

Qanat and Settlement in Iran

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Abstract

This article considers the traditional water network derived from qanat and its effect on the development of the city of Meibod in arid zone of Iran. The elements such as traditional water network (qanat), Abbanbar (Water Reservoir) Payab, yakhchal (Icehouse), Hozkhaneh (Cellar), had a fundametal effect(in developing houses, localities and urban settlements.

The Qanat of Meibod had its own rules and regulations. All naming of farms and agricultural lands have remained after the conversions to settling lands and the localities in the forms of new alleys and new localities. Infact, the texture, morphology, road construction and housing of Meibod City had been derived from the traditional water network and qanat.

Introduction

An analysis of the background of the civilization, which took their shape and flourished during the course of history, explicitly indicates the fact that accessibility of sufficient amount of water plays a vital role in the shaping, origin, consolidation and perpetuation of the civilization. The impact of water on the expansion of settlements has always been a subject of history. As a matter of fact, without water and its hammering, the dry land of Iran could not afford to be the center of one of the oldest human civilizations of the world. One of the methods, widely practiced for the exploitation of underground waters which gradually advanced, has been the qanat (subterranean water canal), which has been put on par with the water supplying bridges

of the Romans and ancient Greece. During the course of history, in addition to agricultural use, this technique has played a basic role in finding a place for settlement, dispersion of the settlements and their subsequent expansion. The present paper, while making an analysis of qanat phenomenon from the point of view of historical process, traces the reason for its nomenclature, structure, establishment links, (orientation and the dispersion of the settlements and qanats in Iran).

The province of Yazd is situated at the heart of Iran's desert. The main source of people's life and living in this area had been qanat. It seems that traditional water nets are derived from qanat which had become the source of development and had a great effect on the morphology of Meibod City.

The aim of this article is first, to consider the water phenomenon and qanat and its effect on the location of cities in Iran. In this regard, elements such as water reservoir (Abbanbar), Payab, yakhchal (Icehouse) which had a great effect on the emergence of Meibod City is the matter of concern. Secondly, the utilization system, laws and regulation in the consideration of qanat, and its effect on the traditional water net work of qanat with respect to the development and morphology of Meibod city is aimed at.

The method of research is descriptive and is carried out with interviews and observations in these two important cities.

Qanat in the Historical Process

The oldest qanat in the history of ancient Iran has been attributed to "Orarto" tribes living in the present-day (Uhlu) town in the north of Urmiyeh Lake. Later on, this tribe taught the art of architecture, iron casting and the qanat technique to the Medians and Parthians who introduced this technique across the Iranian plateau (Goblot, 1992). During the Sassanid Era (224 A.D), the technique of qanat construction not only expanded in the Iranian empire, but was also taken as far as China and Transoxiana. Divan-e Qanat or the special administration for qanats, was created in Iran for the management, control and sketching of this network (Wahidy, 1963). In the wake of the Arab aggression of Iran, a part of this network was destroyed, but during the Deylamites and Samanides eras certain advancements were made in the field of irrigation, which, regrettably were severely destroyed during the Mongol invasion. Only

during the Safavid era attention was paid again to the qanat technique in Iran (Farwarden, 1972). In the 12th and 17th centuries "Marco Polo" and "Towerni" have mentioned about several qanats in Kerman, in the desert areas and in Khorasan (Goblot, 1992). Infact, qanat appears at the beginning of the first millenium B.C. in Iran and expanded rapidly and then spread to east and west and resulted in the creation and expansion of Ekbatan, Pasargard, Persepolis and Rags (Reyy) cities and even brought its impact on the form of political regimes. This system was transferred to Egypt in 500 B.C., to Spain in 750 A.D., to Los Angeles region in 1520 A.D., to "Pe Ka" region of Chile in 1540 A.D., and to lyre Eastern China (Torfan) in 1780 A.D (Zolfeghary, 1999). During Qajar era(1786-1910), qanat and its traditional irrigation system faced a recession, but during the post constitutional period, once again, great attention was paid to qanat building.

