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URBAN RURAL LINKAGE THROUGH WATER INFRASTRUCTURE IN THE IRANIAN PLATEAU: CASE OF SEMNÂN

LIAISON RURALE URBAINE PAR L'INFRASTRUCTURE D'EAU DANS LE PLATEAU IRANIEN : CAS DU SEMNÂN

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ABSTRACT

For centuries, complex hydraulic systems had a pivotal role in shaping Iranian cities. As socio-technical systems, water infrastructures outlined a strong connection with the socio-spatial organization of the Iranian cities.

This article examines the traditional urban rural linkage in the city of Semnân and shows how this linkage was shaped in various aspects based on the traditional water infrastructure of the city. The paper focuses particularly on the socio-spatial connection between water infrastructure and urban-rural structure in Semnan before the mid-twentieth century. It successively outlines this traditional interconnection in three scales of territorial, urban and architectural organizations. It then puts into question the current situation of the traditional hydraulic system and its correlation with the modern development of the city.

The Results of the research shows that the traditional water infrastructure in Semnan had a leading role in Urban-Rural linkage, and spatial organization of the city on different scales until the mid-twentieth century. It shows the integration between hydraulic systems and rural and urban organizations was not limited to the physical aspects. But the hydraulic system governance and organization was in fact deeply integrated with a hierarchical societal system which formed the socio-spatial organization of the Semnan.

Keywords: Urban Structure, hydraulic infrastructure, Iranian Plateau, Traditional water systems, socio-spatial structures, socio-technical systems.

RESUMÉ

Pendant des siècles, des systèmes hydrauliques complexes ont joué un rôle central dans le façonnement des villes iraniennes. En tant que systèmes sociotechniques, les infrastructures hydrauliques présentaient un lien fort avec l'organisation socio-spatiale des villes iraniennes.

Cet article examine le lien traditionnel entre les zones urbains et rurales à Semnân, et montre comment ce lien a été façonné dans divers aspects autour de l'infrastructure d'eau traditionnelle de la ville. L'article se concentre particulièrement sur le lien socio-spatial entre les infrastructures hydrauliques et la structure urbaine-rurale à Semnan avant le mi-vingtième siècle. Il esquisse successivement cette interconnexion traditionnelle à trois échelles d'organisations territoriales, urbaines et architecturales. L'article examine donc la situation actuelle du système hydraulique traditionnel dans le contexte moderne de la ville.

Les résultats de la recherche montrent que l'infrastructure hydraulique traditionnelle à Semnan a joué un rôle de premier plan dans le lien urbain-rural et l'organisation spatiale de la ville à différentes échelles. Il souligne que l'intégration entre les systèmes hydrauliques et l'organisation rurale et urbaine ne s'est pas limitée aux aspects physiques. Mais aussi la gouvernance et l'organisation du système hydraulique étaient profondément intégrées au système sociétal hiérarchique qui formait également l'organisation socio-spatiale du Semnan.

Mots-clés : Structure urbaine, infrastructures hydrauliques, plateau iranien, systèmes hydrauliques traditionnels, structures socio-spatiales, systèmes socio-techniques.

INTRODUCTION

Generally, in the history of hydraulic systems and civilizations, Iran is well known for Qanat and hydraulic systems for exploiting underground water (Goblot, 1995; English, 1968; Wulff, 1968). The establishment of permanent settlements in the central Iranian plateau was became possible thanks to the qanat system (Manuel, et al., 2018; Semsaryazdi and Labbaf Khaneiki, 2017; Papeli Yazdi and Labbaf Khaneiki, 2000). Among them, cities such as Yazd, Kerman and Tehran are the most famous. However, on the rime of the central plateau of Iran, on piedmonts, many cities exploited water of seasonal rivers and mountainous runoffs. In some cases, like Qazvin, the urban area was nourished by underground water and series of qanats while the rural orchards were irrigated by other hydraulic system exploiting the seasonal runoffs (Akbaryan, Alehashemi, Nouri, 2021; Iranmanesh, et, al., 2021). In other cases, like Semnan, both urban and rural areas were nourished by the same hydraulic system exploiting water of small rivers. Semnân, considered also as an example of the Iranian cities which its traditional water infrastructure continuous to operate face the rapid urbanization and modernization pressures (Alehashemi and Coulais, 2021). All these make Semnan one of

the representative examples to read urban-rural linkage through the water infrastructure in Iran. Water infrastructure of Semnan was a complex system which on one hand designed the relationships between urban and rural areas, and on the other hand integrated deeply with the spatial and socio-cultural organizations of the city.

The main objective of this paper is to identify the role of traditional water infrastructure in the urban-rural linkage in Semnan. This research is not limited to analyze the traces of hydraulic systems on urban morphology, to show that the shape of urban parcels, the formation of main and secondary roads, and the direction of urban development pursue the traditional hydraulic system. The facts that were studied and proved by Iranian or western scholars in other Iranian cities such as Yazd (Bonine, 1979; Noghsan Mohammadi, 2021), Mehriz (Bonine, 1979), Meybod (Jniballahi, 2005), Sabzevar (Estaji and Raith, 2016). The paper investigates the integration between socio-spatial organization of the city and the hydraulic system. It, particularly tries to find the traces of this bottom-up societal organization in the urban-rural linkage in Semnan via water infrastructure.

