Bagh-e Nazar

Bagh-e Nazar, 18(97), 33-48 / Jul. 2021
DOI: 10.22034/BAGH.2020.226317.4513

Persian translation of this paper entitled:
نقش آب در ریخت‌شناسی شهر تاریخی قزوین (دورهٔ قاجار)
is also published in this issue of journal.

Original Research Article

The Contribution of Water to the Morphology of the Historic Qazvin City (Qajar Era)

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Received: 10/04/2020; accepted: 13/12/2020; available online: 22/06/2021

Abstract

Problem statement: Even though the dearth of water has long been a permanent challenge in Iran, a large majority of Iranian cities have managed to survive by harvesting underground water through the Qanat system. All these cities share some special features in terms of urban morphology and their traditional water infrastructures have influenced their urban texture to a large extent. Of these cities, the historic city of Qazvin has been selected as a case study.

Research objective: This study attempts to examine the contribution of water to urban morphological elements. Since water as a natural element of the urban context determines urban forms (street, plot and building systems), this study seeks to identify such effects on these systems.

Research method: The historic city of Qazvin was selected as the research site. Data related to the elements of the urban form of this city in the Qajar era were collected through field observation and interviews with old citizens of Qazvin and experts. Also, relevant documents were examined and analyzed. For data analysis, related software programs were used.

Conclusion: Examining the presence of water in four elements of urban forms shows that water as an independent factor has had a large effect on urban morphology. It mainly affects street systems but this effect for building systems was much lesser. However, this effect on the plot systems has been very slight. Overlooking this effect while carrying out intervention in the historic urban texture might lead to some misunderstanding and result in an incorrect decision in the historic urban texture.

Keywords: *Water, Urban Morphology, Traditional Water Infrastructure, Historic City of Qazvin.*

Introduction and problem statemen

The importance of water for survival is known to everyone. This truth has been mentioned in this Quranic verse: "و جعلنا من الماء کل شی حی" as well. Iran is a country with limited water supplies and a large majority of Iranian cities suffer from water-

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scarce. However, Iranian cities have managed to survive for a long time in this region. In most Iranian historic cities, urban planning has paid much attention to sunshine (the Qibla), river and Qanat (Papoli Yazdi, 2010, 69).

Most Iranian cities do not have access to surface water such as rivers and freshwater lakes. These cities have risen to this challenge by harvesting underground water through the system of qanats. The water from the qanats flows underground or is drawn to the surface near human settlement. This water infrastructure used to be one of the important factors contributing to shaping the urban elements. This paper examines the effect of water and traditional water infrastructure on shaping the morphological elements of Iran's cities (i. e. dry regions of Iran). To this purpose, the historic city of Qazvin in the Qajar era was selected as a case study and the contribution of water to the elements was investigated. This study concludes that water is part of the natural context of the city and includes underground water which is bought to the city through the qanat system. Also, water has an important effect on three other urban elements namely streets, plots and buildings.

This study attempt to answer the following questions:

1. What are the effects of water on the morphology, morphogenesis of Qazvin and the placement of land uses of the city?
2. How have the infrastructure and traditional water supplying method of Qazvin city contributed to the shape of the city?
3. How are the morphological elements of the historic city of Qazvin (street, plot and building system) associated with the qanats and water infrastructure in the city?

Literature review

This review section consists of two parts. The first section of literature focuses on the presence of water in arid cities of Iran and delves into the urban elements especially hydraulic structures. In the second section, urban morphology, its schools and approaches are presented.

Examining the pertinent literature on water and settlement shows that one study exists on traditional water supplement net and its contribution to urban morphology in Maybod (Janebollahi, 1987) and one book is also available on the effect of natural factors (e. g. water, the slope of the ground and sunshine) on "Shekl-e Shahr-ha-ye Iran" (The Shape of Cities of Iran) (Kheyrabadi, 1997). Bonine (1979, 2003) has investigated the form of Iranian cities especially in hot and dry regions and examined how water can influence the morphogenesis of urban form. In this line, there is also research on the form of city and location of urban elements in relation to the path of water in "Khoranagh" city (Roaf, 2003). In their study, Ardalan and Bakhtiar (2001) has also mentioned this in some of the systems in Iranian settlement. Edvard English (1968). has carried out some investigations about the historic cities of Iran and examined the status of qanats in them.

The traditional irrigation system in Iran and especially the intellectual technique in harvesting underground water (qanat) has been the concern of several scholars. The oldest information about the system has been documented in the Alkaraji's book (1994) that provides information about the way a qanat was created 1000 years ago. So far, several books have been written by Javad Safinezhad (1980, 2002, 2004) on this issue. In his works, Safinezhad has explained the traditional system of distributing the water in cities as well. Iranmanesh (1980), Behnia (1988), Sajadi (1982), Reza (1971) and Haeri (2007) have detailed the qanat system and its elements. They have also explained the compatibility of this technique with the water resources of Iran and the natural environment. In some books, apart from some descriptions on the qanat system, there are some explanations about the system of water distribution and hydraulic structures, for example in the book entitled The qanat of "Zarch" in Yazd city, Semsar Yazdi (2014) has described the qanat and the related hydraulic structures. Khazaee (2015), Dehghani (2012), Ghobadian (2003) and Memarian (2002) have conducted some studies about

hydraulic structures and their different types and provided some information about their elements.

The second part of the literature focuses on urban morphology and approaches. Three schools (i. e, British, Italian and French) have mainly contributed to the concept of urban morphology. Later, an organization called ISUF developed this concept by combining the ideas of the schools in urban morphology. Some scholars (Moudon, 1997; Whitehand, 2001; Oliviera, 2016) have substantially contributed to theories and literature on urban morphology, its characteristics and application.

