

Full Length Research Paper

Sustainability and water transmission system in the Bagh-Shahr of Isfahan

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In this paper, firstly, we seek to explain the urbanization and sustainability principles in the Isfahan and compare them, present overlaps of the sustainable designing principles and the urbanization principles. However, it describes the role of the natural and garden-building elements based on the historical references in the Isfahan and the ways to change a city located in a hot and dry climate to a Bagh-Shahr. Finally, we will review the Chahar-Bagh features, communication network and its effect on the city sustainability.

Key words: Bagh-Shahr, Chahar-Bagh, the sustainable city, urbanization, hot and dry climate, nature.

INTRODUCTION

In the ancient civilization of Iran, nature was always considered a holy creature, because of it was located in a hot and dry climate and encountered some limitations in the water supply, water transmission system and water saving were key elements. Since last 15 centuries, after Islam's arrival to the country, people have looked at nature as God's signs on the earth. And this thought not only. Nature elements should not only be analyzed, but also respected (Hellinga et al., 1998). In this regard, garden-building has been important in Iran. The oldest document is the Pasargad garden that was built by the Great Cyrus. Garden-building has been developed in different eras and reached its highest point during Safavid era in Isfahan through the creation of Bagh-Shahr. Therefore, this paper presents the formation of the Bagh-shahr and factors influence them based on the research method in the Isfahan. However, it uses the adaptive comparison method for comparing these factors with the sustainable designing principles in contemporary ages. Finally, it presents research methodology, case studies, the research findings and the research results for

future research.

Related works

Cities are seen to be sustainable if in the words of the world commission for environment and planning (Hellinga et al., 1998), they meet 'the needs of the present without compromising the ability of future generations to meet their own needs'. In order to gauge progress toward this desirable state of sustainability, measurable indicators are needed, which assess urban efforts in economic, social, technical and environmental field (Jetten et al., 1997). Such analysis immediately reveals that a city cannot be sustainable in isolation, but instead is a part of the global urban system, where any single city effects at least to some degree, the others. At the same time, however, no single city can contribute to overall sustainability if its own component parts are found not to be sustainable. The concept of sustainable development (SD) has become an important objective of policy makers in the industry. The Brundtland report defines the sustainable development as development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs (Mulder, 2003). There are numbered of frameworks of

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sustainability assessment that evaluate the performance of companies. The World Business Council for Sustainable Development (Fux et al., 2003), the global reporting initiative (GRI) and development of standards were the foundation for sustainability reporting. Fux et al. (2003) developed a framework for sustainability indicators for the mining and minerals industry, which is also compatible to GRI. Jetten et al. (1997) collected and developed a standardized set of sustainability indicators for companies covering all main aspects of sustainable development. Indicators and composite indicators are increasingly recognized as a useful tool for policy making and public communication in conveying information on countries' performance in fields such as environment, economy, society or technological development. 'Indicators arise from values (we measure what we care about), and they create values (we care about what we measure)' (Strous et al., 1997). The main feature of indicators is their ability to summarize, focus and condense the enormous complexity of our dynamic environment to a manageable amount of meaningful information. By visualizing phenomena and highlighting trends, indicators simplify, quantify, analyze and communicate otherwise complex and complicated information (Abeling and Seyfried, 1992).

There is a widely recognized need for individuals, organizations and societies to find models, metrics and tools for articulating the extent to which, and the ways in which, current activities are unsustainable. This need arises on multiple layers ranging from supra-national (for example, the negotiation of protocols for environmental protection), national (for example, via some version of "greening" GDP) and sub-national levels (for example, in regional development forums). In an effort to introduce and define sustainability science, Mulder et al. (1995) provided seven core questions for research. Two of them are particularly connected to the issue of assessing sustainability: "how can today's operational systems for monitoring and reporting on environmental and social conditions be integrated or extended to provide more useful guidance for efforts to navigate a transition toward sustainability? How can today's relatively independent activities of research planning, monitoring, assessment, and decision support be better integrated into systems for adaptive management and societal learning?" According to Schmidt et al. (2003), the purpose of sustainability assessment is to provide decision-makers with an evaluation of global to local integrated nature (society systems in short) and long-term perspectives in order to assist them determine which actions should or should not be taken in an attempt to make society sustainable. The need for an integral systematic approach to indicators definition and measurement is recognized (Schmidt et al., 2003) in order to give well-structured methodologies, easy to reproduce and to assure that all important aspects are included in the measurement. However, before developing the methodology and the indicators,

what is needed is the clear definition of the policy goals towards sustainability. This appears to be even more difficult since in most cases the development of indicators has started while there are still arguments over what constitutes sustainable development.

