

Compatible Ecological Strategies Used in the Design of Traditional Houses in Iran's Hot and Dry Climate Case Study: The Boroujerdis House in Kashan

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ABSTRACT

Today, due to the lack of proper structural models for increasing productivity as well as residents' comfort through optimal deployment of climatic factors in building, many climatically inappropriate and at times conflicting models are being used in construction. The present research aims to look for architectural tips regarding the use of hot-and-dry climatic factors used in the ecological design of the Boroujerdis House in Kashan. In the meantime, the study searches for certain design strategies which take into account natural energy resources. For this reason, a descriptive-analytic approach was adopted by deploying planimetric tables/descriptions in order to present the climatic characteristics as well as ecological design of the Boroujerdis House. This study was conducted during one season in the three sections of the house, i.e., the Summer Residence, the Winter Residence, and the Myansara (middle area). The ecological design solutions and their application in the Boroujerdis House in Kashan outline strategies for environmentally friendly architectural design. The obtained results showed that climatic factors such as topography, seasonal orientation of the residence, adjusting sunlight, etc. can be employed in designing building forms, spatial organization, landscape and plants, construction materials, technical installations, and the like. The ecology of the region should be considered for the construction of proper structures in the creation of sustainable-building environments, and also, in addition to these old solutions, solar, water and wind resources which are renewable should be considered more for the construction of new houses in Kashan with its dry climate.

Keywords: ecological design, physical environment, structural environment, hot and dry climate, the Boroujerdis House, design strategy

INTRODUCTION

Climatic design is a method for reducing energy consumption in construction (Naderi, 1995, p.67). Favorable use of natural resources combined with artificial/man-made possibilities for the purpose of providing comfort for desert climate inhabitants has led to the emergence of the Hot and Dry Climate School in traditional Iranian architecture (Tavasoli, 1982, p. 22). The houses built in this style in Kashan are interesting architectural examples where ecological factors were successfully used to create a sustainably compatible background for coexistence of natural and man-made environments. In the architectural design of the Boroujerdis House in Kashan, various ecological tips were deployed for utilizing renewable energies as well as respecting the natural environment. Such houses can be

imagined as living intelligent creatures who save energy by making use of natural resources. The peaceful atmosphere that reigns in old Iranian houses is due to their architect's close attention to human nature, needs and demands (Sedigheh, 2009, p.24). However, in modern Iran, reliance on technology has led to gross neglect of these traditional environmental experiences in architecture. It certainly is true that in the past, architects interacted favorably with the environment by using local materials in building houses and placing the houses close to water resources. They even made assessments of the extra materials in order to recycle them (Yaren, 1990, p. 90). Ecological design is based on renewable energies technology and natural resources, and is closely related to architectural design (Karman, 1995, p.250). The present study aims to discover the strategies used in the

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ecological design of the Boroujerdis House, as well as to find ways of dealing with and utilizing the climatic factors in this regard. Through the study of the deployed tips in traditional architecture, it is possible to present new design strategies in modern architecture. The purpose of the present study is to find out what architectural points exist in the ecological design of traditional houses in Kashan, and how these hints can affect climatically oriented residential designs in contemporary architecture.

METHODOLOGY

This study uses the descriptive-analytic method as well as planimetry tables and descriptions to define the design characteristics and indicators of the Boroujerdis House in Kashan. To accomplish this purpose, field observations, sampling, and measurements from the house were deployed to describe and analyze the relation between its architecture and the climatic factors. Information obtained from libraries, as well as observation, photography, etc. were some of the tools used for gathering data, and the field methodology was used to analyze the collected information.

ECOLOGICAL DESIGN

Ecology is defined as “the science of studying mutual interactions of an organism with its environment, which, in its most general sense, can encompass all environmental conditions.” (Rezairad,2006). Ecological design entails sustainable systems which combine in line with ecological principles human societies with their natural environment in a mutually benefitting fashion. In construction studies, materials, buildings, and landscape are used. Today's technology-based designs concentrate solely on human interests without heeding environmental concerns. Such a self-centered approach in design cannot act successfully in controlling the living environment and adversely affects our health. Ecological design must not use the environment solely as an abstract space. If we are to pay long-term attention to the environment, culture, and economy, we must

Table1. classification of climatic factors

Climate	Sun	Comprises two components: sunlight angle and sunlight direction.
	Humidity	Amount of water vapor in the atmosphere.
	Water	Sea-side or lake-side locations
	Air Temperature	Varies in different locations
	Wind and Airflow	Differences in pressure and

properly organize the systems which maintain our health and ultimately guarantee our survival, as well as introduce fundamental reforms in our planning models (Bozorgi, 2005, p.54). Ecological design criteria include components which encompass several climatic dimensions by considering the status quo of each.

