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Rediscovering Community Participation in Persian Qanats: An Actor-Network Framework

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ABSTRACT

Most of Iran's inland areas have permanently lain within arid regions. Today, Iran's groundwater depletion-rate today among the fastest in the world. From the beginning of the agricultural revolution and land-reform in the 1960s, Iran has adopted a governmental highly bureaucratic approach to water management fuelled by technological improvements in high water-dam constructions and modernization of irrigation infrastructure. However, these systems relied on the centralized water management which couldn't solve the issue of the country's increasing water-stresses and therefore it has been challenged by many critiques from civil society and academia.

For centuries, Iran has relied on socio-economic networks to manage groundwater and the traditional method of water-exploitation named qanats which represents an effective system of social corporation and civic participation in water management and in solving the issue of water scarcity in dry regions. This paper introduces a theoretical framework for the necessary transition from the centralized water management towards a multi-actor water-governance regime by adapting the Actor-Network Theory for understanding the traditional patterns of collective water management inside qanat-dependent communities.

KEYWORDS

Qanats; Participatory Water Management; Social Ecosystem; Actor-Network Theory.

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Qanats culture and history

During the last two decades, Iran has been facing extreme drought. Increasingly mounting demands and inappropriate water management are imposing unmaintainable pressures on Iran's water resources. The Iranian environmental activist Kaveh Madani states: "Frequent droughts coupled with over-extraction of surface and groundwater through a large network of hydraulic infrastructure and deep wells have escalated the nation's water situation to a critical level. This is evidenced by drying lakes, qanats, rivers and wetlands, declining groundwater levels, land subsidence, water quality degradation, soil erosion, desertification and more frequent dust storms."[1]

For thousands of years, the Iranians have lived in an arid climate inside the dry Persian plateau, which is not suitable for human life. More than two-thirds of their country is a desert and receives less than 50mm of rainfall a year. Other regions of the world with so little rainfall are barren of attempts at agriculture. So far, Iran has been traditionally a farming country that not only has grown its own food but also managed to produce crops for export, such as cotton, dried fruits, oilseeds and so on.[2] The Iranians have achieved this remarkable accomplishment by developing an ingenious system of qanats for tapping underground water in a way that we would nowadays call sustainable. They traditionally used to live in harmony with their environment, so their techniques to supply water did not end up in the annihilation of groundwater resources.[3]

A qanat or *kariz* is a sloping tunnel which drains the groundwater from an aquifer and leads it to the surface by using gravity flow conditions. It contains a series of vertical shafts in sloping ground, connected underground by various tunnels. These shafts are sunk at intervals of tens up to hundreds of meters in a line amid the groundwater recharge zone and the irrigated land. From the air, a qanat appears as a line of anthills leading from the foothills across the desert to the greenery of an irrigated settlement. **[Fig. 1]**

In his 1979 publication *Les qanats: technique d'acquisition de l'eau*, Henry Goblot describes qanats as the primary factor for the development of civilization inside the Iranian plateau.[4] The development of qanats is not an epiphany of a genius inventor, but a culmination of an evolutionary process resulting from a network of people and institutions. It can be argued that qanats presented a proper way of civic participation inside their societies to solve the problems of water scarcity and empowered the social

1. Kaveh Madani, Amir Aghakouchak and Ali Mirchi, "Iran's Socio-economic Drought: Challenges of a Water-Bankrupt Nation," *Iranian studies* 49, no. 6 (2016): 997–1016.

2. H. E. Wulff, "Qanats of Iran," *Scientific American* 218, no. 4 (1968): 94–105.

3. Ali Asghar Semsar Yazdi and Majid Labbaf Khaneiki, *Qanat Knowledge: Construction and Maintenance* (Dordrecht: Springer, 2017), 9.