Until 1960s. 80% of all activities of the people in the central region relied on qanat (khirollah. 1997, 1968). Regardless of who constructed the qanat, whether a kind governor, landlord, chieftain, or a be efactor, its main purposes had been the creation of habitation, expansion of agriculture and economic development. In 1966, the total number of qanats in Iran was estimated to be 40000 with 600000liters output per second (Kardawani, 1988). But P.W. English has mentioned the total number as 37500 (English, 1966). The Iranian Statistical Center has mentioned the total number of qanats as 30759 in 1996 with a total output of 9581 million cu.m. The calculations carried out so far show the average length of each qanat in Iran as 4360 meters and

the total length of the entire digging carried out so far, as 3108001 k.m. or 8 percent of the distance between earth and moon and 7.8 times of the length of equator (Ghaiour 1991). Around 90 percent of qanats existing in the world are placed within the cultural atmosphere of Iran (Goblto, 1992).

The Reason Behind The Nomenclature Of Qanat

“Ahniad Hami” holds that qanat is a Persian term, and says that “kanat” is composed of two parts: kanch,” i.e., digging the kan of which has been deleted with the passage of time, and at (a Plural sign). On the contrary, “Mo”ne” Dictionary considers qanat to be an Arabic term and qanavat being its plural. “Kashef mentions that qanat in Arabic means a combined word “koh riz” (koh+riz) and means the water which flows out of the mountains, which later on became Kariz, Kahriz, Kaahriz and Kakooriz (Zolfeghary, 1999). Still other researchers believe that the term qanat means an aqueduct and is derived from the Akadi word of kano, which means “reed” and changed in Arabic and became canal and is pronounced as “kanaya” which has been changed into “qanat” in Arabic (Saidsajadi, 1982). In European languages such as Latin and Greek, the term caana and cana means reed and canal means water carrier and pipe. In the Italian language, this term has come in the form of “candah”. In the eastern parts of Iran, Afghanistan, Central Asia and Transoxiana the term kariz is in use and even a number of villages in these areas have been named in combination of this term with other terms. In the littorals of the Persian Gulf, the word qanat is current. But in Oman and Yemen the words “afraj” and

“filaj” in North Africa “fagar”, in Morocco “khatara” and “retara”, in Tunis “harija” and in Central and South America “galiria filranta” and in the Alps the qanat is known as “karirani”.

The Conditions Suitable for the Creation and Construction of Qanat

The natural and suitable conditions for the construction of a qanat are related to the climatic, hydro geologic and topographic conditions. A qanat is usually dug out of the reservoirs of surface waters, are temporary and perennial underground waters, are with the land slope of up to 0.5 per thousand and with the cultivable area or where the traces of water can be found such as brook, seepage, vegetation (with tall summer herbs) (Noel, 1944). A preliminary construction of a qanat has been the identification of the existence of underground waters at the foot of a conic projection. Afterwards, through the digging of wells called “gomaneh” (Appraisal), an evaluation of the water is carried out. If the expectations for water are approved then the digging is continued and as a result the construction of a qanat is completed. A qanat consists of a mouth (open), (fig. 1) tunnel-like channel from the mouth of the mother well is constructed, which connects several wells equal to 60 X 120 cm. (kheirollahi, 1997). The distance between the two wells ranges from 15 to 20 meters (and in exceptional cases reaches up to 200 meters). The manner in which the qanat are distributed is related to the geographical and topographical conditions of different areas and takes place mainly in three ways, namely: successive, parallel and convergent.

Water and Location Cities

In the past, location and development of Iranian cities has been dependent to water following the special characteristics of time and place. In spite of the importance of security, defense, political, road and access on the Iranian plateau during the course of history, the need to build city near water resources showed up very early and the plain and mountain-side cities were formed (Kheirollahi, 1997). Undoubtedly, along with the advancement and development of irrigated agriculture and finally the qanat technique, the spatial expansion of cities and their population increase, the role of water became more important (Nazarian, 1995, p.200). Due to its climatic diversity and the perspective of natural environment, the Iranian Plateau does not enjoy flowing water resources everywhere. Therefore, in many of Iranian cities, the water needed by the people used to be provided from underground water resources such as fountains and qanats. At present in Iran, the total water utilized is provided from qanats (13%), fountains (26%), semi-deep

wells (18.4%) and deep wells (42.6%) (Ministry of Energy, 2003).

