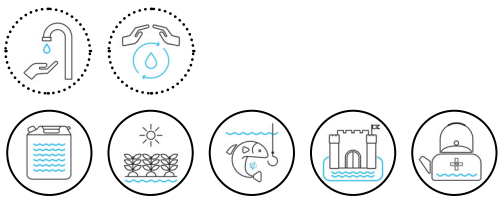
Blue Papers
2022 (Vol. 1 No. 1), 138-149
10.58981/bluepapers.2022.1.14

Collaboration Between Nature and Humans in the Desert: The Qanat System in Iran

Massoud Ghaderian
Delft University of Technology

The qanat system exploits groundwater aquifers in arid and semi-arid regions with the help of local water facilities and infrastructure. The system originated in Iran's central plateau and then spread widely around the world, from the Middle East and Eastern Asia to Europe, North Africa and even South America. This historic water system, which reduces costs and energy consumption, offers a model of how humans can connect to their environment in a completely sustainable way. This system not only satisfies human water needs but does so without depleting natural resources. The relationship between humans and nature is very fragile in desert regions and the qanat system is capable of sustaining settlements even in Iran's hot and dry climate. This historic system enables settlements and agriculture to survive while inspiring a unique desert-specific approach in line with the UNESCO Historic Urban Landscape (HUL) approach. This ecosystem-like approach involves not only the qanat's canals but also associated natural structures and historical components like water reservoirs (Ab-Anbar), water mills (Asiab), water coolers (Yakhchāl), gardens (Bagh) and farms (Mazrae) and floodways (Masil).

KEY THEMES



CLIMATE

Bsk
Tropical and Subtropical Steppe

Introduction

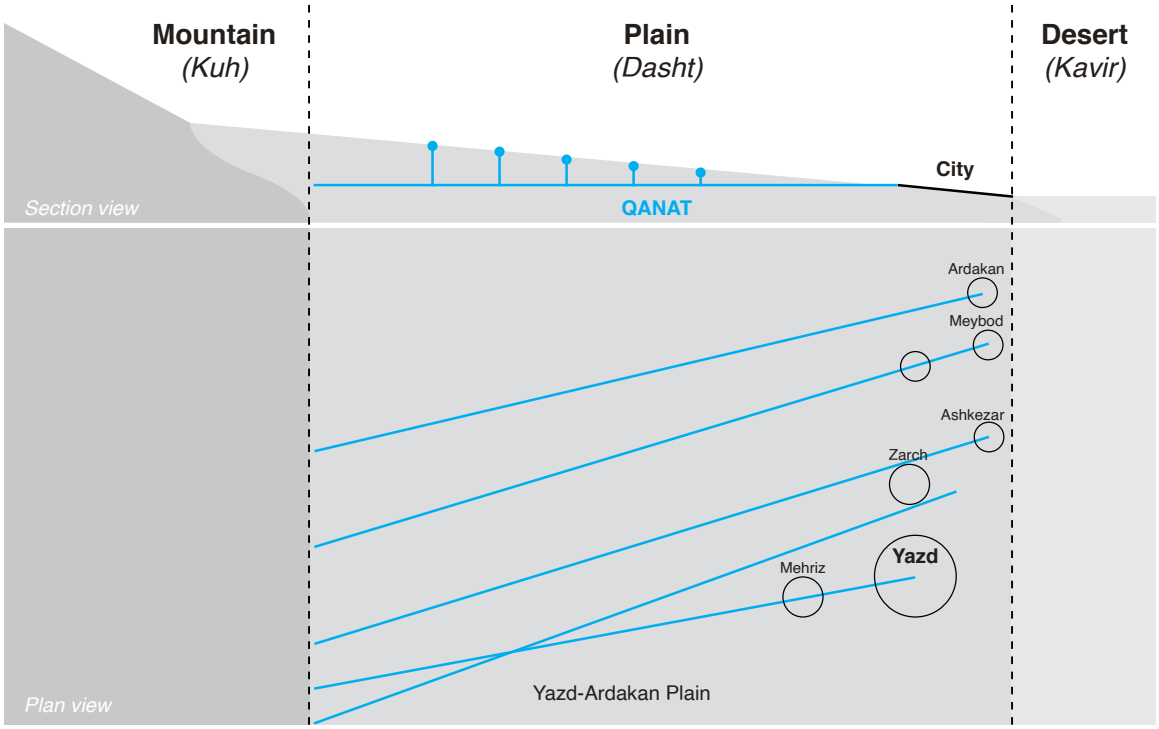
A significant part of central Iran is covered by dry deserts; obtaining adequate water has always been a challenge. Throughout the arid regions located in the margins of the central desert, the agricultural and permanent settlements are supported by the qanat ancient irrigation system (*kariz* in Persian). This system conducts water through underground tunnels to the earth's surface with the aid of gravity from the main well. It allows water to be transported over long distances without losing water to evaporation, and it provides water for drinking, agriculture and other uses at considerable distance from the main well (about two to eighty kilometers; Semsar Yazdi 2019).

