

Sustainability in Space Composition of Traditional Architecture of Hot Arid Zones of Iran

Farshad Kheiri

Abstract—Iran Central Plateau encompasses a large proportion of this country. The weather in these flat plains is warm and arid with very little precipitation. Different attempts in architecture have been done to alleviate the weather severity of this area and create a living place compatible with humans' comfort criteria. Investigations have showed that some of the most successful approaches in traditional architecture of the area has been forgotten or are not being used widely. As sustainability is defined as an appropriate solution for environmental, economical, and social disorders, this research is a try to demonstrate the sustainability in aforementioned architecture and based on these studies, propounds solutions for today architecture in hot arid zones.

Keywords—Hot arid climatic zone, Iranian Architecture, Sustainability, Vernacular architecture.

I. INTRODUCTION

IRAN has diverse climatic zones with their special milieu characteristics. The central part of it, called Central Plateau is placed in central latitude of 32° 25' N and longitude of 53° 24' E, and has 432,084 km² (166,828 mi²) area [1]. It has dry arid weather condition. It has drastic daily and annual changes. So it is completely clear that this severe situation just lets the most practical solutions with least deviation from optimum solutions to be accomplished as the way that conventional buildings were formed and constructed. As many other traditional systems of constructing method, this had been done with patterning the paragons until it plays its role as the subconscious of a society [2]. Therefore, these styles were the consequence of several century selections and answered to its environmental parameters satisfactorily.

Sustainability has become an important approach because Human Ecological Footprint has exceeded the Ecological Capacity of Earth in recent decades [3]. It should be considered in environmental, social, and economical aspects [4]. One way to accomplish this goal is to probe the previous successes and adapt the relative rules to current requirements.

Different researches have been done to find the benefits of traditional constructions in hot arid zone of Iran [5]-[15]. Unfortunately, the lack of concerns to some of those rules has completely affected the current situation. The more we neglect the use of renewable energies and the more we incline to use mechanical systems for Heating, Ventilation, and Air Conditioning (HVAC) systems, the more Environmental effects, costs, lack of resources, and consequently, economical problems will occur.

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In this research, it has been investigated that how did traditional Iranian architecture in central hot and arid parts answer to its context, mainly to related environmental features, and how can it be practical for solving some of the today architectural problems of this zone and other zones.

II. ENVIRONMENTAL PARAMETERS AFFECTING TRADITIONAL HOT ARID AREA OF IRAN

Like many other traditional way of constructing buildings, this area had some biotic and abiotic factors [16] to be answered. Sunlight, wind, humidity, precipitation, geography, local materials, flora, and fauna of the area were the main environmental factors that might challenge traditional architects and the remained masterpieces are great responses to these features.

A. Sunlight

Among the aforementioned features, sunlight had the most effects. As Infrared data from Landsat satellites show the Lut Desert in Central Plateau of Iran reached a blistering 70.7°C (159.3 °F) in 2005, the warmest area of the world is 240 km² "Gandom Beryan Hill" in this area [16]. So, the main problem of this area is hot long summers and cold short winters. Also, the drastic changes between day and night are a problem in some seasons.

B. Wind

The second important factor is wind. Each microclimate has its own characteristics [17] and it is obvious that desirable or undesirable winds directions vary in different microclimates. But we can conceive that most of the cities in this area have two kinds of winds; the undesirable one that comes from dessert and is warm and dusty, the desirable one that is less warm and has less sand particles [9]. The point is that sometimes we do not have this clear separation. In these cases any special attempts had been done to make the undesirable wind to a mean of cooling and ventilating like what we see in Meybod (Fig. 1).



Fig. 1 Wind Catchers in Yazd City [18]

C. Geography

Geography of the land affects the formation of a city. The effects of this parameter are more conceivable in marginal lands of Central Plateau rather than plain areas. As an example, cities in foothills are placed in south side of to gain the solar energy and evade from snowy side of the mountain.

D. Precipitation and Humidity

This zone has very little annual precipitation. So, whenever it is not practical to use aqueducts or wells, like inns outside cities, the roofs had to be designed so that the maximum precipitation to be stored.

The lack of humidity is the cause of some discomforts in human being. The low humidity level dries the skin and as there would remain no perspiration on skin to be evaporated, causes the winds to be more severe.

E. Local Materials

As in traditional civilizations transportation systems were not developed as today, it was too much beneficial and pragmatic for them to supply their required materials by local ones. This would also help the local economy.

