air. Dry weather that wind tower receives passes through the fountain where it becomes cooled by the principles

of evaporation and flows into the room. Below shape shows the path of the wind flow of a wind catcher.

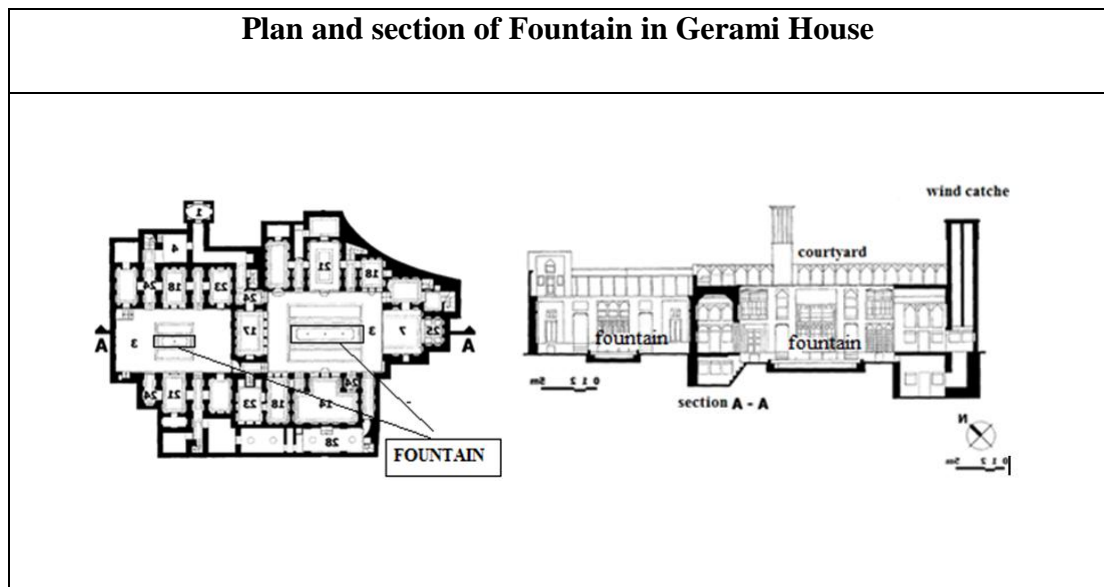


Figure 50: Fountain in Gerami House
(Ganjnameh, 2004)

4.1.7 Material Building in Yazd Architecture

Hot-humid regions are constructed with different materials. The materials used usually contain a lower thermal mass which helps dissipate heat quicker. Wood is a great example of such material but due to the lack of the natural resource, they were only used for more necessary areas such as the frames of the roof, windows and doors. However, other parts of the structures were built using some local material including brick, baked brick, Marine coral, stone and adobe. Such stones and materials are porous which a great thermal insulant is (Shohouhian and Soflaee, 2005).

Local materials should be used where possible and to further the cause using materials that do not require many non-renewable products should be a top priority. If materials are extracted with more labor being consumed rather than energy, it becomes more sustainable and easier to use and distribute. Materials used such as

mud and clay only require manpower which is labor intensive. Earth materials such as mud, soil and clay do not pollute the world and do not put a strain on the environment. The materials are always close by which eliminates the cost of transportation. Until the later stages of the industrial revolution in the nineteenth-century, settlements were constructed largely from building materials obtained close to the site (Abasi, 1996).

When buildings are no longer needed or wanted, the rubble left over from them blends into the environment without any pollution since they were a part of the environment in the first place. The sod or earth roof has a long history reflecting the value of soil and turf as shelter from heat, cold and rain. The earth roof still has great potential in future urban centers of the developed world where it forms a valuable open space in dense developments; it can improve air quality, modify the microclimate, retain rainwater and provide the base for urban agriculture (Soflaee, 2005).

4.1.8 Thickness of Wall

In the hot and dry region, thickness of the wall plays a significant role in the comfort factor of a building. In the city of Yazd, walls are constructed from adobe and brick, which is about 1 meter thick. This thickness can create a comfortable living space for the inhabitants. The reason is that adobe and brick materials can dissipate heat very quickly and during the night, this is exactly what happens. Consequently, the materials temperature remains persistent throughout the day, as it does not absorb much heat during the day. Additionally, the city walls are required to be thick in order to support the heavy dead loads of these vaults and domes. The thick masonry walls work as a very good thermal mass and minimize the day and night

temperature variations between the outer and inner parts of the buildings (Memarian, 2006 and Pourvahidi, 2010).