4. Henri Goblot, *Les qanats: une technique d'acquisition de l'eau* (Paris: Mouton, 1979).

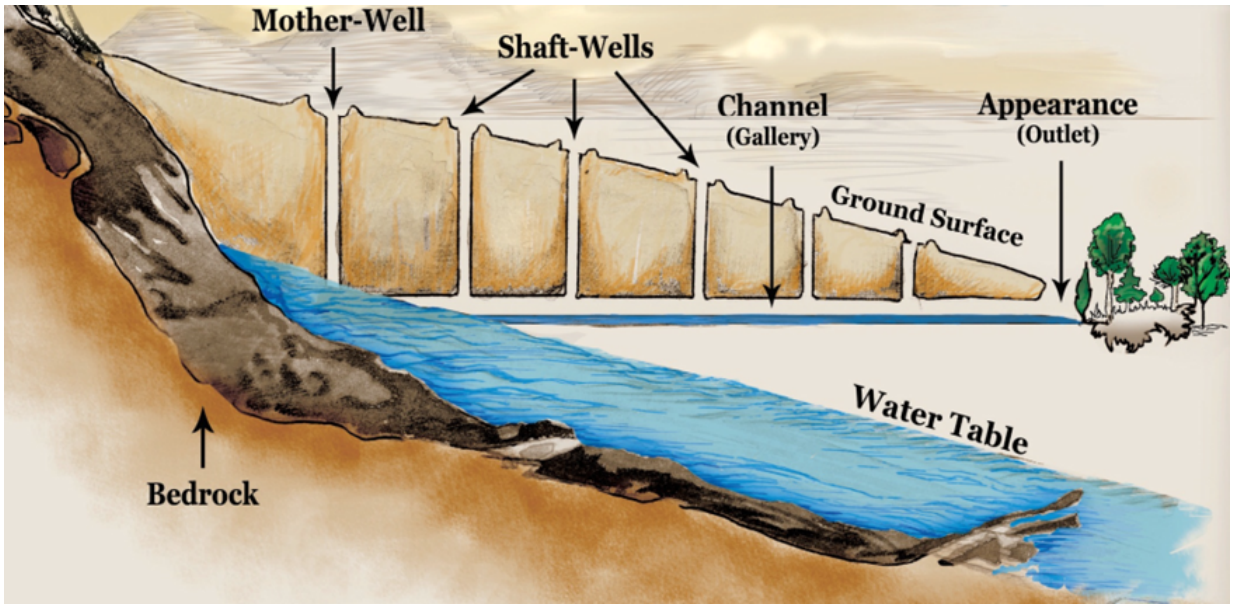

FIG. 1 A qanat profile. Courtesy ICQHS.

coherence rested on peaceful water consumption agreements.

Around the third millennium BC qanat technology was introduced in the central Iranian plateau which revolutionized people's ability to survive and subsist within this arid region.[5] By the first millennium BC, qanats were spread throughout the entire Iranian plateau, from the highlands of Armenia to the lowlands around Kavir, the central desert of Iran. In the Achaemenids era (550–330 BC), the development of qanat technology stimulated the development of thousands of settlements in the entire empire. Fundamentally, qanats reduced the impact of Iran's plain seasonality, allowing for sustainable dwelling in the Iranian plateau, and to utilize the rich alluvial soils.[6] The Greek historian Polybius (200–118 BC) mentions the crucial role of qanats in the existence and development of urbanity in the Iranian plateau and notes the importance of social engagement in their maintenance and functionality: "A true account of these channels has been preserved among the natives to the effect that, during the Persian ascendency, they granted the enjoyment the profits of the land to the inhabitants of some of the waterless districts for five generations, on condition of their bringing, fresh water in; and that, there being many large streams flowing down Mount Taurus, these people at infinite toil and expense construct these underground channels through a long tract, of country, in such a way that the entire society worked together in their construction and use their water and praising the sources from which the channels are originally supplied."[7]

5. Mark Manuel, Dale Lightfoot, Morteza Fattahi. "The sustainability of ancient water control techniques in Iran: an overview." *Water History* 10, no. 1 (2018): 14; Goblot, *Les qanats*, 21; Semsar Yazdi and Labbaf Khaneiki, *Qanat Knowledge*, 4.

6. Manuel et al., *The sustainability of ancient water control*, 15.

7. Polybius, *The Histories of Polybius*, translated by Evelyn S. Shuckburgh (London: Macmillan & Co, 1889), 27.

During the first millennium AD, some powerful administrative institutions were established to protect the water codes and to register and guarantee the access of groups or individuals to qanat water.[^8] A law book from the Sassanid era (224 to 651 AD) mentions the right of every citizen to access water in general, and specifically qanat waters. Their protection from pollution and the need for the public participation in their maintenance are prescribed as public duty.[8]

During the early Islamic era, hundreds of new urban areas were developed as power hubs of Islam around the greater Muslim caliphdom and most of them were supplied by qanat water even if they were established close to rivers. This was due to strategic reasons, namely, because the qanat water was safer and less polluted than river and spring water.[9] In the 13th century, Hamdollah Mostofi, a Persian historian and geographer, describes the city of Tabriz as the capital of farming and agriculture with around 900 ever-flowing qanats. He notes that many of these qanats were built, financed and owned by the local communities or were donated by government or guilds to religious institutions.[10]

During the Safavid era (1501–1736), in order re-establish communications and commerce alongside the ancient Silk Road, hundreds of qanats were constructed for the water supply of the thousands of new caravanserais built along internal and transit roads. Everybody could use their waters but mostly they were maintained and preserved by caravan leaders (*karewan_salar*) and communities and by the few permanent inhabitants of the caravanserais.[11]

During the Qājār period (1789–1925), thousands of new qanats and water reservoirs were constructed. However, many of the peasants were not entitled to own the lands and water they worked on. Therefore, lots of qanats were founded by feudal landlords and rented to individual peasants and their communities through the institute of *boneh*.[12]

In the 1960s, a national agricultural development plan and a land reform program, were presented by the government of the Shah to end feudalism in Iran and allow peasants to obtain the ownership of farms. In this period of technological and governmental modernisation, the traditional patterns of water management changed dramatically. On the one hand, the traditional participatory and community-based water management system

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8. Anahit Perikhanian and Nina G. Garsoian (eds.), *The Book of a Thousand Judgments: a Sasanian Law-Book* (Zurich: Mazda Publishers, 1997).

9. Salma Kadra Jayyusi, Renata Holod, Antillio Petruccioli and André Raymond, *The City in the Islamic World* (Boston: Brill, 2008), 716.