The qanat system consists of a series of vertical shafts in sloping ground that are interconnected at the bottom by a tunnel with a flatter gradient than the ground level. The first shaft (mother well) usually sinks into an alluvial fan, to a level below the groundwater table. The shafts are sunk at intervals of 20 to 200 meters in a line between the groundwater recharge zone and the irrigated land. From a bird's eye view, a qanat system looks like a line of anthills leading from the foothills across the desert to the greenery of an irrigated settlement. Qanats are generally used on the edge of the central desert of Iran. The most important qanats in Iran are located in arid regions in the provinces of Yazd, Khorasan, Kerman, Markazi and Fars. Specific characteristics of qanats vary depending on the region, the type of urban and public space and building scale (Semsar Yazdi and Khaneiki 2016).

From an ecological point of view, qanat structures are part of integrated natural and human networks. With the aid of nature, the nearest snow-capped mountains provide permanent water reserves, flood paths move seasonal rainfall and serve as a temporary source of water, and water streams under the shade of trees, helping to prevent evaporation. The water reaches its final destination in urban areas, where it is used for agricultural and horticultural irrigation. Along with human intelligence and technology for water transportation, distribution, storage and management, qanats are linked to tributaries, channels, water outlets, gates and temporary ponds. This interlocking water system is an outstanding example of sustainable collaboration between humans and natural ecology.

The social and cultural significance of qanats cannot be underemphasized. The qanat is considered a communal technology for water extraction in arid and semi-arid parts of Iran. It requires collaboration and sharing, and it is impossible to build a qanat individually: an or-

^ *Fig. 2 Qanat system in Iran (Source: International Center of UNESCO on Qanat and Historic Hydraulic Structures).*



^ *Fig. 3 Ideogram of qanat system in Yazd-Ardakan plain (Source: Massoud Ghaderian).*

ganized group must gather its forces for construction. After construction, regulations are necessary to clarify the manner of using and sharing. All the techniques related to the qanats, from transfer to operation and maintenance, have become social and cultural traditions over time. Also due to the high value of water for desert dwellers, the qanat as a water supply has a high cultural and social position. Rituals and religious meetings are carried out next to the qanat demonstrating the socio-cultural importance of this water infrastructure. One of the best examples of the social and cultural dimensions of this water system is the marriage with the qanat. During the drought, when the qanat's water decreased, the Iranian villagers believed that if a woman (as a symbol of fertility) was married to the qanat, its water discharge would increase. Marriage with the qanat was performed in a special ceremony next to the mother of the well with joy and the giving of food.

As the vital water infrastructure of arid and semi-arid regions, qanats have played an important role in these regions' economies: water is an essential prerequisite for development. The qanat brings groundwater to the surface by gravity, which is economical and does not require the use of energy. Qanats have not only supplied water at minimal cost, but their components have also provided various water services such as transferring, storing, and cooling water in a sustainable manner. For example, an *ab-anbar* is the type of reservoir that has been the most common way to keep water cool in arid regions. A *yakchal* has been used as a refrigerator to store frozen water in winter to con-

sume in summer. In addition to water-related services, the qanat's water has been the driving force for many daily supplementary services, such as applying the waterpower from water mills to grind wheat. The qanat system has not only been effective in reducing costs, but has also played an effective role in creating direct or indirect added value.

