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Recognition and Reinterpretation of Persian Gardens from Sustainable view Case Studies: Gardens of Mahan and Shiraz

Honey Fadaie*[1], Seyed Majid Moidi[2]

[1]Ph.D Candidate, Department of Art and Architecture, Science and Research Branch, Islamic Azad University, Tehran, Iran.
[2]Assisstant Professor, School of Architecture and Urban Studies, University of Science and Technology, Tehran, Iran

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ABSTRACT

Effects of neglecting climatic and sustainable patterns in green urban spaces are intense in arid regions, while sustainability is observed in many elements of traditional Iranian landscape architecture and describe how these methods of design have responded to climate problems over many millennia. For that reason, the analysis of sustainable parameters in traditional landscape of Iran such as, Persian gardens is very important to the present and future of Iranian cities. This paper is a comparative study on the sustainable parameters of two Persian gardens located on the arid central plateau of Iran. The recognition and reinterpretation of Persian garden design can be an appropriate solution for landscape architects to create sustainable green spaces in modern cities. The main objective of this research is to find the parameters and principles of sustainability in Persian garden as sustainable landscape heritage. The selected case studies of this paper are two historical gardens, located in two different microclimatic areas in arid regions of Iran. By analyzing the sustainable and climatic features of the selected case studies, Shazde Garden in Mahan and Eram Garden in Shiraz, this paper identifies ways to create green space for sustainable landscaping in similar climates. Results demonstrate that in Persian gardens design, sustainable principles have been used to moderate local climates and provide food for people of those areas. Results also, confirm that the differences in selected gardens can be observed because of sub climatic areas they are located in. At the conclusion, the authors present guidelines and recommendations for sustainable landscape design.
KEYWORDS: Arid Regions; Eram; Persian Garden; Shazde; Sustainable Landscape.

INTRODUCTION

Today, a majoir contributing factor to increase pollution and consequently many diseases in the big cities of Iran is the lack of sustainable green spaces and the usage of unsustainable models in architecture and urban open spaces.The lack of green spaces in the vast central plateau of Iran was the main reason to force the Iranian architects to create gardens. In effect, the traditional landscape architecture of Iran has developed sustainable characteristics that have allowed its gardens to respond to environmental obstacles[5]. A garden can be acknowledged as the national encyclopedia of a country where new results will be derived from its interpretation [15]. Thus, the analysis of historical gardens from ancient till modern era, as sustainable green spaces of Iran is unavoidable. Studies demonstrate the oldest recovered Persian Garden is Passargad Garden, in southwestern Iran, built as a royal garden of Achamend emperors, by Cyrus the great in the 6th century B.C[1]. The archaeologist David Stronach in 1960s discovered the ancient Passargad site by the observation of the remnants of stone channels during his excavation of the site, and he has also depicted the Passargad garden(Fig.1). By the observation of a garden in the carpet of sisteenth-century, Stronach concluded that, “From the appearance of such carpets it was already clear that Safavid gardens(in16th century) included numerous water channels, multiple parterres, and a centrally placed garden pavilion which often stood within a rectangular pool on the long axis of the plan”[17]. Based on findings described above, the authors conclude that, from 6 centuryB.C, when Iranian designers built the first Persian Garden, untill 19th century, when Iranian architects began to embrace modern design, the Persian Gardens have been constructed based on the same conceptual design and, they also experienced a garadual evolution in design techniqus[5]. According to Stronach depiction(Fig.1), Passargad was rectangular garden , contained pavilions and water channels. Passargad and other Achanemid gardens were called “Pardis”, meaning in Farsi, “ closed garden” or “walled garden” and this word as a symbol of surrounded garden, has a lot of features based on sustainable parameters.