In the past, access to water resources in the Iranian cities was practiced through one of the following three ways:

1. Flowing and river waters
2. Traditional water supply network made of qanats
3. Reserved waters including water reservoirs (Abbanbar)

The river waters have played an important role in creation and development of major cities of Isfahan, Ahvaz, Tabriz and so on.

Before the introduction of urban water piping in Iran (1966), from the total of 249 cities, 152 cities (61%) were situated beside the rivers. 22 cities (8.9%) were situated beside the sea and 75 cities (30%) were situated far from the sea and river, inside the Iranian Plateau which were watered only by the traditional water supply network of qanats. In this relation, from the entire 9.7 million urban population of Iran, 4.7 million

Table 1 : Water and Spatial Distribution of City and the Population of Traditional Cities of Iran before Urban Water Piping (1966)

Location Selected for Cities	Number of Cities	Percentage	Urban Population	Percentage
Cities situated by the river	152	61	4339047	44.6
Cities situated by the sea	22	8.9	654554	6.8
Cities situated by the mazhar (mouth) of ganats	75	30.1	4721011	48.6
Total	249	100	9714612	100

Source: Farid, Yadollah, (1970), *Research Method of Iranian Cities*, Tabriz University press, Tabriz.

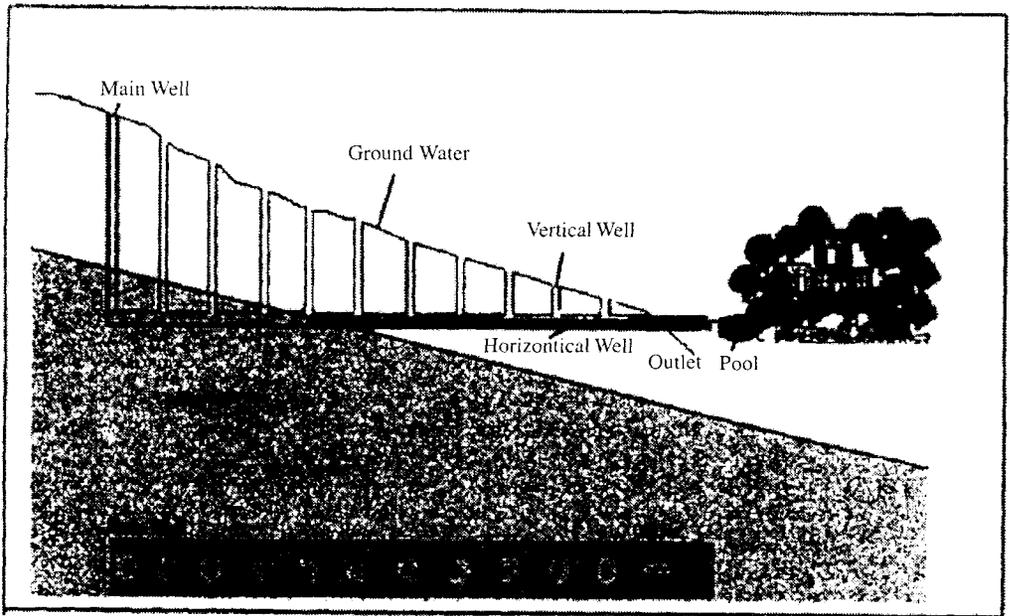


Fig. 1 Farm, Village or City

people (48.6%) survived on the traditional water supply network (qanats) (Table 1).