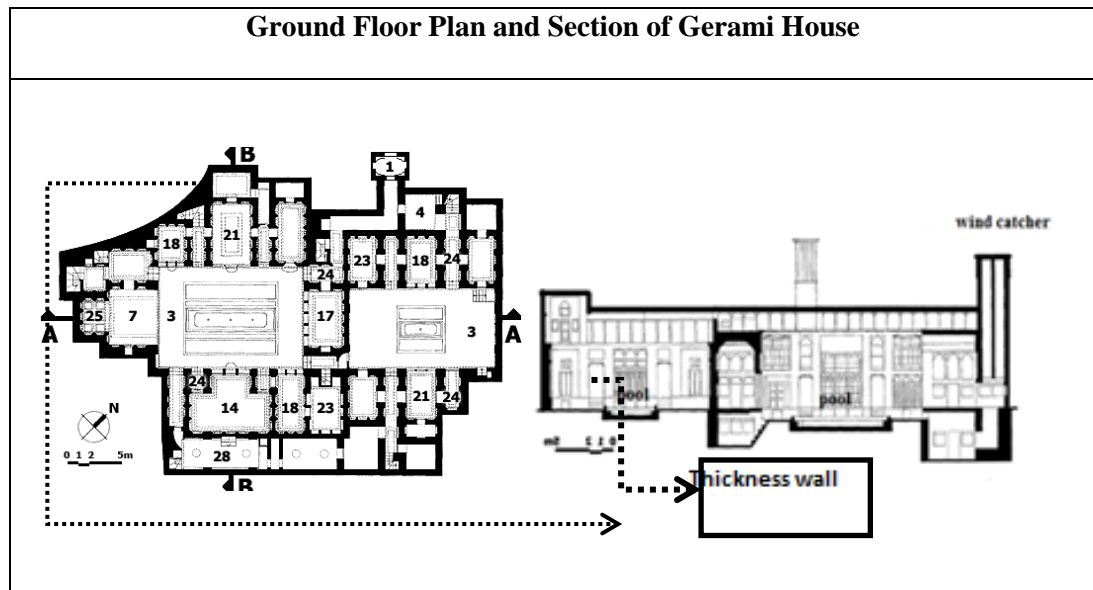


Figure 51: Ground floor Plan and Section of Vernacular House in Yazd (Memarian, 2006)

4.1.9 Summary

In this thesis, residential architecture of Yazd city is a sample of environmental architecture. Vernacular architecture in hot-dry area is in accordance with area and regional factors such as desired, undesired winds and sun. planning each of the full and empty spaces like courtyard, surrounded rooms, wind catcher room and pools, fountain , basement and roof is for special hours of day and night of cold-average and hot season. However, architectural and constructional fields are planned in a way to have maximum of sun radiation during winter and maximum of shade during summer to use natural ventilation and comfort for the house residents. The vernacular house of courtyard with indicators like thick wall, porches, underground, wind catcher, roof (dome and flat), pools, fountain and air circulation (direction of

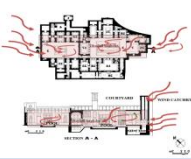
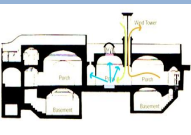
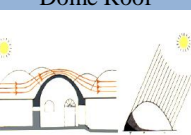
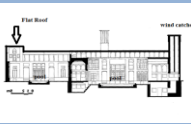


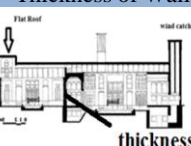
house), are clear examples of architecture understandings of environmental condition in Yazd city.

Moreover, In this region the creation of courtyard in the middle of building, making pool, fountain and flower increases humidity in building environment and the materials of wall such as brick and mud-brick, which are made thick, due to heavy weight of arched and dome and flat roof, acting like a thermal condenser, decrease the variance of temperature during day and night for human comfort in hot-dry area.

The most important vernacular architecture components that are related to the environmental sustainability factors have been selected and the details of each component have been explained briefly and have been developed in order to utilize the natural resources without needing any excess electrical resources. With the growing success of technology in today's world, architects can solve many of the basic problems that were once difficult and continue to use and incorporate their solutions into today's architecture.