Climate and Climatic Factors

Environments are different in various climates, so that each climate has its own particular environmental characteristics. Climatic design is a method for comprehensive reduction of energy consumption in a building (Eghtesadnam, 2005, p. 4). Combining a building with its environment basically entails taking into account certain characteristics such as topography, climate, etc. Rational deployment of such environmentally friendly systems leads to the minimization of negative effects on ecosystems, leading to climatic proportionality in the construction (Krusche, 1992). At all levels, constructed urban spaces and the environment mutually affect one another (Schiller, 2007). Like all other systems, human body is highly sensitive to the four environmental factors, namely, temperature, humidity, radiation, and air stream (Razjooyan, 2009, p.21). In his book titled “Traditional Buildings” (1998), Vahid Ghobadian enumerates environmental factors as: 1) Sun, 2) humidity, 3) water, 4) wind, 5) plants, 6) geographicallocation, 7) ground depth. He further attributes certain components for each factor. In his book published in 2007, Sasan Moradi presents somewhat climatic factors, namely, sunlight, humidity, airflow (airstream), and air temperature. Shahram Poudehimi (2011) categorizes climatic factors in the following groups: 1) ground (shape and material), 2) natural factors (plants, trees, and water), 3) artificial factors (buildings and urban volumes), 4)heat pollutants, and 5) pollutants. In the present research, a general classification was considered for climatic factors, as presented in the following table:

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		temperature, as well as Earth rotation cause wind.
	natural factors (plants, trees)	The existing vegetation in a region
	Topography and Geographical Location	Latitude and longitude (geographical coordinates) of a place Topography of a place (It will affect the wind/air flows, which will eventually affect the temperature of the designed structure)
	pollutants	Factors that pollutes the air

Sources: The Author

The Built Environment

In reacting/referring to their environment, people often use terms that are meaningful to them. Evaluating the built environment is predominantly an all-effective, encompassing subject rather than an analysis of certain aspects. It is more implicit than explicit, and is expressed through visual imagery and ideals (Rapaport, 1998, p. 60). Philip Wagner classifies man's relation with his built environment in terms of two categories, namely, production and demand. He divides the built environment as spaces for production and spaces for consumption as follows: 1) Natural resources, 2) paths of

Table 2. Ecological Design Components

Built Environment		Climate
<ol style="list-style-type: none"> Structure Form Spatial Organization Landscaping and Plants Design Construction Materials Technical Installations 		<ol style="list-style-type: none"> Sun/Sunlight Water Humidity Wind Air Temperature Geographical Location (Topography) Plants

Sources: (Baran, 2011, p. 610)

Based on this, for creating a structure in line with climatic conditions, we must somehow incorporate each of the climatic factors in our design so as to provide relaxation and comfort for the inhabitants of this artificial environment.

THE HOT AND DRY CLIMATE

In the hot and dry climate zones which cover most of the subtropical regions, the weather is excessively dry due to the immigrant winds blowing from the south western regions towards the equator. In the central Iranian plateau, surrounded by high rough lands and considered as the most extensive region in Iran, the hot and dry climatic conditions prevail (except for the marginal areas connected to high lands and certain internal zones), characterized by harsh

motion, 3) production sectors and installations, 4) plants and agricultural land, 5) residential parts, and 6) service spaces. In ecological design, the built area presents functional solutions through its physiological form. This is realized through spatial organization. In this regard, architecture considers not only the aesthetic, but also the environmental characteristics of the built environment (Baran, 2010, p. 614). In building such structures, due attention should be paid to construction materials, structure form, landscape, and technical installations, so that energy savings can result (Baran, 2011, p. 610).

cold winters and hot dry summers (Kasmai, 2006, p.84). Plateau plains extending from northern parts to the southern Alborz boundaries, predominantly form the vast central regions of Iran, covering more than two thirds of the country's area (Shakibamanesh, 2009, p. 135). The unfavorable environmental conditions, i.e., hot weather, dryness, and water shortage, as well as various social, political, and security problems, make life difficult for the inhabitants of this region. Under such circumstances and with due attention to all climatic, cultural, religious, social, security, and spatial organization, a certain style of housing was somehow initiated in this region, which, through creating small yet different aesthetic aspects, provided a relaxed internal refuge for

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the inhabitants away from the harsh external environment.

Iran's hot and dry climate, the most notable of which are those set forth by Shahram Pourdeihim.

Many strategies have so far been proposed for using climatic factors in built environments in

Table 3. *Deployment of Climatic Factors in the Hot and Dry Climate Built Areas (Pourdeihim, 2011, p. 86)*

Purpose	Principles	Design Solutions
Reduction of Heat Accumulation/Production	Reduction of heat/water vapor produced during daily activities	<ol style="list-style-type: none"> 1. Separation of cooking spaces from living quarters 2. Using semi-open spaces and shaded areas for cooking 3. Locating the kitchen on the north of the building 4. Creating the yard on the northern side of the building
	Reduction of the heat introduced through the environment	<ol style="list-style-type: none"> 1. Reducing size of windows and designing them in the completely shaded parts 2. Using ground characteristics for stabilizing temperature during hot days 3. Using thick walls and ceilings to stabilize temperature in hot days 4. Incorporating the outer walls in the shaded areas of the building
Radiation reduction and heat loss increase	Minimizing absorption of short-wave solar radiation	<ol style="list-style-type: none"> 1. Minimizing the window area in the rooms 2. Fixing facade windows in deep recesses 3. Using horizontal shades 4. Using vertical shades 5. Incorporating serrated forms in the outer walls which are exposed to sunlight 6. Building high walls for creating shaded areas 7. Site building intended to create shaded areas
	Crating shaded areas; reflection of short-wave length solar radiation; reduction of long-wavelength solar radiation	<ol style="list-style-type: none"> 1. Placing green space near the building and its windows 2. No extended construction surfaces near windows 3. Creating shaded areas on the build with vegetation 4. Using light colors on outer building surfaces 5. Expanding the built area at ground level to increase reverse radiation 6. Using construction materials with low diffusion coefficients
	Insulation	Insulating the building on the side that is exposed to radiation
Heat transfer reduction	Internal ventilation	<ol style="list-style-type: none"> 1. Closing windows in daytime and opening them at night 2. Using high ceilings to create