In these areas, the most prevalent materials were soil and clay. This had prompted the native architects to use probes, and bricks, as approximately the only structural material of a building. It is worthwhile to mention that in some cities in which enough resources of other materials like wood had been available, they had been used for example in the roof of many foothills.

The mentioned system was used for majority of the buildings, but in some cases there may be some exceptions. For example, around Shiraz city, the soil was not suitable for bricks and probes, so they used the soil of Lar or Khankoreh as their raw materials [19].

F. Flora and Fauna

Because of the benefits like being used as food supply, creating oxygen and humidity by respiration, producing shadows, filtering the dust of the air, and psychological

connection to natural elements, green spaces were quite much important in these areas. But these were accomplished by the careful selections due to the difficulties in irrigation with limited supply.

Flora in different zones played an important role for materials used in buildings. In areas that there are enough trees, their woods were used in different structural elements specially, in flat roofs. The usage of flora of the area did not limit to structural usages; thorns, pedicels, and small tree branches were used in wind catchers as filters against insects and dust.

The animals were important for ranching and would be used as their food supply. These had had their effects on building compositions.

III. PHYSICAL FEATURES IN COMPOSITION OF TRADITIONAL ARCHITECTURE OF HOT-ARID AREA OF IRAN

A. Orientation of the Building

Different directions can cause drastic changes in environmental effects and human comfort in a building. There have been some factors that dictate the orientation of a building like sun path, winds, and topological features.

Among these factors, sunlight and the direction of sun were the most important features. Due to the warm weather in summer, they needed to have a special place with its fenestrations faced north. Also, as the winter is very cold, it was needed to have a space which gains the solar energy and consequently faces south. These factors caused the buildings to have an orientation that uses maximum shaded spaces in hot seasons, and uses maximum energy of the sun in cold seasons. West and east sides of the house which had less area than other sides were used as service areas. As warm periods are more than cold ones, the south part of the house was bigger than north part. This also helps to have more ventilation in part for summer usage with higher roofs, and warming the winter spaces more easily with lower roofs and smaller dimensions (Fig. 2).



Fig. 2 North and South Parts of a Borujerdiha House in Yazd City; Photo by Iran News Agency [20]

Wind was important in two steps. First in locating a city at the first stages of shaping the city, second, in directing some elements like wind catchers. Based on the quality of the wind in different directions, these elements might face the wind direction to grasp it and get it into the space, or have the opposite direction with the wind to create suction for ventilating the indoor air. In the latter one, the same volume of air would come from the controlled cooled or moderated air of the courtyard through the windows and doors to the indoor space (Fig. 1).

Geography of the site was another factor in orientation of a single building and more importantly the orientation of the city. This was more concerned at peripheral parts of Central Plateau which was not completely flat. As in these areas the weather was to some extent cooler than central parts, the aim was to use the side of a mountain which faced sun and to prevent the severe winters.

B. Courtyard

Courtyard was the core of the buildings that would play essential works. This, as the heart of the building, was an open space for gathering different spaces with internal connections, and a place where for some activities like washing. In some places like Sharestan of Yazd city, the earth in about 2 meters below the earth surface was quite strong for bearing the buildings load. So, the courtyard sometimes is deeper (Fig. 3). They used to use the soil of the building site for preparing the adobes needed for building it; also they wanted a place in a lower level of the alley to facilitate the flow of urban water to the building. So the courtyard would be a space mostly lower than urban space that has the privilege of having the shadows produced by the surrounded spaces [21]. This helps to have a cooler weather at its surface and helps to have more green spaces.



Fig. 3 Laryha House in Yazd City; an Example of Deep Courtyard;
Photo by Alix Wilkinson [22]

C. Direction of the Rooms

The most important factor in accommodating different spaces in traditional Iranian buildings in hot arid area was sunlight. These constructions had two parts for summer and winter. This division is just for using the thermal energy of the sun during cold seasons and occluding the entrance of solar rays during hot seasons. It is worthwhile to mention that the

fenestrations of different spaces faced courtyard not the outside and urban spaces (Fig. 4).

Based on aforementioned information, the north side of the building, which gains solar energy, was the place used in cold weathers. As the heat climbs up, the height of these rooms were lower than ones in the south edge (Fig. 5).