The table below consists of environmental sustainability factors, special vernacular organizations of Yazd, vernacular components of houses and recommendations so it could be used as a way to solve all these components and can be developed in today's architecture.

Table 7: Environmental Sustainability Components of House Yazd`

Environment Sustainability		
no	Environmental Sustainability Factors	Characteristic of Vernacular Architecture in Yazd City
1	Climate	<p>Air Circulation and Ventilation</p>  <p>The courtyard is a special space with an environmental function. The importance of placing that considering the wind direction. It can be used in summer time for inhabitants to be comfortable inside the vernacular houses.</p>
2	Renewable Energy Usage	<p>Wind Catcher</p>  <p>The base of action is that wind blowing is used to suck the cold air to the inside of building and the reaction of it is used for sending out the hot and pollutant air from inside the building.</p>
		<p>Dome Roof</p>  <p>Dome roof and flat roof due to having convex and unstable surface the effect angle of sunbeam on doom and arch roof. However, Remains in shade during morning and afternoon times, for this object the curved form is suitable for releasing and releasing waves during night and supports to the night cooling and flat roofs are capable of saving energy during the daytime and night time.</p> <p>Flat Roof</p> 
3	Water Consumption	<p>Pool (Huze)</p>  <p>Use of pools to help cooling and air circulation of the environment especially for hot and dry climatic.</p>
		<p>Fountain</p>  <p>Fountain to cool down the heat, meanwhile the water of Fountain is cycling and changed the environment temperature during the summer time</p>
4	Sustainable Building Material	<p>Thickness of Wall</p>  <p>Use of material by considering the isolation in order to protect the building such as hot and cold focused daytime and nighttime.</p>

4.2 Discussion

As mentioned in this thesis, Yazd region is based significantly on environmental architecture. Courtyard plans, roofs, high ceilings and large walls of summer parts, low ceilings and small walls of winter parts, pools and basement spaces and material that provide natural ventilation, shading areas and indoor environment comfort for inhabitants.

Yazd city is built with consideration of the hot and dry characteristics of this region with regional factors taken into account such as undesired winds, sun and have affected the planning of each space whether it is full or empty, such as the court yard with tall and shaded walls, enclosed spaces, porches, rooms facing different directions, corner rooms with wind-catchers and ponds, basement and the roof which is meant for special hours of the day and night (for both cold and hot seasons). In addition to this, all vernacular buildings of Yazd, both in the architectural and in the constructional fields, are planned in a way that utilize the maximum amount of sun radiation during winter and have the maximum amount of shade during the summer periods in order to exploit the natural ventilation properties and to provide peace and comfort for the occupants.

The previously used construction materials and common techniques had high maintenance costs, energy storage and the potential of temperature balance in the constructed buildings which were heavy compared to the relatively low weight of construction materials used today. The vernacular materials and techniques were utilized for the sustainability factor of the buildings and also in the main load bearing

elements of buildings such as walls and ceilings or to be more general, the vertical and horizontal elements of the buildings.

It is worth mentioning that in the construction of sustainable buildings, only a very small amount of the buildings built are incompatible or inconsistent with the surrounding natural environment of the region and the country. Construction techniques are put in place in order to provide the highest quality and achieve a higher degree of economic, social and environmental conditions.

Therefore, in order to inhibit the buildings from using high amounts of energy, buildings are constructed in a way that uses natural resources for maximum sustainability and efficiency. Not only using natural resources is saving energy, but it also results in having a better, more technical, scientific and aesthetically pleasing buildings. Undeniably, the overall objectives of sustainable buildings can be the issue, which are the proper utilization of resources and energy, preventing pollution and complying with the surrounding environment.

According to this section, vernacular architecture of the Yazd region and the features that have an effect on the design characteristics of environmental factors such as climate, renewable energy usage, water consumption and sustainable building materials could be good steps to follow for contemporary architecture. with the collection of important vernacular architecture components (air circulation and ventilation, Wind catcher, roof, pools, fountain, material, thickness) compared to environmental sustainability, these factors can be used and geared towards today's architecture. There are some positive and negative explanation these factors have that

can be solved with the aid of science and technology and due to the perseverance and efforts of architects that strive to live comfortably in the Yazd region.

