Review

A comparative study of urban spaces of hot and arid areas with the principles of sustainable urban design (A case study: City of Yazd)

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Abstract : The concept of sustainable development seeks solution for the current environmental, economic and social crises in local or global levels. The important point is that the goal of sustainable development is creating and forming a particular social, economic behavior towards the nature which protects the life of environmental and natural systems for the next generations. In fact, sustainability in not a state to reach ,but an effort we should move towards . Therefore, it can be stated that sustainability is an attitude and a process. The ancient architecture of Iran is a chain of experiences and values which have been passed from person to person during thousands of years by artists, architects and people.

The match between Iranian buildings, towns and villages with social, cultural ,religious and environmental condition has made it possible for Iranian architecture to always meet the material and spiritual needs of the society. Hot and arid climate is one of the four climates found in Iran and the city of Yazd is the most outstanding sample the design of which can clearly depict spatial characteristics of an ancient Iranian city in a hot and arid area ,although the city has undergone significant structural changes since 1340s.

The present study aims at investigating the characteristics of residential spaces in hot and arid climates and compare them with the principles of ecological sustainability .

Keywords: Hot and area -the parameters of sustainable development- ecological characteristics, texture compression, human scale, usage overlap.

Introduction

Having a vast geographical area, Iran benefits from four climatic condition.hot and arid climate covers many parts of the country and is home for a large number of people; that's why the present study has aimed at investigating this climate. Yazd is a significant sample of this climate and unique compatibility of this structure with the geographical conditions of that area has helped the city to survive during the history.

Some researchers in the field of architecture have conducted some research studies on the city of Yazd and generally on hot and arid climate. The results o f these studies can be found in some books such as "Architecture and city construction in Iran's hot climates" by Mahmood Tavasoli. Furthermore, there are numerous books and articles focusing on sustainable development. However, there are few studies an investigating the compatibility of the city of Yazd in general and the architecture of residential buildings in specific ,with the principles of sustainable development. To this goal, the present study concentrates on the recognition of the principles governing the ecology of Yazd and presents some information about hot and arid areas of Iran and the architecture of residential buildings in this city.

The investigation of the city shows how compatibility with nature can be achieved by respecting the principles of sustainable development. The present research study shows although sustainable development seems a new concept , it has always been observed in sustainable architecture during history, and Yazd is not an exception from this rule.

1. Investigation of different climates in Iran

Considering the specific geographical situation of Iran and its diverse environmental conditions, the country is divided into 4 different climates ,as follows:

a. southern shore of the Caspian sea (fine and humid)
b. northern shore of Persian gulf and Oman sea(hot and humid)
c. mountainous areas and highland plateau (cold and arid)
d. plateau plains (hot and arid)

The present work investigates hot and arid climates and the principles of design in these areas and a case study of it (the city of Yazd).

2. The city of Yazd and its specific significance

Geographical characteristics of Yazd, historical characteristics of it and some reasons for selecting this city are the most important issues to be discussed.

2.1. Geographical characteristics

Yazd is located in central Iran, in central mountain ranges of the country. This province is a neighbor with Isfahan from north and west, and is neighbor with Khorasan from north-east , from south-west it limits to Fars province and its south-Western neighbor is Kerman.
Yazd province includes approximately 4/37 percent of the country.
Being located on the world's Arid belt, Yazd province has cold and quit wet winters and hot and long summers.
Based on the census in 1375, the population of the province is 750769 people. 75/15 percent of this population live in urban areas and 24/85 percent live in rural areas.

2.2.Hhistorical characteristics

Yazd is the first adobe city and the second historical city after Venice in Italy. These two characteristics are enough for Iranians to be proud of having a country as old as the history of the world and a city like Yazd.
The second historical city in the world, Yazd, has the best tourist, historical and cultural attractions, each of which can be unique to the eye of tourists and lovers of cultural heritage and the history of Iran and the world. The city is also famous for its air wells. Yazd is nicknamed as the city of bicycles, sweets, contentedness, religion, fire and sunlight.

