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Comparative Study of the Living Structure Theory in Historical Gardens of Tehran (Case Study: Niavaran, Esharat Abad, Eyn Al Doleh Gardens)

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Abstract

Gardens are one of the most important built environments throughout the history of Iran in terms of symbolism, semantics, social construction, mythical elements and physical and functional spatial relationships. The coexistence of natural and built environments is more obvious in the Persian garden compared to any other functions. In this research, the nature of Persian gardens is analysed in terms of physical and functional structures and spatial and natural relationships based on a qualitative approach and a comparative-analogous method and the data is collected through library research and field investigations. Then, the components of the living structure theory, introduced by Christopher Alexander, are surveyed as research theoretical framework. The components are analysed and scored using AHP and the comparative analogy is done by 15 scholars. The data reveal that the physical, functional and natural structures are prioritized in order of importance with weights of 0.428, 0.334 and 0.238, respectively. The total interaction of components demonstrates that Ein-al-Doleh Garden possesses a living structure better than Eshrat-Abad Garden for all three structures, but it is weaker in natural structure, the same in functional structure and stronger in physical one in comparison to the Niavaran Garden. The local symmetries (0.125), strong centres (0.214) and roughness in the cultivation system (0.194) represent the most effective factors. For today, In consequence, it is possible to revitalize living structures in historical gardens through the revival of strong centres, attendance of green spaces, spatiality of Kushks and intense relationships between gardens and the Kushks.

Keywords: The Persian Garden, Living Structure Theory, Historic Gardens of Tehran, Qajar Architecture, Urban Green Space

Introduction

In the present era, creating a space that, especially in lands with historical backgrounds, both meets today's needs and retains its cultural identity, is a challenge for designers. Certainly, gaining an accurate knowledge and cognition of the structures that created such spaces is one of the most essential instruments to achieve this goal.

Over the history, gardens are one of the important built spaces in Iran in terms of symbolism, semantic, representation of the adaptation of social and cultural structure, mythical elements and relationships between physical and functional aspects. This provides a valuable source of data responding to the perception and revitalization of the historic quality of Persian architecture today. The harmonious coexistence of natural and built environment forming a coherent structure is the most obvious character in Persian gardens among all other functions. The Persian gardens are cultural, historic and physical phenomena in Iran and usually established as an enclosed area where plants, water and buildings are integrated within a specific somatic system and provide a favorable, protected and pleasant environment for human being (Shahcheraghi, 2009). According to the Florence Charter on Historic Gardens (O'Donnell, 2014) as a garden is defined as an architectural composition of objects, plants and living spaces that reflects the culture of a nation and its climatic conditions, the Persian garden can be considered as a type of landscape and one of the most important garden styles over the world which has the spirit of its own place (Medghalchi et al., 2014). Hence, they become an entry to the identification and perception of past Persian

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architecture and the study on this regard can redefine the principles of sustainable life in cultural context of Iran.

In this manner, the Persian garden can be recognized and reproduced based on the historical heritage of human being in the tradition of settlement in accordance with comprehensive worldviews and theories founded on the unique nature of human being such as living structure theory introduced by Christopher Alexander.

In this study, it is assumed that it is possible to analyze the Persian garden using living structure theory. The components of living structure can be analyzed based on the structures of Persian garden. It is attempted to detect influential criteria of living structures by introducing three gardens of the Qajar era in different regions of Tehran metropolis and identify the garden with the strongest structure using AHP method. In this research, it is sought to answer these questions by data analysis: Which structures are included in the Persian garden? What are the components of living structure theory? Which garden has the strongest living structure among the gardens studied in terms of generalization of living structure theory and which components are practical to revitalize the living structure of Persian gardens?

This study aims to introduce an applicable instrument to recognition living structure of historic gardens and to achieve design principles to rebuilding that atmosphere based on certainly defined components for living structure theory.

Regarding to multidimensional nature of Persian gardens and their significance in Persian culture, understanding them and the characteristics of their elements lead to the recognition of one of the most substantial representations of form and meaning derived from Iranian beliefs (Tousi & Emamifar, 2011: 59). In the other hand, as an essential phenomenon, the Persian garden has affected the structure of architecture and construction of external spaces and sites over the history of Iran and its colonies. The Persian garden can be found in all Iranian settlements; hence, the style of gardens and gardening is plausible in Iranian dwellings (Bemanian & Saleh, 2011).

In this study, the structure of the Persian garden is initially investigated in terms of physical landscape, functional structure, spatial relationships, natural structure and cultivation system. The characteristics and components of living structure are then surveyed for each of these three main structures in accordance with Christopher Alexander's theory. Finally, they are scored for three important gardens of Qajar era in Tehran: Ein-al-Doleh Garden, Eshrat-Abad Garden and Niavaran Garden. The research path is shown in Figure1.