The same rules were accomplished for warm weather spaces. They were placed in south side of the building with openings faced to north. The heights of them were higher than other spaces (Figs. 5, 6). Mostly these spaces were cooled with wind catchers directed to the side of the pleasant breeze. The use of water pool under wind catcher was to alleviate the dried air by adding water evaporated and enhanced the humidity of the air. The mentioned surface evaporation, as an endothermic process, helps to cool the air and therefore causes to have more comfortable situation.

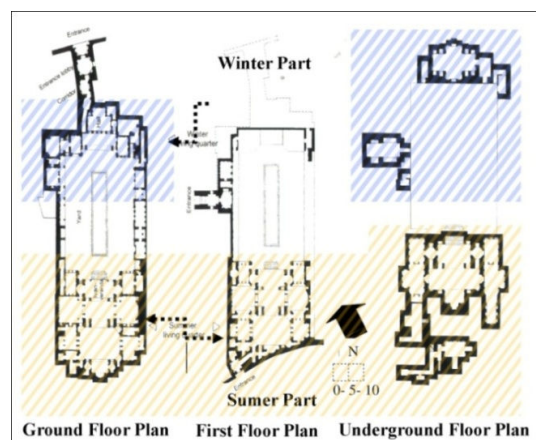


Fig. 4 Plan of Borujerdiha House in Hot Arid Zone of Iran [9]

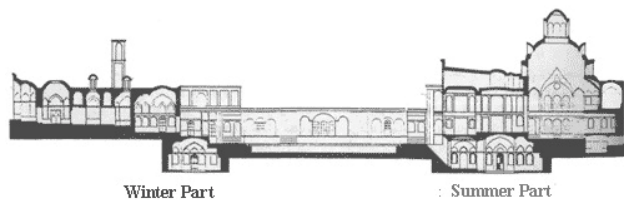


Fig. 5 Section of Borujerdiha House in Hot Arid Zone of Iran [9]



Fig. 6 Summer Part of Borujerdiha House [20]

The east and west sides of the building were mostly used for utilities. This is in accordance with the less propitiate sunlight that these sides of the constructions gains.

D. Modular Design

Considering the body proportions of human being in different positions has always been an important factor in designing a space for him. This item plays a pivotal role in contemporary standardization of architecture [23]. This was implemented in the measuring system of that time. Basis of that system was human body proportions like “Arash” (40cm), which was the distance from elbow to the end of the fingers, “Gaz” (60cm), which was 24 fingers, and “GOVAR” (1.60cm), that was the distance from right hand fingers to left ones when they are completely stretched [19].

The design of the traditional buildings in this area of Iran was based on “Peimoun” [19]. This was some previously fixed modules, like modules in ancient Greek, and was implemented in plans, elevations, and even ornaments. So, all of the proportions would be in congruence and it also guaranteed constructing features especially for roofs. The other important factor of modularization of buildings was prefabrication of windows and doors.

Modules were the width of doors and had two major divisions; the small module was 93cm (14 “Gereh”) and the large module was 120cm (18 “Gereh”). Mostly the building was constructed based on one of these modules. The Spaces created on these bases were:

1. Corridors (created with one module) called “Yekdari”.
2. Small rooms (created with two modules) called “Dodari”.
3. Medium rooms (created with three modules) called “Sedari”.
4. Large rooms (created with five modules) called “Panjdari”. (Fig. 7)

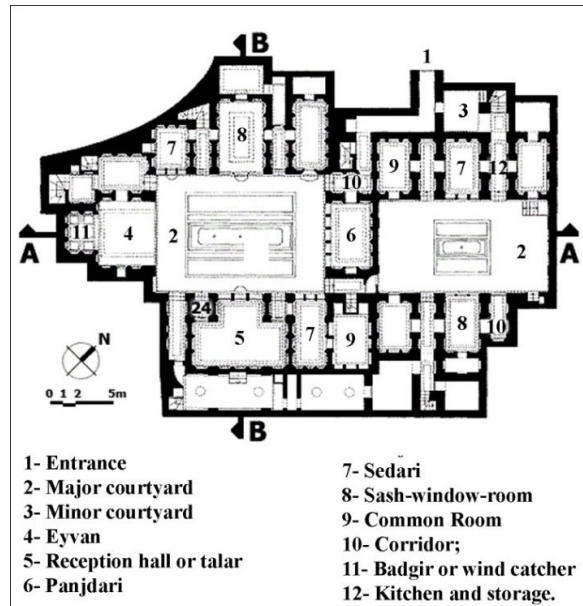


Fig. 7 Ground Floor Plan of Gerami's House in Sahl Ibne Ali District of Yazd City [24]

E. Context Connection

Each micro ecosystem has its own characteristics. All parts of it had been selected during a long period of time. The results of these natural selections are compatible features in these systems. Therefore, it can be concluded that local potentials should not be forgotten when constructing a building.