		heat traps 3. Using extra windows just under the ceiling
	External airflow	1. Inducing airflow on the outer surfaces exposed to solar radiation 2. Creating airflow inside court yards through wind towers 3. Effective cooling of the yards through effective use of water and vegetation
Increasing surface evaporation	Using water for cooling	1. Using water-plant surfaces in open spaces 2. Cooling air with the humidity existing in soil

Factors Affecting the Comfort of Living in Traditional Houses of Kashan

You may have seen an old house from nearby. Houses which are full of beauty and comfort for someone who lives in them. These houses are light throughout the day without the use of lighting fixtures. But the point which attracts the highest attention in summer, is the coolness of these houses in this hot season of the year. To create comfort and its related factors in old houses, the factors below should be investigated. During summer, houses are heated and cooled in a number of ways. If we are to examine the heating factors, they should be stated as follows:

- Heat gain from the sun as radiation, is one of the important factors in the heating of houses and heat gain by conduction, is another one of these ways.
- Heat gain through internal heating sources and heat gain due to the entrance of outdoor air, are of the factors for the heating of the space of these houses.

The factors preventing the entrance of heat in these houses during summer are:

- Sunken garden being of these houses (being placed in groove) accompanied by tall and shadowy walls.
- The existence of louvers, ventilators and skylights which do the ventilation and cooling of the space and also lighting.
- Directional building. It means by considering the direction while building, a construction would be built in a way that receives the least amount of heat. Meanwhile, the radiation direction of the sun, regional and monsoon wind direction are also effective.
- The use of materials with high thermal resistance such as bricks and bright coatings such as thatch which were very effective for preventing heat penetration.

- Doming of roofs and also doubling them and also caring about height in spaces.
- Wooded and shaded gardens along with large pools and wooden frames of doors and windows with colored glasses are all effective at the softening of the air.

THE BOROUJERDI HOUSE IN KASHAN

With an area exceeding 2100 hectares, the central city of Kashan is built facing the desert plain away from the mountainous area behind it. Kashan lies at an altitude of 945 meters above sea level and its geographical coordinates are 51°27' longitude east, and 33 degrees, 59 minutes latitude north. There are more than 150 old houses in this city. In addition to the Seljoughi era, Kashan particularly prospered during the reigns of the Safavid and Kajar dynasties. This city has hot and dry summers and cold winters, and the heat level during summer, sometimes reaches 47C and during winter, the coldness level sometimes reaches 10C. With an annual rainfall of about 150 mm, Kashan has one of the lowest rainfalls and is one of the driest cities of Iran. The existence of hot and dry summers, cold winters, winter burning-winds and summer cyclones, has made this city a city with harsh climate. However, the existence of one of the oldest centers of ancient civilization in the median between Kashan and Fin, called Silk hills, show that Kashan's historical antiquity dates back to at least 7000 years ago. According to what's perceived from Asam Kufi history, Kashan during Sassanid was a large city with great economic facilities. Although this city sits on the edge of the desert, it never backed down against desert storms and fearsome sandstorms (Farrokh Yaar, 2011:74). The not so proper environmental conditions, excessive heat, dryness, water shortage, along with social, political and security problems in Iran's hot and dry central regions, have made life

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for the inhabitants very difficult. Under such conditions and by considering all climatic, cultural, religious, social and security factors and also the idea and principle of organizing architectural space, some houses are built which far from all these worldly problems, have brought about a small and different beauty for the inhabitants. The type of architecture and materials, have decreased the undesirable effects of environmental factors, and by controlling them and using proper components, a suitable place has been constructed for living. In these houses, all the small and large spaces are placed based on their function with a specific arrangement around a comfortable yard with a pool at the center of it with flower beds full of trees placed all around. All these spaces, are arranged in a symmetric geometry with proper shapes and sizes, and while having diversity,

they all have created a uniform and integrated combination under a particular special layout. As much as possible, it was tried not to leave any space simple, and diverse decorations which are all taken from the mystical circulation of human soul and mind, cover everywhere. Therefore, what's felt in these houses is a secure and comforting space and a balanced and coordinated world, in a limited place. (Farrokhyar, 2011, p. 74).

In the hot and dry climate of Kashan, orientation of buildings along the northeastern-southwestern axis in the summer and along the northern-southern axis in the winter makes it possible to utilize the functional benefits that each season offers the city (Muhaisen, 2006, p.1731). In general, Iranian houses can be considered as spatial reflections and inner meanings (Farzian, 2009, p.24).