10. Hamdollah Mostofi, *Nezhat ol-Gholoob*, edited by Mohammad Dabir Siaghi (Tehran: Tohoori, 1957), 47.

11. Mohamad Ebrahim Zarei and Zohreh Soltanmoradi, "Barresi-e ertebat-e sobat-e siasi ba modiriat-e ab dar Esfahan-e Safavi [A Survey on the Relevance Between Political Stability and Water Management in the Safavid Isfahan]," Journal of History of Islam and Iran 26, no. 31 (2016), 133.

12. Manuel et al., *The sustainability of ancient water control*, 14.

was replaced by a centralised bureaucratic system of water companies and technocrats working under the patronage of the government.[13] On the other hand, qanats were substituted by the construction of large water dams, irrigation channels and deep wells with electric and fuel-powered pumps.[14]

After the Islamic revolution of 1979, the new administration pushed the so-called *Jihad Sazandeghi* (the Jihad of Construction), to improve the self-reliance of the country. Subsidizing water and energy for the agricultural sector and allowing famers to dig water wells were among the government's plans to encourage agricultural expansion without considering the traditional water resources of the country.[15] Later, the Iranian government tried to change this pattern through some reform with the ratification of the regional Water and Wastewater Companies Law of September 1990.[16] But the efforts in the activation of civil society participation in water resource management and the stimulation of local community engagement in this field have been inadequate.[17] In the 1980–2000 period, more than 14,000 qanats dried out due to falling water tables related to extractions of 500,000 pumped wells around the country.[18]

Traditional Collective Ownership of Water Resources in Qanat Societies and the Actor-Network Theory

> "The Persian qanat system is an exceptional testimony to the tradition of providing water to arid regions to support settlements. The technological and communal achievements of the qanats play a vital role in the formation of this civilizations." (Unesco nomination of the Persian Qanats 2016)

The qanats' social ecosystem can be analyzed from the position and engagement level of various actors and organizations. On the one hand, their existence and functionality are completely related to humans and their creative power in solving environmental problems. On the other hand,

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13. Willem Floor, Agriculture in Qajar Iran (Washington, DC: Mage Publishers, 2003); Kaveh Madani, "Water management in Iran: What is causing the looming crisis." *Journal of Environmental Studies and Sciences* 4, no. 4 (2014): 315–328.

14. John Anthony Allan, "Water in the Environment/Socio-Economic Development Discourse: Sustainability, Changing Management Paradigms and Policy Responses in a Global System," *Water and opposition* 40, no. 2 (2005).

15. S. Mehryar, R. Sliuzas, A. Sharifi and M.F.A.M. van Maarseveen, "The socio-ecological analytical framework of water scarcity in Rafsanjan Township, Iran," *International Journal of Safety and Security Enginnering* 6, no. 4 (2016): 764–776.

16. Reza Ardakanian, et al., "Institutional Capacity Development of Water Resources Management in Iran." In *Capacity Development for Improved Water Management*, edited by Maarten Blokland, et al. (Boca Raton, FL: CRC Press, 2010), 179-199.

17. Ali Mirchi, et al., "Modeling for watershed planning, management, and decision making," in *Watersheds: Management, Restoration, and Environmental Impact*, edited by Jeremy C. Vaughn (Hauppauge, NY: Nova Science Publishers, 2010).

18. Farideh Delavari-Edalat and M. Reza Abdi (eds.), *Adaptive Water Management: Concepts, Principles and Applications for Sustainable Development* (Berlin: Springer, 2017).

qanats have affected the foundation of life for human beings and they affected the structure of the local communities in a positive, sustainable and resilient way. Qanats are environmentally, socially and economically woven into the social structure and communities of their users. Through centuries many complex paths of human-water interaction in arid regions of Iran have been developed based on the existence and functionality of qanats.[19] Moreover, as not many individual farmers could afford the investment in labor and wealth which was required for construction and maintenance of qanats, the development of qanats has been totally dependent on collective actions of various members of local communities.[20]

The Actor-Network Theories (ANT) of Latour, Callon and Law can help us to understand the institutional background and networks and the interaction between leading actors and factors in the past and present which have been established related to the existence and functionality of qanats.[21] Through ANT, social ecosystems may be described as social-ontological phenomena.[22] Moreover, according to ANT, actors can be not only humans, but also non-humans, like flora, fauna, geography or existing infrastructures, etc. In that case, one speaks about actants. According to Latour, these actants have the ability to change their environment, as they have the capacity for agency.[23] An existing mountain, river, road or groundwater resource allows specific spatial development opportunities, as would the availability of technology, money, etc. However, change comes only when these actants interact; or, in other words, whenever they enter a network or association. In these networks, human and non human actants shape themselves by virtue of their relations with one another. Governments, landlords, farmers, water users or residents, (water) planners or (qanat) engineers could be seen as actants. But rather than the players themselves, the decisive factor as the input for development is heterogeneous networking. Like governments, in networked societies everyone has to confront themselves with network assemblages between various actants in order to realize their own objectives.

The process of formation and transformation of the network is called translation. The translation of qanats, as any other actor network, has four stages which are described in the following paragraphs.