Moreover, the air circulation of vernacular houses in Yazd city which is connected to environmental sustainability to clarify Circulation of air is the function of natural cooling and ventilation elements in a vernacular house in Yazd. According to the science and knowledge of people in the past, the vernacular houses were built in a way so that protected in cold winters, hot summers and harsh weather due to the geographical location they were in. According to the orientation (direction of the houses) and the design, vernacular houses were built in a way that had harmony with the environment.

Furthermore, Wind-Catchers are environmental and sustainable energy systems for air circulation and cooling purposes. However, wind catchers have several benefits that among them are ventilation and cooling and act like air conditions. There are some disadvantages as well that includes bringing dust inside the house that makes it unusable in winter but due to the improvement of technology in today's architecture there should be a way to make it usable in the winter time.

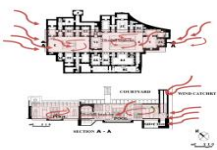
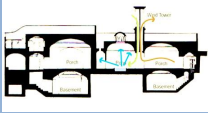
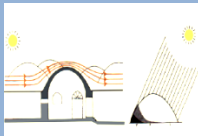
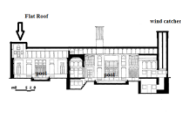


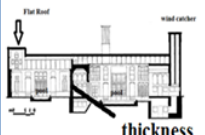
According to the shape and form of roofs in vernacular Yazd houses, the shape and the way the arches were built was the reason that heat wouldn't come into the houses and were resistant towards earthquake. The shape and the way they were built should be developed in modern and new houses.

However, the characteristic of pools (Huz) and fountains is Persian tradition design for ventilation and decoration that shows the quality of life of the house owner. Due to the science and technology pools and fountains should be controlled in a manner that in hot-dry climates these pools and fountains could create a comfortable and easy to live in summers and winter time.

Thickness of the wall plays a significant role in the comfort factor of a building. The disadvantages are the thickness, heaviness and not being economical. These problems have to be developed and its isolation techniques have to be made usable in today's architecture.

Due to the progress and improvement of technology and science the positives and negatives of vernacular architectural components of Yazd could help for a path towards environmental sustainability architecture.

Table 8: Positive and Negative the Environmental Sustainability Components of House Yazd

Environment Sustainability				
No	Environmental Sustainability Factors	Special Organization of Vernacular Houses Environmental of Yazd	Positive of Components Environmental Sustainability	Negative of Components Environmental Sustainability
1	Climate	<p>Air Circulation and Ventilation</p> 	<p>1.orientation of houses that considering the wind direction specially summer time cold winter time hot indoor spaces</p>	<p>1.It needs large space to organize indoor and outdoor courtyards</p>
2	Renewable Energy Usage	<p>Wind Catcher</p> 	<p>1.Cold inside of the house during summer time 2.dont need to electricity</p>	<p>1.Dust and animal going inside of house 2. Winter time it's not useful</p>
		<p>Dome Roof</p> 	<p>1.save energy 2.Control heating and cooling during summer time and winter time</p>	<p>1.Need to space 2.its not useful to the apartment 3.cannot use other flat</p>
		<p>Flat Roof</p> 	<p>1.Radiation sun 2.Thermal heating and cooling</p>	<p>1.its not save energy (Heating and cooling) 2.during summer time to much hot and winter time too much cold</p>
3	Water Consumption	<p>Pool (Huz)</p> 	<p>1.cooling the hot-dry climate 2 circulation weather during summer time</p>	<p>1.During winter time it's not useful 2.It's hard to cleaning that related to the vernacular houses specially pool (Huz)</p>
		<p>Fountain</p> 	<p>1.Placing fountain to cool down the heat 2.the water of Fountain is cycling and no need for new water consumption</p>	<p>1.During winter time it's not useful</p>
4	Sustainable Building Material	<p>Thickness of Wall</p> 	<p>1.considering the isolation in order to protect the building</p>	<p>1.Its too much heavy 2.costly 3.not suitable for new technology and structure</p>

Chapter 5

CONCLUSION

In this thesis, the sustainable buildings should be designed in a way to be able to use the local climatic and energy resources. The recent case studies indicate that the uncontrolled growth of Yazd is a traditional and a modern challenge of urbanization. The most important factor of these challenges is the distorted and the unbalanced developments of the urban and the spatial dissociation of the city. Abandoned lands in the city boundaries, the proportion of poor urban concentration, lack of compatibility with the geographical situation, reductions in the security and safety of the suburbs, increasing costs and cost-effective urban transportation facilities and a lack of infrastructure in some parts of the city exist.