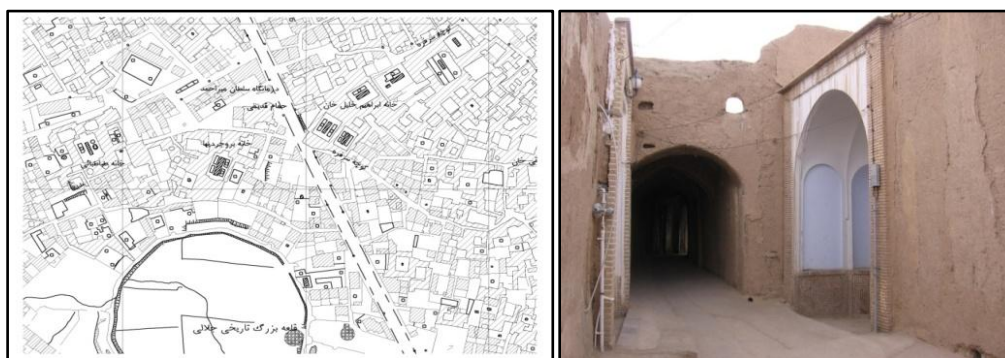


Figure1. The aerial view of the Boroujerdis House (left) and Kashan alleyways behind houses (right)

The Bouroujerdis House was built in 1857. The building of this house was commissioned by its owner, Seyyed Hasan Natanzi, better known as Boroujerdi-ha. The house comprises two inner quarters (andarouni) and one outer quarter (birouni) (Farrokhyar, 1990,, p.24). The most important features of the Boroujerdis House are summarized in Table 4.

ANALYSIS OF THE DESIGN TIPS/TECHNIQUES EMPLOYED IN THE BOROJERDIS HOUSE

Ecological design aims to reduce the inflicted man-made effects on the environments to a minimum. By paying due attention to sustainable living as well as environmental effects, ecological designers introduced innovative solutions through their design parameters. These solutions comprise strategies which can be classified as climatic/built environment strategies (Baran, 2011, p.611). The location of houses in Kashan is such that there exists great compatibility between them





and the climatic criteria, namely, water, soil, and air. The old part of Kashan has an ecologic texture. The houses have organic forms, consisting of central courtyards divided into four parts relative to their two main axes, namely, the north-south axis and the east-west axis. There are narrow alleyways in the old part of Kashan, where buildings are built very close together, thus shading one another as well as the pavements and streets in their vicinity; protecting passers-by from excessive sunlight in the meantime. There are large houses built in the traditional style in Kashan, where household activities revolve around the central court (inner) yard. In hot and dry climates, houses with court yards can satisfy most of the needs of their inhabitants (Al-Azzawi, 2003, p.1099) since these houses are less exposed to solar radiation, thus reducing heat transfer from the outside to the inner compartments. Also, the atmospheric characteristics of the region have led to separation of summer residence and winter residence areas (Table 5) to provide more

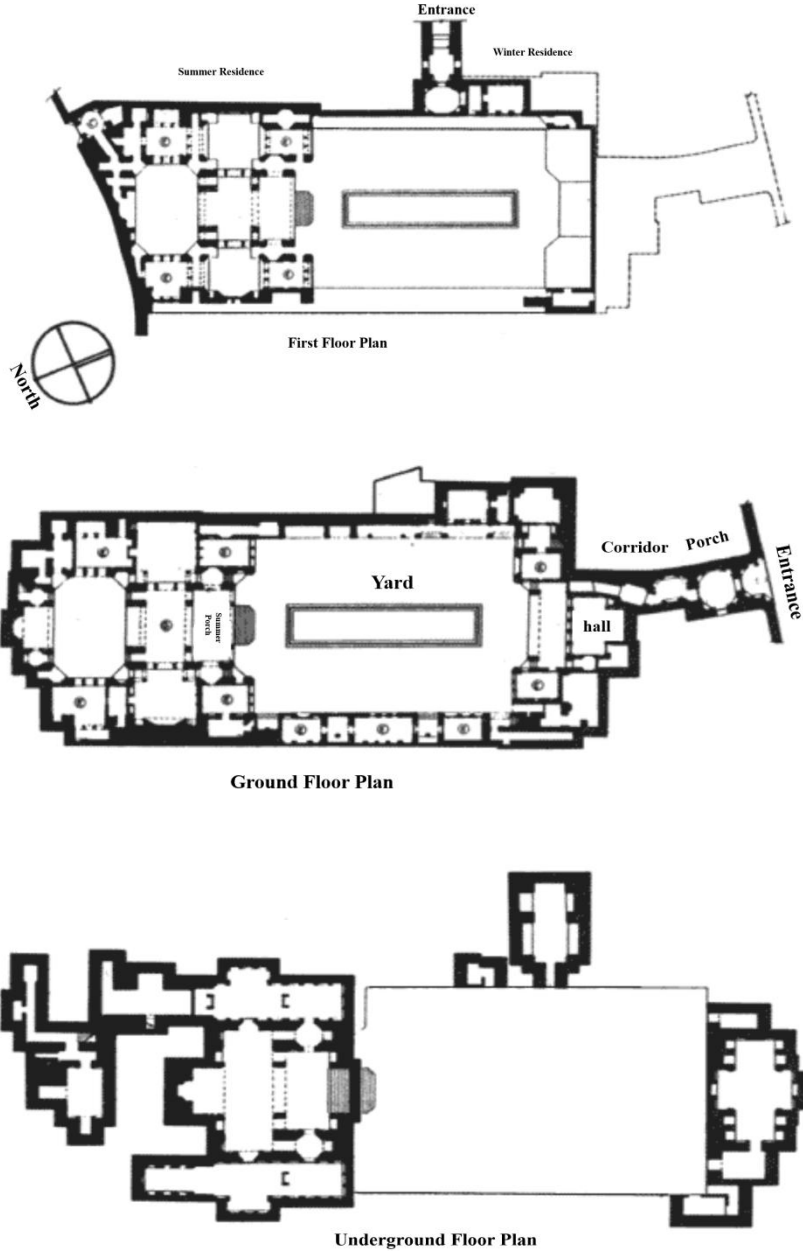
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environmental comfort for the inhabitants. The Boroujerdis House was built in two storeys on the basement floor. The residing family used the first floor (facing south) in winter and the