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19. Michaela Ibrion et al., "At the Crossroad of Nature and Culture in Iran: The Landscapes of Risk and Resilience of Seismic Space," in *International Proceedings of Economics Development and Research* 71 (2014): 39..

20. Semsar Yazdi and Labbaf Khaneiki, *Qanat Knowledge*.

21. Bruno Latour, *Reassembling the Social: An Introduction to Actor-Network Theory* (Oxford: Oxford University Press, 2005); Michael Callon, "Some elements of a sociology of translation: Domestication of the Scallops and the Fishermen of St Brieuc Bay." The Sociological Review 32, no. 1 (1984): 196-233; John Law and John Hassard. *Actor Network Theory and After*. Oxford: Blackwell Publishing, 1999.

22. Latour, *Reassembling the Social*.; Jonathan Murdoch, "The Spaces of Actor-network Theory," Geoforum 29, no. 4 (1998): 357–374.

23. Latour, *Reassembling the Social*.

Problematization

Problematization is the first moment of translation. It relates to the process of a principal or focal actor striving to become indispensable to the other actors by defining the problem/opportunity and motivating them to enter the network. Therefore, problematization describes the process of alliances, or associations between actants by identifying what they want.

Qanats were built by Iranian farmers and landlords out of communal or pure self interest. Qanats functioned as a primary and essential infrastructure for local liveliness. In every qanat's "agricultural assemblage,"[24] we can focus either on the will of human actors—the assignment and founding the qanat's field operations, the set-up of the hierarchical links between actors and agencies, the management of conflicts, planning, governance, policy making, knowledge and institutionalization—or on topography or hydrology. From this point of view, no distinct actor can be seen as the only responsible for the construction and functionality of qanats. The existence of qanats requires many collective and communal acts. All the elements of the network need to play their part at the appropriate time for the network to remain stable. They also need to cooperate, since the elements depend on each other, regardless of whether they are human or non-human.[25]

Let's start from the digging process and development of qanats. Historically, *moqannis* (qanat diggers), as the masterminds of qanat technology, got commissions for the construction and the extension of qanats from local communities, governors and major landlords. They implemented and guided the digging process and monitored the functionality of the water flow after the construction of the qanats. The engineering skills and hydraulic knowledge and experience of the moqannis have been a crucial part in the development of qanats. After the implementation of qanats project, the moqannis delivered the qanats to their owners and in most of the cases the organization/community of stakeholders and water users.

At the stage of the establishment of the network, other connections between actors occur. A heterogeneous organization is established in the core of qanat's socio economic milieu related to the sustainable transport and consumption of the underground water. For instance, qanats were very expensive projects and their exploitation took long time. Village inhabitants and communities could rarely afford the construction costs of qanat projects. For this reason, a series of investors (landlord or local businessmen, religious institutions) funded the construcion of the qanat. In this way, qanats were based on a kind of collective property, funded

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24. Cyrus Salmanzedeh and Gwyn E. Jones, "Transformations in the agrarian structure in Southwestern Iran," *Journal Of Developing Areas* 15, no. 2 (1981): 200.

25. Law and Hassard, *Actor-network theory*, 1999. Bruno Latour, *Science In Action: How to Follow Scientists and Engineers Through Society* (Cambridge, MA: Harvard University Press, 1987). Callon, "Some elements of a sociology of translation," 196-233.

by the investments of landlords, traders, religious organisation, or voluntary labour from local farmers and inhabitants. However, several qanats were also privately owned. Others, were *vaqf*, contributed to religious institutions for public use, or owned by the royal family and central/regional governments.[26]

In this context, the organization of boneh and the qanat councils can be seen as a social unit wherein some agents (i.e. water users and famers) had rights to use qanat water cooperatively, based on the shared interests of the stakeholders. In particular, boneh (land rentals) was the most notable form of rural co-operation in the field of agricultural economy in Iran. However there were also other types of qanat organizations which were established related to private/financial interests or the political or religious reasons.

In some progressive types of qanat organizations, a qanat council in the community of water users and stakeholders was established to manage all qanat affairs. Usually, they were made up of 5-7 members who were selected by farmers and water users. Every year the qanat owners singled out a few people who were believed by all to be trusted, honest and experienced as council members. In turn, the council should have voted to choose, among the most well-known and influential personalities in the community, the representatives to take care of qanat issues. Their task was to network with other organizations and the government to solve qanat issues.[27]

The power and existence of qanat organizations in various regions was dependent on climate conditions and environmental factors. In areas with favorable natural conditions like the northern provinces of Iran, farmers could enjoy individual types of agri-businesses, and they did not need to engage in qanat organizations. But in areas with harsh climate and in permanent water stress, harvesting dependeded on limited water resources. In these regions, famers had vital interactions with qanat communities, and bonehs were the most common forms adopted to efficiently use water for farming. In each organization many practices and laws concerning the qanat's shareholder's interests and the ways of water distribution, farming and herding have been designed and implemented in accordance with the needs of the rural community and their socio-economic traditions.[28]

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26. Morteza Honari, *Qanats and human ecosystem in Iran, with case studies Ardakan and Khur*, PhD thesis University of Edinburgh, Faculty of science (November 1979).