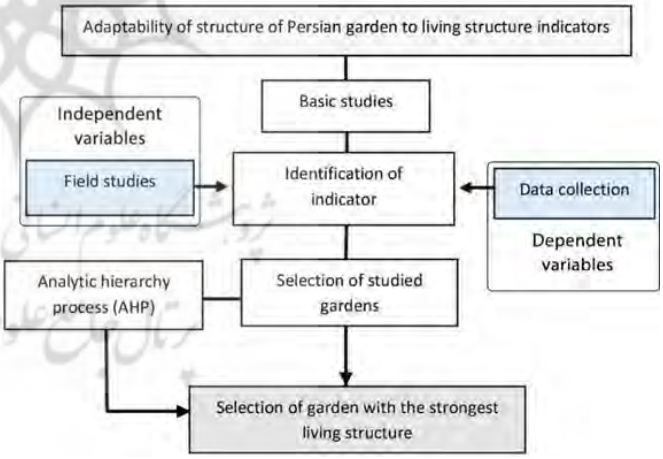


Figure 1. Research conceptual model (Source: authors, 2020)

Research Background

Since the construction of gardens has a long historical background in Iran, it is investigated from a variety of aspects in different eras. In a comprehensive research, Vida Goudarzi has studied the historical genealogy of garden

construction in Iran from the Achaemenid period to the end of the Pahlavi era. Her study shows that on the one hand, gardening in Iran has been influenced by some cultural components, rituals and beliefs of Zoroastrianism and on the other hand has been influenced by environmental conditions (V. Goudarzi, 2016).

In some studies on geometry of the Persian garden since the Achaemenid dynasty up to now, some researchers, e.g. Mohammad Karim Pirnia, attributed the Chahar-Bagh [four gardens] pattern to the Pasargad complex in accordance with studies by Stronach (Stronach, 1993) and Pope (Pope, 2014) and introduced it as an archetype of garden construction in Persia (Pirnia, 1995). In a study, Heydarnattaj and Mansouri rejected the theory of Persian Chahar-Bagh pattern and introduced it as a geometric pattern just in some historic gardens (Heydar nattaj & Mansouri, 2009). In another study, the axial pattern of the Persian garden was scrutinized, and Barati et al addressed the effect of Iranian worldview on the formation of axis in Persian garden (Barati et al., 2018). On the other hand, Hamzenejad et al did a comparative study on Persian gardens before and after the advent of Islam and attempted to make a connection between the both historical eras and reflect the paradise descriptions in gardens under the influence of Islamic culture (Hamzenejad et al., 2014).

Donald Wilber, the American military consultant, is another orientalist who became interested in and investigated Persian gardens; he reviewed the history and formation of Persian gardens during the Ilkhanid, Timurid, Safavid and Qajar dynasties (Wilber, 2011). Alemi addressed the Persian garden in terms of symbolism (Alemi, 2012) and Naeima examined the formation structural elements of Persian gardens through a comprehensive study(Naeima, 2006). According to him, design of the Persian garden and its buildings is a synthesis of pre-Islamic architectural styles and architectural approaches which are known as Islamic architecture. In some cases, however, it was influenced by the architecture and gardens of other countries. The garden in Iran has always been harmonized with the geographical features and climate conditions. In the Islamic era, the architecture (geometry of zones and routes, floriculture and arboriculture) of the Persian gardens was uninfluenced by the immigrant Arabs, but it was spread to distant lands. Among all nations, Iranians properly found out that garden construction is the basis of agriculture and achieved excellent garden styles since ancient times (Naeima, 2006: 3). In a widespread research, Shahcheraghi has dealt with nature, functional, physical and semantic systems of the Persian garden and investigated the sensory systems of Persian gardens, their relationship with other arts and their reproduction techniques (Shahcheraghi, 2016).

Irani Behbahani and Soltani focused on Tehran in their researches. They shows that gardens have been embedded throughout the city as a constituent of urban physical structure since the Safavid era; In the maps of Tehran from the Qajar era, numerous gardens could be observed inside and outside the city enclosure, along the foothills and on the slopes of Alborz Mountains, a few of them are however survived. When the Qajar dynasty conquered Iran and Agha Mohammad Khan was crowned as king in Tehran, the construction of garden-palaces, alleys and streets gave a new form to the city. A great number of recreational gardens and bungalows were built during the reign of Fath Ali Shah, among them, the Qajar Palace in northern Tehran was the most famous due to its irrigation system in form of terraces and waterfalls. Nasser al-Din Shah's trips to the Europe and overseas influenced the architecture and art of landscaping, so that many gardens, streets and squares were constructed as a direct imitation of Western architecture. Therefore, numerous gardens were constructed around Tehran, e.g. Eshrat-Abad Garden in the north of Shemiran Gate, Kamranieh Garden, Farmanieh Garden, Sahebqeranieh Garden, Saltanat-Abad Garden, Shahrestanak Garden, etc. (Irani Behbahani & Soltani, 2003).

In all of these studies, the approach to study has been historical and hence, an attitude to analyze and recognize the Persian garden through comprehensive international theories based on human essence, space syntax and nature and the order of its constituents can be proposed as a new point of view toward the Persian garden.