THE ISFAHAN DOCTRINE

The dominion that prevailed in Safavid era in the Kingdom of Iraq, Syria, and India, which had close relationships with Iran, was briefly named "Isfahan Doctrine." Not only Isfahan, the capital of Safavid, but cities such as Shiraz, Qazvin and Tabriz, had been the capital of this dominion. The Shah Abbas's attention to Isfahan development was not to compete with Paris and London at that time, but to weaken Constantinople, the worst enemy of Iran. And since political destiny of Middle East at that time was appointed by Ottoman Turks and Safavid kings, Shah Abbas tried to make Isfahan more beautiful and magnificent than Istanbul because he envied Istanbul at that time so decided to adorn Isfahan, Safavid capital, so as to attract attention of foreign explorers, merchants and ambassadors. In fact, competition to Ottoman Turks was one of the reasons for development of Safavid and Isfahan.

Comparing the Isfahan doctrine to sustainable design principles

Comparing concepts and attitudes of the Isfahan doctrine to sustainable design principles by the adaptive comparison method, the following results were achieved:

- 1) The Isfahan doctrine insisted on construction of the city coordinated with the surrounding environment and harmonizing it with the surrounding nature so that the city and its elements are considered as an inseparable part of nature. This issue is conceptually consistent with three principles (affecting environment, communicating with nature and understanding natural flows) which are discussed in sustainable design.
- 2) The Isfahan doctrine follows the thriving and development of city through establishing new city collections beside the ancient city, which explains popular understanding principles and the concept of time discussed in sustainable design.
- 3) The Isfahan doctrine considers spatial hierarchy, human scale, spatial equilibrium and physical balance, which covers a part of discussed goals in popular, spatial understanding principal and affecting environment.

The results and overlapping of discussed principles in the Isfahan doctrine with all sustainable design principles show that these principles are developed towards achieving sustainability in city design and its constrictive

elements. Therefore, due to the importance of gardens as a kind of city space and vegetations, as the effective element in this space and decisive role of these elements in Isfahan communication routes in Safavid era, Safavid communication routes as well as vegetation sustainability of these routes and the gardens developed in this historical period will be discussed.

Nature in Isfahan

Isfahan is considered one of the most ancient cities in Iran in terms of antiquity. Several writings indicate the city dating back several thousand years and importance of the city in different historical periods. In the meantime, the Zayandeh-Rood River has had a prominent role in the Bagh-Shahr development. Architectural masterpieces in terms of control and water sharing of the river are observable in bridges and ports of Isfahan. Besides that, Medes in this period designed and established some routes for using the Zayandeh-Rood water in and out of the city and the Zayandeh-Rood shore. In fact, the city structure was based on two natural and artificial functional axes. Functions which are formed by two major axis of the Chahar-bagh (artificial axis) and the Zayandeh-Rood (natural axis) and their connection, are entertainment, public, private and royal functions of the city. Hence, it can be said that Safavid government had used potential natural local elements in development of the city. By creating an artificial axis perpendicular to the Zayandeh-Rood called Chahar-bagh, without destruction of the old city; they located the city in complete harmony with nature and river and paved the way for changing Isfahan to a Bagh-Shahr by development of remaining gardens from the previous period in the form of Chahar-bagh. Gardens development and garden building for changing Isfahan to a Bagh-Shahr was so extensive that in his travel letters, Tavernier described Isfahan as: "Isfahan environment as well as neighborhoods outside the city are as big as Paris; but its population is ten times less, and you should not get surprised from small population of such a big city because each family has a separate house and each house has a private garden; hence, there is a large space without any residents. On each side, you go to Isfahan, first you can see Minarets of mosques and then houses trees, so that from distance Isfahan looks more like a jungle than a city."

Identifying the location and nature/landscape penetration into the city has been considered as concepts of communicating to the nature and space concept in sustainable design principles. Safavid government with awareness of this principle that for sustainability of each garden or landscape, firstly, its water supply is necessary, through site identification, using the Zayandeh-Rood water and land slope and creating some streams branched out of the river, covering the whole city and named Medes, has solved the water supply problem.