Coressponding Author: Honey Fadaie, Ph.D Candidate, Department of Art and Architecture, TehranScience and Research Branch, Islamic Azad University, Tehran, Iran. Email:honeyfadaie@yahoo.com,Fax: +982122961667, Tel:+989122148114

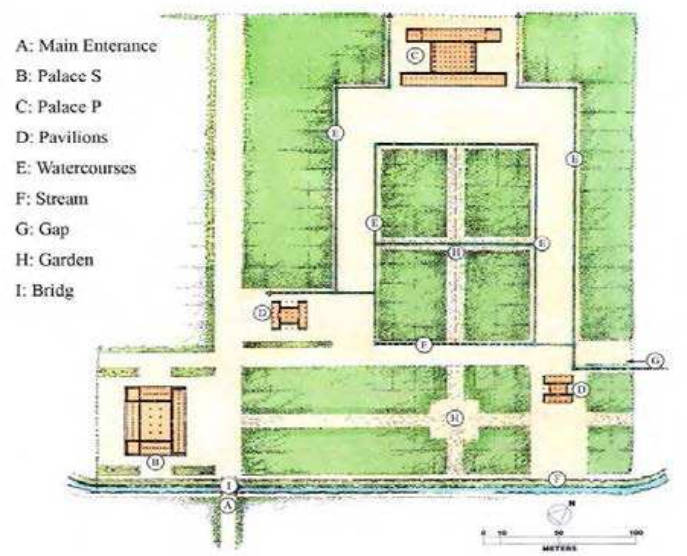


Figure1: Passargad Persian Garden, depicted by David Stronach[9]

The archetype of Persian garden is called *Chahar Bagh*, meaning "four gardens." Many scholars believe that the Chahar Bagh is a surrounded garden which quartered by two intersecting water courses at the right angels[2], but the architect and garden scholar, Mahvash Alemi, based on European travelers' descriptions of Persian gardens in 17th century and indication of Irshad-Az-Zerae(One of Iran's oldest agricultural books, written in 17th century), depicted Chahar Bagh illustration, and concluded that Chahar Bagh's layout is not necessarily four quartered plan. Based on Irshad-Az- Zerae' indication, historical sources, and also the field studies on existing historical gardens of Iran, The authors conclude that the model of Persian Garden design is usually rectangular shape, surrounded by four walls and crossed by water, which flows inside the garden and through the main pavilion [1]. A Persian garden typically features a conceptual design, with the garden's natural and built elements organized around a central axis, and its elements consist of natural elements, such as water and vegetation, and built elements, such as a pavilion, and walls. In addition, ancillary elements such as service spaces (bath, stable) are often included [5]. As it was mentioned, the Persian Gardens have had simillar sustainable charahcteristics for over centuries. Thus, the recognition and reinterpretation of their charachteristics is essential to reduce rate of energy consumption and also, assisst the designers to create sustainable landscapes in open urban areas. Since, the vast regions of Iran are located in arid climates, and the most Persian Gardens are placed in these climatic regions, it is necessary to study and analyze these gardens carefully. Moreover, the complicated of studies of each Persian Garden in arid regions are too great to discuss in a paper of this length, thus for experts' studies and viewpoints on landscape architecture patterns of hot and arid climatic zones, the authors decided to choose two historical gardens from the remnants of Persian gardens, in two different microclimates in arid regions of Iran.

In addition, The main goals of this paper is first to investigate the similarities and differences between the sustainable and climatic features of selected cases; Shazde and Eram gardens, and then to determine various sustainable design aspects of Persian gardens that moderate the environmental conditions.

Description of Case Studies: Shazde and Eram Gardens

The selected case studies are two historical gardens, Shazde and Eram gardens, located in the cities of Mahan and Shiraz in arid regions of Iran. The main reseaon for authors to select theses two gardens as case studies of this paper is the simillarieties between their design. At that time, both selected gardens, located outside the city, on the slope of mountains. The main rectangular pavilion of each garden, constructed in 19th century. Shazde and Eram gardens are currently public gardens, used for leisure.

Shazde garden is still, an oasis in desert, built in 19th century, located on the slope of Mountain, six kilometer away from Mahan. The garden has an extended shape and follows the slopped the overlooking mountain[8], and the main axis of the garden is toward north-south (Fig.2).

Eram garden is located in the northwest of Shiraz, on the slope of Asiab Mountain. The garden was originally built as an oasis, but gradually after the development of city; it has become an urban green space by mixing with the urban fabric (Fig.3). For the first time, Eram garden was constructed in11th century,and its spatial configuration's

been changed several times until 19th century, when the garden was reconstructed and the main pavilion built inside it [14].

Figure2: Aerial photo of Shazde garden (left); Shazde garden within the desert (right) [12]

Figure3: The placement of Eram Garden outside the urban fabric of Shiraz(left);Eram Garden within contemporary urban fabric of Shiraz(right) [9].