In the internal plateau cities where the qanats played the most essential role in the formation and physical expansion and also in forming the morphology of the cities, the residences are mostly compressed around the water reservoirs in the neighborhoods and alleys. In the desert cities, water reservoirs (Abanbar) have usually functioned as the main factor in forming the urban neighborhoods. In Meibod City, water reservoirs (Abanbar) along with mosques or shrines of Imamzadehs (the offsprings of Imams), public bath, bazaar and Main Square enliven the city center complex. The role of water in morphology of cities and formation of the urban neighborhoods has been very effective. Buildings, alleys, passageways mainly follow the water current and are formed along the water

canals and water supply systems. In Iran, the social configuration is also based on the manner of use and amount of use of these waters (Nazarian, 1995). In other words, water has been very influential in dispersion and spatial distribution of Iranian cities (Kheirollahi, 1997). Water caused population increase of cities and employed superior technical skills that in turn encouraged the development of urban industries and agriculture around the city. Around 80 percent of the territory of Iran is affected by arid climatic conditions. Qanats have been the most essential water supply source in the Iranian deserts. At present, in the desert province of Yazd, the total waters obtained from qanats are 28 percent and the number of qanats is 2943 canals (Yazd Regional Water Organization, 2003) and there is no permanent river.

The Iranian desert cities and villages survived on the water obtained from qanats until the introduction of modern technology (1966) and even today, qanats play an essential role in the life of people. The natural conditions in this area has caused the villages and cities of the qanat civilization to appear as oasis. These cities are placed far from one another but are distinguished from other parts of Iran in view of architecture, urban planning and economic considerations. All post-Islamic governments in Iran are rooted in nomadic tribes and groups (Habibi, 1996). None of the war seeking governments in Iran (except local and regional governments) originated from desert and qanat regions. Feudalism was also a phenomenon specific to areas with high precipitation or with river sources.

The reason for this is the poor financial and population resources and the dispersion of habitats and low precipitation. In the Qanat civilization there are no elegant and magnificent palaces such as the palaces of Susa, the Persepolis, Kangavar and Cheghazanbil. However, the traditional architects have created small but valuable works in this region. In this region, practical sciences related to digging, maintenance and repair of qanat utilization system, seeking justice, conservatism and peace loving have reached perfection. The coexistence of religious minorities such as Zoroastrians and Jews, construction of fire temples and churches side by side the mosques can be observed clearly. In the perspective of historical old parts of desert cities and especially Yazd and Meibod, elements such as badgirs (ventilation shafts), water reservoirs, (Abanbar) payabs (a roofed structure on the qanat where water is shallow with different usages), hozkhanehs (part of

the house containing a pond or a stream) and old yakhchals (icehouse) can be seen. All urban spaces including residential, servicing, religious and educational units, mosques, caravansaries and schools have been formed under the effect of the traditional water supply network, i.e. the qanats.

Emergence of Meibod City

Meibod is a city 50 km. to the northwest of Yazd city and in the heart of the Iranian desert. The northern lowlands of Meibod Plain are the dry bed of an ancient lake that has disappeared in process of the climate change of this region during the recent milleniums and Meibod has been formed beside it (Pouya, 1992). The sharp south-north slope of Meibod indicates the terrace of an ancient lake (Mehrshahi, 1991).

The oldest residence centers in Meibod are located at the mouth of Old River of Meibod or near it. Then, due to climatic changes and the reduction of surface waters, the people inevitably developed techniques for making qanats. Upon entrance of Aryans to this region, new changes were introduced to the life style of the people (Pouya, 1992).

Meibod City had a political characteristic as well. During the Achaemenid era (7th to 3rd century B.C), functioned as a base in the border of Persia and Media and as a linking ring of the satrap areas round the desert. At the time of Alexander and during the Seleucide reign, this habitat was one of their military colonies in the region (Parham, 1994).

In spite of the fact that a government organization and a political factor was involved in creation of the old city of

Meibod, the role of the climatic factor, the natural environment and the agricultural and animal farming lifestyle along with the developed technology in provision of reliable water sources (qanat) should not be underestimated. Factors such as ancient road, qanats of thousands of years old, remnants of very ancient industries, pottery and also the religious foundations and urban establishments are believed to have been effective in formation of Meibod (Majidzadeh, 1989).