Research Methodology

In this study, the knowledge is epistemologically subjective and comes from the interaction between the researcher and the subject, i.e. understanding of the living structure in the Persian garden; it is also methodologically acquired through different interpretations of reality. Therefore, this study is a theoretical research and its philosophical paradigm is based on interpretivism and it has a qualitative approach (Bazargan, 2022: 19) This study has a comparative-analogous plan, and the data is analyzed by comparative analogy and Analytic Hierarchy Process (AHP); the data are collected through library research, field observations and surveys by about 15 scholars. During the process of paired analogies, the components of the living structure under the aspect of physical, functional and natural structures have been categorized and investigated in the case studies. In the next step, to accurately calculate the weight of the research criteria, Expert Choice software was used to identify the strongest the living structure among the studied gardens. The research path is shown in Figure 2

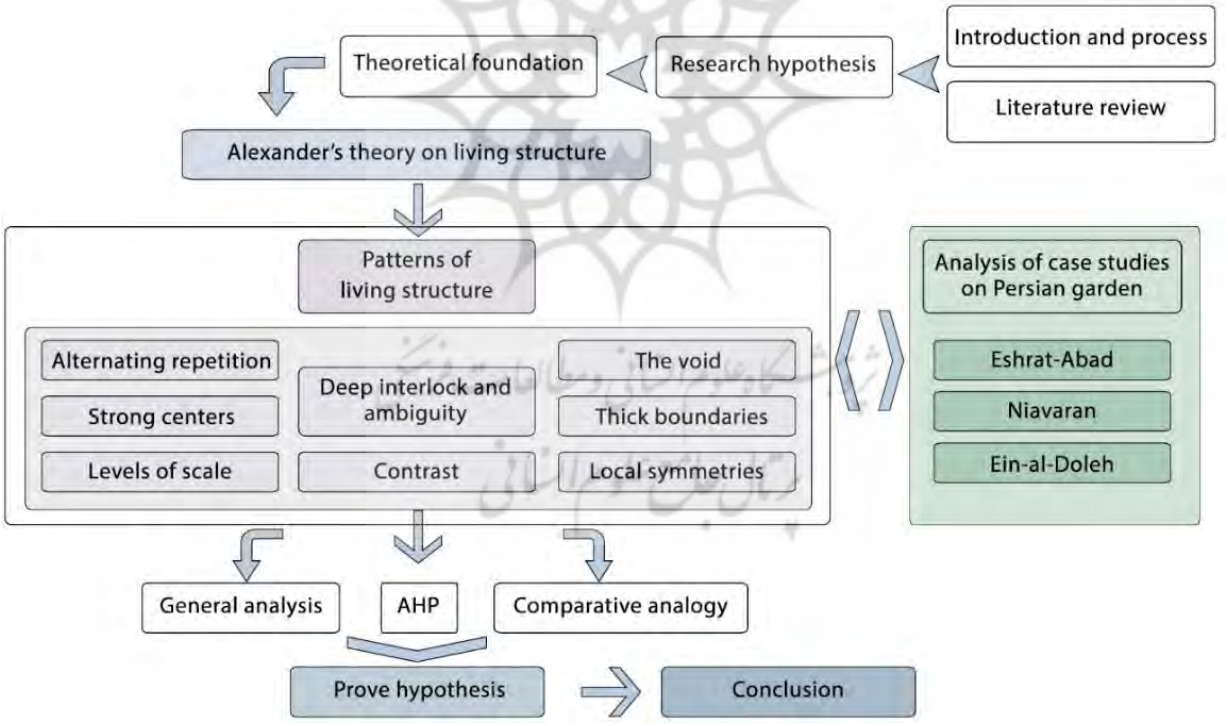


Figure 2. Comparative analogy of studied gardens (Source: authors, 2020)

Theoretical foundations and literature review

In 2002, Christopher Alexander, architect, urban designer and theorist, put forward the living structure theory as a complement of A Pattern Language (Alexander et al., 1977) theory in order to respond to the reproduction of buildings along their historical tradition and to pass through modern and postmodern processes which failed to provide a favorable human space. In the theory of the nature of order, he believes that all phenomena can be investigated in the world as living and non-living structures. Each phenomenon possessed a certain degree of life; natural phenomena have a living structure. In traditional communities where life was interconnected to nature, the vitality was reflected in man-made crafts (Alexander, 2017). This study is based on the components of the living structure theory as a tool for recognition and the reproduction of spatial quality of the Persian garden.

Alexander established a logical framework for architecture, where it is possible to observe the relationship between geometric order and structure of life. He considered the vitality of space as a latent quality in the essence and nature of space that appears in every physical structure. Consequently, each space has a degree of life and vitality (Sabri & Akbari, 2013). He argued that all phenomena can be detected and explored as living and non-living structures over the world. He studied and identified the pattern of living structures in accordance with the concepts of integrated universe and strong centers. In this research, ten geometric features related to the structure of Persian gardens have been defined.