RESEARCH METHODS

Persian Garden as the only alive document of cultural heritage of Iran, should be recognyzed by field studies. Also, Persian Garden architecture have been changed over many centuries, thus, the authors decided to study on historical documents and sources to recognize and reinterperate original design of Persian Garden. For that reseaon, the research method of this paper is descriptive-analytical, based on historical and documented sources and field studies. The authors used two methods to collect their data: library research and field study. In addition, the research framework of this paper includes these processes:

1-An analysis of climatic conditions at Mahan and Shiraz by Koppen's method, concentrating on synoptic station statistics (temperature, amount of rainfall, humidity, etc.) from Iran's weather Web site during the ten-year period 1995-2005, cited in the website[7].

2-An analysis of Persian gardens' natural and built elements (water, vegetation, and pavilion) and the role of sustainability in their design, spatial configuration, and construction.
3-A comparative study of Shazde and Eram Gardens and an analysis of their sustainability. Since the sustainable development has three parts:social, economic and environmental and discus to each part is too great in a paper of this lenth, Thus, for the purpose of this research, both selected gardens will be analyzed by environmental sustainability and by discussing how climatic elements. By the metod of comparative study, the authors will able to present a striking balance between the similarities and differences between these two gardens.

Climatic Conditions of Iran

In Iran, there are several unique climatic regions, each having special characteristics. As a result, Iran is like a little continent. Scientists in Iran and other parts of the world have developed different climatic classifications, the most widely used of which is Koppen's method, which classifies the world into five climatic zones: Hot-Humid (A), Hot-Arid (B), Temperate (C), Cold (D), and Polar (E). There are few countries in the world which contain the four main climatic zones (A, B, C and D). All of these zones and their deviations can be found in Iran [5].

The climate of the central Iranian plateau is arid and semi-arid and receives virtually no rain during the six hottest months of the year. There, summers are very hot and winters are cold. The sky is cloudless, there is no humidity in the air, and there are large differences between daytime and nighttime temperatures. According to Koppen's method, the arid climate's classification is based on annual temperature, humidity, and amount of rainfall, and is divided into four main mesoclimates: BWhs[2], BWks[3], BShs [4]and BSks[5] [3]. These arid climates are characterized by the fact that actual precipitation is less than a threshold value set equal to the potential evapotranspiration[6]. The threshold value (in millimeters) is determined as follows:

1-Multiply the average annual temperature in °C by 20, then add 280(if 70% or more of the total precipitation is in the high-sun half of the year :April through September in the Northern Hemisphere), or 140 (if 30%–70% of the total precipitation is received during the applicable period), or 0(if less than 30% of the total precipitation is so received).

2-If the annual precipitation is less than 50% of this threshold, the classification is *BW* (desert climate); if it is in the range of 50%-100% of the threshold, the classification is *BS* (steppe climate) [10].

Table1: Climatic Conditions of Mahan and Shiraz[7]

city	Wind Direction	Annual Temperature	Temperature in Hottest Month	Annual Humidity	Annual Rainfall in Wettest Month of Winter	Annual Rainfall in Driest Month of Winter	Annual Rainfall in Wettest Month of Summer	Annual Rainfall in Driest Month of Summer	Conclusion
Mahan	NW, SE	16.5	27.5	28.3	32.3	22.8	1.4	0.2	BWks
Shiraz	NW	18.8	31.2	37.95	94.4	54	2	0	BShs

As the table1 indicates, Mahan is located in arid regions of the central plateau (BW), but Shiraz is located in semi-arid(steppe climate) of Iran(BS), and the average temperature in Mahan is under 18°C and in Shiraz is over 18°C. Also, the amount of rainfall in both cities (Table 1) reveals that the wettest month of winter is at least three times wetter than the driest month of summer. However, Shiraz is more humid than Mahan during hot seasons. Based on this data, Mahan and Shiraz can be classified as BWks and BShs microclimates. In addition, the annual wind direction in Mahan is often northwest and southeast and in Shiraz wind often blows from northwest.