To do so, we zoom in successively on the city of Semnan, from its territorial region to its urban area, then to residential quarters and the city centre, and finally we zoom in on architectural unite in the city centre. Through this successive zooming, we investigate the different aspects of integration between hydraulic systems and socio-spatial organization of the city. We analyse not only the physical and morphological interconnection but also the social and cultural integration between hydraulic system and spatial organization in rural areas, urban areas and the residential quarters of Semnan. At the end, the paper looks at the current situation of this traditional water infrastructure in the modern context and the way it still affects the relationship between modern city and historic urban- rural area in Semnan.

The research was conducted mainly based on cartographic study of water networks, and urban and rural morphology of Semnan before and after the rapid urbanization during last decades. These documents were analyzed based on traditional socio-spatial organization of the city. In order to study the various aspects of the interconnection between water infrastructure and urban structures, the research also perused historic documents and social studies on water management system of Semnan as well as urban studies on the traditional morphology and urban management system.

SEMNAN: MIDDLE-SIZE CITY IN THE CENTRAL IRANIAN PLATEAU

Semnan, located at the foot of the Alborz Mountain range and on the edge of the Iranian central desert, represents one of the considerable examples of urban rural linkage interwoven with the hydraulic system in Iran. With an annual average precipitation of 90-100 mm, Semnan is situated in a semi-arid zone. The city and its vicinity nourished by a small river while the villages and agricultural fields in the south of the city were nourished by a series of qanats (Figure 1).

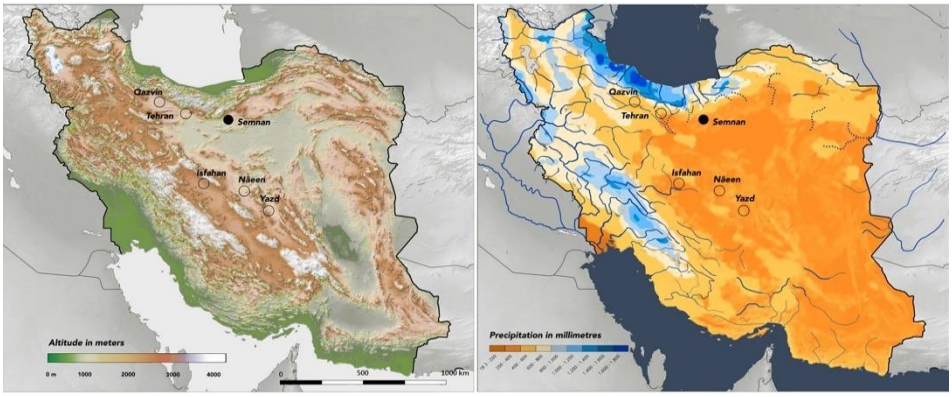

Figure 1: Geographic and climatic situation of Semnan and other mentioned cities on the map of Iran. Source: Author, 2021.

Once remarked the western limit of Parthian region during Achaemenid Empire (550-330 BC); (Mokhlesi, 1976), Semnan was one of the historic cities of Persia before Islam. Probably, the historic city of Semnan during medieval era had developed on the city before Islam. The excavation at Jama Masjid foundation of Semnan in 60s has demonstrated the presence of the fire temple underneath the mosque (Tarh-o Pajouhesh CO, 1974). In medieval Islamic sources, Semnan had always been mentioned as a prosperous and green city with great basins and the houses with water streams passe in their courtyards (Al-Muqaddasi, 1982; Yaqut al-Hamawi, 2000). To examine the traditional integration between hydraulic systems and urban- rural structures in Semnan, we study the city and hydraulic systems before the second part of the 20th century where the massive modernization started in Iran, notably the late of Qajar period and beginning of Pahlavi period. During Qajar Period (in 1886) Semnan had 20 000 population (Khosrobeigi and Ghanbarimaleh, 2011) and its urban structure followed the general urban structure of medieval Iranian cities.

Semnan: An Urban Socio-Spatial Organization

Reading the integration between hydraulic systems and urban structures in Semnan, the paper focuses firstly on socio-spatial structures which shaped the Iranian cities and the city of Semnan as well. The medieval Iranian cities pursued the structure of Iranian cities before Islam (Soltanzadeh, 1997) and was also comparable to the Arabic- Islamic cities in many features (Atash, 1993; Hakim, 2013). In general, the medieval Iranian cities consisted of three main zones (Tavassoli, 2016; Soltanzadeh, 1997):

1. Walled city (Shāristan in Persian): walled city with a dense urban fabric, consisted of residential quarters and public spaces.
2. Citadel (in Persian Arg or kuhandizh): a fortified palatial ensemble where city governors and emirs were housed in. The citadel was found in the middle of the

shâristan like the example of Nâeen (Figure.2-1), or outside the shâristan wall but linked to the shâristan in one side such as citadels of Semnan, Tehran and Isfahan (Figure.2-2), or was situated outside the shâristan and detached from the city wall such as Tous and Bukhara (Figure.2-3).

3. Rural area (Rabaz, Savâd in Persian): rural area which enclosed two other so-called parts, incorporated agricultural fields, orchards and in many cases small hamlets. In some examples Rabaz was surrounded by fortification walls but in the most cases such as Semnan, Isfahan, Tehran, Qazvin, Nâeen and Yazd it wasn't fortified (Figure.2).