The oldest fortress of the old city in Meibod is "Narin Ghaleh" which indicates of a political center in the ancient world. This center as the Kohandej (old fortress) and the central part of the city of Meibod witness the memories of centuries and ages gone by. The circular map and the military values of Narin Ghaleh remind us of the forts and fortifications of Median periods (9th to 7th century B.C) and Parthian (2nd Century B.C to 3rd Century A.D) (Pouya, 1993, p.10).

Considering the ziggurat share of the fortress it seems that it has once been used as a religious center and a temple as well. However, the existence of deep moat, huge walls and the fortifications, the multiple walls, good defensive position and the overshadow on the region are more indicative of the military specifications of the fortress which attributes its foundation to the Median period (Pouya, 1993, p. I).

During the Sassanid ear (3rd to 7th Century A.D), the old territory of Meibod City developed. The expansion of this city was based on a forethought plan and maps. The plan of the Sassanid city is rectangular and includes Kohandej and Sharsan. During the foundation of the Sassanid city,

Kohandej (Narin Ghaleh) and the older sites (Meibod city center and small neighborhoods) which surrounded the Kohandej were placed inside the walls of Sharsan. The area of the old Sharsan (city) of Meibod is about 1000 hectares which is significant when compared with other Sassanid cities (Jafari, 1995, p.42).

The coins left from the Sassanid era which have been minted in Meibod bear the name of Meibod and this in turn shows that Meibod was called so during the Sassanid period (Pouya, 1993, p.19). The Iranian ancient cities in Median, Achaemenid, Seleucides and Sassanid eras consisted three parts of Kohandej, Sharsan or Sharestan (city) and Rabz or suburbs which were separated from one another by wall (Habibi, 1996). Kohandej was usually the main nucleus of the city and the political - administrative center. It was the residence if the king and the ruler and the royal family, the military, government reserves and treasures were placed therein. This section was encircled by manifold walls.

Narin Ghaleh in Meibod is precisely a Kohandej. This part is among the few sun-dried mud brick (Khest-e-Khom) ancient monuments that are still afoot. Narin Ghaleh is placed on a high clay hill. The mud bricks (Khest -e-Khom) used in the foundations of Narin Ghaleh (Kohandej) were of large and thick moulds and their size is mainly 40 x 24 x 10 cm. At that time, no specific standard size was developed for the mud brick moulds.

Narin Ghaleh Kohandej was used until early present century. Around and inside Narin Ghaleh, the mouth of the qanat can be seen. There is a hidden underground corridor from Narin Ghaleh to 3 km. west

of Meibod that has been of economic, social and military applications and has been used during wars and sieges.

In the old city planning system, Sharsan was the main part of the City and its surrounding was fenced by moat, towers and fortifications. The villages located around the city wall and outside the gates were called Rabaz or Savad or suburbs. The economic life of the city was dependent on the suburb villages. The suburban villages of Meibod included Bashnighan, Firoozabad, Barjin, Koochehbagh, Mehrjerd, Bideh, Khanghah, Yakhdan, Dehabad, Bofrouieh, Hassanabad, Shamsabad, Badrabad and Roknabad each functions as a main neighborhood in today Meibod. Usually, the said villages have evolved round the mouth of one or more qanat(s) and have their own qanats. In the lands down the villages, first there are the gardens and then farms with walls and door and then the plantations that have filled the distance between the villages. The plantations, farms and gardens used to function as protective measures against natural and human hazards.

Some of these villages located in the suburbs had a fortress of their own which mainly acted as barn for storing grains and other valuable products and for protecting them from the looters. At the time of dangers, these fortresses were used as shelter (haven). In all cities of Yazd region, especially in Meibod, a big or small wall is formed as City Square that has been of different social functions. In Meibod, there is a square in each neighborhood.