Alexander generalized the concept of life to traditional buildings and art works and studied the nature of order in all phenomena over the world. He argues that the living structure is a structure composed of living centers over a generative process. The concept of centers is described as building blocks which form an entity. It is possible to observe and perceive the life and its structural characteristics by explaining the living centers and the entity (Alexander, 2017: 129-149). According to him, a living structure possesses 15 geometrical properties which should be recognized to create any living structure. In this study, 10 geometrical properties associated with the structure of Persian gardens are surveyed and analyzed.

Components of the living structure

- **The void:**

The void is of great importance so that its absence causes chaos, disruption and disorder during the formation of living centers, the energy of the center would be unabsorbed and amplified and no entity would be generated. In any living center, everything is organized around the void (Alexander, 2017: 186-188).

- **Local symmetries:**

The existence of each strong center is exacerbated within any context by local symmetries. At the position of each center, the context and functions must be kept from inflexible symmetries. Local symmetries provide the real bonding force for the creation of life by their connections. Moreover, the integration and coherence of each living structure depends on the number and type of local symmetries (Alexander, 2017: 154-158). The overall structure is not symmetric, but its whole elements and components are arranged symmetrically.

- **Levels of scale**:

The concept of levels of scale refers to the gradual changes in the qualities, sizes or distances. The centers change and form systematically during the development process of living structures. As a result, more and stronger centers are generated. Without the levels of scale, a living structure lacks the inner entity and life (Alexander, 2017: 169-171).

- **Thick boundaries:**

The living centers are emerged and strengthened by boundaries. The boundaries represent edges

separating each center from another. Any center can be focused through the boundaries. If the boundary is separated from the world on the other side, it serves both to separate and connect. In both cases, the bordered center is more accented and strengthened (Alexander, 2017: 127).

- **Strong centers:**

This property serves as the essential constituent of living entity. It appears as a field and refers to an enormous variety of dimensions and proportions in a living creature. Strong centers perform a fundamental role in generating the focal points necessary for any living structure. Any center organizes entities around it and establish a larger center and hence, an interconnected chain of centers is formed (Alexander, 2017: 118-126).

- **Deep interlock and ambiguity:**

is conceived when an ambiguous region belonged to the both center and its surroundings makes it difficult to distinguish between them and encompasses interlocked forms. In this property, two centers are linked to each other by an inseparable node and take their consistence from the middle center (Alexander, 2017: 162-165).

- **Roughness:**

The elements are not the same in detail in any living structure, although they may seem similar generally. The roughness of elements is essential to form an entity. No roughness occurs if a structure consists of similar units exactly located in the same places. The roughness happens involuntarily and unconsciously (Alexander, 2017: 174-177).

- **Alternating repetition:**

Repetition represents a way where centers can effectively support each other in their lives. Centers exacerbate each other by repetition. Most objects are produced through the repetition of some surfaces, e.g. repetition of atoms, waves, cells, roofs, bricks and tiles, but a particular repetition occurs in living objects. The sense of order in any structure is raised form the fact that its elements and components are repeated over and over. However, this repetition gradually becomes inaccurate and rhythmic in many cases where the structure possesses a robust life for the repetition. A beautiful and subtle diversity subsequently emerges from the same energetic, alternating and life-giving repetition (Alexander, 2017: 135-137). Interaction of these components is shown in Table 1

Table 1- Interaction of components of living structure (Source: Alexander, 2017: 201)

If A depends on B or A involves B, Then AB is marked.									
	Feature B								
Feature A	**Components**	**The void**	**Local symmetries**	**Levels of scale**	**Thick boundaries**	**Strong centres**	**Deep interlock and ambiguity**	**Roughness**	**Alternating repetition**
	Strong centers	*	*	*					*
	Roughness			*		*			
	Thick boundaries		*		*	*	*		*

	Deep interlock and ambiguity							*	*
	Alternating repetition					*	*		
	Local symmetries	*							
	The void		*		*				
	Levels of scale		*	*		*		*	

Structure of the Persian garden

Here, the structure of Persian gardens is defined as physical, functional and natural structures in order to present the AHP tree diagram and pairwise comparisons of case studies.

- **Physical structure: position of buildings**

The analysis of physical systems shows that the physical scheme of Persian gardens is based on highly accurate and calculated geometric structure; its exterior environment is often square or rectangular and separated from the outside by walls (Shahcheraghi, 2016: 85). The physical structure of Persian gardens is simple, clear and unambiguous. The geometry of them is formed by architecture, landscape, irrigation and planting systems (Mirfendereski, 2004). Sometimes two Kushks[i] were placed along the longitudinal axis of the garden that formed the geometrical structure of the garden. In some gardens, there are also other mansions such as Howz-Khaneh,[ii] Kolah-Farangi[iii] and sliding bathroom (Naeima, 2006: 223). The geometric order of Persian gardens can be divided into two equal sections or four the same divisions based on longitudinal and transverse axes or four non-equal pieces according to the location of the transverse axis.