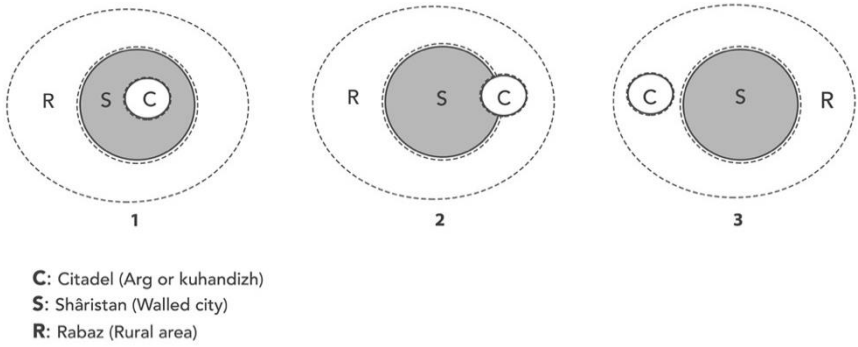

Figure 2: Typical models of companionship of three main parts of the Iranian cities: Citadel, Shâristan (walled city) and Rabaz (rural area). Source: Author.

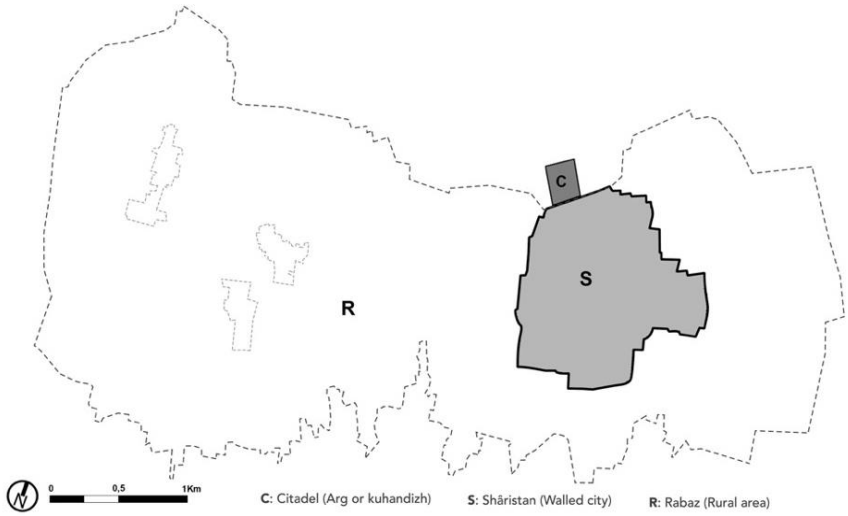

Figure 3: Citadel, Shâristan and Rabaz of Semnân during Qajar period. Source: Author based on the aerial photo of Semnan in 1956 and Bâgh-e Andisheh, 2009.

Semnan's rabaz was immense and consisted of orchards and three small hamlets which once had their own fortifications (Mokhlesi, 1976: 65-66) and were lately transformed into the residential quarters of the city detached from residential quarters in the shâristan. The rabaz enclosed sharistan and the citadel which was ruined completely in Qajar period was situated outside the shâristan in the north, and was attached to the city wall (Figure.3).

Shâristan was the heart of the city, a walled city with gates and hierarchical socio-spatial organization. In general, shâristan was divided in two main parts: the "public" zone occupying the city center and bazaar, and the "private" zone chiefly devoted to the private dwellings.

In the Iranian cities the city center consisted generally of principal religious, administrative and public facilities such as main public square, Jama Masjid, madrasa, public bath, water reservoir, main courthouse, etc. The main throughfares connected the city center to the city gates, and the principal bazaar was developed mainly between the city center and one of the main city gates in a linier way. The city center with its religious, cultural, administrative and commercial aspects, and its direct connection to the peri urban, had a decisive role in the spatial organization of the city (Figure 4); (Soltanzadeh, 1997).

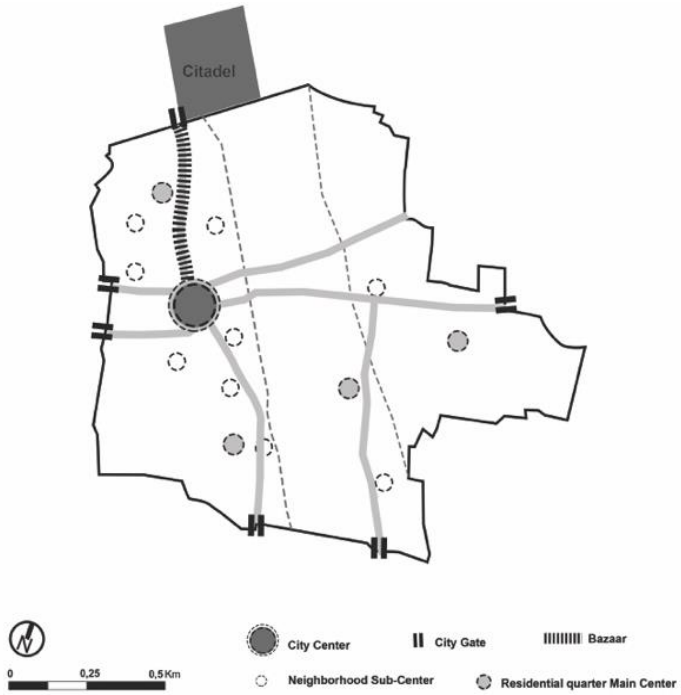

Figure 4: General layout of shâristan represented in the city of Semnân. Source: Author based on Bâgh-e Andisheh, 2009.

Beyond these public zones with direct access to the city gates and rural areas, shâristan consisted also of numbers of enclosed residential quarters (*mahalleh*). Each residential quarter provided dwellings for a population which were gathered together mainly based on ethnic, kinship, religious or profession similarities. The residential quarters were relatively enclosed with a controlled and hierarchical communication, acted as small independent core (Mansouri, 2013; Kiani, 1982). Each quarter had one or more small public centers which incorporated mosque, public bath, small bazaar and other small facilities in the scale of neighborhood to supply daily needs of residents. Unlike main thoroughfares in the public zone, the streets in the residential quarters were mainly irregular, narrow and in their final stage were ended to the dead ended alleys.