The case study selected for this research is Qazvin city which has been described in many historic resources, such as "Hudoud al-Alam" (Ibn al-Faghih, 1983), "Mokhtasar al-Buldan" (Ibn al-Faghih, 1970) and the "Safarnameh" (Travelogue) by Naser Khosrow Ghobadiani (1983) and "Tarikh-e Gozideh" (A Selection of History) by Hamdollah Mostowfi (1983). Golriz (2007) in "Minoudar" and Dabir Siyaghi (2003, 2010) and Mojabi (2009) in their reports from this city have described it from different aspects in different historical periods. Azarkia (2010) and Karimian (2003) are among the researchers who have carried some studies on the qanats of Qazvin. The elements of Qazvin city (e. g. Bazaar and traditional Bathes and the hydraulic structures of this city) have received much attention from scholars (Parhizgari, 2017, 2018; Maraghi, 2013; Alehashemi, 2012; Bahrami, 2015).

To the knowledge of the researchers of this study, just a few studies have focused on qanats in Iranian cities. However, available studies have not examined this issue through the lens of urban morphology.

Theoretical framework

The history of morphology goes back to the 17th century. The idea of urban morphology was proposed in 1960 by M. R. G. Conzen (1960), the founder of a British school in urban morphology. This approach is mostly analytical – descriptive. Ten years later, the Italian school employed a descriptive- prescriptive approach to urban morphology. At the same time, the prescriptive French school of thought examined the urban morphology through the social perspective. Recently, the ISUF community has introduced an integrated approach to urban morphology and has highlighted different functions in the field of general health, energy and especially in heritage and tourism (Oliviera, 2016, 181).

This study draws upon the Conzenian School to approach the data because this architectural school emphasizes the physical elements of urban form. This study attempts to examine the effect of water (i. e. independent variable) on the elements of urban form (i. e. dependent variables). Water as an element of the natural context is an independent factor influencing the other elements street, plot and building system.

The elements of urban form

Conzen has categorized the elements of urban form into four main categories: Natural context, street, plot and building system. Of the factors shown in Table 1, natural context is an independent factor affecting the above-mentioned factors.

The following conceptual model indicates the relationship between these factors (i. e. independent and dependent variables) in water-scarce cities of Iran (Fig. 1).

The important point is that urban elements selected for this study have been recognized by different schools of urban morphology. This increases the generalizability of the research results.

Though in this study, the general concept of urban morphology has been defined through the lens of the British school, both analytical-descriptive and prescriptive approach has been employed. The purpose of this study is to develop prescriptive ideas just like Italian and French schools.

Research method

The research method is basic and developmental and the method of this study is descriptive, documentary and analytical. The research site was the historic area of Qazvin city. The street, plot and building systems were dependent variables (Fig. 2), but water and natural context were independent variables of the study.

Table 1. The elements of the urban form. Source: Oliviera, 2016, 26-28.

Natural context	Street system	Plot system	Building system
Natural context is the first condition influencing settlement and organization of different elements of urban form. Natural features such as topography, the quality of soil, climate, and the degree of being exposed to the sun, wind, and natural landscapes contribute to shaping a habitat. Land, the placement of the settlement near the water (sea, lake, or river), and other natural features of land affect settlement.	Streets in different blocks identify the city and distinguish what is accessible to the public from what is private or semi-private. In urban morphology, streets are the most durable element of urban form. The process of forming a city is time-consuming. This process is subject to recurring changes (in the past, present, and future) In this transformation process, streets are more durable and sustainable than other urban elements	The plot system is one of the elements of the urban form which separates public from private realms. However, the role of this fundamental system has been overlooked by agents and stakeholders. This is due to the low visibility of plots. The definition of a plot system is an important factor contributing to the urban form processing and has noticeable durability.	Although buildings are not as durable as streets and plots, they are the most important elements contributing to the urban form and maybe they are the most visible ones. In general, a city consists of two types of buildings: ordinary or uniques