Gardens and urban open areas in Isfahan

Since Isfahan climate position is so that it has a static mode for 200 days a year, appropriate landscape can dramatically affect pollution decrease. In terms of sustainable urban development, what has been stated in traditional programs, caused by the fact that designers pay special attention to landscapes and gardens such as Chahar-Bagh, Hezar-Jarib, Khargah (on the west side of Chehel-Sotun), Kheimegah and Nazer whose entrance has been in coppersmith market, Kachave-Khane beside dyeing market, Tohid, Bagh-Nazar in the middle of which passed "Madi Niasarm", Takht on the west of Chahar-bagh, Abbas-Abad, Zereshk in the top Chahar-Bagh, Ghush-Khane in the north-east of Isfahan, Bolbol or Hasht-Behesht, Charkhab etc. This shows the residents' special attention to the weather delicacy and the city atmosphere of fun. There was a garden called "Naghshe Jahan" beside Naghshe jahan square. One of the garden's gates was connected to the "Kushk" and was called the door of Kushk. In Saljooghi's era, Naghshe jahan square was known as "Kushk square." In the same period, one of Saljooghi's gardens was "Bagh-e Karan" located in the current place of Khajoo and Hafiz has said about it that: "Zandrood, bagh-karan". Of course, it can be assumed that to what extent these gardens have caused Isfahan to be flourishing and beautiful and have a delicate weather. Urban planning was exactly based on sustainable development without knowing its concept. Street drawings and creating public pathways in a regular and accurate way was first done during Safavid era in Isfahan and each street besides being a place for local traffic had also been considered a park. For instance, Chahar-bagh Street was 60 m wide in which there had been planted 8 regular rows of poplar and sycamore trees. Between each tree, there were some flowers, including roses and jasmine and these trees had four streams. The widest had been located in the center and carved stones had adorned its surrounding.

On the street had been also some pools and fountains with special designs and some flower bunches were floating on the surface of water to redouble its beauty and grace. Therefore, in the past, urban planners considered the plant as a great factor of creating a healthy environment, landscape beautification and weather purification.

Medes in Isfahan

In Safavid era due to population growth and urban development and water increasing requirements, knowledge of well-known scientist Sheikh Baha'i was used. His petition was prepared and used in 923 AH at the time of Safavid Shah-Tahmasb. The Zayandeh-Rood water division is known by the name of the petition attributed to Sheikh Baha'i. According to this shared

letter, the river water flows towards the last levels of Abkhor Lands during four sharing stages. The most important effect of Medes has been stabilization of landscapes (gardens) surrounding streets and several gardens in the city. Due to water supply, Medes have been the most important factor in garden's development, thus providing a possibility to disperse water-dependent jobs such as mills, etc., from the river shore towards different places around town and had a major role in changing Isfahan to a Bagh-Shahr with several garden lanes. Chahar Bagh axis with a Boulevard form begins from in front of Jahan-Nama Mansion and passes Si-o-se-pol towards Bagh-e Hezar-Jarib. In the middle of Chahar Bagh there was a stream passing all its length having pools with marble fountains in regular intervals and due to the slope of Chahar Bagh, there were some small watersheds, which added to the street's beauty. All garden walls were net-like and pedestrians could see tree planting space, garden freshness and flowers, pools, fountains, waterfalls and their central Kushk in a vague, stimulating and inviting way. In the travel letter of Tavernier (6 travel; 1038 AH), it had pointed to a big stream started from Jahan-Nama-Kushk all along the street towards the bridge. Existence of the stream in the middle of Chahar Bagh made of stone cutting had been mentioned in most travel letters and history, and a lot of illustrations and pictures proved that. Chahar Bagh was a tree planted street. The number of trees at the beginning of Chahar Bagh construction is not clear and the only document mentioning Chahar Bagh during the first century of its life was the report of Jamali-Kareri, an Italian explorer. He had been in Isfahan in 1105 AH on the death of Safavid Shah Suleiman and coronation of Shah Hussein.

From Tavernier words also, it can be assumed that two rows of trees existed on both sides of street. Therefore, it can be acknowledged that communicating to nature and giving identity to the routes and neighborhoods by natural elements such as flowing water and trees, is of major features of Safavid urbanism in Isfahan Bagh-Shahr, which got possible by Mede's development throughout the city.