The hierarchical relationship between the residential quarters and between each quarter and public zone of the city formed a particular socio-spatial organization in the city. In the shâristan of Semnan this hierarchical relationship between public zones in the city center and bazaar, which linked the city center to the northern gate near the citadel, and main three residential quarters of the city was considerable. Each of these principal residential quarters were divided into sub-neighborhoods. Each sub-neighborhood provided more private zone for a group of families, and acted as a small semi-independent socio-religious colony among the residential quarter. Each sub-neighborhood had its own public center with their own public place (Tekyeh) mosque, hammam and water reservoir. The more equipped public place in each residential quarter was considered as the principal public center of the residential quarter. During the Qajar period, these three residential quarters were divided into 19 sub-neighborhoods (Haghighat, 1991). The Shâristan consisted of one city center, 3 main residential public centers and around 18 sub-neighborhood centers (Bâgh-e Andisheh, 2009). Each neighborhood center linked to the main center of the residential quarter and then connected to the city center and the main urban throughfares via the main road of the quarter. Semnan had 6 gates which were linked to the city center or bazaar through the main throughfares.

With a dense urban fabric and some inner wall orchards, Nâsâr residential quarter was the most popular and important neighborhood of Semnan. This residential quarter consisted of 3 principal neighborhoods (Nâsar, Isfanjân and Choubmasjid) and 16 sub-neighborhoods, each of which had their own mosque and public center. Equipped by main public facilities of the city, the principal public center of Nâsâr residential quarter which was situated at the end of the bazar, acted as the city center for Semnan (Figure 5). Other main and secondary public centers of neighborhoods were located also alongside the main roads of the quarters or main throughfares of the city. In the east, where the Jonbandan residential quarter was divided in two main residential quarters of Latibâr and Shâhjough, urban fabric was less dense and most of the neighborhood's surface was dedicated to the inner wall orchards.

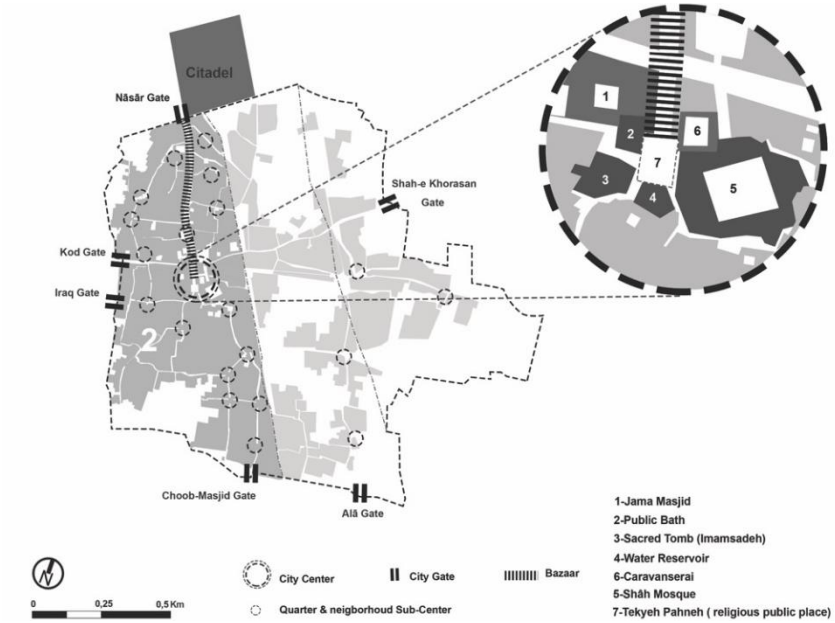

Figure 5: Sharistan (walled city) of Semnan. The urban fabric of Nâsar residential quarter and two other main residential quarters of the city in the middle of 20th century. Source: Author, based on Semnan aerial photo 1956 and Bâgh-e Andisheh, 2009.

SEMNAN: URBAN RURAL LINKAGE AND WATER INFRASTRUCTURE

Reviewing the hierarchical socio spatial organization of Semnan, the paper then focuses the integration between water infrastructure and this particular organization the city in three sequences:

First Sequence: Water infrastructure and territorial organization

Until 1960s, Semnân and its Rabaz were fed only by the low-flow river of Gol-e Roudbâr, with an average flow of 450 L / s (Safinejad, 1980). The river was enriched by several qanats and springs along its way, while seven qanats nourished the villages and their agricultural field in the south of the city by the underground water (Haghighat, 1974). To distribute this water to the city and its rural orchards a water infrastructure was constructed and developed during centuries. Like many other examples in Iran, water of this hydraulic system was divided in many big or small water shares for water owners. Water ownership was inherited and water owners can also sell or rent their water shares (Ahmad Panahi Semnani, 2002).

Even a small amount of water had its own particular destination and ownership, and an accurate governance system was developed and was integrate with natural and socio-cultural flows of Semnan. The hydraulic system was stablished based on storing water for each main residential quarter of the city, and then distributing periodically to the water owners in agriculture lands or residential areas in each residential quarter. According to the historic documents this hydraulic system was established at least since the 10th century with its particular water sharing system adapted to dividing city area into semi-independent residential quarters (Rafei, 1962; Ahmad Panahi Semnani, 2002). Semnan's hydraulic system was composed of following elements which distributed water to all water owners with private or public interests in Sharistan and Rabaz, deeply respected the urban division of Semnan in six neighborhoods (Figure 6).