second floor (facing north) in summer months. The other parts of the house were mostly used

Table 4. *Prominent Quarters of the Boroujerdis House*

			
<p>The Summer Residence</p>	<p>The Winter Residence</p>	<p>The Western Wing and its Corridor</p>	<p>The Eastern Wing and Service Quarters</p>

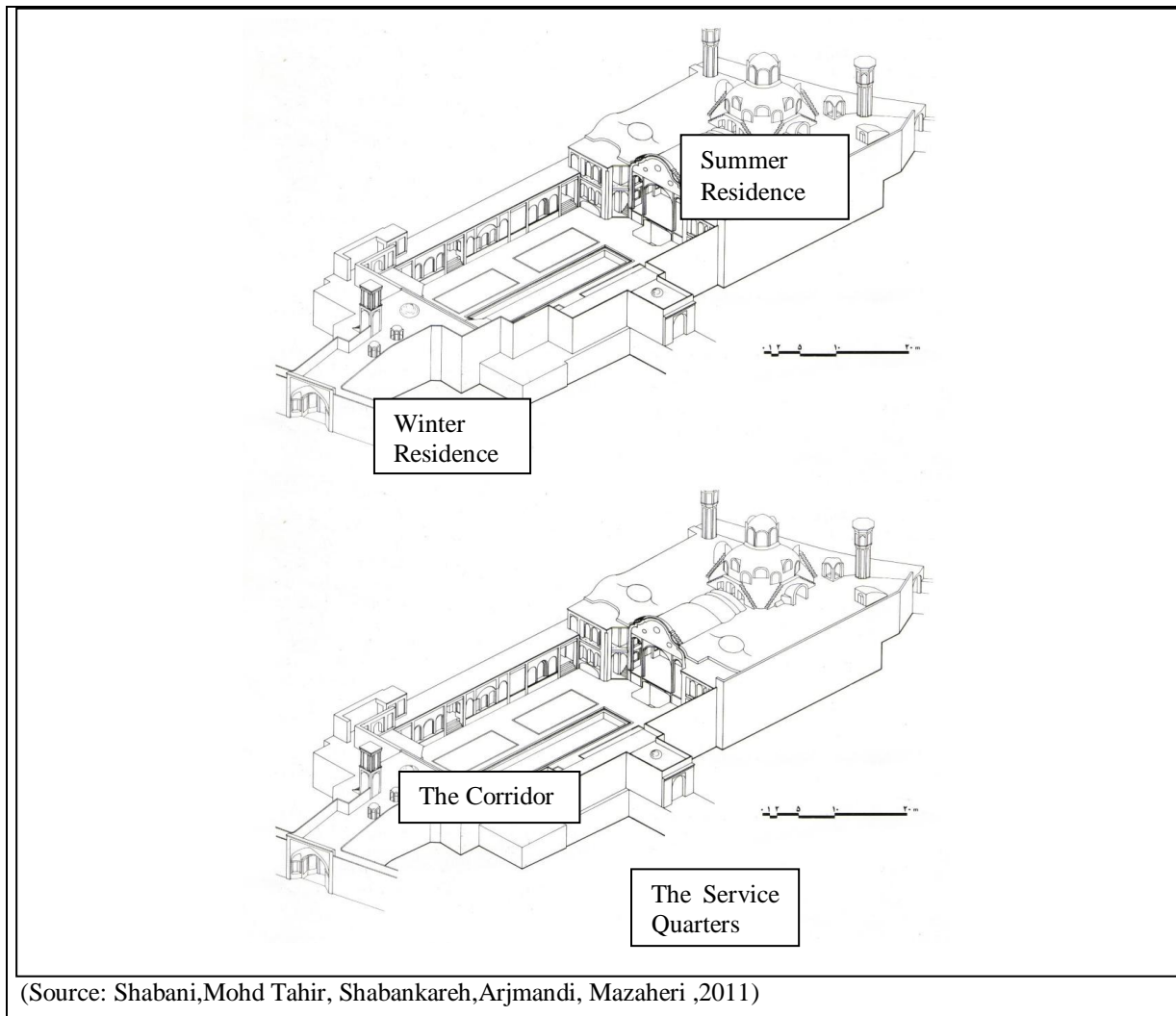


First Floor Plan

Ground Floor Plan

Underground Floor Plan

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as service quarters. Particular care was exerted in the design of the summer residence which is located in the southern corner of the yard where rooms face northward to protect their inhabitants from sunlight. The second storey is also used in the summer. The rooms in this storey have wide windows opening to the yard, as well as wide doors opening onto terraces, leading to a semi-open space. Opening any window would cause air currents to provide natural ventilation and natural light to stream into the room. In most areas around the house, there are spacious floor areas which reduce heat conduction. Thus, during the height of summer, the greenhouse effect can be reduced by simply opening the windows. The winter residence has a single storey and is located due north to protect the inhabitants from cold winds. The rooms in the winter residence have smaller floor areas and lower ceilings, as well as fewer openings/windows. Due to this design, heat transfer as well as convection within the house is reduced. The service areas are located between the summer and the northern wings and

extend in the east-west direction. Certain parts in the house including the yard, the central pool, and the gardens serve the purpose of cooling and moisturizing the environment. High walls surrounding the house provide shade for the narrow alleyways outside as well as the yard. Airflow first enters the courtyard and then the inner space, providing constant high pressure air inside the house. As mentioned earlier, atmospheric information plays an important role in the ecological design of buildings, and, correct assessment of such information can provide significant energy savings in these building without forsaking the comfortable environment enjoyed by the residents. Thus, comfort can be provided through limited use of natural resources. To verify this, a comprehensive study was conducted on the regional climate from mid-March through mid-June (this period is representative of the year-round climatic variations in the region). Daily temperature measurements were taken at certain hours in each room in all four parts of the

house, as well as in the yard, the kitchens, the terraces, and the cold room (cellar).

Building Form

The compact texture of houses in Kashan can be attributed to cultural and topographical influences. The economic condition of households as well as climatic conditions affects building forms and classification. The houses have outer and inner courtyards surrounded by 4-5 meter walls. A narrow passageway is the only means of accessing the Boroujerdis House. The form of the house is the result of setting together certain spaces and not necessarily due to any planned arrangement. There are no windows or openings on the outer walls of the house that open to the alley or the street. At the entrance to the house, there is a space called "the vestibule" as well as a corridor which prevents external noise from infiltrating into the house, thus providing peace and quiet for the inhabitants. The courtyards provide protection against solar radiation and act as a refuge against the hot and dry winds (Gedik, 2004, p.1). Generally, buildings with inner courtyards are more functional in hot and dry climates (Aldawoud, 2008, 0.906). The segregated spaces designed for men and women are the result of cultural and religious influences, leading to "inner" and "outer" parts in the residence.