Inside the Sharsan of Meibod, a caravansary (established in 1810 A.D), water reservoir, (Abbanbar) icehouse

(Yakhchal) and the route of numerous qanats are observed. A permanent water current of the qanat has been flowing inside the caravansary. Facing the entrance door of the caravansary, there is Kola water reservoir (Abbanbar) which, according to the stone tablet installed thereon, its construction goes back to 1621 AD . A post office Chaparkhaneh (courier by horse) is located beside the caravansary and its building goes back to the

Safavid era and has been used until early present century. Later, by the establishment of Post & Telegraph Department (during First Pahlevid era -1921-1941), this ancient communication organization was closed.

Some Factors Effective in the Life and Development of City

Elements such as icehouse, (Yakhchal) water reservoir, (Abbanbar) cellar or hozkhaneh (Sardab) and payab had an essential impact on the emergence and expansion of urban neighborhoods in Meibod which are described in short as follows:

Icehouse

Two icehouse (Yakhchal) buildings existed in Meibod; one in the southern part beside the caravansary road which is located opposite the main inn of the city. Fortunately, the larger portion of this building still exists. The other icehouse which is located in the northern parts of Meibod and has given its name to a nearby village "Yakhdan". Icehouses were made on lands with relatively low permeability of soil. all the construction materials of

icehouse are of mud brick (Khesht-e-khom) and it generally includes the following major parts:

1. Pond (freezing site).
2. Shadowing walls.
3. Ice reservoir.
4. Large dome (Gonbed).

The freezing area in Meibod icehouse is a shallow mud pond in an area of 800 square meters and depth of 0.5 meter. The high base wall is 2 m. thick and 8 m. tall. The depth of ice reservoir is 6 meters. The ice reservoir is the place of storing ice. The icehouse functioned during January-February in winter and July-August in summer. In winter, which was the season of producing and storing ice, some water was poured into the freezing area at nighttime. In the winter cold and at the shadow of the shadowing wall, the water froze. When the ice grew thick enough, it was crushed into smaller pieces and transferred into the reservoir. The ices inside the reservoir were separated by wood and straw layers and when the

reservoir was filled, the doors of the dome were closed by brick and mud and clay and straw. The ice thus stored was preserved until summer that was the utilization season in a protection of land and straw and thick mud brick walls and under the big dome.

Water Reservoir

In Meibod, building water reservoirs (Abbanbars) in neighborhoods and beside the caravan routes have found a special position in the endowment culture. Since 1966 onwards, the water reservoirs in the cities lost their former importance because the urban water supply network and the change of transit roads reduced their value and their performance. During the Islamic reign on Iran (7th Century AD onwards), water reservoirs were built in every neighborhood as one of the significant urban structures. Their huge domes and tall Badgirs (ventillation shafts) were recognizable from very far distances in the face of the cities. Shortage of rain, lack of