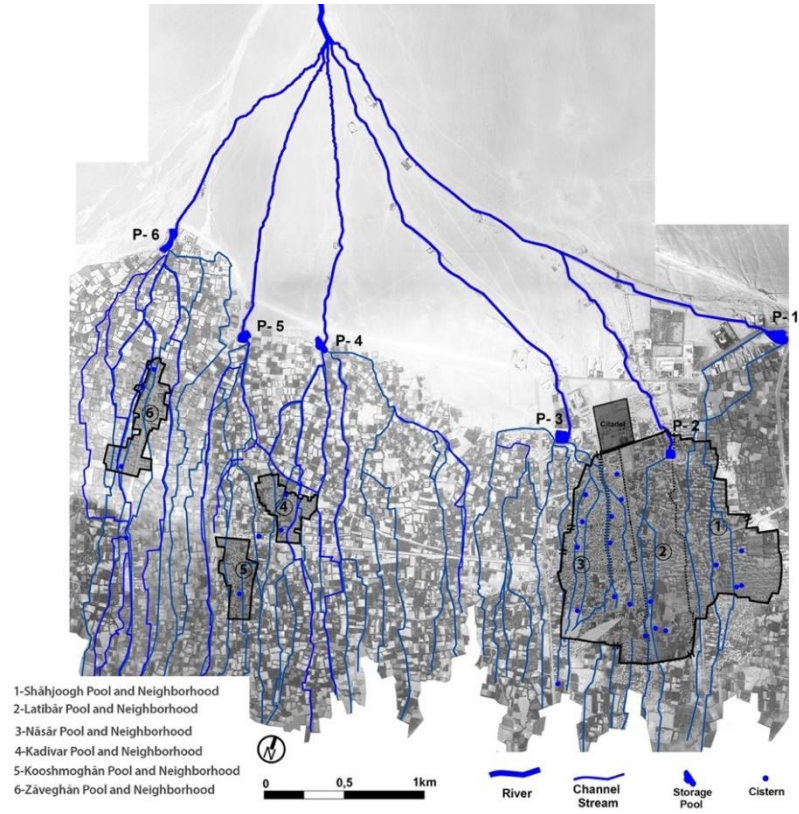

Figure 6: Aerial photo of Semnan, 1956. Traditional hydraulic system, six main residential quarters of the city has been indicated. Source: Author, based on aerial photo of Semnan in 1956 and Bâgh-e Andisheh, 2009.

1. Main water divider (Pârâ); In three kilometers north of the city at a region called "Para", the river arrived to the main water divider with five frames and is divided accurately into five portions (Rafei, 1962);
2. Main distribution channels: Five (and later six) channels transferred water to six main residential quarters (three residential quarters of Shâristan and three detached neighborhoods in Rabaz), each of which named after the neighborhood it was nourishing. Jonbadan quarter in the east of shâristan was lately divided in two separated residential quarters of Latibâr and Shâhjou. Therefor the water channel which transferred water to this neighborhood was also divided in two channels, in a place called «Chihil Qiblah». This place, lately gained a particular respect and was used traditionally for holding congregational prayers in demand for rain (AhmadPanahi Semnani, 2002).
3. Watermills: On their way these five main channels nourished watermills of their assigned neighborhoods. At the end of Qajar period, there 17 mills were installed on the trajectory of six main channels (Safinezhad, 1980);
4. Main storage pools (estâlah or istakhre in Persian); On the northern limit of residential quarters, were located huge pools (Figure 7). These six pools were responsible for storing water to nourish orchards and dwellings of each of six main neighborhoods. Water was stored in these pools during the nights and was distributed to the lands during the days. The pools had irregular form and looked like semi-natural lakes. The volume of each pool was depended on the volume of water needed in each neighborhood. The biggest one was Nâsâr pool (with 8 shares out of a total of 32 shares of water) which nourished the main residential quarter of the city (Nâsâr) and its orchards (Rafei, 1962: 22);
5. Main water streams (Nahr in Persian): series of water streams transferred and distributed water in down streams (for orchards and also dwellings);
6. Secondary water dividers: each main water stream had water divider in its way which divided the water into different portions for different part of neighborhoods and orchards (Figure 8);
7. Secondary water streams (Jouy in Persian): from dividers water flowed in secondary streams. Through these streams water was brough to different parts of each neighborhood. These streams were also divided into more small streams which nourished sub- neighborhoods or groups of orchard parcels.
8. Water reservoirs (cisterns): in residential neighborhoods water was stored in the public of private cisterns to provide dwellings with water during the summers where water was totally dedicated to the irrigation of orchards and fields;
9. Endowed plot: in the south of Nâsâr residential quarter, the hydraulic system irrigated endowed lands which their outcomes were intended to cover the management and maintenance expenses of water and hydraulic system which nourished public facilities of the city in Nâsâr residential quarter.

Figure 7: Examples of Semnan's main storage pools with irregular forms. from top-left to bottom-right: Shâhjouy pool, Zaveghan pool, Nâsâr pool, Koushkmogân pool. Photo by: M. Jamshidian, 2011.

Figure 8: Examples of secondary water dividers in main streams among the orchards. Photos by: left: M.Jamshidian, 2011 & right: S. Lavaf, 2020.