27. Semsar Yazdi and Labbaf Khaneiki, *Qanat Knowledge*, 13.

28. In order to understand the magnitude and effect of bonehs in the rural economy of Iran, it should be said that, in the 1940's census, at least one million Iranian famers (from the country's total population of 14 million) were participated in this kind of cooperatives. See Morteza Farhadi, "Vareh, ya noei tavanoe kohan va zanane dar Iran va dalael emtedad aan, ['Clause' or a traditional cooperative and of the persistence of old women in Iran]," *Elm-e ejtema'i* 1, no. 2 (1990): 129-162).

FIG. 2 Major stakeholders of the Zarch qanat from 1960, source Semsar Yazdi, The qanats of Zarch, with permission.

Before the agricultural revolution and land reform of the 1960s, these organizations protected the water rights and supervised the distribution of water, and set the rules for the maintenance of qanats inside each qanat community. In most of the rural areas, every farmer could irrigate his land as much as his water share permitted him to do. The water share could range from few hours up to some months, according to the contribution and the share sizes of water users in qanats. Qanat shares were regularly allocated on the basis on the financial capability of their owners. Everyone could buy qanat's water shares even if he or she did not live inside the qanat region and had any land property in the village. However, the share-holding of many qanats were based on more complicated systems, based on a schedule rotating within a certain period. This water division system was consistent with all the likely fluctuation in the volume of water during the year, while quenching the farmers' demand for water.[29]

Most of the shareholders of qanats should have participated in crucial decision-making processes and all the important economic and social matters of their qanāt community.

In a recent study concerning the initial stages of qanat-related social participation, Semsar Yazdi have described the organization of stakeholders and board of one of the few remaining qanat organization inside the historic city of Zarch (Yazd province). The organization and council of this qanat is still the most important decision-making body running this qanat. Every year some 50–60 of the qanat owners congregate and single out

29. Mohammad Hosein Papoli Yazdi and Majid Labbaf Khaneiki, *Qanatha-ye Taft* [The qanats of Taft] (Mashhad: Astan Ghods, 2004).

few people who are believed all to be trusted, honest and experienced as qanat council leaders. Though a share of qanat water is not prerequisite for taking membership of the qanat council, the council members are usually from among the qanat owners who are believed to have stronger motive to take care of qanat issues.[30] [Fig. 2]

These collective and participatory organizations have been taken as the main and principal actors of this socio-ecological assembly network. However, while the qanat's stakeholders and water users were responsible for the existence and functionality of qanats, they needed to work in close cooperation with governmental, judicial and religious institutions as they needed technical, socio-cultural and foremost religious support to achieve their goals.

Interessement

After the network is formed, what terms of commitment are established among actants to protect their own interests? Every actant struggles with the other actants to reinforce their identity through his/her/its system of references, ideas and concepts. How can actants be drawn into problem-solving networks? To answer these questions we need to focus more on the social and institutional aspects of water management and water distribution as crucial socio-economic elements inside qanat's environment. This concerns the participation of water users and investors to develop and maintain the qanats; the ways of civic engagement and social participation in qanat's development and maintenance; traditional water management organizations inside the qanat areas and their interaction with water consumers. While economic issues have been major reasons for construction and maintenance of qanats, we cannot analyze qanat's social-ecosystem only from a financial perspective. The socio-economic environment of qanats is shaped on many lavels by the interaction of networks and institutions mobilizing communities from political, religious and cultural motivations. Within the social and cultural domain of qanats, we cannot find a single motivation as a driver for the existence and functionality of qanats. This is because qanats are more than just economical, technical or even agricultural assemblages. Inside the qanat's social ecosystem the political, religions, technical and socio-cultural institutions have been faithfully linked together. For example, governments had different economic and military interests in development and expanding of qanats compared to religious organizations. The development of qanats could increase governmental revenues and enable the self-sufficiency of urban-rural communities to resist in the case of sieges and military blockades. Water is also a vital resource in Islam, to which everyone has the right to a fair share. This is emphasized in prophet Mohammad's *hadith* (word)

30. Ali Asghar Semsar Yazdi, *Qanat of Zarch* (Yazd: ICQHS, 2014).

that defines water clearly as communal resource to which all, rich or poor, have a right.[31] Therefore, many Islamic institutions founded qanat's development or bought several shares of qanats duty to make qanat water freely available to the Muslim community. Also, many qanats of Iran were *vaqfs*, which means a usufruct or a collective property for religious purposes and public utility.[32] Therefore, many religious institutions, clerics and, in many cases, the qāḍīs (magistrate or judge of a Shari'a court) have directly or through their representatives participated in the establishment and implementation of qanat's regulations and water codes.

Enrolment

Enrolment refers to how these common interests can be translated and concerted into potential associations or assemblages. What are the specific role that actants can assume within these potential alliances?