- **Functional structure**

The Persian garden can be discussed in terms of vastness and functionality on architectural scale, urban scale and intermediate scale where the garden is described merely as a part of nature (Shahcheraghi, 2016: 47). Based on the duration of settlement, the functional system of Persian gardens can be classified as permanent and temporary settlements: residential, governmental and temple gardens fall in the first category (Soltanzadeh, 2000), while ceremonial, governmental-aristocratic, administrative and military gardens fall in the second category. The Persian garden is classified as vast and courtyard gardens in terms of architectural function. Vast gardens include Kushk gardens, palace gardens, tent gardens, Tajir[iv] gardens, castle gardens, flat gardens and temple gardens, while courtyard gardens include introverted and extroverted gardens (Shahcheraghi, 2016: 49-55).

In the functional structure of Persian gardens, the most significant indicators include the creation of responsive spaces for functional needs, consistency of spatial relationships and circulation in outdoor and indoor spaces. In governmental and ceremonial gardens, the socio-political structure is overwhelmingly dominant in spatial relationships. In residential gardens, the social structure dominates the functional system because most of these gardens belong to the aristocratic class.

- **Natural structure** (planting system)

In Persian gardens, the cultivation system and geometric structure were generated through a mutual relationship. There is a particular system for placing trees in accordance with every

climate. The research shows there are mostly two types of cultivation techniques in Persian gardens. In the first one, trees were planted in parallel in the plots. In this system, the overall shape of gardens was undestroyed visually and spatially if the trees were disappeared. The second one represent the five-point method where trees were planted at each vertex and the center of a square. In this technique, the trees were planted in individual or paired rows across each other (Shahcheraghi, 2016: 65-68).

In planting system, the most important thing is to create the main axis of the garden with a completely wide view perspective. Hence, plane and cypress trees were often planted to emphasize the axiality of space (Daneshdoust, 2017). Therefore, tall green walls were formed on both sides of the main axis as if the earth was connected to the sky (Wilber, 2011).

- **Irrigation system**

In Persian gardens, the system of water circulation is called the spirit of garden (Zangher et al., 2012: 41). The water did not circulate permanently through the gutters in the plots and the trees were generally irrigated using flood water which is mainly circulating along the main axes.

Representing different forms of water (whether flowing or stagnated), the human dominance on this vital, clear, chilling element was emphasized in entire gardens. Water emanated from a point to irrigate the whole garden; therefore, the water circulation was displayed in a variety of forms in addition to its function and carry out a key role in providing coolness, light reflection and delightful sounds in each space (HeidarNattaj, 2017: 7).

In addition to irrigation, the water circulation additionally embodied a symbolic meaning. It brought sound, humidity, scent, freshness, cleanliness and refreshing air. In some gardens, the ground surface was terraced to better display water and small artificial waterfalls were created to enhance the presence of water. Moreover, vast shallow ponds in front of the mansion also improved the reflection role of water.

Living structure in Persian gardens

As the result of adaptation of properties of the living structure and the structure of the Persian garden, it is possible to consider the garden's components in an integrated attitude as it is introduced in the table below as the criteria for measurement and analogy.

Table 2: Criteria and indicators of structure of Persian garden adapted to components of living structure

Adaptation of structure of the Persian garden to components of the living structure	Physical structure	Quality of the voids between gardens and mansions
		Creation of local symmetries in gardens and mansions
		Levels of scale in circulation and elements of gardens and mansion
		Thick boundaries in gardens and mansions
	Functional structure	Creation of strong centers in gardens and mansions
		Deep interlock & ambiguity in spatial relationships in gardens & mansions
	Natural structure	Roughness in cultivation and irrigation systems
		Alternating repetition in cultivation and irrigation systems

Case studies

In this study, three gardens from important ones of the Qajar era in Tehran are investigated. It should be mention that during the Qajar period, Tehran expanded a lot and many gardens and buildings were built in it. In 1867, a new octagonal enclosure with twelve gates was built during the reign of Naser-al-Din Shah, known as the Naseri enclosure (Ghobadian, 2018: 55). In this era, the citadel (Arg in Persian) was a vast courtyard where royal buildings, offices, state warehouses, some embassies and governmental houses were located and separated from the city (Goudarzi, 2009: 27-28).

Selected gardens in this study possess dominant common features: suburban location, residential function in summer, complex spatial relationships in the mansions, imported ornamental elements, architectural evolutions in Kushk, particular cultivation structure, irrigation system and presence of water in the gardens, particular function of gardens, possibility to trace the components of the living structure in the gardens and Kushks, possibility of comparing gardens with each other, importance of the gardens in the history of Persian gardens during the Qajar dynasty, etc.