In the territorial scale, water and hydraulic system marked the limits of rural area (Rabaz) as well as the connection between rural orchards and urban areas in residential quarters. The hydraulic system was formed and governed based on the division pattern and the interaction between six main neighborhoods. This division pattern in to six main portions with the centrality of the main residential quarter of Nâsâr was connected with the function and the spatial organization of the hydraulic system. On the other hand, the hydraulic system showed also a deep connection with the natural flows and topography in the region. In the territory scale, Semnan was managed based on bottom-up neighborhood governance system, and hydraulic system played as unifying thread which linked territorial organization to the socio-spatial organization based on which city was divided in six main organizing colonies (residential quarters) and the smaller semi-dependent communities.

Second Sequence: Water Infrastructure and Urban Fabric

Focusing on Nâsâr quarter, we study the integration between the hydraulic system and spatial organization of the city in urban scale. The integration which was not limited to the urban morphology but also very well linked to the socio-spatial organization of the neighborhoods. Nâsar residential quarter was the main urban space of Semnan and consisted of the main urban public facilities including city center and bazaar. From the main storage pool two main streams entered the city in the north. In this scale, hydraulic system pursued the hierarchical structure of the city based on public and private zones.

As we can see in Figure 9, one of these main streams passed through the bazaar, and the other one passed through the other main north-south throughfare. The stream which passed through the bazaar continued its way from north to south and reached the city center. Along its trajectory this main stream nourished the public facilities in this public zone of the city, some sub-streams were also branched off from this main stream to nourish the residential neighborhood in the east of bazaar. The other main stream passed through the throughfares, nourished all the main and secondary quarter centers located along main throughfares and their public facilities including water reservoirs, mosques, public baths, etc. many small streams were also branched off from this main stream on its trajectory to nourished more private parts of neighborhoods. Basically, every neighborhood had large and small public water reservoirs as well as public baths which were usually constructed by the philanthropy efforts in the scale of neighborhoods or the city. The funds for guaranteed water for these public facilities were raised also through the endowed shares or surplus water in the system (Ahmad Panahi Semnani, 2002: 101). The main streams were open air channels, which passed through the main throughfares in the city and in residential neighborhoods, linked the main and secondary public centers. In the main streets these canals were flanked by trees and shaped a particular urban landscape for the city.

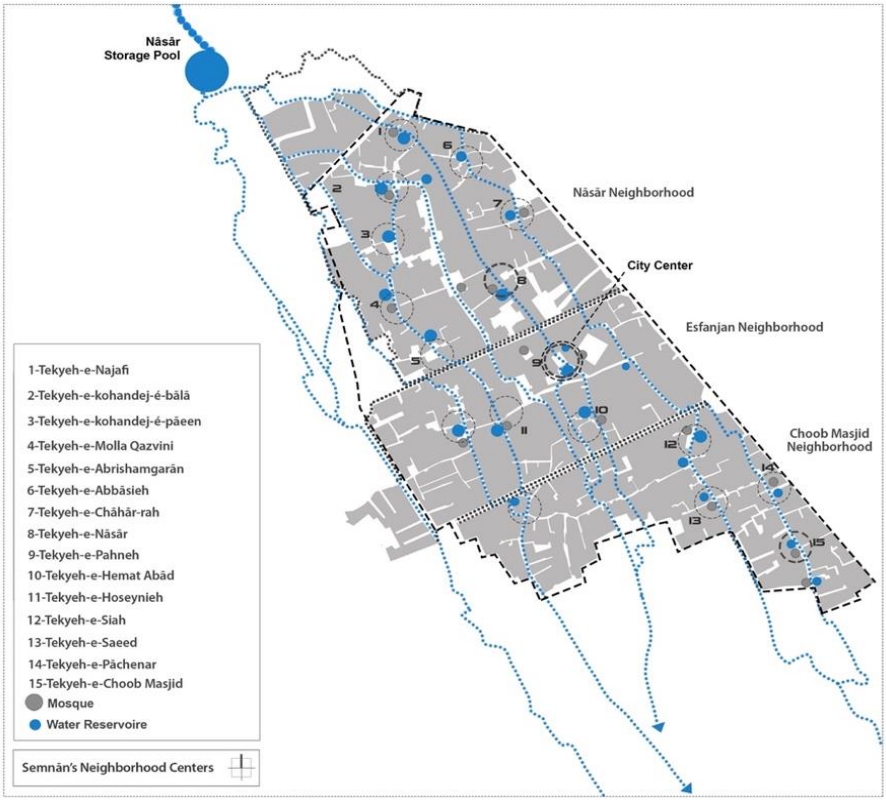

Figure 9: Nâsâr residential quarter: urban morphology and hydraulic system. Source: Author, based on Aerial photo of Semnan in 1956 and Bâgh-e Andisheh, 2009.

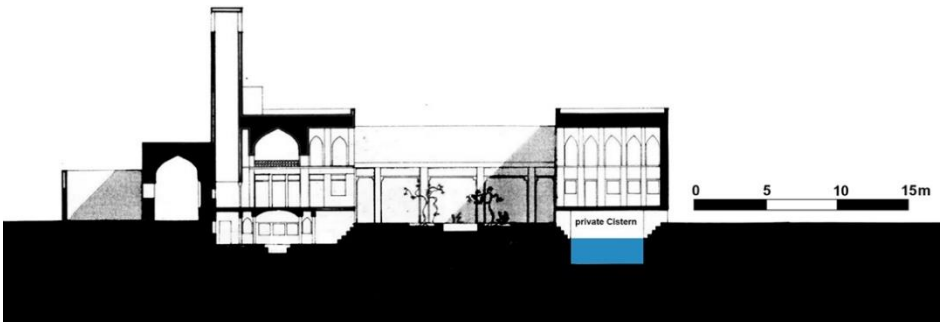

Figure 10: Section of a mansion in Nâsâr neighborhood and its private cistern which was used to supply water for garden and courtyard of the house during the summers. Source: Author based on Tarh-o-Pajouhesh CO., 1974.

