The Historical Gardens of Iran: Issues for Sustainable Landscape Design

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ABSTRACT

This paper is comparative study and concentrates on a research based on sustainable parameters of four Persian gardens, located on the central plateau of Iran. The lack of green spaces in the vast arid regions in Iran, has forced landscape architects and gardeners to create many innovative solutions to heat and dryness and the design method of Persian garden is one of them. Historical gardens of Iran have had special role to moderate local climates in arid regions and their design methods can be strategies for contemporary landscape architects. The selected case studies of this paper are Chehelsotoun, Fin, Shazde and Dolatabad gardens which are placed in the cities of Isfahan, Kashan, Mahan and Yazd respectively in arid regions of Iran. The research method adopted in this paper consists of descriptive-analytic and deductive analyses, and by the analysis of sustainable features and characteristics of these selected historical gardens; such as, planting and irrigation systems, and relationship between natural and built elements of Persian gardens, the authors identify an appropriate approach to create green spaces for present sustainable landscaping in similar climates. Results confirm that the similarities and differences between these selected gardens are because of the different microclimatic regions they are located in. At the conclusion, the authors classify the main characteristics of Persian gardens from sustainability view and present recommendations for sustainable landscape design.

INTRODUCTION

Today, increase of fossil fuels consumption and the usage of nonstandard and unsustainable models in architecture and urban design in Iranian cities are the main reasons of problems, such as increase of diseases, heat, drought and climate change. While in the past, sustainability was the essential factor in traditional Iranian architecture and landscape design. Iranian gardeners could create sustainable green spaces in their own cities and used the historical gardens to moderate local climate over many centuries. The traditional landscape architecture of Iran has developed sustainable characteristics that have allowed its gardens to respond to the environmental obstacles for thousands of years and the Persian garden has known as a famous traditional landscape of Iran. The Persian garden’s characteristics are mainly based on climatic and sustainable factors and some other intellectual features. Historical Persian gardens’ design method is one of the well-known Iranian traditional method in hot and arid regions, which plays a role in works of beauty and aesthetic as well as compensating poor humidity to create a sustainable microclimate for human living [18], Persian gardens were called “Pardise” meaning “heaven” and “Walled garden” in Farsi and significantly this word entered Semitic languages as well as, Arabic, “Ferdous” and in English, “Paradise”, The English word, “Paradise” was derived the Greek word” Paradiesos” which in turn was derived from the old Avesta (holey Zoroastrian book)“Pairidaeza” , meaning an enclosure[1]. This word, expresses such gardens which have been closed and its feature based on climatic conditions and sustainable principles. The archetypal of Persian garden is called Chahar Bagh, meaning “four gardens” and many historians believe that the of Chahar Bagh is rectangular shape, surrounded by four walls and crossed by two water courses which intersect at the right angle[12]. By the observation of Persian carpets, handicrafts and some miniature paintings from 16th and 17th century during Safavid era, many Persian gardens scholars concluded that, the Persian garden model is rectangular, quartered shape which is crossed by two axes and has had effective role to create other Persian arts during the history[11]. Until only a few years ago, there was a still prevalent opinion that the celebrated garden carpets of the sixteenth-century
Safavid Iran provided the oldest extant evidence for the form of the early Persian garden [20], but Today, many Scholars found some evidences to prove that, the Chahar Bagh plan was not necessarily quartered by two axes. The oldest recovered Persian garden is Passargad garden, in the southwest of Iran, built by Cyrus the great in the 6BC. The remnants of stone channels in Passargad discovered by archeologist David Stronach during his excavation of the historical site and in his first depiction of Passargad have proved the plan of garden’s not been quartered by two intersecting water channels (Fig.1).

Another garden scholar\(^1\), depicted the layout of Chahar Bagh, based on descriptions of oldest Iranian agricultural book\(^2\), which describes Chaharbagh model as rectangular shape, crossed by water which flows inside the garden. Based on that book’s descriptions, the common interpretation of the layout of Chaharbagh is that the garden quartered by two intersecting water channels was refused [2].