Spatial Organization

Comprising two storeys and a basement, the Boroujerdis House consists of three main parts: 1) the rooms, 2) the service quarters (kitchen, toilet, bathroom, etc.), and 3) special spaces (the cold room or cellar, and the terrace).

The rooms can be varied in different ways and many activities can be performed in them. They are large in dimensions of 8m x 4m and 5.5m x 3.8m, with ceiling heights of 4-5 meters in the summer residence and 3-4 meters in the winter residence. The rooms are built from cob (clay and straw mortar). There are cross walls in each room for sitting during the day and sleeping at night. There are niches and corbels on which decorative objects can be placed, thus serving as aesthetic/functional elements. The interior of the rooms is almost completely made of indigenous materials provided from natural resources such as wood and wild flax. The service compartment lies on the first floor for convenience as well as easy access. The heat produced in the kitchen which is close to the winter rooms, can also be used for heating these rooms. The kitchen

utensils are made of materials such as wood, copper, and clay. The privy is located outside to avoid unpleasant odors in the inner house also to facilitate connection to the main sewage system. The Boroujerdis House was equipped with a bathroom where wood was burned to heat water. In spite of the high courtyard walls, the natural environments there have not been neglected. Other parts consist of cold rooms (cellar) in the basement for keeping foodstuffs fresh for daily consumption as well as for long storage purposes in winter. These spaces are accessed from the yard by going down a few steps. They are fixed with small windows for ventilation as well as providing comfort for the ground floor inhabitants (Sozen, 2007, p.1811). The special spaces like the terraces and cellars reflect the ecological aspects of the Boroujerdis House. The terraces which are due north have ceilings and comprise semi-open structures. They are located between the open and closed spaces so as to absorb sunlight in the winter and provide cool drafts in the summer. These spaces are ideal in the summer since they are shaded and cooled through natural ventilation. The cold rooms or cellars lie 80-120 cm below ground level and provide cool air in the summer residence during summer months.

Man-Made Landscapes and Plants

These two parameters are among the most effective ecological design criteria and consist of the pool, the water well, and the green space around the yards. These provide a natural space for the inhabitants to enjoy and utilize at will. As an aesthetic element, the pool creates a peaceful impression, and, at the same time presents physical characteristics for adjusting the ecosystem. One such characteristic is the water canals around the pool where water is vaporized, thus cooling the environment. Various plants are grown in the yards including fruit trees with large leaves which turn yellow in the autumn, thus providing biological diversity as well as a positive effect on the inhabitants' morals. These plants also provide shade in the summer and protect the house against harsh winds in the winter. They also reduce noise level and control air pollution.