In affluent neighborhoods, the system supplied water for private reservoirs which were constructed in the mansions. In many cases, these private reservoirs were also equipped with free public access from the street, and anyone could benefit from their water (Figure. 10).

Water management system followed a bottom-up and participatory governance system based on the collaboration between main residential quarters of the city and sub-neighborhoods in each residential quarter. The management and maintenance of the hydraulic system in each residential quarter was shared between water owners in each neighborhood in residential quarter and then between neighborhoods in each residential quarter. Each main residential quarter was responsible for the water distribution between water owners in its limits from its main water channel and pool outside the city to the water streams and water reservoirs inside the city. By a general agreement between water owners, part of the water was reserved for the use of residential areas and also supplied the public reservoirs. Here the donation system (or waqf) was playing an important role in supplying the city with water. In general, different types of volunteer's endowments or obligatory donation regimes supplied water for the public benefits in Semnan. In these cases, a particular water owner donated part of their own water shares, or a group of water owners in each residential quarters or neighborhoods decided together to donate a part of their water shares periodically. *Ab-e Waqfi*, *Ab-e Khaleseh* and *Ab-e Sahar* were among the most famous endowed water shares which nourished public facilities such as mosques, madrasa, public baths and public cisterns in neighborhoods, bazaar, the city center, public green spaces or administrator facilities in the city (Ahmad Panahi Semnani, 2002: 88-90).

Main water divider and river itself as the common parts of the system shared between all six quarters, and was managed by *water council* which its members were selected by officials of the mains six pools.

Third Sequence: Water Infrastructure and architectural units

The city center, at the end of bazaar, consisted of main public facilities including public square (religious space of Tekyeh Pahneh), Jama masjid, Shâh masjid, sacred tomb, public bath, great water reservoir. *Tekyeh* is a place where Shiite Muslims gather to mourn *muharram*. Such places are particularly found in Iran. They are usually traditionally designed with observable elements of Persian architecture. Particularly, during the Qajar period this public space gained important role in the Iranian cities.

The main stream which passed through bazaar nourished also all these main public facilities gathered together in the city center (Figure 11). Shâh masjid was constructed at the end of 18th century (during Qajar period) (Mokhlesi, 1962) and had its own access and the right to water of the main water stream of Bazaar. This Mosque had a direct access to the Tekyeh Pahneh through a long corridor and also a direct connection to the public place in the north near bazaar via its main entrance.

The water stream entered the courtyard of the mosque underneath the main entrance, passed in between the courtyard in an open-air channel, filled the ablution basin in the

center of the courtyard and then left the mosque and continued its way to nourish neighborhoods in the south. The spatial organization of mosque and its courtyard was adapted with this water flow in the middle of courtyard (Figure 11).

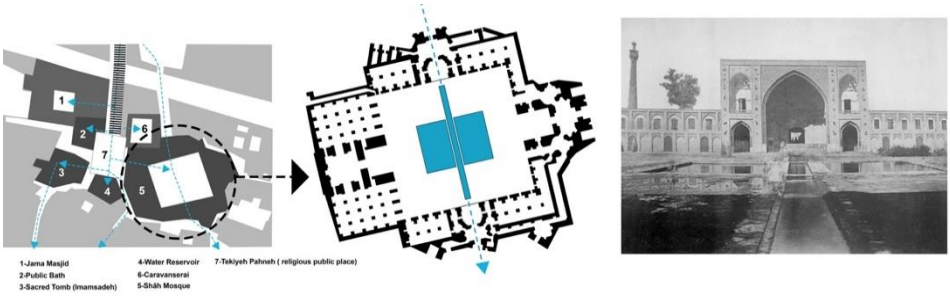

Figure 11: Semnan's city center and the passage of water stream in Shâh Mosque in 1882 in the city center. Source: Plans: Author based on Tarh-o Pajouhesh CO, 1976; Photo right: Hashemi, 2018: 204.

Here we have one of the most symbolic emergences of Semnan's hydraulic system. This symbolic presence of water stream in the middle of the principal mosque of the city was like a cultural statement in the time. It showed socio-cultural position and importance of this infrastructure and in a mutual way gave the high respect to this system while it passed within the courtyard of the mosque. The subjective connection between prayers and people with the hydraulic system was guaranteed.

Semnan, Traditional Hydraulic System in the Modern Era

Like many other Iranian city, urban development of Semnan was limited to its Qajar city wall until the mid-twentieth century, during 60th and 70th modern urban fabrics replaced the inner wall orchards and some small parcels in north of the historic city were constructed. The city's first urban plan, implemented in 1976, and the population increased fivefold since 1970 and reaching more than 185,000 inhabitants in 2015. As we can see the aerial photo of Semnan in 2020, the modern urban areas have developed in the north of the historic shâristan and rabaz. While the development of urban fabric inside the city wall always pursuit the layout of orchards and agricultural parcels which themselves pursuit the capillary network of water streams, the modern urban fabric was developed rapidly in the northern lands in a checkered pattern. So, two distinct zones were shaped, the historic rural and urban area with organic fabrics which perused the traditional water infrastructure, and the modern city which developed in the north following top-down modern urban planning.