Based on historical documents’ studies and observations of the existing historical gardens of Iran, the authors conclude that; Persian garden model is usually rectangular shape, surrounded by four walls and crossed by the main axis which is often water course. The main design elements of Persian garden which are nearly the same in all of them consist of natural elements, such as water and vegetation and the built elements, such as pavilion which is usually located on the main axis perpendicularly and walls (figures2, 3, 4&5). Walls act as borders between inside and outside of the garden. Other ancillary elements like service spaces (bath, stable) are often included. A Persian garden typically features a conceptual design with its natural and built elements organized around a central axis. Today, in the big cities of Iran, there are different green spaces, replaced the ancient gardens and modern parks are the most famous of these green public spaces, while, their design method has never corresponded to sustainable parameters and climatic conditions. Because of, the location of Persian gardens’ archetype is arid region of Passargad and also many Persian gardens are located in arid areas of central plateau of Iran, the authors decided to select four gardens in arid regions as case studies of this paper. The selected gardens of this research are placed in four arid cities, Isfahan, Kashan, Kerman and Yazd and they are still used as public gardens. Since usually it is argued that landscape plans should be informed by species requirements, should show an understanding of supporting biological and physical processes, and should attempt to ensure process integrity [3]. So, The main goal of this paper is to determine sustainable design aspects of Persian gardens that moderate environmental conditions.

**MATERIALS AND METHODS**

The research methodology of this paper is descriptive-analytical method, based on historical and documented sources and field studies. For data collections, the authors used two methods: library research and field study and this research framework include these processes:

- The introduction and description of historical Persian gardens mentioned above as selected case studies of this paper.
- The analysis of climatic conditions of selected gardens’ cities, Isfahan, Kashan, Mahan and Yazd by the Koppen’s method concentrating on synoptic station statistics during ten-year period 1995-2005, cited in Iran’s weather website.
- A comparative study of selected cases’ and analysis of their natural and built elements from sustainability view.

**Description of Case Studies:**

Persian garden was actualization of latent potential of environmental and cognition of its complexity in the past times [7]. In Persian garden, everything followed the geometric order and organization, and was confirming and coincided. Residing garden, refreshing garden, ceremonial garden, shrine-garden, mausoleum-garden, mosque garden and school garden can be named amongst different type of Persian gardens [7]. The selected case studies are four existing gardens in four different cities in arid regions of Iran. At that time, all of these gardens were used as residential garden for royal families and today, they are currently used as public gardens.
for leisure:

*Chehelsotoun garden, Isfahan:*

Chehelsotoun meaning is forty columns in Farsi is one of a few royal surviving gardens of Isfahan, built during Safavid period (17th century). Its location is close to the main square of city and its configuration is based on three (E-W) axes. The main garden’s pavilion is located on the central axis, others axes are parallel to the main. The Chehelsotoun pavilion, placed in the west side of the garden, with a lot of beautiful ornaments, was a special place and used for royal ceremonies during hot summer days (Fig.2).

*Fig.2,3: Chehelsotoun Garden, Isfahan (Left), Fin Garden Kashan (Right) [17].*

*Fin garden, Kashan:*

Fin garden is in the southeast of Kashan road, near the historical Soleimanieh spring. When the garden was built, it was an oasis at the time, but gradually after the development of Kashan; it has become an urban green space by mixing with the surrounding gardens. The main pavilion of garden is located on intersection of perpendicular axes and other ancillary spaces are placed around the garden into the garden’s walls. The southeast orientation of the garden would increase morning sun exposure and also would reduce the afternoon radiation [8].

*Shazde garden, Kerman:*

Shazde garden is an oasis in desert, located on the slope of Joupars Mountain in Kerman province, six kilometer away from Mahan, close to the major Mahan-Bam thoroughfare. The main axis of the garden is toward north-south [6] (Fig.4).