1. Materials: The materials of a construction were mostly caught from that special site. Excavating the land and creating the necessary adobes from that soil has at least five advantages. First, there would be no energy and time consumed for transporting the required materials to the site. Second, as the site has been dug in for adobes raw material, the site is excavated. So, the constructed building lower than alleys can cause to use the thermal capacity of the earth for alleviating the climatic severity. Third, it would help the use of water streamed along the alleys. Also, in most of the areas of that zone like Kashan, Zavvareh, and Naiin, water was underpass. So this helped to have easier access to underpass water. Fourth, it would use the earth as the buttress of arches, so these arches would transfer loads to earth more efficiently and more safely. Fifth, using local materials help the renovations much easier.
2. Connection of Buildings to Urban Spaces: The system in which urban spaces had been developed was affected by people's beliefs and preferences. As an example, the sequence of spaces from urban space to the interior parts where the family lived which was called “Andarouni” is described as bellow:
 - 1: Exterior door which was preceded by a semi open space, mostly equipped with two stone benches in opposite sides as a place for some social connections.

2: A space which divided two parts of the house. The first one was the aforementioned "Andarouni", and the other one was a place for hosts and was called "Birouni". Most of the time, each of these spaces had its own courtyard. This division space was called "Hashti" which is similar to vestibule. "hasht" in Persian means protrusion. "Hashti" was the only protuberance of a house toward the exterior door [19]. Although these spaces have octagonal plan shape sometimes, but they have had square, oblong, or other shapes too. This space could be the articulation space for more than one house. Mostly, these homes were relatives and were opportunities to connect them to each other.

3: A hall which is connected to the courtyard from one side and vestibule ("Hashti") from the other side. This is an occlusion for being seen the private spaces by people in the alley or vestibule.

4: Courtyard that is described in "Part III.B" of this paper.

5: Veranda which was called "Ravagh" or "Eyvan". The size of this semi open space was the cause of desirable shadows on windows.

Sequences among different spaces played a pivotal role in these buildings. This could be assigned for environmental effects such as lowering thermal decade, or psychologically like separating the identity of different spaces or for cultural features.

IV. CONCLUSION

Living in an environmentally better world needs planning based on sustainability. In architecture and urban planning, this would of course lessen the dependence on nonrenewable energy sources and would create a compatible milieu.

Traditional architecture in hot arid zones of Iran had propounded some useful solutions for alleviating environmental discomforts. As now we are faced to different items like population, transportation, and the style of living, these solutions cannot be implemented with the same characteristics as in traditional architecture. But the principles can be renovated with compatible characteristics of today. Some of these items are described as bellow:

1. *Sustainability in Different Scales*: Urban planning can cause drastic changes in individual architectures. For example, sun occlusion by buildings can deprive others from gaining passive or active solar energy. So, it is obvious that urban planning should be with sustainable concerns as described in Orientation of the Building in Section "III", Subsection "A" of this article. At other levels we reach at architectural composition, and finally details of the building. For having a sustainable built environment, it is more practical and low cost to concern sustainability in all levels.
2. *Semi-Controlled Exterior Spaces in Sequence of Spaces*: Exterior climate in hot arid area of Iran is harsh. This severity has been amplified by the usage of engines and cars in recent centuries. If we control a special volume of exterior space in different levels with shades and green

spaces, we would have different open spaces with compatible functions vertically.

3. *Context Connection*: Most of the time, the costs and energy for excavation and transportation of the materials away from special site are high. So, it is better to use vernacular materials processed with today technology that can improve their quality. It also enhances local economy and provides the opportunity for easy repairing.
4. *Renovation of Traditional Elements with Today Desirability*: There are different elements in traditional buildings which can be used now. Wind catchers can be implemented like patios and atriums for ventilation. Also, they can be used as light tubes which are quite useful in central zones of dense apartments that cannot catch enough solar energy.

Altogether, sustainability needs global concerns and it is obvious that each area has its own potentials and requires special considerations. It is clear that each of the items in this paper needs further concentration. With the cooperation of national solutions and international declarations, we hope to lessen environmental effects and have better globe to live.

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