Current Approaches to Preserving and Managing Water Heritage

In the list of national heritage in Iran, initially, the qanats and their associated structures were registered separately. With the recognition of the qanat as a historical water supply system and traditional technology, in 2016, eleven Iranian qanats were listed as World Heritage sites. Those qanats are still active water carriers and have retained not only their architectural and technological structures but also their function. They continue to provide the essential resource of water, sustaining Iranian settlements and gardens, and they continue to be maintained and managed through traditional communal management systems. These management systems have remained intact and have been transferred from the distant past thanks to the collaboration of many, including users of the qanats. The government of the Islamic Republic of Iran established the International Center on Qanats and Historic Hydraulic Structures in Yazd, Iran, under the auspices of UNESCO. Since the world's recognition of the qanat, UNESCO has developed rules and regulations to ensure the continued functionality of the qanats and the water catchment areas included in the buffer zone, and they have been committed to protecting their essential function in the provision of water resources. Likewise, the agricultural areas affected by the distribution and use of qanat water resources have been protected through buffer zones to allow the full long-term protection of the qanat system.

In the past, committees consisting of local people were responsible for managing the water obtained by the qanats. This management included the construction and maintenance of the qanat and the distribution of water. The traditional communal management system, which is still in place, allows equitable and sustainable water sharing and distribution. Nowadays, urbanization, government agencies, including the Water Management Organization, are responsible for maintaining the qanats. In recent years, with the introduction of the qanats as cultural heritage, the National Cultural Heritage Organization has carried out activities in matters of protection and tourism related to the qanat. Some qanat researchers have suggested that highlighting qanats as tourist attractions could help justify the conservation of qanats. They believe that tourism and its revenues could help protect the qanat as well as stimulate regional development.

The approaches to preserving qanats vary depending on the organizations associated with their management. Three categories of institutions in Iran are in charge of qanats: water management organizations, cultural heritage organizations, and groups of public and communal owners of qanats. The Water Management Organization of Iran and its provincial branches generally ignore the role of the qanats as a water resource due to the low volume of water discharged by qanats. The Cultural Heritage Organization of Iran pays more attention to the qanat as a tourist attraction. Groups of co-owners focus on the amount of water produced and on managing property related to the qanats. Unfortunately, qanats have no particular role in spatial development planning and little research has been carried out related to Historic Urban Landscape (HUL) approaches.

^ *Fig. 4 Activities of daily living in the desert in tandem with the qanat system. Due to its activities and applications, the qanat system has played a significant role in the social, economic and cultural life of desert city residents. (Source: ICQHS, International Center of UNESCO on Qanat and Historic Hydraulic Structures).*

^ *Fig. 5 Water pumping by digging water wells, Yazd, Iran,1959. In the 1950s, the digging of wells to extract water directly from underground sources by pumps accelerated. At that time, people and officials were pleasure to gain direct access to water, while less than 50 years later, the water levels underground were greatly reduced, which resulted in the lack of water again, the destruction of the qanat system and its components (Source: Vaziri).*

Current and Future Challenges to this Water System

The historical and sustainable water system of qanat has been gradually replaced by the digging deep wells and expanding water pipes over the last fifty years in Iran. The construction of deep wells for pumping groundwater has caused most of the qanats to dry up. Furthermore, it is very difficult to rehabilitate them because the new deep wells have already lowered the natural water level significantly. In addition, with the expansion of the modern water distribution network along with urbanization, qanats have not been considered due to high maintenance costs and low levels of irrigation. A few qanats are being used only for agricultural purposes, while other abandoned qanats are often blocked or drained.