*Dolatabad garden, Yazd:*

Dolatabad garden was originally built as an oasis in a suburb of deserted city, Yazd. During last century, Yazd city continued its outward growth, and today, Dolatabad is an urban garden, located in the centre of Yazd. The garden includes both public and private sections, which are the main axes, intersect each other perpendicularly. The main gateway and some public spaces including the bath, stable, and public hall are located at the intersection of two axes (Fig.5).

*Fig. 4,5: Shazde Garden, Mahan (Left) and Dolatabad Garden, Yazd (Right) [15].*

*Climatic Conditions:*

In Iran, there are several climatic regions, each having special characteristics. As a result Iran is like a little continent. Many scientists in Iran and other parts of the world have worked on different climatic classification, and the most widespread method is Koppen’s method, which has classifies the world into five climatic zones: Hot-Humid (A), Hot-Arid (B), Temperate (C), Cold (D) and Polar (E) climate. There are a few countries in the
world, which contains the main four climatic zones (A, B, C and D). All of these zones and their deviations can be found in Iran.

The climate of central Iranian plateau is arid and semi-arid, and receives almost no rain during the six hottest months of the year. The main characteristics of this climate are also a very arid summer and cold winter. Furthermore, in this area, most of the time, the sky is cloudy and there is no humidity in the air, and there are large differences between daytime and nighttime temperatures. According to the Koppen’s method, the arid climate’s classification is based on: annual temperature, humidity and amount of rainfall, and is divided into four main microclimates: BWks, BWks, BShs and BShs [8]. According to Koppen’s method (Table 1), all selected cities are located in desert arid regions (BW). The mean annual temperature of Isfahan and Mahan are below 18°C and in other cities are over 18°C. Also the amount of rainfall in all selected cities (Table 1) reveals that, in the wettest month of winter it is at least three times more than the driest month of summer. Based on these data, Isfahan and Mahan can be classified as BWks microclimates and Kashan and Yazd are located in BWks microclimatic areas. Moreover, Kashan is the most humid city and Yazd is the least one. In addition, the annual wind direction in Isfahan is often southwest and west, in Mahan is often southwest and northwest, in Yazd are northwest but in Kashan, wind blows from all directions with low velocity.

### Table 1: Climatic Conditions of Isfahan, Kashan, Mahan and Yazd

<table>
<thead>
<tr>
<th>City</th>
<th>Altitude</th>
<th>Annual Temperature</th>
<th>Temperatur e in Hottest Month</th>
<th>Annual Humidity</th>
<th>Annual Rainfall in Wettest Month of Winter</th>
<th>Annual Rainfall in Driest Month of Winter</th>
<th>Annual Rainfall in Wettest Month of Summer</th>
<th>Annual Rainfall in Driest Month of Summer</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isfahan</td>
<td>1550</td>
<td>16.6</td>
<td>29.2</td>
<td>35.5</td>
<td>46.3</td>
<td>4.4</td>
<td>1.5</td>
<td>0</td>
<td>BWks</td>
</tr>
<tr>
<td>Kashan</td>
<td>982</td>
<td>21.2</td>
<td>31.6</td>
<td>41</td>
<td>36.9</td>
<td>30.9</td>
<td>2.3</td>
<td>1.2</td>
<td>BWks</td>
</tr>
<tr>
<td>Mahan</td>
<td>1755</td>
<td>17</td>
<td>28.6</td>
<td>33.6</td>
<td>34.7</td>
<td>26.2</td>
<td>1.5</td>
<td>0.5</td>
<td>BWks</td>
</tr>
<tr>
<td>Yazd</td>
<td>1273</td>
<td>18.9</td>
<td>43</td>
<td>26.4</td>
<td>10.47</td>
<td>10.2</td>
<td>1.03</td>
<td>0</td>
<td>BWks</td>
</tr>
</tbody>
</table>

### RESULTS AND DISCUSSIONS

**The Parameters of Sustainability in Elements of Persian Garden:**

Natural elements: water and vegetation:

Water and vegetation the natural elements of Persian gardens are key ingredients in garden design. Since the gardens have been built in arid regions, water, used as an important design criterion to create a comfortable microclimate in Persian gardens by channeling breeze over the existing water to reduce air temperature and increase humidity. Also, the extent of garden’s been followed the amount of water. Another important modifying element is vegetation. In these gardens, vegetation perform functions, such as; create an architectural framework, produce aesthetic effects and modify the microclimate [14]. Gardeners use vegetation to guide and filter the breeze and to increase evaporative cooling. By placing vegetation strategically, Landscape designers and gardeners are also able to provide shade and absorb the sun’s ultraviolet radiation. In addition, plants modify the climate in three ways: wind control by guide and filter the breeze and ultimately cause to increase evaporative cooling, modification of sunlight and change the moisture [14].Excluding the central axis of Persian garden, on which the pavilion is located, the entire garden is covered by vegetation. In all selected gardens in this research, water is used in two main ways to regulate garden’s microclimates; through the Irrigation of garden and the creation of water displays:

The irrigation of garden:

Since all selected gardens are located in arid regions the source of water and irrigation systems are two important factors to find water and prevent wasting it. The source of water/ irrigation method for two gardens of Dolatabad and Shazde is Qanat, indigenous irrigation method, was invented by ancient Iranians to carry water from mountains bed through the interconnected wells, creating underground streams, and transporting water to far-off places (Fig.6). At the entrance part of the garden, water stream is divided in to narrow canals to irrigate the entire garden, thus this method can prevent to waste the water [13]. As Henri Goblot, a French geologist mentioned, the irrigation system by Qanat is one of the greatest methods of irrigation in the history of civil engineering [13]. At 63km, Dolatabad Garden’s Qanat is the longest in Yazd province [15].

The Chehelsotoun garden like other royal gardens of Isfahan was irrigated by streams, called; Madi, following from river in Isfahan; Zayanderoud River. There are ten Madis following from the main river to irrigate the Isfahan’s farms and gardens. All the Isfahan gardens were orientated to Madis’ directions.

For Fin garden, the source of water is Soleimanieh spring, 2km away from the garden. The water from that spring flows to a large pond in the garden and from there, to the garden’s water streams [15].
The lack of water in such arid regions required the designers to create sustainable methods for irrigation system and water displays. The irrigation system influences the geometrical design of the garden, thereby, preventing the waste of water [17]. After the water in all gardens irrigates the trees and other vegetations, it transports to the outside of gardens to irrigate farms and other lands (Fig. 7, 8).

**Types of Water Display:**

There are many ways to display water in these selected gardens. Large pool and pond store water for drought seasons, canal and streams are employed to irrigate the plants and many kinds of fountains are demonstrated. The fountains are not just utilized for beautification, but also increase humidity during hot days. Since the Shazde garden is located on the slope, the water cascades display on the main axis of the garden and create pleasant landscape inside the garden. Also, the direction of wind is an important factor for pool and canal settlement. At Chehelsotoun garden in Isfahan, the large pools were extended alongside the wind direction (NE-SW) and at Dolatabad garden in Yazd the large pool and canals are located in the northwest part of the garden thus, the wind could create evaporative cooling effect, however at Fin garden, the winds blow from every direction, therefore, the water is channeled and streams are placed throughout the garden, in order to create an evaporative cooling effect in every corner.

**Planting the Garden:**

The vegetation supported by each selected gardens is diverse and includes; Flowers; Rose, Jasmine, Clover and many types of trees. In Persian gardens, trees are usually used for; beautification, shade and fruitful. In all selected gardens; Evergreen trees such as Cypress, Pine and Plane, are located in the main passageways and Fruit trees such as Berry, Pear, Quince and Apricot at Fin garden, Pomegranate, Fig and Berry at Dolatabad garden, Apricot, peach and cherry at Shazde garden are located between them (Table 2). Persian gardens are able to support fruit trees due to their sustainable features, including geometrical designs and economical use of water through irrigation systems, thus the gardens are always shown sustainable and green (Fig. 7). Evergreen trees in these gardens are not only used as natural shading devices, but also protect inside the garden from storms and local dusty winds. Furthermore, in Persian gardens, instead of Lawn, a type of clover called Spest was used as a walkway. Spest had many sustainable characteristics; absorbs the weather nitrogen and transports it to the soil, repels the insects, it is easy to maintain it, requires less water than Lawn and also, used as cattle feed during cold seasons [21].