2.3.The reasons for selecting the city of Yazd

Yazd is the most outstanding example which can depict spatial construction of an ancient Iranian city in Islamic era, although it has undergone significant changes since late 1340s.
The characteristics of the city have caused the city to be considered as the best sample and base for the studies focusing on the architecture of cities in hot and arid areas.

The investigation of the appearance of the architecture of the villages in hot and arid areas of Iran shows that the factor of the weather has played a significant role in shaping the texture of cities and the specific architecture of these areas. During thousands of year, the people have always been affected by the factor of harsh weather and this has led them to finding solutions to make the weather condition more tolerable and less annoying.
Since climatic borders are not related to political borders, the people living in hot and arid climates in all around the world have found similar solution to tackle their problems.

These solutions, although may be different in shape, are similar in nature. These solutions have been used in the structure of all historical cities which have survived for thousands of years, as well as in each structural element, and also in the components of each element; for instance "direction" is found in the whole structural elements, such as block, and alleyway, as well as in the components of a house, for example veranda and air well .So, direction is considered a basic principle which can be clearly observed in every corner of the city and it is part of the identity of it.

3. Principles of sustainability

The world "sustainability", the concept of "sustainability" and "sustainable development" are important is issues which will be discussed below.

3.1. the word “sustainability”:
The term “sustainability” was first used to refer to a system of principles to direct economic, social and environmental developments, locally, regionally and globally. It described a world where human systems and nature live in peace.
The history of sustainability:
It was first introduced in 1970 in “forestation and agriculture” project.
In 1993, the term was used in Rio de Janerio to describe large-scale development policy(Zaker Haghighi,1389).
In the following years it is was used again and again in different seminars such as AIA, UN conference and so on.

3.2. The concept of sustainability and sustainable development:
Sustainable: the survival of human systems and natural systems for future.
Sustainable development: based on Bertland report, it is the satisfaction of primary needs of people and giving this chance to each individual for a better life.
There is a set of six principles included in Instruction 21, which was introduced in Earth conference in Rio. Below, they are briefly presented (Zaker Haghigh,1389):

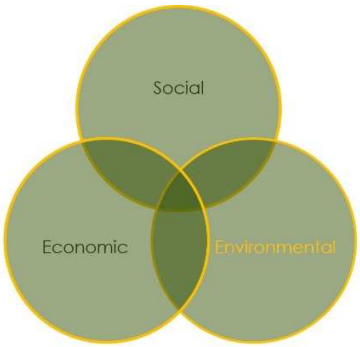
- Efficient use of natural resources of the earth
- Protection and management of world communities
- the design and management of human settlement
- Economic development based on the principles of sustainability

In the sources of the methodology of sustainable development, the general consensus is that sustainable development consists of 3 dimensions:

- social dimension
- Economic dimension
- environmental dimension

(kolshus et al,2001,Najam et.al,2003,Olhoff et.al,2004).

4. The compliance of the city of Yazd with the principles of sustainable urban design(a case study: hot and arid area);



4.1. Social dimension
Human being is always an important part of each space and has a role in the identity of each structure and city. Human being gives life to a structure and spaces gradually become part of the shared memories of people. Urban spaces should be flexible so that they can meet the need of participation of people.

4.2. Economic dimension
A healthy and balanced economic development results in social justice.
Social justice is in line whit respect to environment and is considered an important element of energy and using sustainable sources of energy helps economic development and sustainable development. The economy of Yazd basically revolves around textile industry in workshops. Today, complicated forms of social-economic relation and alteration of urban production in Yazd and also the dominance of factory

production over workshop production along with the social-economic communication network which the city is part of, have caused neighborhood system to disappear and neighborhood, as a unit of urban life, has lost its significance, compared to the past.