Niavaran Garden and Palace

Fath Ali Shah, second king of Qajar dynasty, commanded to construct an extensive garden in an area with pleasant weather outside Tehran for spending leisure time in summer. Therefore, a small mansion was constructed in the current Niavaran Garden (Naeima, 2006: 243). Mohammad Shah, 3rd king of Qajar dynasty, on top constructed a private, modest building in this garden. In 1851, Naser-al-Din Shah demolished these two buildings and erected a magnificent mansion recognized as Sahebqeranieh Palace for the 30 year reign of Naser-al-Din Shah. Another building was constructed in the complex during the reign of Ahmad Shah. Hence, a complex was constructed, which consisted of the Sahebqeranieh Palace, Howz-Khaneh and Ahmad Shah's Kushk. The building was somewhat based on the tradition of Persian architecture and included a few imported elements and decorations. The mansion has a gable roof and typically enclosed spaces, where the porches occupy a minor area. The garden additionally utilizes a vast area.

Eshrat-Abad Garden and Mansion

In 1874, Naser-al-Din Shah proposed the layout of an extensive garden outside the Shemiran gate in the Eshrat-Abad in north of Tehran, where he planted four trees by his own. The evidence shows that the garden possessed an enormous four-story building known as the dormitory (Naeima, 2006: 241). The survived pictures indicate there was a circular pool next to the building and similar small buildings were arranged around the pool. According to various references, the number of these buildings was seventeen or fourteen. Naser-al-Din Shah stayed in the main mansion and the private constructions were dedicated to his wives. Various spaces are decorated by plaster work, mirror work, painting, muqarnas and Khatam (inlay). The garden was mostly used for royal weddings and recreations (Haji Qasemi, 2015: 104-278).

Ein-al-Doleh Garden and Mansion

Ein-al-Doleh mansion-garden was dedicated to the residence of Prince Abd-al-Majid Mirza known as Ein-al-Doleh in summer, who was the grandson of Fath Ali Shah and the minister of Qajar dynasty for three times. This garden was constructed outside of Naseri enclosure and included a ceremonial mansion, a vast pool and several gardens (1892-1912). The two-story and extroverted mansion has a veranda on its three sides. The building has imported decorations, Greek Corinthian columns, plastered ceilings and mirror works in the alcove. The staircase is located along the axis of symmetry as the most primary examples influenced by Western architecture. The building has a gable roof with a

Kolah-Fanargi (cupola) along its axis of symmetry.

Plans, site plans and main façade of the gardens are shown in Table 3.

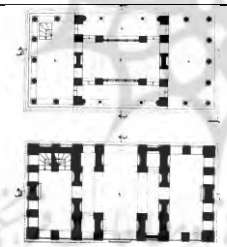
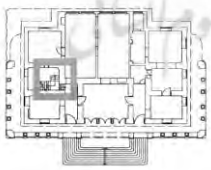
5. Research findings and data analysis

5. 1. Physical comparison of indicators of the living structure

Visual analysis of indicators of the living structure in case studies is presented in **Error! Reference source not found.** Aimed to recognition of the strongest living structure among three case studies, the indicators are considered at two levels at this step so the tree diagram possesses four levels in this analytical model. The goal is placed at the first level: the selection of strongest living structure. The structures of the Persian garden are placed at the second level and the components of the living structure are considered as sub-criteria at the third level. The studied gardens are also placed at the fourth level. Tree diagram is presented in Figure 3.

At the weighing step, all components at the second and third levels are compared to each other based on their importance in the living

Table 3: Case studies (source: authors, 2020)

Garden Name	Total area	Construction date	Current function	Plan	Site Plan	Main façade
Niavaran	110000 m^2	1850 Qajar	Museum			 (Farrokhi, 2010)
Eshrat-Abad	42211 m^2	1874 Qajar	Mansion			
Ein-al-Doleh	11900 m^2	1892-1912 Qajar	Mansion garden			 (Saeedi, 2016)