**Built Elements:**

**Wall:**

Wall is the main built element of Persian gardens. It surrounds all the garden’s elements and acts as a border
between inside and outside of the garden. Wall has not only the security role for the garden, but also climatic function to protect the garden against hot dusty winds, preserve the humidity inside the garden [19]. Moreover, wall as a shading devices create the shadow inside the garden in arid regions.

**Pavilion:**
While most traditional urban buildings in the arid regions are introverted, in these selected cases like other Persian gardens pavilions are extroverted. In Persian garden, a close relation with nature is obtained in a simple manner and there is no interval and boundary line between the pavilion and the rest of the garden, so that it cannot be seen where one begins and other ends [6]. Perhaps due to the amounts of vegetation and water that is used in Persian garden to create a microclimate. The gardens’ pavilions are analyzed from these points of views:

**Location and Orientation:**
The pavilions of Persian gardens are located on the main axis, from centre till end of the garden. At Chehelsotoun garden, the designers built the pavilion on the 1/3 end of the garden and it’s been completed during a long process of time. In the first phase of pavilion design, the extension of pavilion was alongside the north-south axis. In the next phases, the additive parts were attached to the east side of the building and extended the pavilion in to the southeast orientation (Fig. 9). At Fin garden, the pavilion’s built near the centre of garden to utilize breezes from all directions, and orientated to southeast, following the orientation of garden itself. At Shazde garden, pavilion is located on the northern slope. Despite of the orientation of Shazde garden is in north-south direction, the pavilion; pool and planting the trees are extended alongside east-west axis. At Dolatabad garden, the main pavilion, used as summery residence, built on the southern side of garden to create the breeze from north and northwest winds and the building is orientated to southeast. All of these selected buildings are orientated to southeast. The southeast orientation of the garden would increase morning sun exposure and also would reduce the afternoon radiation. As it was mentioned before, in all selected cases, the buildings’ orientation and the location of their openings are following to climatic conditions, especially wind direction of the cities.

![Fig. 9: The process of Expansion of Chehelsotoun Pavilion [17].](image)

**Passive Cooling Elements of Pavilions:**
The most important strategies for passive cooling in buildings’ design in arid regions are: to provide shading and natural ventilation by wind and water. The mentioned strategies have been noticed for Persian pavilion design by creation of appropriate spaces and evaporative cooling elements for many centuries. Some of those strategies will be discussed below [10]:

**Iwan and Balcony:**
Iwan is a single vaulted hall which is opened into the outside and acts as an entrance space of pavilion and connects building to the garden. The balcony is an isolated part of pavilion. The balconies usually placed where they could have a panoramic view while remaining invisible to the eyes of strangers in the garden [11]. Despite the similarities between selected pavilions, the number of their iwans and balconies differ. As table1 indicates, in the coldest city; Isfahan, the Chehelsotoun pavilion has the largest iwan between all selected pavilions, which it’s extent approximately 2/3 of pavilion’s area and open from three sides to create a pleasure breeze within the garden, and in the most humid city, Kashan, the garden’s pavilion with the four iwans and twelve balconies has the most numbers of semi open spaces to flow humid breeze in to the pavilion. Since, wind blows from all directions in Kashan, the iwans and balconies are located on four sides of the pavilion. However, due to the local dusty winds, at Shazde garden, the pavilion ‘s balconies are located only on north and south sides of the building , and at Dolatabad pavilion, there are only three iwans and two balconies open to the outside of the garden(Table2).
**Water Ponds and Streams:**

There are different ways of water design, which is displayed in all selected cases. Despite of Shazde pavilion, other selected pavilions, contain central ponds that act as a cooler in building through evaporation (Table2); especially in Dolatabad pavilion, the high wind catcher at the top of pond would increase evaporative cooling. Although the physical effect of evaporation is essential, psychological effect of water is even greater. The sound of water inside the building is known to bring relief to its inhabitants. Also, in each selected garden, water canals around its pavilion can modify airflow. Water canals are used to cool the Hot air as it passes above. In all of these pavilions, the outside water ponds are orientated according to wind patterns [9].