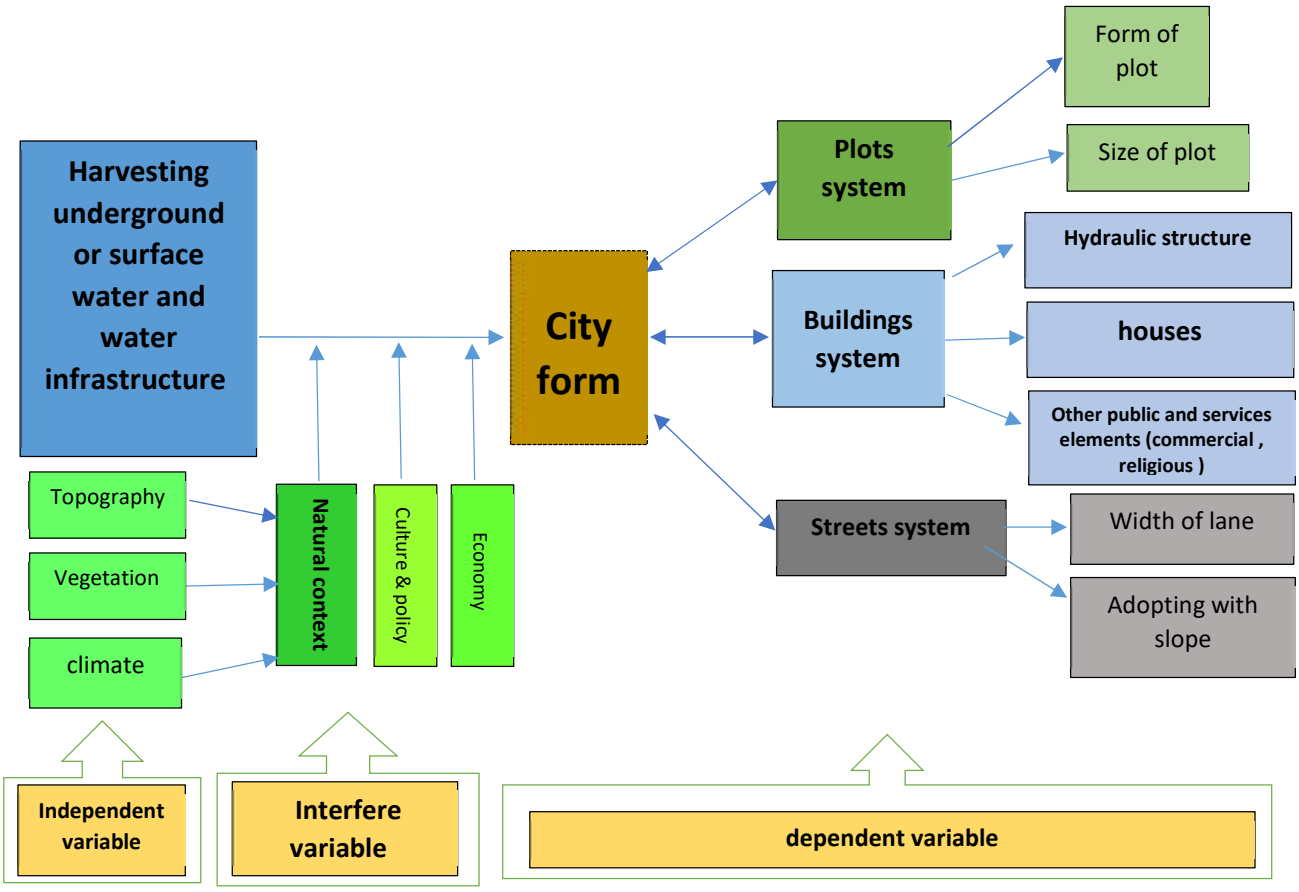


Fig. 1. The conceptual model of urban form and its variables in cities of Iran. Source: authors.

In the first phase, the area in the historic region of Qazvin city and the path of qanats and surface water were identified by aerial images. Then, the pertinent literature related to this issue such as books, papers and documents were reviewed.

As the historical urban fabric of Qazvin has changed a lot in the recent decade, most of the historical elements of the city (e. g. residential houses and hydraulic structures) have been ruined. Therefore, in addition to field research, relevant data were collected from senior citizens and old residents through interviews. The focus of the interview was on water resources, traditional water nets and urban form and its morphology.

Fig. 2. Urban elements (dependent variables) including buildings, plots, streets. Source: Pourmohammadi, Sadr Moosavi & Jamali, 2011, 4.

To collect data from the senior citizens of Qazvin and experts, the first author carried out a semi-structured interview. Questionnaires (open and closed) were distributed to the respondents. The result of the study was analyzed by SPSS and Super Decision software. Only a small number of participants participated in this study because only a few old seniors of Qazvin could remember information about the water infrastructure and hydraulic structure of old Qazvin. This was one of the limitations of this study. Also, the number of experts with such information was limited.

Data was approached deductively and inductively. At the micro-level, the effect of water on three elements of urban form (streets, plots, buildings) was surveyed. Three elements of the urban form had sub-elements and the effect of the independent variable (i. e. water) on the dependent variables or each of these sub-elements (i. e. residential houses, mosques and other public buildings) was surveyed.

This survey included elements at the macro-level (i. e. streets and plots and land use of buildings) and elements at the micro-level (i. e. spaces and structural elements).

The effect of water on morphological elements of the historic city of Qazvin

In this part, the urban elements of historical Qazvin city were analyzed using the Conzenian approach (which complies with the principles of other morphological schools).

- **Natural context of Qazvin city**

Qazvin city has a general land slope extending from the north to south and the percentage of the land slope is between 0-2.5. This percentage means when the water coming from Qanats to the surface runs into the conduits with a slight slope.

The location of Qazvin city has been accurately selected in line with military importance to protect the Sasanid borders and Qazvin plain. This was shows the knowledge of the urban developer about the geography of the region and reflects their foresight for the future development of the city. The current position of the city near two seasonal rivers has not been selected by chance. In this location, the two natural mountain axes intersect and through which the seasonal rivers Dizaj and Arenzak are running. The rivers meet each other at the foot of the mountain where the plain starts.

Analyzing the geography of the region can be used to prove that this place was in a special position in terms of the accessibility to water resources and its selection was reinforced by a strategic necessity at that time. These rivers were the first water resources of Qazvin filled in rainy seasons but then dried up (Parhizgari, 2017, 2).

These rivers have been irrigating the traditional gardens of Qazvin for over 1000 years old. These gardens used to surround the city completely but by stretching the city toward the north, the gardens embraced the city partially just like a horseshoe.

Qazvin city used to use water of wells for drinking until the 4th century. Since then, the most common way to harvest water for the city has been the technique of qanat.

In the Qajar era, qanats were still in use. Some of these qanats belonged to the 14th century. The path of qanat and their locations have been indicated in Fig. 3.

The maps show that most of the qanats appeared in the city and the water was flowing on the ground in the city. It can be said that the water of qanat creates a part of the cityscape after reaching and flowing the ground.

- **The streets system of the historic city of Qazvin**

The historic city of Qazvin has a hierarchical street system. According to the rule of thumb, to enter the house, first, we have to pass through "Hashti" then the corridor, a dead-end street, the side alley leading to the connective roads and finally reaching the main streets (Mojabi, 2009, 125).

One of the most important streets in Qazvin city is "Sepah" known as the first street of Iran. This street was built in the Safavid era by order of "Shah Tahmasb I".

Data from observations and documents showed that the source of water in streams of Sepah was Teyfori qanat (Fig. 4) or lay people's term "Keyfori" (Golriz, 2007, 308).