4.3. Environmental dimension

The present work has specifically focused on the ecological investigation of housing architecture from an environmental point of view.

- 4.3.1. Paying attention to ecological characteristics

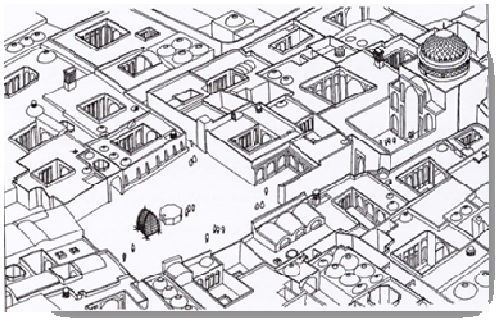
Climate

A residential system in hot and arid climate of Iran and their spatial values which have formed in response to climatic condition during many centuries: Harsh climatic condition have affected the shape and structure of Iranian cities. For instance, in houses with yard, cold air stays at the bottom of the yard at night time and during the day the house, especially the part of the house which is the opposite direction of the sunlight is cool. This coolness is felt more in the yards with a garden and covered spaces.

The appearance and direction of houses in accordance with climate

Direction is the most important feature of the texture of the city, the base structural element of it which is block, and the most important components such as houses with yard.

Direction has been formed by taking summer afternoon sunlight into account. Other factors, such as warm winds, the location on earth and making the best use of water resource, have been important in it too. The city of Yazd is located on 32 degrees latitude and is approximately in Eastern south-eastern direction, near the direction of Kaaba and most residential buildings are built in this direction.



The roofs and facades of houses in Yazd (domes and air wells)

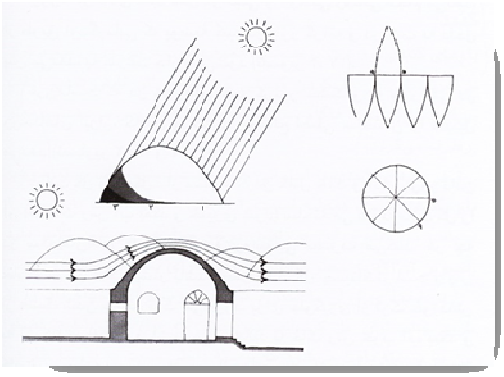
Two of the most important elements affecting the roofs of houses in Yazd are domes and air wells. It is worthy mentioning that these elements have also greatly influenced the sky line and view of the city and have made the city unique.

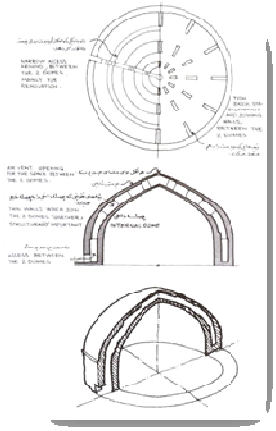
Dome

Dome-like roofs are always exposed to breeze, thanks to their shape. This can reduce the heat the roof gets from the sun light and also reduces the time the roof needs to give back the heat at night time.

In dome-like roofs part 3 always receives less heat than part 1, as the intensity of sunlight is not equal all surfaces of the roof. This can decrease the temperature under the dome, especially if the dome has a stool.

In Iranian architecture, the problem mentioned above has been solved more interestingly through the invention of two-shelled (two-layered) domes. This means insulation in the space between the two shells makes the inner shell cooler than the outer one. This is frequently found in the architecture of public places where many people come and go. Iranian architects have always sought better solution for keeping the space under domes cooler in summer and warmer in winter. Geometrically, the span of a hemispherical dome is almost three times as big as its base; therefore, the intensity of sunrays on the round body decreases and the lower part of the dome gets less heat. In addition, a round shape can send the heat out of the structure at night time more efficiently and faster.