The most important issues that are considered are things that resulted in these problems, which are the improvement of incompatible elements of nature and the environmental factors such as climate, renewable energy usage, water consumption, sustainable building material, reducing waste and open space or greeneries as well as ignoring and forgetting vernacular architecture that is compatible with the regional climate of every region. The effect of the development stages of Yazd city on the urban pattern of this city have been analyzed in different historical periods.

The traditional and modern urbanizations are not only in conflict with each other, but they are in the process of achieving sustainable development and localization of

complements unlike some of the engineers and architects. Furthermore, there are a lot of sand storms because of the desert-like location in the area. Flat and domed roofs are one of the solutions applied in Yazd city.

In a vernacular house, the usage of natural resources as well as energy is one of the principles of architectural designs regarding their construction and spatial organization. Other characteristics of the old houses in the deserted region of Yazd include, being mainly located in the direction of Qibla (direction of prayer for Muslims). The orientation of the climatic conditions has created spaces for summer rooms in the house. The courtyard is enclosed from all sides with the help of the indoor spaces, and the cool night air is saved in the pit and is utilized during the hot summer days.

Moreover, the studies made in sustainable architecture and courtyard along with their role in the sustainable architecture of Yazd, it can be concluded that today, they should prepare a strategy to renew the yards, pools, gardens and equip and supply the same cells and take advantage of vernacular architecture. Perhaps one of the biggest decisive components of the environmental conditions should be reviewed and evaluated based on experience, in order to form stable structures.

The other significant point for a suitable utilization of energy and sustainable architecture is a yard design with the pool in the center. Although, the central yard has resulted in the better utilization of wind flow as well as building single layered walls, the best ventilation performance would be achieved by opening the windows

that are facing the yard and the alleys. In this type of width ventilation performance, the heat concentration and the humidity decrease.

In this research, the findings are a proposal for the new buildings that are matched to the environmental sustainability and also transmit vernacular architecture into today's architecture in the city of Yazd; Orientation of the houses such as air circulation , Wind catcher, Roof structure, Pool, Fountain, Material and thickness of Yazd city.

In conclusion, vernacular architecture of the Yazd region and the features that have an effect on the design characteristics of using natural energy sources and environmental factors could be good steps to follow for contemporary architecture. Entrance (Hashti), Pool and Garden (Huz and Baghche), Living room (Saloon), Wind catcher (Badgir), Basement (Sardab, Shabestan) and also natural material are the considerable specifications needed in hot-dry region in comfortable indoor spaces. With the arrival of modern architecture and the utilization of mechanical facilities, the role of climatic conditions in the buildings has become very important.

However in today's world, with a lot of attention towards the climate and the environment, environment friendly technology related to architecture and with the utilization of pure energy such as solar energy, wind and water, broader range of sustainability in our constructions can be arranged. From this revolution, in the architectural field, environment and climatic conditions play an essential role in building design. Moreover, it should be mentioned that the subject of environmental sustainability issue should be considered regardless of the effects of today's

limitations and struggles with the issue. Therefore, to achieve better results, appropriate training and awareness is essential in order to benefit from the advantages of environmental sustainability architecture and to be able to utilize it universally.

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APPENDIX

Appendix A: List of Local Terminology

1	Orusi	Colorful Small Pieces of Glass Between the Beautiful Wood ties
2	Badgir	Wind Catcher
3	Eivan	Semi-Closed Space that is Blocked on Three Sides with an Opening to the 4 th Side that is Located on the Edge of the Courtyard or Veranda
4	Seh Dari Room	Spacious Room that has 3 Windows.
5	Panj Dari Room	A Larger Area with 5 Adjoining Windows
6	Tarme	Corridor
7	Hashti	Entrance, Vestibule
8	Talar	Balcony, Semi Open Space which is Located in South Part of Courtyard
9	Godal-Baghcheh	Deep yard Located at the Center of the Main Courtyard of the House. Its Depth Usually One Story.
10	Shabestan &Sardab	Basement Spaces which are Equipped with Small Pool in the Middle