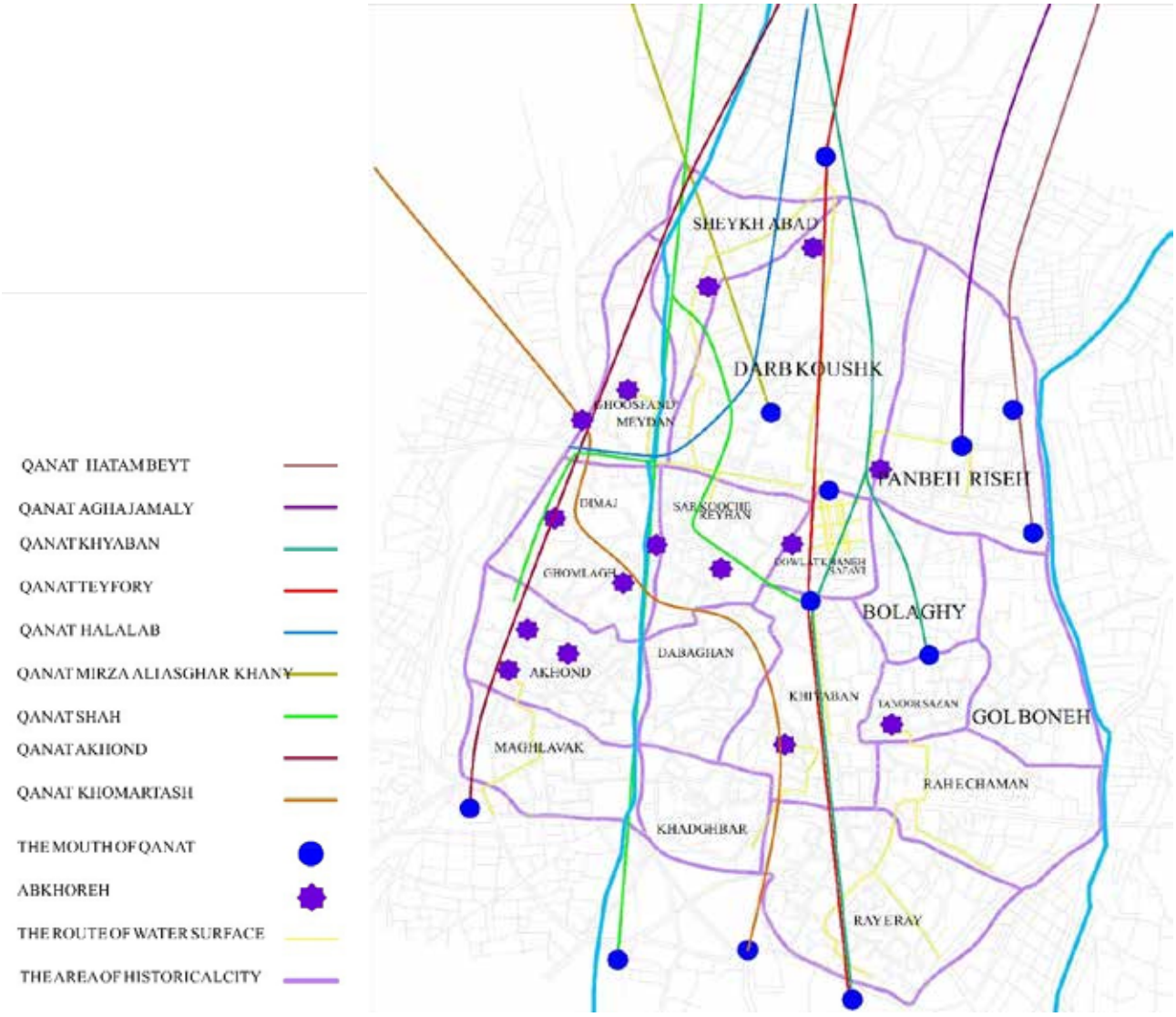


Fig. 3. The map of the historic city of Qazvin and the path of qanats in seventeen districts. Source: The historic map of Qazvin 1919 and Golriz, 2007.