MATERIALS AND METHODS

It was decided to adopt case study approach for this paper as there is little existing research on analysis of sustainability levels; it has been based on the descriptive research. This descriptive type research has been carried out using questionnaire as the research tool for gathering the required data. Data gathering involved both reference document and a questionnaire survey. Sampling was simple random sampling and the data-gathering instrument was the questionnaire. In November 2009 a request for interviews and questionnaires was sent to a number of people. Prior to the interview and filling the questionnaire, the author explained the purpose of the research and made it clear that this information would be in the public domain, so any confidentiality concerns could be noted. The interview and questionnaire from April 2009 to December 2010 lasted 10 h per week.

RESULTS

Development and modeling the Bagh-Shahr of Isfahan

Isfahan and the principles used in its urbanism, including city sustainability and its landscaping elements namely vegetation and urban landscape, changed to an excellent urbanism model to create the Bagh-Shahr and route gardens such as Chahar Bagh, which was used in designing some other cities such as Shah Jahan Abad in India. In Shah Jahan Abad, the water of Jumna River was transferred using some canals towards the city to establish royal gardens and supply water of the city and construction of a linear axis having features of Chahar Bagh named Chandi Chuk. Chandi Chuk in fact is a ceremonial passage which is designed extracted by Chahar Bagh with a stream in the middle.

Current image of Isfahan

Unfortunately, nothing has currently remained from the glory and beauty of this street but a name and a shadow; because this street started to change from 1311 AH at the time of Zel-o-Soltan, who was the ruler of Isfahan by the Nasereddin Shah Qajar. The Qajar reign was the decline of Iran's civilization. In this era, the kings and rulers destroyed Iran civilization, wealth and vastitude. In Isfahan, due to deficit and jobbery, Zel-o-Soltan sold the gardens around Chahar Bagh and even the marble fountains in the waterfronts, destroyed many landscapes and cut Chahar Bagh trees. The remaining legacy from Bagh-Shahr is an industrial city with high per capita landscape. Currently, Isfahan landscape area is about 23 km² which makes 11% of Isfahan. Total per capita landscape in Isfahan due to the city population in 1375 (1266072 people) was 18 m² and net per capita was 17 m². Table 1 determines Comparing per capita landscape in big cities of the world and Isfahan.

Conclusions

Comparing concepts and attitudes of Isfahan doctrine to sustainable design principles, overlapping discussed principles in Isfahan urbanism doctrine with sustainable design principles was proven, and it seems that these principles are created in line with achieving the sustainable form of the city in Isfahan. It seems that creating sustainability in both micro and macro scales had been considered in Isfahan urbanization. In macro scale, the new city is located beside the old city to use facilities and potentials of the old one and get formed without damaging it. Then, creating some facilities, jobs and innovative urban areas such as gardens and Chahar Bagh Street in the new city, which could also meet some parts of the old city requirements, provided some conditions for gathering population in both the old and

Table 1. Indicates comparing per capita landscape in big cities of the world and Isfahan.

City	Per capita landscape (m ²)
Tokyo	2.5
Osaka	2.7
Paris	8.4
Montreal	13
New York	19.2
London	30.4
Isfahan	17

new city, which is one of major factors in city sustainability. In micro scale, Isfahan doctrine urbanization was the result of sustainability in urban areas which has accomplished by creation of flexible, dynamic and versatile areas with various applications like Chahar Bagh and the gardens around that. Besides city sustainability, Isfahan urbanization had possibly been formed as a result of creating a new identity for Isfahan. This identity has been achieved through the establishment of various gardens in the city and some open small gardens. Sustainability of the Bagh-Shahr identity depends on its vegetation sustainability and survival that have provided its sustainability by development and establishment of Medes network and water distribution in the city. Actually, we can say that in ancient Isfahan, traditional planning has paid special attention to landscapes and different kinds of gardens. Chahar Bagh has a global reputation. Karan, Farah Abad, Hezar-Jarib etc. is the evidence of urban planners' attention in the past to landscape and its role in people's lives. In traditional planning of Isfahan, attention has always been paid to landscape creation such as public parks and what they wanted of natural environment beauty was to generalize using it for all citizens. They believed that everybody should enjoy these beauties. They were fully aware that landscape effects on citizens' spirit and climate mitigation in different seasons, could be useful in maintaining environmental health and citizens' mental health. In the end, it can be said that valuable experience of the Bagh-Shahr proves the role of open urban area in environmental improvement.

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