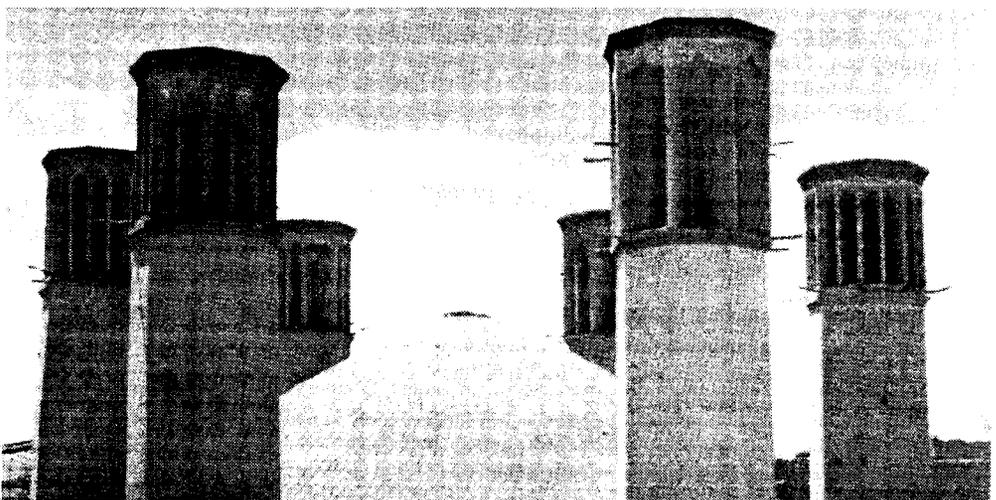


Fig. 2 Water Reservoir

rivers and fountains and lack of access to permanent potable water necessitated the construction of water reservoirs (Abbanbar). Water reservoir was a place for storing water during the rainy season for the use by urban neighborhoods. Some texts, attribute the emergence of water reservoirs in Iran to the Elam and Achaemenid eras (Ghobadian, 1998, p.298). Based on the manner of positioning, the water reservoirs are divided into reservoirs inside and outside the city (Pirmia, 1991). In water reservoirs, a small window was incorporated on the roof or on the badgir for ventilation. In Yazd and Meibod cities, in each neighborhood, two, four or six badgirs are seen. The water of the qanats was flowing on a level higher than the reservoirs and could therefore flow into the reservoirs.

Cellar or Hozkhaneh

That part of the buildings in the arid regions (Yazd and Meibod) which were used during the warm seasons of the year was the cellar or basement of the houses. In some of them, a branch of the qanat was passing through and even in some cases, the water of the qanat used to enter into the small pond in the cellar from one side and exit from the other side. In the past, this space was called Hozkhaneh. The existence of these water ponds and the entry ducts of badgirs and the fact that part of these cellars were located into the ground made it cool and desirable during the warm seasons. One of the characteristics of Yazd and Meibod residences is the lower level of the houses relative to the level of urban alleys which makes entry of water from the qanats into the houses possible and enables the residents to use the qanats for supply of their required

water and also the facilities of cellar and thus, the residences were developed.

Payab

One of the methods of accessing water of the qanat in Yazd and Meibod cities is Payab. Payab is a row of stairs connecting from the surface to the depth of the ground where the water of the qanat is flowing. Payab is built in two types of public and private. Payab is a Persian word and enjoys a history of at least 1000 years in Persian language. In Persian, Payab means depth of water, depth, survival, and durability where people may fetch water from easily (Dehkhoda, 1953).

Construction of payab like the construction of other public buildings has been a charity work for the people and the