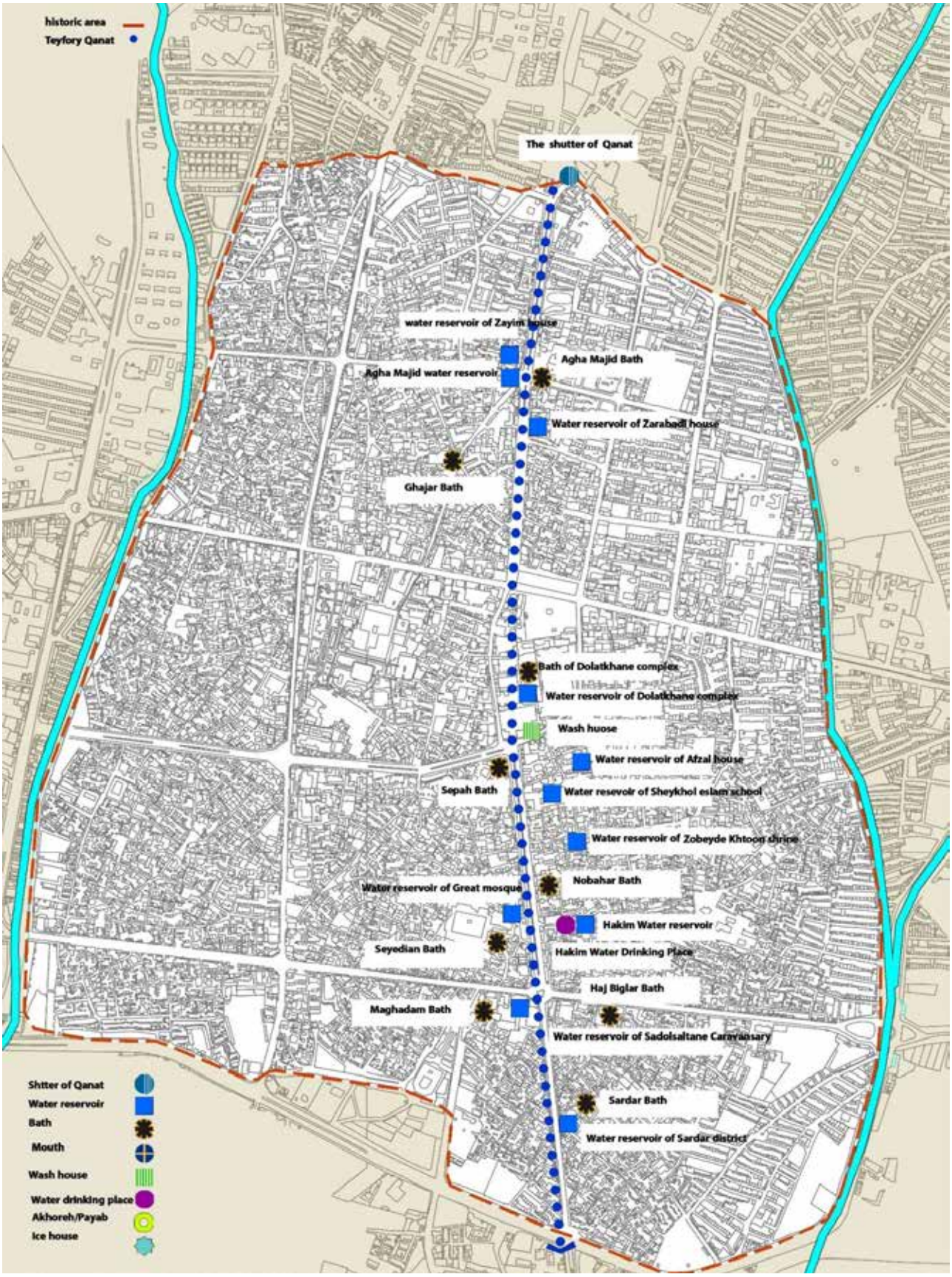


Fig. 4. The path of Teyfori and its related hydraulic structures. Source: aerial photo 1964 and Golriz, 2007.

Except for Sepah street, the rest roads of Qazvin were determined by the water flow paths of qanats. The water of qanats was directing towards intra-urban passageways (Fig. 5) and then a water distributor (in Persian: "Mirab") was responsible for distributing water among the owners based on their turns and their ownership.

Plot system of the historic city of Qazvin

Qazvin in the Qajar era had 17 districts (See Fig. 3). All forms of the residential districts of Qazvin were organic and non-geometric. This fabric was characterized by connectivity in the massing of adjacent buildings. This feature played a key role in creating an integrated whole unit in traditional fabric. Houses used to be surrounded by adjacent houses from two or three sides and just one side opening to the passageway was not closed since on which the entrance was placed.

Some of the residential plots of upper social levels were located on the path of qanats and residences had accessibility to the water of qanats. However, in Qazvin city, there weren't many "Akhores"[1] because the water of most of the qanats was running down the conduits through intra-urban passageways in the middle of the city. Direct access to water in Jame mosques was a necessity. For this reason, the Jameh mosque of Qazvin had an Akhore which was connected to Khomartash qanat (Fig. 6).

In comparison with the geometrical system of farms and gardens, the residential plots were irregular and this irregularity was associated with the violation of the construction rules. However, as the water consumption in gardens and farms used to be measured, they were organized, orderly (English, 1968, 7).

An example of this can be seen in the district of "Panbe Riseh" and its plot system (Fig. 7). The plots with irregular geometry are located next to the passageway, the special plot in this area is the mausoleum of Hamdallah Mustawfi located in the center of the plot. The massing of the rest buildings is on three or four sides or in some cases can be seen on two sides or in a linear form.

The building system of the historic city of Qazvin

In the building system in Qazvin city water infrastructure had a large effect on the placement of different land uses. The locations of hydraulic structures and even other land uses were determined based on the path of qanats. This was true about the locations of water reservoirs, "Akhore", bathes, wash house, etc. (Figs. 4 & 6) show the path of qanats and its related hydraulic structures. The supply of water to these structures was determined according to the ownership of water. It was accessible to the owners through streams or clay pipes based on their turns. The task of water distribution was undertaken by water distributors.

Table 2 shows the presence of water in some buildings.

Discussion and analysis of data

As discussed before, part of the data was collected through observation by attending the field. One of the limitations of this study is associated with reconstructions in the historic area of the city. Due to the reconstructions, many historic buildings and hydraulic structures of Qazvin, especially Akhores and "ice houses"[2] have been ruined.

Also, the growing need of the city for water was a reason for digging a lot of deep wells. Many qanats either dried up or ran out of water due to lack of maintenance and reconstruction.

The use of qanat water was greatly reduced and even they faded in the city. For this reason, in the second phase of the research, two kinds of questionaries (open and closed questionaries), were prepared and distributed among the senior citizens of Qazvin and experts.

The data of the questionnaires were analyzed in SPSS software and the result was entered in the Super decision software. the conceptual model created to describe the relationship between the variables, the effect of water on the street, plot and building systems were evaluated.

The output and aerial images show that water had the most effect on the street system. The paths of

Fig. 5. The primary arterial roads of Qazvin city in the Qajar era. Source: Golriz, 2007, 288.