Two-shelled dome

Two-shelled dome, the variety of which was introduced here, works as follows:

1. the space between the two shells works as insulator. So the inner shell receives less heat and stays cooler than the outer one.
2. the inner shell supports the dome stool and prevents its collapse when the horizontal driving pressure imposed by the weight of the shell is too much.
3. The inner shell gives the space under the dome harmony, while the outer shell makes the building more harmonic, externally.

Air well, wind energy

In some cities and villages located in hot and arid areas verandas are built in the direction of cold wind and cool breeze from sea. Examples of this can be seen in beach cities in North Africa and Persian Gulf, for example Bandar Abbas. However, in most cases, because of the density of the system, city breathes just through air wells. Air well is a feature of the structures in hot and arid climates and only if the city is located on highlands, which definitely means the city is cool enough, or if the city is prone to warm winds and storms, it is without air wells. True examples of a city with air wells can be seen in Yazd, Kashan and Abarghoo.

Air well is normally located somewhere to cool the area used in the summer. Most commonly, it was put exactly in the pivot of 5-door rooms in the middle or in both sides. Another common place was in the pivot of hall, which usually had a way to the basement too. In Yazd these samples can be frequently found. However, there are cases which haven't used air wells for cooling. The examples can be found in Zavareh, where there is a fan just in the center of building above char-taghee (4-ceiling room). This fan can also lighten char-taghee.

Three dominant features of cities located in hot and arid areas are a yard with veranda, dome and air well.
Density of residential blocks (neighborhood classification and density of texture) Urban blocks, which are the most important components of urban structures, are normally vast and compact with narrow pathways. This skeletal composition is a reflection of centuries of monotonous social-cultural life in hot and arid climatic conditions.
One structural feature of Iranian cities located in hot and arid areas is that city, gardens and rural neighborhoods exist together. Old neighborhoods in cities are formed adjoiningly, in a castle-like way. But rural neighborhoods are separated by gardens. Agricultural lands and gardens within rural and urban neighborhoods have greatly affected the weather and made it more pleasant.

As it was earlier mentioned, the classification of city to neighborhoods has had social, cultural and religions bases. However, the scales, sizes and distances of neighborhoods from the center have been affected by climatic conditions. The residential blocks are compact combinations of internal parts including neighborhoods with large, normally one-storey blocks, adjoining roofs and narrow pathways and alleys which receive much less sunlight and heat.

The role of yard in residential houses and the direction of it
It is attempted in this section to elaborate on the function of residential systems against climatic challenges and weather problems, as these issues are of vital importance in clarification of reasonable shape of these systems. The analysis of the style of life and work in such systems is possible through investigation of social-economic features of family such as closed relationship between family members and neighbors, family dimensions and cottage industry in historical cities. These characteristics were partly studied in the first part. Here, the effects of climatic factors are discussed.

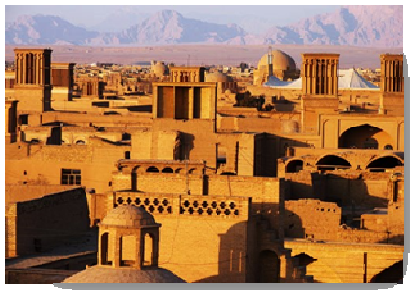
The effect of climatic factors: sunshine, wind, humidity, the case of Yazd
In addition to the orientation of houses, some other factors affect climatic conditions. These factors will be mentioned below. To be safe against the hot sun in the summer, especially in the afternoon, the part of the house which was supposed to be used in the summer (summer-part) has been built in the opposite direction of kaaba, which is approximately opposite the south. This part is cool and in local language is called “Naser”.
The opposite side is in the direction of kaaba, which means it gets sunlight in winter when this side of the house is used. The yard is deep, due to its high walls. Therefore it has shade during hot summer days. Cool air stays low in the deep yard and keeps the yard cool and pleasant for early hours of the day, when the sun has not risen completely. As the sun rises, the yard gets warm. Yet, the temperature of the part of the house designed for the summer is still much less than the temperature out. Basement is the part the temperature of which is astonishingly low. Except in hot summer afternoons, you feel cold when you go there.