RESULTS AND DISSCUSSIONS

Parameters of Sustainability in Persian Garden's Natural Elements

Water and Vegetation

Natural elements of Persian garden; water and vegetation are key ingredients act as natural cooling devices in Persian Gardensg . The extent of Persian garden, depends on the amount of water, and the garden designer create microclimate, by channeling breezes over water to reduce air temperature and increase weather humidity. In these gardens, vegetations perform functions, such as; create an architectural framework, produce aestetic effects and

modify the microclimate[11]. Vegetations guide and filter the breeze and increase evaporative cooling. By placing vegetation strategically, designers are able to provide shade and absorb the sun's ultraviolet radiation and also, the placement of the plants can direct the wind and alter the microclimate. In addition, plants modify the climate in tree ways; wind control [11] by guide and filter the breeze and ultimately cause to increase evaporative cooling, modification of sunlight andchange the mouisture(I bid). In both Shazdeh and Eram gardens, excluding the central axes, on which each garden's pavilion is located, the entire garden is covered by vegetation. Evergreen trees, such as cypress, pine, and plane, used as shading devices and also, protection from storms and local dusty winds.In both selected gardens, evergreen trees are located in the main passageways, while fruit trees are located between them. Despite the arid climate, the gardens are able to support fruit trees due to their sustainable features, including geometrical designs and economical use of water through irrigation systems. A large number of trees are planted for the sake of shade, and as a result the garden contain narrow walks[2]. Moreover, Persian gardens typically feature a type of clover called spest, which function as a walkway. Spest is very sustainable in that it absorbs nitrogen and transports it to the soil, repels insects, is easy to maintain, requires less water than grass, and can be used as cattle feed during cold seasons [18]. As it was mentioned before, and table2 indicates, many kinds of evergreen and fruit full trees in both selected gardens are used for different reasons; they are used to moderate local climatic conditions, eating and also some of them are used as medicine for many disease' treatment. According to these charachteristics, the autors can conclude that, the planting system in Persian garden design is corresponding to different parameters of sustainability(environmental, economic,..).

In both selected gardens of this paper, water is used in two main ways to regulate the garden's microclimates: through irrigation and creation of water displays:

Source, Irrigation Systems and Types of Water Displays

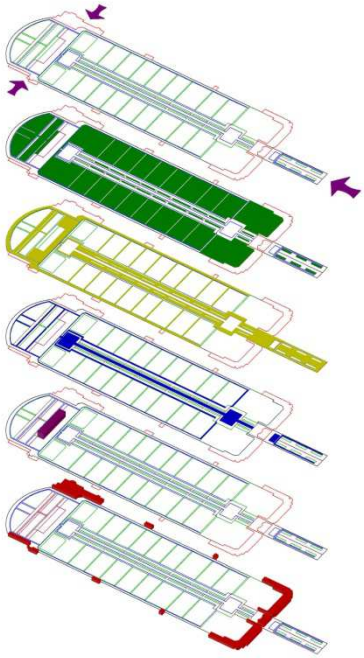
The source of water/irrigation method for Shazde Garden is Tigaran Qanat which is bed is Tigaran Mountains from northern of Mahan. Qanat is an indigenous method of irrigation that was invented by ancient Iranians to carry water from mountain beds through interconnected wells, creating underground streams and transporting water to far-off places .For Eram Garden, the source of water is the branch from the great river (Nahre-Aazam), located in the northwest of Shiraz. At that time, the great river was the source of water for many gardens of Shiraz. The water from that river flows to a large pond in the main pavilion of garden and, from there, to the garden's water's pool, canals and streams to irrigate the garden(Table2). The lack of water in such arid regions required the designers of Shazde and Eram Gardens to create sustainable methods for irrigation and water displays. The irrigation system influences the geometrical design of the garden, thereby preventing the waste of water[16]. After the water irrigates the trees and other plants in each garden, it flows outside the garden to irrigate farms and other lands (Table2). There are many ways to display water in a garden. Each way, in turn, has its own effect on sustainability. Large pools and ponds store water for drought seasons, while canals and streams irrigate plants and,Fountains and cascades are used for beautification of gardens and increase weather humidity during hot days.At Shazde garden, the main axis consists of water course, runs through the whole garden, forming the series of pools [8],and cascades. Another strategy for evaporative cooling in both Shazde and Eram garden is their main pools' are orientated according to wind directions, so, the wind could create an evaporative cooling effect (Table2,3). Since Shazde and Eram gardens are placed in hot and both of them are considered as a mictoclimate in these regions, the most areas in both gardens (approximately62%) are covered by vegetations(Table3). Despite the similarities between Shazde and Eram Gardens, there is a major difference between the amounts of water in the gardens. As Table 3 indicates, there is much more water in Shazde garden than in Eram garden, because Shiraz is more humid than Mahan during hot seasons and also the amount of rainfall in Shiraz is more than Mahan (Tables1&3).