**Table 2:** Comparison of Schematic Spaces and Locations of Pavilions of Selected Persian Gardens

<table>
<thead>
<tr>
<th>Garden</th>
<th>Pavilion in the Garden</th>
<th>Pavilion Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chehelsotoun</td>
<td><img src="image" alt="Chehelsotoun Pavilion" /></td>
<td><img src="image" alt="Chehelsotoun Pavilion Plan" /></td>
</tr>
<tr>
<td>Fin</td>
<td><img src="image" alt="Fin Pavilion" /></td>
<td><img src="image" alt="Fin Pavilion Plan" /></td>
</tr>
<tr>
<td>Shazde</td>
<td><img src="image" alt="Shazde Pavilion" /></td>
<td><img src="image" alt="Shazde Pavilion Plan" /></td>
</tr>
<tr>
<td>Dolatabad</td>
<td><img src="image" alt="Dolatabad Pavilion" /></td>
<td><img src="image" alt="Dolatabad Pavilion Plan" /></td>
</tr>
</tbody>
</table>

- **Green Spaces**
- **Closed Spaces**
- **Semi-Closed Spaces (Iwan)**
- **Water**

At Chehelsotoun garden, the pavilion is surrounded by water canals. In Fin pavilion, the streams flow in three directions, connecting the building’s central pond to other pools, ponds and streams in all parts of the garden (Table2), thereby increasing humidity and at Dolatabad garden, the large pool and all the ponds outside the pavilion are located to the northwest of the pavilion to create similar effect.

**Shading Devices:**

The use of shading devices is an important strategy in sustainable design. Shading devices should be designed to reduce direct solar radiation and prevent reflecting on to any part of the building or opening [9]. At Fin Garden, four domes are located over the main ponds of the garden to provide shade and prevent wasting the water [13]. In all selected pavilions, arcades and porches as shading devices protect the building from intensity of sun radiation.

**Roof Design:**

Despite the flat roof in Chehelsotoun pavilion, the form of other selected cases, just like other traditional buildings in arid regions of Iran, is in dome form.” Dome roof would shade part of its surface and also could shadow the other surfaces during the day. “At night a domed roof surface area means the greater area from which long-wave radiation and heat loss can take place” [16].

**Building’s Materials:**

The main material used in Dolatabad pavilion is adobe and in other selected pavilions is brick. Adobe and brick are extremely sustainable materials because, they have thermal resistance, and thermal capacity and they are good at absorbing the sun’s radiation. They don’t require much energy to produce and also, have the potential for reuse if the building is demolished. Furthermore, another material which is used in some pavilions, such as Fin pavilion is tile. Tile has also sustainable features; it can be changed and washed easily. These vernacular materials could be found resourcefully in arid regions. Table3 indicates the summery of all selected pavilions’ characteristics:
Table 3: Characteristics of Chehelsotoun, Fin, Shazde and Dolatabad Pavilions