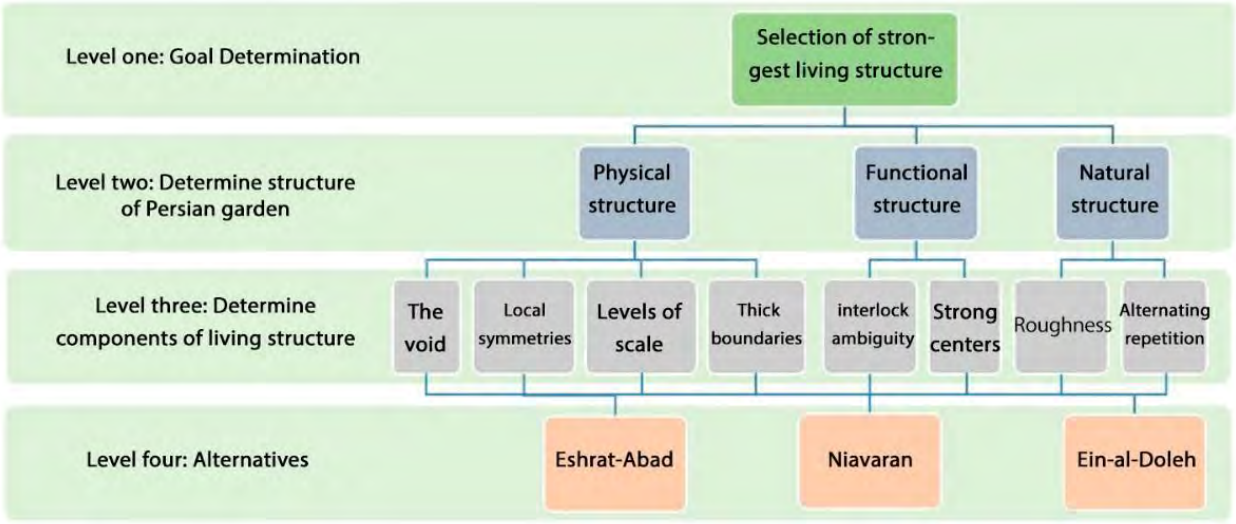
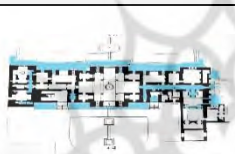
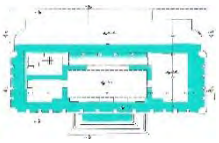
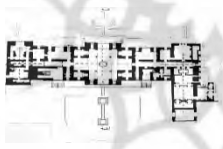
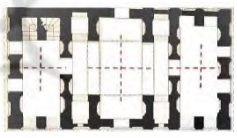
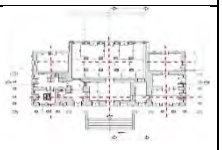
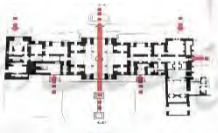
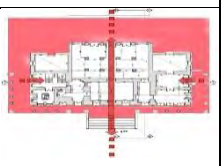
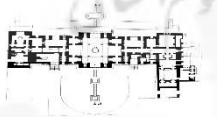
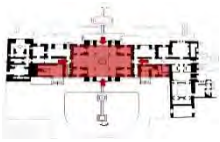
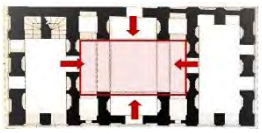
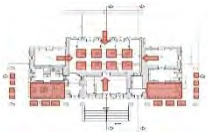
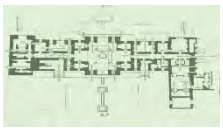
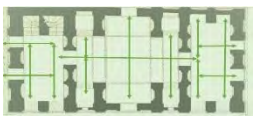
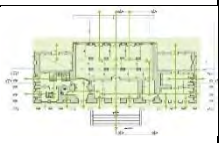


Figure 3: Hierarchy of components for the selection of strongest living structure (Source: authors, 2020)

Table 4: Comparative analysis of components of living structure in case studies (Source: authors, 2020)

The Persian Garden Structures	The Living Structure Properties	Niavaran	Eshrat-Abad	Ein-al-Doleh
Physical Structure	The Void			
	Local symmetries			
	Levels of scale			
	Thick boundaries			
Functional Structure	Strong centers			
	Deep interlock and ambiguity			

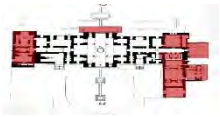
Natural Structure	Roughness			

Table 5: Score scale for structures and components of living structure in studied gardens (Nobakht, 2017: 431)

Priority and importance	Weight
Extremely Important	9
Very strongly Important	7
Strongly Important	5
Moderately Important	3
Equally Important	1
Intermediate values	2, 4, 6, 8

Figure 4: Ultimate weight of physical, functional and natural structures based on components of the living structure (Source: authors, 2020)

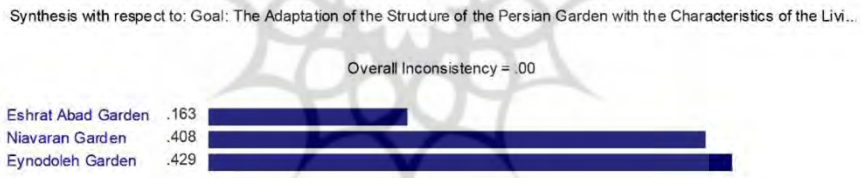


Figure 5: Ultimate scores of studied gardens in adaptation to the living structure, using Expert Choice software (Source: authors, 2020)