Each qanat organization includes some key roles. A *Sar boneh or Sar āb ŷar* (chief water manager) and their assistants (yavr boneh or āb ŷar) were in charge of the qanat management. The *Mirābs* were in charge of the water distribution. As we have already seen, the moqannis were in charge of the construction and maintenance of qanat structures. Farmers were the main water users.[33] The position of the sar *boneh* or the chairman depended on his work experience or his financial privileges but was also sometimes determined by kinship and even by the geographical origin of the person.[34] Because of the complexity of bookkeeping of the interests of different individuals in quant water, abyars and mirabs should work permanently during the whole year, and their salaries were determined by the shareholders of the qanat at the end of the crop year or in Nowruz.[35] In bigger qanats, inhabitants and water users chose also some local dwellers to assist the chief mirab which had kind of autonomy for controlling his administration. In most regions of Iran, bonehs were established more on less because of the same reasons, but with different organisational structures. In the case of the Zarch qanat in the Yazd province, qanat organization is shaped as follows:

1. qanat council or the board of stakeholders;
2. *Mirab* (chief water distributor);
3. *Dashtiban* (Land watcher);
4. *Sartaq* (qanat administrator);

31. "Muslims have common share in three things: grass (pasture), water and fire," Prophet Muhammad, cited in Naser I. Faruqui, Asit K. Biswas and Murad J. Bino (eds.), *Water management in Islam* (Tokyo, New York and Paris: United Nation's University Press, 2001).

32. Faruqui et al. 2001.

33. Mostafa Azkia and Valiollah Rostam Alizadeh, "Janbe haie ejtemaei taghsim ab dar Iran [Social Aspects of Irrigation Systems in Iran]," *Ensaan Shenasi* 12, no. 21 (2015): 11-43.

34. Farhadi, "Vareh".

35. Honari, *Qanats and human ecosystem*.

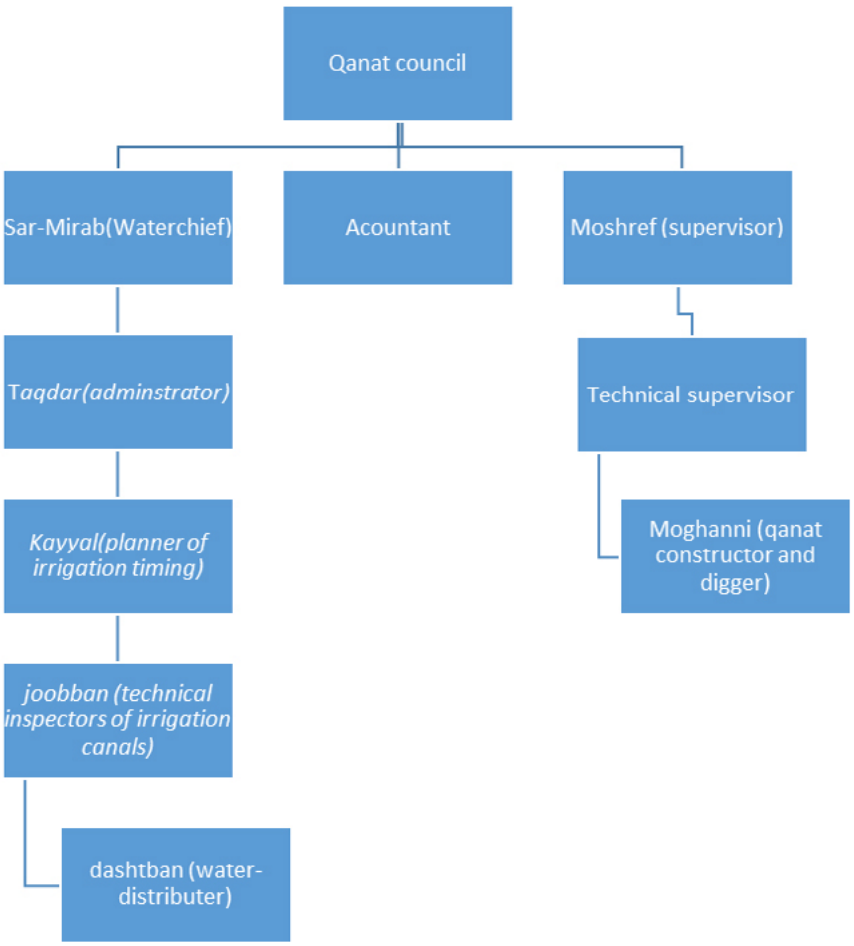

FIG. 3 Management organization of the Zarch Qanat, based on Semsar Yazdi, The qanats of Zarch, with permission

5. *Aab yaar* (watering assistant);
6. *Zaree* (farmers);
7. *Moqanni* (qanat engineer).[36]

For the organization of small qanats, the qanat council has been the most important decision-making body running the qanat. The qanat council had some representatives who were in charge of many issues and in fact they were the executive board for the council. In addition to the council members and representatives, there were also members like *Moshref, Mirab* and *Sabookesh,* who were usually in charge of the irrigation tasks, but they also played important roles in qanat's administration and management. Also, in some qanats an accountant has been added to this organization to take care of financial affairs and to oversee the qanat budget.[37] [Fig. 3] But in the Khorasan region, except for qanat owners (stakeholders) and mirab, in many cases moqanni and a local cleric also participated in qanat council.[38] In case of emergency and for major maintenance tasks, hundreds of men from various villages and cities inside the region voluntar-