<table>
<thead>
<tr>
<th>Garden</th>
<th>City</th>
<th>shape</th>
<th>Location</th>
<th>Orientation</th>
<th>Roof Design</th>
<th>Shading Devices</th>
<th>Water Displays</th>
<th>Materials</th>
<th>Cooling Spaces&amp; Elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chehelsotoun</td>
<td>Isfahan</td>
<td>Rectangular</td>
<td>1/3 end of axis</td>
<td>NW-SE</td>
<td>Flat</td>
<td>Canopy</td>
<td>Pond</td>
<td>Brick, Wood, Tile</td>
<td>Iwan, Water Pond</td>
</tr>
<tr>
<td>Fin</td>
<td>Kashan</td>
<td>Square</td>
<td>Centre</td>
<td>NW-SE</td>
<td>Dome</td>
<td>Arcade</td>
<td>Pond</td>
<td>Brick, Tile</td>
<td>Water Pond, Iwan &amp; Balconies</td>
</tr>
<tr>
<td>Shazde</td>
<td>Mahan</td>
<td>Rectangular</td>
<td>1/3 end of axis</td>
<td>N-S</td>
<td>Dome</td>
<td>Arcade</td>
<td>-</td>
<td>Brick with white Stucco Plaster</td>
<td>Iwan &amp; Balconies</td>
</tr>
<tr>
<td>Dolatabad</td>
<td>Yazd</td>
<td>Semi-octagonal</td>
<td>End</td>
<td>NW-SE</td>
<td>Dome</td>
<td>Arcade</td>
<td>Pond</td>
<td>Brick</td>
<td>Balconies, Water Pond&amp; Wind catcher</td>
</tr>
</tbody>
</table>

Conclusions:

This paper shows that the objective of Persian garden design as traditional landscape architecture in arid regions has been to moderate local climatic components. From the comparative study and analysis of Chehelsotoun Fin, Shazde and Dolatabad gardens, the authors draw the following conclusions:

- The characteristics of selected gardens reveal that, despite many similarities in design and elements of Persian gardens in the same climatic areas, there are some dissimilarity between them. Thus, climate even within a very similar classification range can be the main design determinant for Persian gardens.
- The orientation and layout of selected gardens are determined by natural elements such as sun, wind and water, which are essential to construction of Persian gardens.
- Persian garden in arid regions use natural soft and hard landscaping can be considered sustainable method, which are not only influenced by climatic factors, but also has had an effective role to increase passive cooling.
- The irrigation systems of these selected gardens, use a minimum amount of water, are representative of social, economic and environmental sustainability in traditional Iranian landscaping.
- Locally available materials such as brick and adobe, by providing their durability within the garden in arid climates and also by absorbing sun’s radiation, can increase sustainability of Persian gardens.
- In sustainable development model, considering to social, economic and environmental developments is suggested. Since society includes a group of people and environment includes, natural and built environments, therefore, in Persian garden’s pavilion, there is relationship between human, built environment and nature and this relationship is based on model of sustainable development.
- Based on this analysis of Persian garden’s natural and built elements’ characteristics (Table 4) and the strategies of their design, the authors conclude that it is possible for current designers to create sustainable green spaces.

Table 4: Sustainable Characteristics of Persian gardens' Elements

<table>
<thead>
<tr>
<th>Natural Elements</th>
<th>Built Elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Optimization using water sources in irrigation</td>
<td>Plants</td>
</tr>
<tr>
<td>system</td>
<td>Solar heat absorption and decrease weather temperature</td>
</tr>
<tr>
<td>The irrigation system following to geometrical form of garden</td>
<td>Accordance of planting to geometrical form of garden</td>
</tr>
<tr>
<td>Prevent wasting water by appropriate irrigation system</td>
<td>Using local fruitful trees</td>
</tr>
<tr>
<td>Using water streams &amp; pools to increase evaporative cooling</td>
<td>Planting the trees according to wind directions &amp; solar radiation</td>
</tr>
<tr>
<td>Appropriate Location &amp; orientation of ponds and pools to increase humidity</td>
<td>Planting evergreen trees on the main passageways for shading</td>
</tr>
</tbody>
</table>

End Notes:

1-Mahvash Alemi; Architect and Garden Scholar
2-Irshad-AZ- Zerae; one of the oldest Iranian horticultural books, written by Fazil Heravi in 17th Century
3- BWhs: Desert climate with the average annual temperature over18°C.
4- BWk: Desert climate with the average annual temperature below 18°C.
5-BShs: Steppe climate with the average annual temperature over 18°C.
6-BSKs: Steppe climate with the average annual temperature below 18°C.


REFERENCES