Construction Materials

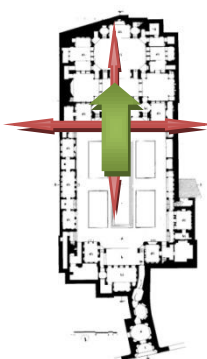
The effective component in selecting materials is the comfort provided through maintaining warmth in the internal parts of the house. Materials must be chosen properly from insulation materials. In the traditional houses

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built in hot and dry climates, usually materials with high heat capacities are utilized to take advantage of the insulation mechanisms. Kashan lies in a desert region with clay ground. Therefore, due to its accessibility, clay is mostly used for making building bricks in this region. Massive stones were used for building columns, the poolside, and certain parts in the walls. To provide more comfort for the inhabitants, the kitchen wall thickness was considered as 0.5-0.8 meters, thus minimizing heat transfer through the kitchen walls to the outside environment. Also, the time required for heat transfer from outside through this wall is long due to the great thickness of the wall. The thick walls also protect the house against external (and sometimes even internal) noise. The inhabitants spend the winter months in the inner spaces where there are no problems regarding the transfer of sound between adjacent rooms due to the adequate thickness of the walls. Thermal resistance of the walls exposed to solar radiation is high, so, in the afternoon, the inner windows can be opened to bring down the temperature through heat transfer to other inner rooms. In the summer residence, the windows are placed high on the walls to provide proper ventilation (since hot weather rises due to its lighter weight) as well let in natural light. This recurrent radiation and cooling continues well into the next morning when the cycle is repeated (Demirbilek, 1998, p.30). In most cases, the upper windows are fitted with various rounded or grilled grids for better ventilation. In some parts, small glassless windows or rods are implemented.

The general characteristic of the Boroujerdis House is its flat earthen roof commonly used in

Table 5. Ecological Values Created from the Design Tips used in the Boroujerdis House

Ecological Values	Plan metric Descriptions	Ecological Design Strategies
Building Form		
<p>Compatibility with the natural environment based on topographical features. Creation of shaded areas in the yard due to high walls.</p> <p>The ceiling height is between 3.20 to 7.00 meters.</p> <p>The summer residence is due north and the winter residence due south.</p> <p>Hot dry summers, Winter is not cold, Low precipitation, Northern winds, Long hours of solar radiation,</p>		<p>The residential areas have organic forms with the yard located below ground level.</p> <p>The house location comprises 4 main axes.</p> <p>Climatically designed yard and orientation of living spaces.</p> <p>The residential areas location controls sunlight through adjustment of ceiling height in the building</p>

hot and dry climates. Table 5 demonstrates the ceiling of the house in detail. This characteristic increases the time delay for heat transfer as well as the heat capacity of the ceiling. The other materials used in constructing this house include unbaked Kaz bricks (made from oven ash, sand, goat wool, and tragacanth), wood and iron.

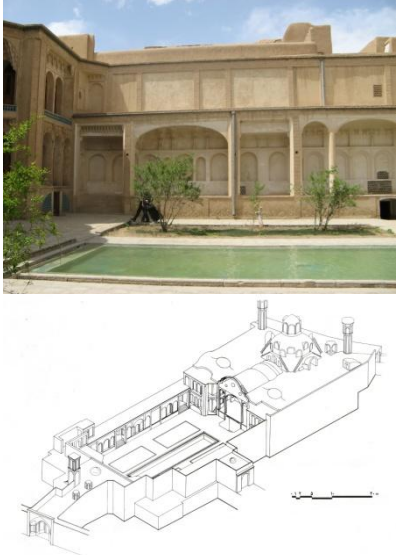
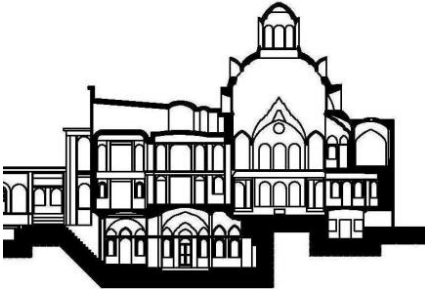
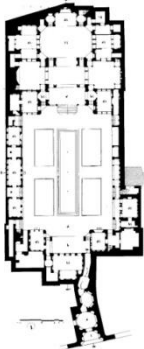

Technical Installations

The technical installations in the Boroujerdis House are incorporated in the building design, the sewage system, as well as in gathering and providing water for the house. Water evaluation includes important parameters in preservation and recycling of natural resources. The kitchens and outer privies (water closets) are placed close to the street. The water necessary for household chores is drawn from the well. Also, the water available in the pool suffices for washing purposes as well as cleaning the house. In general, liquid sewage and waste materials are used to water the gardens. The conducted evaluations indicate the methods used in so doing are optimal since they employ both natural resources and waste materials.