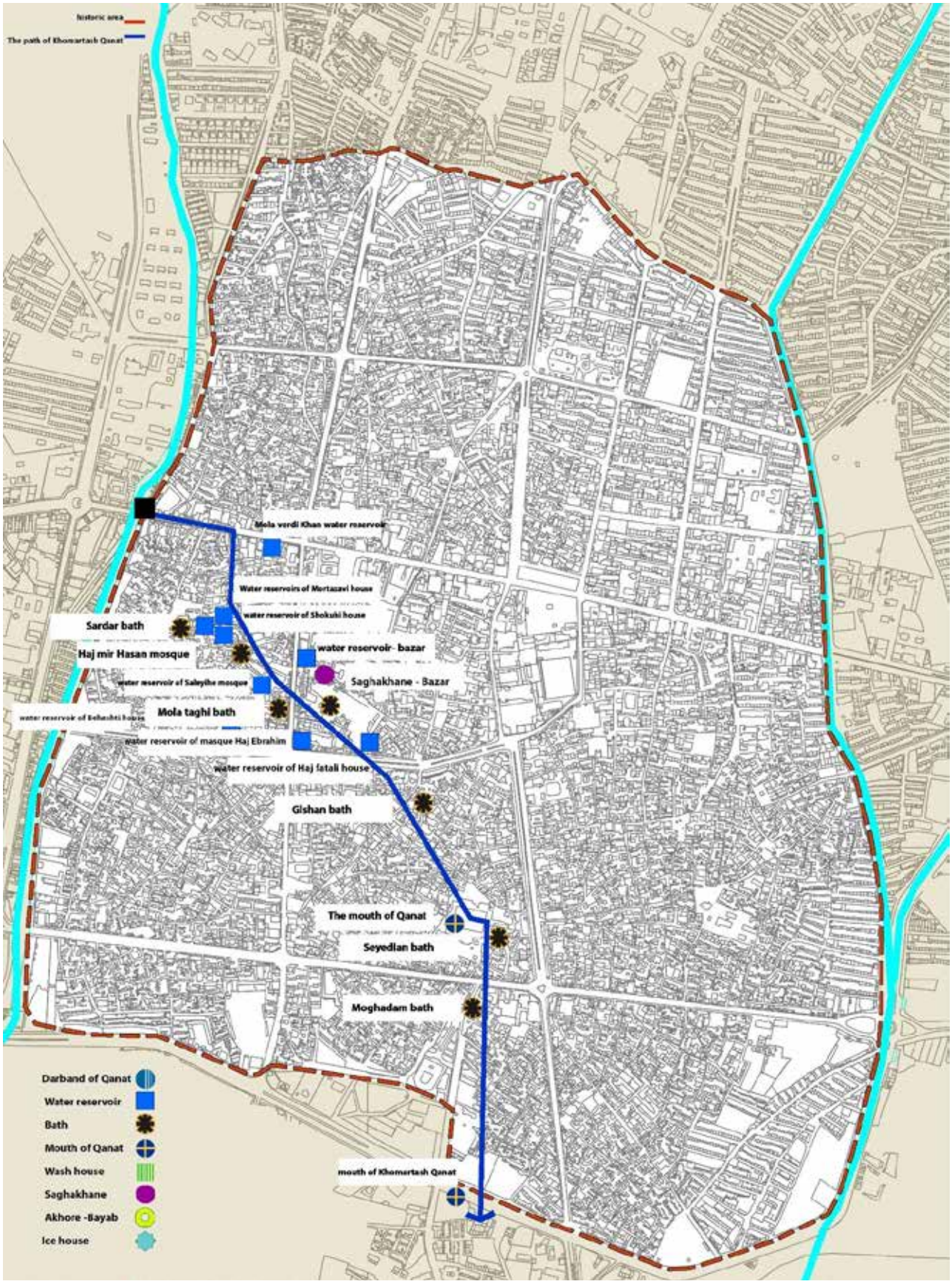


Fig. 6. The map of Khomartash Qanat in the historic urban fabric of Qazvin. Source: Golriz, 2007.