In Semnan, from 1963, wells and mechanical pumping became the main water resources of the city, and its agricultural and industrial lands (Armanshahr, 2016). Today, more than half of the water consumed in Semnān is supplied by deep wells and mechanical pumps, and less than 50% by surface water, either from the local river or rivers from more distant

regions. In 1975, 75% of the inhabitants used the modern system for their drinking water, and the rest used traditional water reservoirs (Tarh-o Pajuhesh, 1974). Today, water of traditional hydraulic system mainly nourishes orchards and fields of the historic rabaz and also public green spaces in the historic city. But the interesting thing is that the traditional hydraulic system continues to operate according to its traditional governance system rolled by the private water owners. So, the hydraulic system operates in the historic urban and rural parts of the city in the south of modern urban areas which nourished totally by modern canalizations.

Rapid glimpse on the current situation of this traditional system and its relationship with the modern city, shows also the role of the hydraulic system with its complex governance system on the linkage between modern urban development and historic urban and rural fabric (Figure 12). By focusing more on, we can distinguish also the traces of the traditional hydraulic system in the modern urban fabric.

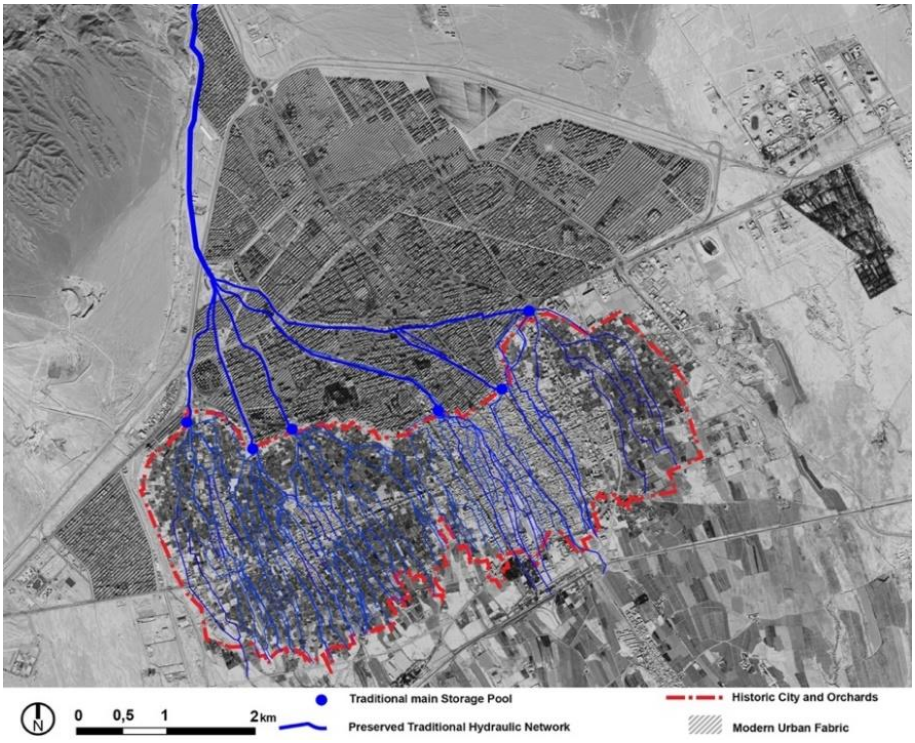

Figure 12: Traditional hydraulic system, historic city and orchard next to the modern city of Semnan in 2020. Source: Author based on the google earth aerial photo of Semnan in 2020.

CONCLUSION

By analyzing historic aerial photos and maps as well as traditional urban organization of the city of Semnan, this article tried to study successively the interconnection between human settlement in Semnân and water infrastructure at territorial, urban, and architectural scale.

The result of the paper showed that the integration between water infrastructure and urban structure in Semnan was not a simple morphological interaction between water infrastructure and the spatial organization. The paper showed the bottom-up governance system which was hierarchically managed by a group of water owners in residential quarters, formed a complex traditional hydraulic system in Semnan. A socio-technical system which organized the territory as well as the urban and a rural fabric. The paper highlighted the adaptation between the water governance system and the hierarchical societal urban governance system of Semnan. This societal urban governance system formed itself the hierarchical socio-spatial organization of the city based on six residential quarters and their sub-neighborhoods which consisted of a series of families. A group of sub-neighborhoods together formed a residential quarter; six main residential quarters of Semnan had the main role in the spatial organization of the city of Semnan and its rural areas. Water infrastructure was formed and governed adapted to this socio-spatial division into six main cores and responded to hierarchical division systems they had. The traditional urban-rural linkage in Semnan was formed by this bottom-up water governance system based on six main residential quarters of the city. Where each residential quarter managed its own branch of hydraulic system which nourished its own urban and rural areas.

In Semnan, water infrastructure acted as urban rural interface, let the urban rural linkage to be integrated with water governance, religious, cultural, economic, social and finally spatial structures of the city. The paper highlights the importance of this multidimensional integration between hydraulic infrastructures and rural-urban settlements. The integration which deeply embedded in various scales from territorial, to urban and architectural scales. The integration between hydraulic infrastructures and socio-cultural organization as well as spatial organization of the settlements and the connection between these socio-spatial aspects in one hand, and the way water and the hydraulic systems were governed in a collective way on the other hand had led to the creation of highly complex hydraulic system. This bottom-up formation of water infrastructure, with its multidimensional integration with social, cultural, economic and familial life of citizens, guaranteed the persistence of water infrastructure in context of centralized top-down governance system arrived with modern urbanization in Semnan.

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