36. Azkia and Rostamali Zadeh, Janbe haie ejtemaei".

37. Ali Asghar Semsar Yazdi and Majid Labbaf Khaneiki. *Veins of desert* (Yazd: IWRMO/ICQHS, 2010).

38. Honari, *Qanats and human ecosystem*.

ily assisted the mirabs and qanat constructors. Each qanat organization had complex multilevel links with many networks and institutions inside and outside the settlements including landlords, local governments, clerics and qadis or notarial institutions.[39] This sort of network, with all its complexity and affinity, supported the existence and functionality of qanats. This assemblage, because of its multiplicity in systematizing and supervising the society upon which it is based, presents a remarkable network of actants and institutions. The power of this network lays on its ability for organizing a water management network based on the social participation and rational consumption of water and land resources. The water consumers made sure that the available water resources were consumed carefully and justly. Then, all the actants communally brought their requirements and demands up to the level of the nature's limited boundaries. The evaluation and transformation of the network happened throughout the ages on the basis of various principles, but more or less based on "caring and sharing".[40]

During this enrolment process, qanat councils inside the qanat's socio-economic environment became as such the spokesmen of many social institutions like farmers, neighborhoods, villagers, etc. They were developed in concordance to the overall evolution of the qanat network. In fact, these organizations justified their legitimacy by the agricultural-hydraulic links between the landlords, farmers and inhabitants in one hand and with the judicial-religious institutions on the other hand. Therefore, a complex institutional structure covered the qanat's water distribution based on the water and land ownership, irrigation rights, time sharing etc. This institutional structure was adapted into the socioeconomic status of the local communities, geographical, hydrological and physical things (i.e. expected fluctuations in the volume of water over the seasons) and constituted an accurate way of planning, water management and judgement based on interaction between various institutions. Consequently, within the established institutional structure of local communities a complex network of actors and agencies (same as peasants, landowners and their representatives, for instance *Miraabs, moqannis,* stakeholders and farmers) with various interests and motivations in exploitation and functionality of qanats have raised. The multilevel interaction between qanat and humans has constituted the traditional socio-economic patterns and technical structure of the qanat social ecosystem.

A specific culture based on an ethical duty to water resources has been established in the qanat-based societies which safeguarded water and regarded it as something more than a simple product. The participation of water users in the maintenance and administration of qanats was

39. Ibid.

40. Masoud Yazdanpanah et al, "Iran's traditional water management system as a governance paradigm and learning system," *International Conference on Traditional Knowledge for Water Resources Management*, Yazd, 12 February 2012.

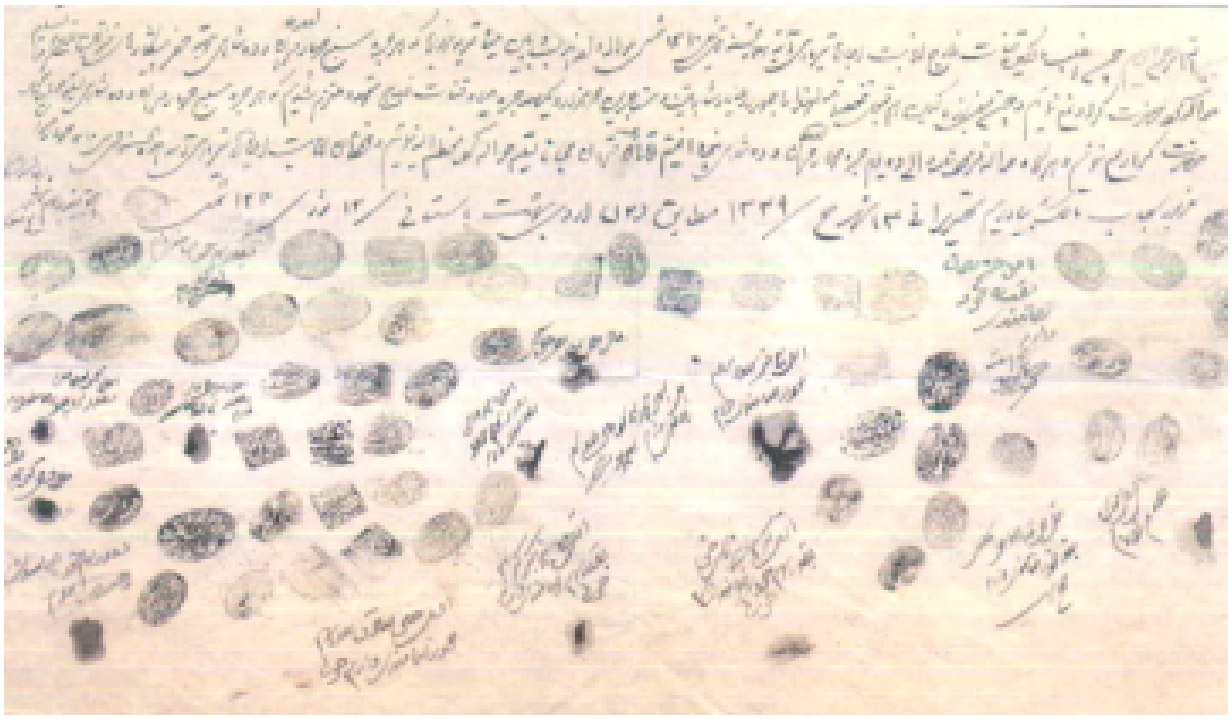

FIG. 4 A document which shows the accordance of the shareholders of Zarch's qanat for general maintenance activities of Zarch's qanat in 1924. Source ICQHS with permission