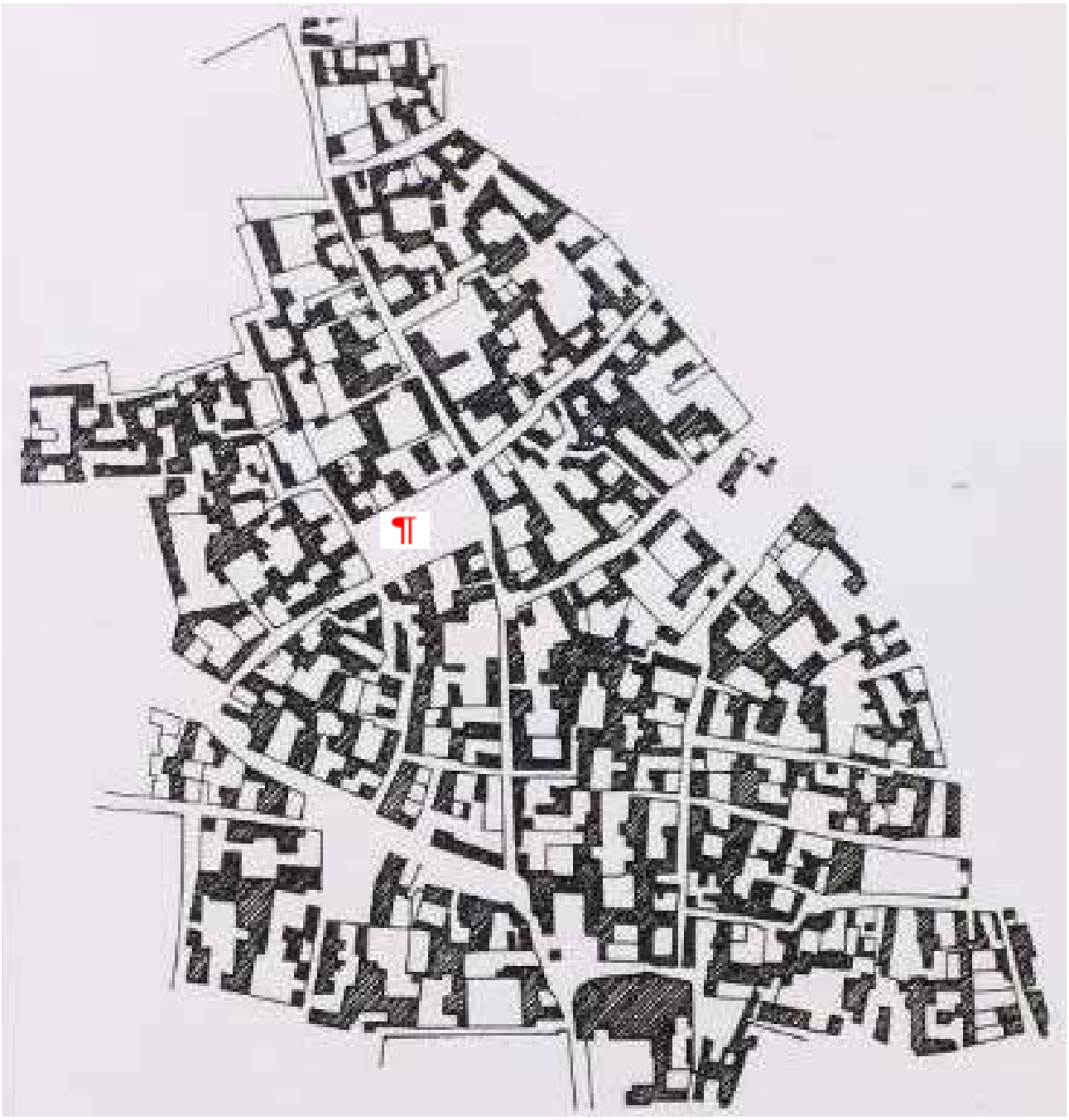
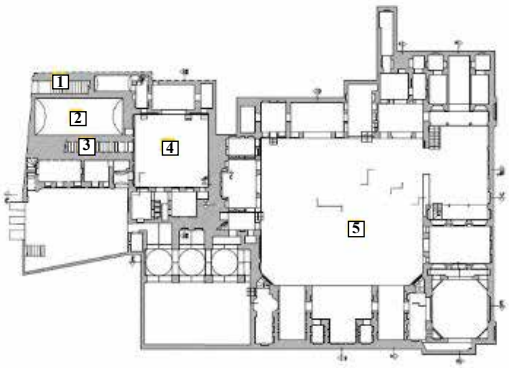
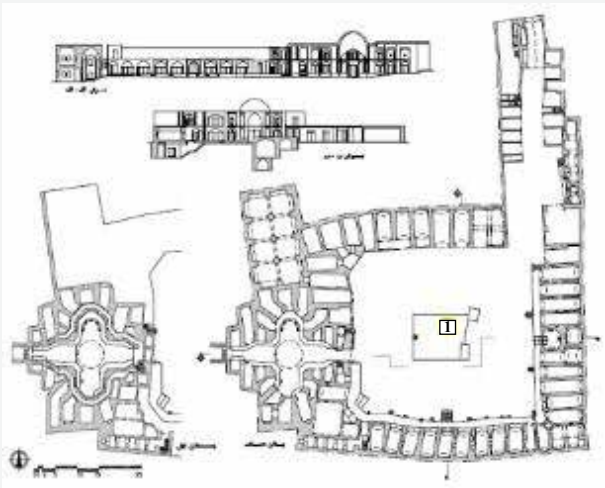
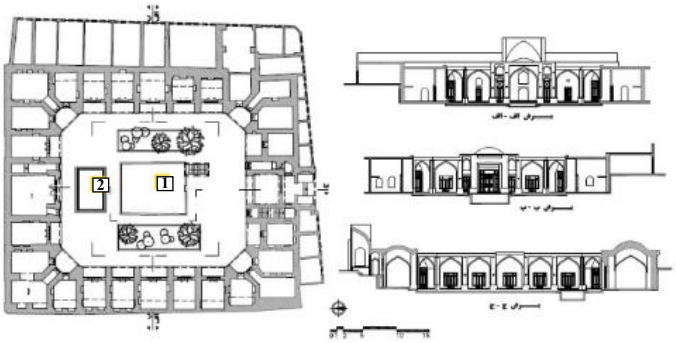


Fig. 7. The plot system of Panbeh Riseh district and the location of the mausoleum of Hamdollah Mostowfi. Source: Mojabi, 2009, 297.

qanats played a key role in determining the street system, the most durable factor of urban form. The conduits of qanats and shafts were accessible to the public not to disturb the privacy of citizens at the time of maintenance and dredging. When the water of qanats was coming to the surface, it was running down the conduits through intra-urban passageways to be accessible to several people because the water was endowed or owned by a large number of people. Water distributors were responsible to deliver the water to the owners based on their turn. Analysis of an in-depth interview, observations and examining the documents showed that regarding the street system, the greatest impact of water flow was on the north-south slope of

Table 2. Some examples from historic buildings of Qazvin city in the Qajar era and demonstration of the presence of water. Source: Mohamadzade, 2006.

Building	Presence of water	Plan
Asadi House	1. Water faucet from outside 2. The location of the water reservoir 3. Water faucet from the inner yard	
Mortazavi House	1. The faucet from the passageway 2. The tank of the water reservoir 3. The faucet indoor 4. The pool in the yard 5. The pool in the yard	
Panbeh Caravansary	1. Water reservoir	
Etefaghiye School	1. Water reservoir 2. Pool	

the land. qanats on the western parts of the city were generally underground and therefore, the surface water flowing in the passageways was less while the number of Akhore was more.

Also, data collected through the interviews and documents confirmed that water affected the building system. In most buildings, there was a space for water display or storage. Data from questionnaires showed that most houses of Qazvin had water reservoirs and pools. Due to space limits, statistics and tables related to this section are not presented here. Each of the hydraulic structures serving different services to citizens was related to surface water or underground water. However, water had the least effect on the plot system. This system was mainly influenced by different contextual factors (e. g. Sunshine and Wind), or cultural issues (e. g. Qiblah and Privacy). The economy issue (A factor determining the size of the plot) and the orientation of building massing in the plot had a stronger effect than water.

(Tables 3, 4 & 5) show the presence of water in each of the elements of urban form:

Conclusion

Table 6 shows the effect of water, which is part of the natural context of the city, on shaping three elements contributing to urban form:

Briefly speaking, examining n the elements of the form of the historic urban fabric shows water has a major effect on the streets system (i. e. primary and secondary arterial roads and urban spaces) and then on the buildings system (different land uses such as residential, religious and commercial). However, water has a minor effect on the plot system.

Water, a key element to survival, substantially contributes to the morphology of the historic dried cities of Iran. Overlooking the role of water, we cannot gain an accurate understanding of historic urban fabric.

Since the traditional water infrastructures of Iranian cities were Qantas, understanding them as an effective factor influencing urban form is a necessity. This was the concern of this article and was investigated using the Conzenian approach.