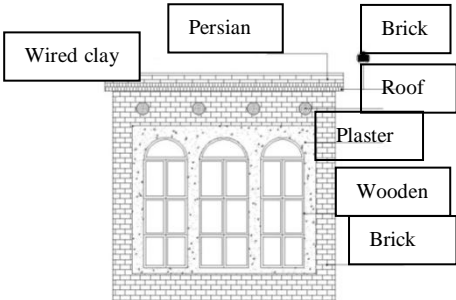
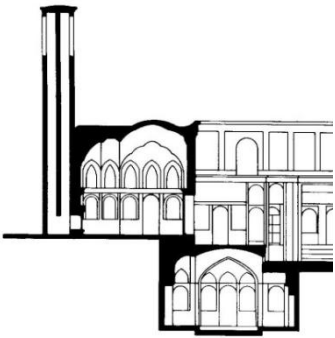
DISCUSSION

This study was conducted based on ecological design strategies deployed in the construction of the Boroujerdis House in Kashan. The strategies are mainly related to structural principles (building type, spatial organization, landscape, materials selection, and technical substructures) as well as to the physical environment (topography and climate). The ecological values obtained from this study are presented in Table 5.

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<p>Divisions are based on the family structure.</p>		
<p>Spatial Organization</p>		
<p>Various plans with different forms and dimensions for yards, terraces, spacious rooms, Use of natural elements, One room sufficiently functions for one family, Specific service spaces, Aesthetic values, Life style based on cooperation, comfort, and health of extended families, Relations with neighbors, Economic structure.</p>		<p>Design is based on life style, Spaces can be used in various ways based on user's circumstances, No unused spaces, Friendly relations within the family, Presenting natural working apparatus and the subsequent comfort,</p>
<p>Shaded cool terraces in summer, General-purpose rooms: warm in winter, hot in summer, Long hours of solar radiation, Special spaces proportional to hot climates (the cellar), Climatic elements including gardens, pools, open and semi-open spaces.</p>		<p>Spaces proportional to climatic conditions, Smaller dimensions of the winter residence (20m x 25m) as compared with those of the summer residence (25m x 32m)</p>
<p>Landscape and Plants/Vegetation</p>		
<p>The compatibility of the house with planted vegetation reduces the greenhouse effect and is environmentally friendly, Use of water canals around the pool for irrigation, moisturizing, and cooling the yard.</p>	<p>Pool dimensions proportional to the yard length</p> 	<p>Natural inner environment created by water, pools, as well as inner spaces, Appropriate use of bushes and trees, Providing favorable atmospheric and environmental conditions, Protecting Nature.</p>

**Compatible Ecological Strategies Used in the Design of Traditional Houses in Iran’s Hot and Dry Climate
Case Study: The Boroujerdis House in Kashan**

		
Construction Materials		
<p>Using indigenous materials, Ease of access and activities proportional with local conditions and people’s state of health, Energy savings through employing renewables,</p>		<p>Traditional insulation materials based on old technologies, Covering of surface soil.</p>
Technical Installations		
<p>Presenting natural economic solutions for technical substructures Making the most of local materials Recycling waste.</p>		<p>Comfortable use of the substructure (infrastructure), Spatial organization of the structure, Functionality of spaces,</p>

Source: The Author

CONCLUSION

This study aimed to discover the secrets and tips used in the design of such durable, economic, and comfortable/functional houses as the Boroujerdis House in Kashan where climatic conditions greatly influence architectural styles. Such structural tips consider ecological advantages, since people who used to live in such houses often speak of their much more comfortable circumstances as compared with those they enjoy upon moving to more modern residences. This is due to the fact that modern buildings are not in harmony with their structural and physical environment. The reason for using indigenous materials in houses was primarily their availability and practicality, as well as their being environmentally and ecologically friendly. Light, the most non-material tangible element of the nature, has always been present in the Iranian architecture, and is in fact a sign from the high world and spiritual space. During traditional architecture

era, the type of the view towards light under the influence of Islamic thought reaches its most excellent degree, and is considered as the manifestation of sanctity and the spiritual world. Moreover, such materials provide comfortable, healthy, and inexpensive living spaces for their inhabitants. Regarding their local topography, the design of the yards and their different orientation in different seasons, as well as the possibilities for changing the functionality of the spaces based on the user’s needs were considered. It was concluded that, the ecology of the region must be taken into account in creating sustainable building environments. Moreover, traditional solutions as well as using solar and other renewable energy sources must be utilized on a greater scale in building modern houses. Light is a sign of movement towards truth, which lacks physical and material form, and this issue is discussed along with other factors such as the climate and the position of a building and the form of the

use of light. In spite of the hot and dry climatic conditions in Kashan, it is possible to use open and semi-open spaces during three quarters of the year. The turning points in traditional buildings discussed in this article is their semi-open spaces (terraces), gardens, planted areas, and their pools which are used for cooling purposes and can provide useful clues for modern architects in designing their residential environments. However, corrections must be introduced in the outer spaces in traditional buildings to make them more functional according to modern standards.

RECOMMENDATIONS

- In order to accommodate surrounding spaces, new applications should be added to the outer space of traditional houses
- The modern residential buildings should be designed by architects and urban planners who have economic, political, methodological, and physical possibilities.
- Architects and urban planners should pay attention to renewable energy sources, proper sewage disposal methods, climatic comfort, as well as protection of scenery and natural resources.

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