Table2: Basic Data of Natural Elements of Shazde and Eram Gardens

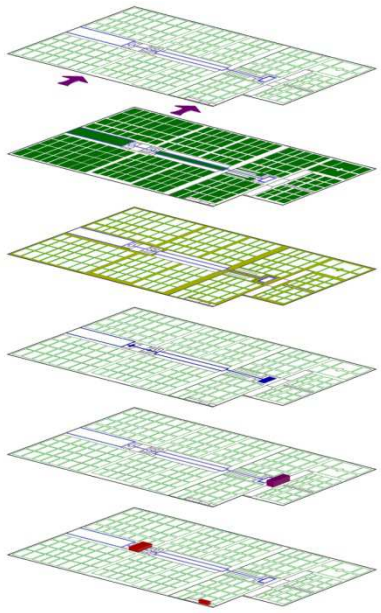
		Plant		Water			
City	**Garden**	**Fruitless trees & their functions**	**Fruitful trees & their functions**	**Water Resources**	**Types of Water display**	**Relation to Built space**	**Orientation**
Mahan	Shazde	Cypress Tree-Shading &Ever Green Pine-	Apricot, Peach, Pear & Cherry, used for Eating	Tigaran Qanat from northern mountains	Pool, canals, cascades , streams &Fountain	Located in the large pools in front of the	Corresponding to the slope(N-S)

		Protective against Storms & ever green				building	
		Plane-Shading &Protective against diseases					
Shiraz	Eram	Cypress Tree-Shading &Ever Green	Pomegranate, Citrus fruits , Apricot, pear, Pediment &Apple, Used for eating	Great River(Nahr-e-Aazam)	Pound, Pool, Canals, Streams& Fountain	Located inside the basement of pavilion and divided there to running in to the garden	NW-SE According to garden's Orientation
		Plane-Shading &Protective against diseases					
		Pine-Protective against Storms & ever green					
		Willow-usage for medical treatment					

Table3: Comparison of Natural and Built Spaces in Gardens of Shazde(Left) and Eram(Right)



Area Percentage		
Entry		
62%	GreenSpaces	62%
20%	Passageways	26%
10%	Water	1%
1%	Pavilion	4%
7%	Ancillary Spaces	7%



Parameters of Sustainability in Persian Garden's Built Elements: Pavilion and Wall

The main built elements in the most Persian gardens are pavilion and wall. The pavilions in Shazde and Eram gardens like other pavilions in Persian gardens are extroverted, which are opened in to the outside, while most traditional buildings in arid regions of Iran are introverted, perhaps due to the amounts of vegetation and water that create the gardens as desirable microclimates. Another recognized built element in Persian garden is the wall, which surrounds all the garden's elements. The wall has not only the security role for the garden, but also has climatic function to protect the garden against hot dusty winds, preserve the humidity inside the garden [16]. Furthermore,

wall in gardens are used to cut out direct sunlight and glare from reflecting surfaces [13]. Although many Persian gardens' pavilions, contain central ponds, there is not any central pond inside the Shazde pavilion and only a water pond can be found in the basement level of Eram pavilion that help to cool structures through evaporation. In addition, the Persian gardens' pavilions can be analyzed in a number of ways:

Pavilions' Form and Location

At Shazde and Eram Gardens, the rectangular form of pavilions, which they large surfaces are orientated to north- south, at these will receive the lowest solar radiation [13]. Also at Shazde and Eram gardens, designers situated the main pavilions on the highest point of the garden, on the 1/3 and 1/6 end of the gardens respectively (Table4), where the cool winds blow from the North West.