In such closed houses, air flows through an air well behind the summer-part of the house. This air well has a way to the summer-part and also in some houses to the basement of the house.
The existence of a pool in the yard and vegetation and trees in the garden, as well as the airflow caused by air well make the house more pleasant by increasing the humidity. At summer nights, the people sleep on the roof or in the yard (on the bed over the pool). Air well spreads cool air in all over the house. This cool air cannot escape, as the house is closed. Therefore, in most day-time the temperature is still low.

The veranda with the hall facing the yard, normally with half-open spaces, forms the main part of the summer-part of the houses in the of Yazd. Its north-eastern direction is approximately the opposite direction of kaaba. This feature is seen in most Iranian cities in hot and arid areas. The north-eastern direction of the part of the house used in the summer makes this part stay in shade, while the opposite side of the house used in winter gets the pleasant sunlight in winter. The owner of the house may want to build the other two sides of the house, if he can afford it. Thus, those houses with a yard in the center and four rooms around are called four-season houses. However, the part which is thoughtfully architectured and designed is just the summer-part. The veranda in the summer part is a half-open space which is used in summer evenings as soon as the sun starts to set. Veranda is a few stairs above the ground and is dominant to the yard. There is a basement fan opening in this height difference. Basement is where food is stored and is the best place to rest in summer afternoons.

Materials
For centuries, the most important materials for construction in hot and arid climates have been adobe and thatch.
Clay and straw mortar: By mixing soil and water and kneading it (to make a paste) mud is formed. Clay mortar is used in clay, adobe and rural buildings. The more the clay in soil, the more sticky the mortaris and consequently the more it cracks when dried. To avoid the cracks, straw is added and the clay is given time to rest and absorb water. Clay mortar is used for coating underlining shell and sealing for water and heat.

In thatch-coating the roof, it is advisable to add some salt to the water of mortar to avoid the leakage of rain and snow. Salty soil paste stays paste-like; water does not leak in it and it does not freeze in sub-zero temperatures. This material is easily and cheaply found and is used professionally. The light color of thatch reflects the sunlight which is good in hot and arid climates.



Color

The light color of thatch can reflect the sunlight very well. The dome-like shape of domes, apart from having constructional reason, is cost-effective and economic, since wood is rarely found in these areas. It can easily cover a wide opening and also match the climatic conditions by absorbing less heat and giving back the heat at night.

Shaping systems

Shaping systems include weather (negative system), plant, water and soil system. These elements each help shaping the system of different spaces. For instance, welcoming or avoiding wind has caused the distinctive element of air well to exist, and in order to conserve and maintain valuable water, spaces like water reservoirs and refrigerators with stunning beauty have been designed which properly are appropriate for urban spaces.

Construct

In this climate, thick roofs and walls prevent the penetration of heat. Adjacency of house, urban elements and neighborhood play important roles too.

Traditional architects designed a hollow between the dome-like roof and flat roof so that the heat could not enter the inner space and the flat roof served a good place to sleep in summer. In addition, the pressure of the roof on the walls could be decreased in this way.

Conclusion

Sustainable architecture is not a single – international solution for all communities, cultures and people. Rather, each community, based on its history, culture, climate and infrastructures, should choose and present special solutions for sustainable architecture and urban design.

Urbanism and architecture in Iran has a long history and high values which are achieved during thousands of years of experience. Through using these principles, along with using recent scientific experiences, the true concept of sustainable Iranian architecture can be achieved. However, being inspired by these old values does not mean we should exactly copy the skeleton and shape of them, as new life style demands its specific solutions.

Overall , the present study elaborates on some principles of sustainability in the traditional architecture of the city of Yazd in the field of environmental factors. The article discusses the climate, ecological characteristics, texture intensity, harmonies and human scales.

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