Available studies that have employed this approach are quite limited. Future studies need to pay attention to use the knowledge of morphology in heritage.

Table 3. Examining the street system of some historic roads of Qazvin and categorizing two groups of lanes. Source: authors.

Streets system	Name of the road	Presence of water	Direction of streets	Description
Primary arterial roads	Sepah street	Some streams emanating from Teyfory Qanat were running on two sides of the street	North-south street	In the Qajar era, some streets and important passageways on the east-west had no streams (water of Qanats). An example of this is the old Tehran street (Vaypoor). This street was located in one of the driest districts of Qazvin city (Rah Rey district). Although this street was one of the main passageways, no special measurements were made to address its water shortage. This issue was not discussed until the water piping system for the city was introduced. Pahlavi Street, (now Imam Khomeini), which was widened to the east-west was one of the main access points of the city on the western axis. The supply of water to this area was maintained by Shah and Halal Ab Qanats. Generally, northeast passageways were on the path of some qanats (See Fig. 5)
	Naderi street	Teyfory	North-south street	
	Pahlavi street (Imam Khomeyni)	Halal Ab and Shah Qanat	East-west street	
	Syadi - molavi street	Shah Qanat	North-south street	
	Tehran – Montazeri street	Probably no stream	East-west street	
	Bolaghi street	Probably there was only one stream on Khyaban street at the end of the passageway	North-south street	
Secondary arterial roads	Hamd Allah Mostofi lane	A branch of Khiyaban Qanat	East-west street	
	Obeyd Zakani	Halal Ab Qanat	North-south street	
	Tabriz	Akhond Qanat	North-south street	
	Imam Zade Ismayeel lane	Probably no stream	North-south street	

Table 4. Examining the plots system in the historic city of Qazvin and its effective factors in it. Source: authors.

Plots system	Situation	Description
The general pattern of plots	L form U form Central yard	The plots had one of these patterns (L, U, and Central yard). They were oriented towards the sun and Qibla and the power of the economy was a factor determining the size of the plot.
Enclosing of plot	Enclosing from one side Enclosing from two sides Enclosing from three sides	Usually, plots were enclosed by other plots from three sides or at least two sides
Geometry of plots	Regular Irregular	The forms of the plots in the historical fabric of Qazvin were more irregular compared to gardens. The regularity of gardens facilitated irrigation measurement or some farming-associated affairs.

Table 5. Examining the presence of water in buildings system of the historic city of Qazvin. Source: authors.

Buildings system	Type of space	Presence of water	Description	The rate of presence of water
Presence of water in traditional houses	Pool	Almost in most houses	In most houses, the presence of water can be seen in pools and small wells and there were a lot of water reservoirs, instead, the number of Akhore and personal baths were very limited	High
	Small well	Almost in most houses		
	Akhoreh	Very limited in houses		
	Water reservoir	In most houses especially large houses		
	Personal bath	Very rare		
The presence of water in hydraulic structure	Watermill	Located in the path of seasonal rivers	Except for water mills which used seasonal rivers, the rest of the hydraulic structures were irrigated from the water of qanats. The water distribution to these structures was managed by a water distributor based on the ownership and turn of everybody. The water distributor had to deliver the water required for the hydraulic structure.	High
	Akhoreh	Located directly on the underground path of Qanat		
	Water reservoir	Irrigated by clay pipes		
	Bath	Near the path of Qanat and connected by clay pipes		
	Washhouse	Connected to the water of Qanat by clay pipes		
	Icehouse	By the water of Qanat		
	Saqakhaneh	Usually was filled by hand or a pump		
Presence of water in the mosque	Jame mosque of Qazvin	Availabliity of Akhoreh	Like many other Jameh mosques, the Jame mosque of Qazvin had accessibility to the qanat directly (the water of the qanat was pouring into the pool of the mosque)	Average
	The mosque of Salehiye	Availabliity of a deep yard for holding the water of Qanat		
	Other mosques	Availability of a pool and sometimes a water reservoir		
The presence of water in the caravansary	Most of caravansary	Absence of a pool but the availability of a water reservoir		Average
The presence of water in Bazar	Most of the Bazars	Availability of a water reservoir and a public drinking place (in Persian Saqakhaneh)		Average

Table 6. The effect of water (i. e. independent variable) on urban forms (i. e. three dependent variables) and the degree of its effect. Source: authors.

(The elements of Urban morphology) Dependent variable / Independent variable	Plot system	Street system	Building system
Water (Natural context)	Generally, agricultural plots and farms were formed more regularly and geometrically. This was associated with measuring the amount of water required. In contrast, in the texture of the urban system, the plots were formed irregularly and organically because they were under the influence of natural factors such as climate (e. g. wind and sun), topography, and the Qibla were formed.	Generally, the water of Qanats after reaching the surface was running down the conduits through intra-urban passageways to be accessible to several people because the water was endowed or owned by a large number of people The water distributor was responsible for delivering water to each building. The street system generally was formed according to the natural slope of the ground.	The locations of hydraulic structures used to be determined based on the paths of qanats on or beneath the ground. Also, in many houses, there were water reservoirs, pools, and even Akhores (The water of the qantas was accessible to people). The presence of water can be seen in other land uses such as religious buildings or other services caravansary Baazar. The presence of water can be seen in pools and water reservoirs and sometimes in Akhores.
The Degree of the Effect of Water	Low	High	Average

Endnote

1. Akhore refers to a place that has access to underground waters.
2. This term refers to an insulated building widely used for storing rice before the invention of the fridge.

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HOW TO CITE THIS ARTICLE

Iranmanesh, N., Pourjafar, M. R., Khatibi, M. R., & Ziari, K. (2021).The contribution of water to the morphology of the historic Qazvin city (Qajar era). *Bagh-e Nazar*, 18(97), 33-48.

DOI: 10.22034/BAGH.2020.226317.4513
URL: http://www.bagh-sj.com/article_130953.html?lang=en