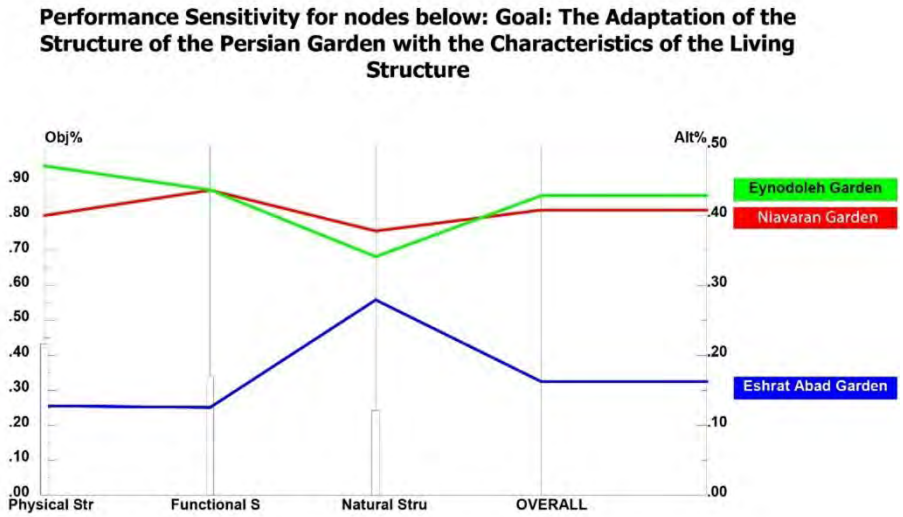


Figure 6: Analysis of studied gardens based on structures of the Persian garden. This chart compares the importance of physical, function and natural structures (source: authors, 2020)

Table 6: Priority of structures and components based on weighing results (Source: authors, 2020)

Goal	Structures	Weight	Components of the living structure	Reference weight	Normal weight
Adaptation of structure of Persian garden to components of living structure	Physical structure	0.428	Quality of the voids between garden and mansion	0.208	0.70
			Creation of local symmetries in garden and mansion	0.375	0.125
			Levels of scale in circulation and elements of garden and mansion	0.125	0.42
			Thick boundaries in garden and mansion	0.292	0.97
	Functional structure	0.334	Creation of strong centers in garden and mansion	0.643	0.214
			Deep interlock and ambiguity in spatial relationships in garden and mansion	0.357	0.119
	Natural structure	0.238	Roughness in cultivation and irrigation systems	0.583	0.194
			Alternating repetition in cultivation and irrigation systems	0.417	0.139

Conclusions

The results findings in response to the research questions demonstrate that in the adaptability of structure of studied gardens to the concept of the living structure and its properties, the physical structure with a weight of 0.428 is the most important in the structure of the Persian garden based on the void in the garden and mansion floors, local symmetries in the arrangement of spaces and elements, levels of scale in the privacy for accessibility and thick boundaries in the edge of elements and spaces. The functional structure with a weight of 0.334 takes the second place based on the creation of strong centers as the foundation of the living structure theory and deep interlock and ambiguity in the spatial relationships between the mansion

and the garden. The natural structure with a weight of 0.238 takes the third place, which consists of roughness in the cultivation system and alternating repetition. Finally, the general interaction of all eight properties indicates the Ein-al-Doleh Garden has a living structure than Eshrat-Abad Garden for all three structures, but it has a weaker natural structure, same functional structure and stronger physical structure in comparison to Niavaran Garden. Generally, Ein-al-Doleh Garden with a score of 0.429 takes the first place compared to Niavaran Garden with a score of 0.408 and Eshrat-Abad Garden with a score of 0.163.

The creation of strong centers with an ultimate weight of 0.214 is considered a factor affecting the selection of Ein-al-Doleh Garden as a strong living structure, which shows that the attendance quality of space and the spatiality of building are stronger than other indicators. Subsequently, the roughness in cultivation system with a score of 0.194 and the alternating repetition of elements with a score of 0.139 are considered important. The strong connection between the garden and the mansion with a veranda also leads to the maximum interlock between the indoors and outdoors and makes this garden distinct.

In this research, it is attempted to define the Persian gardens based on the living structure theory and with AHP model, to highlight the structural characteristics of each garden and to develop an evaluation technique and criteria for its more proper understanding aimed at approaching the reproduction of favorable architecture along the tradition of garden construction. Today, a solution for urban green spaces management in Tehran, then can be defined as creating the sense of spatiality in green space, constructing buildings or Kushks that revitalize the sense of being indoors and providing users with the experience of simultaneous presence in open, semi-open, semi-closed and closed spaces. Moreover, it is necessary to establish an intense and reasonable connection between buildings and green spaces and enhance the attendance in green spaces for a variety of individual and collective behavior patterns. These strategies are able to revitalize the Persian cultural-historical continuum through experiencing the green spaces and play a leading role in proving an identity for the citizens.

As a result, some practical suggestions for the revival of the living structure in historic gardens are: 1. Prioritizing the spatial quality of historic gardens and develop their green spaces in accordance with their cultural value and spatial quality. 2. Construction of enclosed gardens which possess an increased sense of attendance than modern urban green spaces and enhance the sense of attachment and security amongst citizens, which is an old tradition in the Persia. 3. Constructing semi-open monuments using the historic patterns of Kushks. 4. Establishing an effective relationship between the Kushk and the green spaces. 5. Creating diverse spaces for presence and vast central open spaces which provide the void. 6. Generating a variety of functions and spaces based on local symmetries and roughness.

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NOtations

[i] A kind of pavilion in Persian architecture, mostly constructed in gardens

[ii] An interior space in Iranian architecture with a pond in the middle, usually located in the basement

[iii] A kind of cupola in Iranian architecture

[iv] A lattice enclosure around some Persian gardens