Along with the destruction of the qanat as an ecosystem, the natural and man-made components are also being destroyed. Gardens, agricultural lands and farms are examples of these natural components that had been used to protect against desert and seasonal floods as a green belt. The destruction of the city against recent floods and droughts is an example of the result of the destruction of the qanat and its green components. In the past, seasonal floods have been part of the water system in historical cities for watering gardens and farms which were green belts of cities. Nowadays, with the drying out of historical gardens and farms, seasonal floods are damaging the historic core of cities.

Conclusion and Future Approaches

Qanats are an environmentally friendly method of using groundwater aquifers. They can aid sustainable development in arid and semi-arid areas by utilizing local facilities and infrastructure, lowering costs and reducing energy consumption. They offer a way forward for a country facing environmental and economic crises. If economic, social, cultural and environmental values are aligned, the government, and society in general, will conclude that instead of focusing entirely on transferring water from the seas to cities, qanats can contribute to the water supply and also provide benefits as an ecosystem. The HUL approach will be extremely beneficial to integrating qanats in existing opportunities and future challenges. The UNESCO Recommendation on the HUL proposes a six-step action plan. In line with that plan we can think of the qanat in terms of:

1) Mapping cultural and natural resources

According to the Ministry of Energy and Water of Iran, there are more than 36,000 qanats in Iran. Only in fewer than 20 qanats has their main route has been accurately identified. Although it is difficult to map qanats due to their numbers, depth and complexity, it is impossible to protect them without knowing their location. New technologies can help to map qanats.

2) Consulting stakeholders, including communities, about which values and attributes to protect

All stakeholders, including local people and officials in the sectors related to water management and cultural heritage, should be familiar with the value of qanats and the historical water infrastructure as an ecosystem.

3) Assessing vulnerability

Due to the sensitivity of historical water infrastructures and qanats, annual monitoring is necessary to identify damage. It is also necessary to document maintenance operations along with protective action.

^ *Fig. 6 Destruction of historical fabric due to flooding, Yazd, Iran, 2022 (Source: Majid Jahrahi).*

4) Integrating heritage elements in spatial planning

After identifying the historical water infrastructure and qanats, an active role in urban development plans should be considered for them. This goal requires spatial analysis and spatial statistics at the urban network level.

5) Prioritizing policies and actions for preservation

Although protection policies for qanats have been on the rise in recent years, coordination between them at the national to local levels is still weak. A hierarchy of policies based on regional characteristics of qanats and stakeholders can help prioritize protection policies.

6) Developing partnerships to implement projects

Improving the performance of historic infrastructure and qanats is possible with knowledgeable intervention. Planning and design interventions are possible in the form of projects. To implement projects, it is necessary to develop a network of participants.

With the HUL approach, we could focus on the preservation of historical water infrastructure as water heritage by integrating development with environmental and socio-economic changes. This approach aims to provide sustainable planning and design interventions of water infrastructure within historical environments. In this way, qanats can become an inseparable part of the current urban infrastructure networks.

Acknowledgment
This contribution was peer-reviewed. It was edited by members of the editorial team of the UNESCO Chair Water, Ports and Historic Cities: Carola Hein, Queenie Lin and Matteo D'Agostino.

References

Semsar Yazdi, Ali Asghar, and Majid Labbaf Khaneiki. 2016. *Qanat Knowledge. Construction and Maintenance*. Dordrecht: Springer.

Semsar Yazdi, Ali Asghar, and Majid Labbaf Khaneiki. 2019. *Veins of the Desert. A Review on Qanat*. Aalborg: River Publishers.

International Center of UNESCO on Qanat and Historic Hydraulic Structures (ICQHS). n.d. Homepage. Accessed October 17, 2022. https://icqhs.org/

Massoud Ghaderian has 10 years of experience as an urbanist on the verge of academia and practice including urban design and planning in tandem with research on urban topics and projects within multi-disciplinary teams. He is investigating historic cities and water heritages from a spatial-temporal perspective, with particular reference to green-blue infrastructures.

Contact: massoud.ghaderian@gmail.com