Openings and Semi closed Spaces

Iwan and balcony are semi closed spaces of Persian gardens' pavilions. An iwan is a single, vaulted hall which opens to the outside and acts as an entrance space for the pavilion, connecting the structure to the garden. The balcony is an isolated part of the pavilion. Typically, the design of the balcony offers a panoramic view of the garden, yet remains invisible to the eyes of strangers in the garden [6]. Also, these semi closed spaces (Iwan &balcony) are often built to create a breeze within the garden. At Shazde and Eram Gardens, the iwans and balconies are located on the north and south sides of the pavilion are orientated to the wind directions. As table4 indicates, the area percentage of semi closed spaces of Shazde pavilion in cooler city, Mahan is less than Eram pavilion. Despite the similarities between the pavilions at Shazde and Eram Gardens, their number of openings differs. In the hotter city, Shiraz, the numbers of Eram Pavilion are more than Shazde pavilion. Due to the local dusty winds, in Shazde Pavilion, there is not any opening and also, in Eram pavilion there are only a few openings on the east and west sides, open to the outside of the garden.

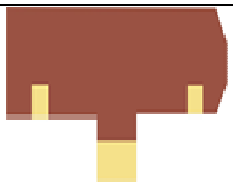
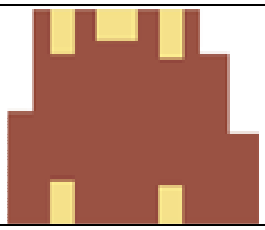
Shading Devices

The use of shading devices is an important strategy in sustainable design. Shading devices should be designed to reduce direct solar radiation and prevent reflection onto any part of the building or through any opening [4]. Both pavilions of Shazde and Eram gardens have arcades and porches, act as shading devices.

Building Materials

The main building material used for both selected Gardens' pavilions was brick. Brick is extremely sustainable materials because it possesses high thermal resistance and thermal capacity, and it is good at absorbing the sun's radiation. Also, brick does not require much energy to produce, has the potential for reuse, and it is easily found in arid regions. At Shazde Garden, the pavilion is built by brick with white stucco plaster to reflect the heat of sun. Furthermore, the tile's been utilized in some parts of Eram pavilion, can be washed and changed easily. In such arid regions, these vernacular materials can be found resourcefully.

Table4: The Comparison Characteristics of Shazde and Eram Pavilions

Garden	Pavilion	Location	Area Percentage			Openings	
			Water	Semi-Closed Spaces	Closed Spaces	Number	Direction
Shazde		1/3End of the Garden	0	18%	82%	21	N
						20	S
Eram		1/6End of the Garden	0.7%	28.3%	71%	65	N
						52	S
						7	E
						2	W

CONCLUSION

This research shows that the objective of Persian garden design as traditional landscape architecture in arid regions has been to moderate local climatic components. Due to climatic factors, both selected gardens of this paper utilize natural soft and hard landscaping. Such landscaping causes to increase the evaporative passive cooling which contributes to Persian garden sustainability and finally, by the analysis and a comparative method on the study of Shazde and Eram Gardens, it can be concluded, the characteristics of both selected gardens reveal that in spite of many similarities in Persian gardens' design, there are some dissimilarities between them because of different microclimatic areas, which the gardens are located in. Also, Persian gardens in arid regions by utilizing natural soft and hard landscaping can be considered as sustainable method, which are not only influenced by climatic factors, but also have effective role to increase much needed passive cooling. Their irrigation system with the use of minimum amount of water is sustainable method and their planting systems by usage of evergreen and fruit trees are according to sustainable agriculture. Moreover, the use of vernacular and sustainable materials (i.e. brick) with high thermal capacity and resistance in the built spaces of gardens in arid regions reveals the importance of using the sustainable materials in gardens of Iran. Based on descriptions mentioned in this paper, the authors conclude that the sustainable strategies in Persian garden design, mentioned in this paper, could be a contribution to the future of the profession of landscape architects and an appropriate solution for environmental problems of current cities.

ENDNOTES

1-BC abbreviation of Christian's era and stands for: before Christians.

2- BWhs: Desert climate with the average annual temperature over18°C.

3-BWks: Desert climate with the average annual temperature below 18°C.

4-BShs: Steppe climate with the average annual temperature over18°C.

5-BSks: Steppe climate with the average annual temperature below18°C.

6-Evapotranspiration: Sum of evaporation and plant transpiration from the earth's land and ocean surface to the atmosphere.

7- Weather statistics used in this paper are retrieved from synoptic station statistics of Iran's weather website during ten years (1995-2005): http:// irimo.ir/statistics/synopH/index1.htm.

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