done often voluntary but in the case of emergency: it was the duty of each healthy male water user to work for their qanats.[41] Every user should have protected the qanat and its domain (*harim*) from pollution and any source of poisoning.[42] Harim is usually constituted by a boundary of about 1.2 km in proximity of shafts in the hard soil areas and about 0.5 km in soft soil. The right/duty of domain protection gave the qanat's water users the possibility to reach the surrounding areas around the shafts in case of any required maintenance and shelter the qanats from any activities alongside the wells that could affect the purity of the waters or the functionality of qanats. [Fig. 4]

Many Islamic law books prescribe that a new qanat cannot be dug if it damages a qanat nearby, although the distance between the qanats is more than the determined harim.[43] Because of this culture, the interaction, collaboration and participation of water users in construction of qanats was based on a kind of communal duty and responsibility toward others.

Mobilization of allies

Mobilization deals with the representatives of the people and things, and the institutional links by which the actants form a resilient relationship.

41. Semsar Yazdi and Labbaf Khaneiki, *Veins of desert*.

42. Seyyed Hossein Hosseini and Zoheir Jahandideh, "Chalesh ha ie hemaiat keifari az ghanavat [Criminal support challenges of Qanats (Case Study Gonabad Ghasabe Qanat)]," *Motalate hoghoghi energy* 2, no. 2. (2016): 289.

43. Abu Hesab Karaji, *Estekhraj e ab haie penhani [Extraction of Hidden water]*, edited by H. Saedloo (Mashhad: 1998), 42-45.

Over centuries, thousands of qanat communities or networks of stakeholders and water users were established in qanat regions based on a collective network structure. Within these communities many frameworks and guidelines for the development and functionality of qanats, together with legislation of water codes and property rights. were defined and agreed upon by the majority of the engaged actors and agencies. For instance, agricultural activities should adapt to a sustainable land use with the careful consumption of the available qanat water. Each network, however, was not self-sufficient, and it was linked into a broader network of the landowners, other qanat communities within the region, the representatives of government and tax organizations, together with qanat experts (qanat engineers and diggers) as well as the clerics or the representatives of religious organizations. Salmanzedeh and Jones described the qanat-based communities as "agrarian structures," which are evaluated over thousands of years by a multilevel set of interrelated human and non-human actors and institutions, that replicated persistently across the dried Iranian plateau.[44] This "agricultural assemblage" effected the productive land use and raised the viability of the social investment.

This participatory water management culture has strongly affected the socio-economic structure of qanat regions throughout their history. Several factors were key to the acceptability of this mobilization:

- The involvement of concerned and influential agricultural/business/religious institutions with a commitment to shared goals and a clear focus on the community's primary demand for water supplies.
- The formation of appropriate multi-functional technical; judicial and social organizations for qanats.
- The development of decision making mechanisms through the setting up of water codes and regulations to facilitate involvement and participation of the stakeholders.
- The support and legitimization from local and intra-regional agencies, and from organizations with sufficient resources devoted to build the alliances.
- The economic power which rested upon agricultural activities and land-watering relations.
- The technological and regulatory rules, which helped qanat organizations to establish direct links between various water users within their domain.
- The water-related spatial planning which in qanat's actor-networks was established based on the collectivity and hydraulic diversity, rather than religious and political power hegemony.

Through the lenses of the Actor-Network Theory, the qanat network has

44. Salmanzedeh and Jones, "Transformations in the agrarian structure".

been described and translated to clarify the phenomenon of the qanat's participatory culture within this network environment. Studying and following the actor-networks, we have looked at how, throughout history, the institutional stages of actor-networks have facilitated the participation of farmers, business and civic organizations in water management in the development of qanats.

Toward a resilient collective water management

The hydraulic bureaucracy of our time lacks the essential public participation in water planning and management. As part of the efforts towards promoting sustainable water management, it is required to empower civic society and representatives/agencies of the local communities to partially overtake their traditional roles in water management. This does not mean returning to the pre-modern agricultural patterns but to tackle the problems concerning civic participation in water management and to show ways to ease the establishment of non-governmental institutions inside water governance structures as a drive for sustainable society.

For sure, more socio-historical analysis is needed to assist non-governmental actors in forcing governmental water companies to recognize the operative position of qanat organizations in water-management and decision-making networks. The successful governance of underground water depends on the interaction of law, policy, actors and institutions. Relying either on a local actor-based or upon a centralist organizational/

FIG. 5 Preservation and maintenance of one of Tehran's qanats during 1915-1918 period by local citizens. National Library and archive of I.R.I

institutional perspective may fail to provide sufficient underground water management. In this regard, Actor-Network Theory can partly demonstrate some paths of negotiation between governmental and non-governmental (community-based) allies and sustain water distribution and management structures in Iran. Similarly, the professional development of regional water companies and planners is needed to effectively support and facilitate local communities' involvement in water management and distribution. [Fig. 5]

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