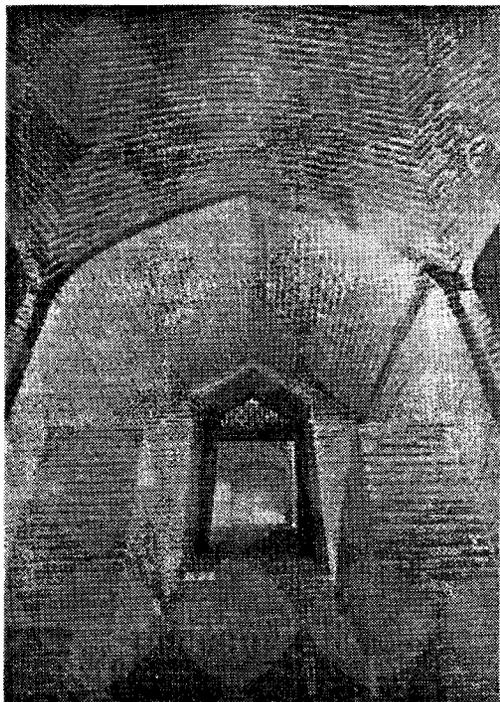


Fig. 3 Payab

charitable people built payab side by side building mosques, schools, water reservoirs, (Abbanbar) public buildings and caravansaries. In many houses of the rich, payab was constructed. Payabs were effective in expansion of neighborhoods and population density. This can be seen in all neighborhoods of Yazd and Meibod cities. The flowing water of qanats used to enter the neighborhoods of Yazd and Meibod in a number of ways. One was in the form of open flowing stream and the other in the form of payab. Payab was created where the location of the neighborhoods and the buildings were higher than the height of the qanat route. In places where the depth of qanat did not allow water to appear on the surface, payabs were built. In addition, the access of water, payab was a very cold place. Pouring water from the qanat to payab was done by purchasing water shares from the qanat authorities. Payab was a place for access to water, a small room for rest, placing and hanging foodstuff and rinsing clothes. Entry to payab was made possible from the yard of the house of mosque or from corridors in the basement. During the construction of Yaghoubi Qanat and later, Yaghoubi neighborhood in Yazd in 1020 A.D, the primary payabs of this qanat were also constructed simultaneous with the construction of qanat and the complex buildings of the neighborhood. Upon development of urban spaces or change of application of its spaces, construction of payab was always considered for meeting the needs inside the new complex. In the desert and hot cities of Yazd and Meibod where the temperature sometimes reaches 45 degrees Celsius, the payab has a fixed temperature of 28 to 29 degrees Celsius during the entire year. Payabs, also had the

function of defense as well. During the sieges, payabs acted as safe underground shelters for the inhabitants of Yazd and Meibod. The women, children and the elderly used to go into payabs during the time of danger and were mostly safe. During the wars, qanat canals and ducts were usually used as means of communication between different neighborhoods in the city and between the city and outside. Payabs of the city and the gates were considered as a communication tools. If needed, people took shelter in the qanats and canals by way of payabs. Hence, the city could remain safe during the sieges.

The city was even able to maintain its productive and servicing function during the hard conditions of siege and develop an underground performance. In some cases, the city dwellers could provide food and fodder for the city through the route of about 1000 wells of qanat linking the residences to the hills outside the city. They could exit the products and commodities and the passengers at risk and could enter or exit the city through these canals with the help of guides. The city guards attacked the enemy at night through these wells. The neighborhoods of Yazd and Meibod cities were organized in a manner which made the entrance of attackers on horseback impossible due to its specific structure of alleys, passageways and roads. It seems that the qanat canals, wells and payabs had been effective in the stability and resistance of Yazd and Meibod people in some of the raids these cities have passed through.

As the development and survival of Meibod is directly linked to qanat, at this part of the article, we study the qanats of this City.

Qanat Water Utilization System

Meibod City has an average precipitation of 60 mm per annum. In this city, 25 qanats were flowing which irrigated 14447 hectares annual farms and 833 hectares gardens. In Meibod qanats, whether owned by endowed, the ownership of water is in two forms, water with land or water without land. Qanats in which big shareholders are in majority belong to major landowners and the ownership of water and land is not separate. In Meibod, the water division system is based on day and 24-hour periods which is called Taqbandy in local dialect. Each 24 hours is divided into two Taqs. From the sunrise until the sunset is called Taqroose (or Day Taq) and from sunset to the sunrise is called Taqshab (Night Taq). The smallest unit for division of water is Tasu that is 1/4th of a Taq. For example, Shahabad Qanat of Meibod was divided into 95 Tasus (before the Land reforms of 1962) and each Tasu had five Qafizes of land.¹

Of course, the more water a qanat yields, the more land it has for irrigation. In petit feudalistic qanats, ownership of water is separate from ownership of land. Qanat is divided into numerous shares regardless of land and every person owns one or more share(s) depending on his financial capabilities. In some cases, one may own numerous shares in qanat without owning any piece of land. For example, Jadideh qanat in Firoozabad village² was divided into 2291.5 shares in 1962 owned by 302 shareholders. Even sometimes, the big shareholders of Meibod qanats were not

native people of Meibod. In Meibod, the right of using water is called Jarra. The maximum right of using water is 75 minutes and the minimum 4 minutes.

In petit feudal qanat, the division of water is based on minutes and seconds. Administration of the division and distribution of water needs logical and consistent management system headed by Mirab. Therefore, the petit feudal qanats are called "Mirabi" qanats as well. Parts of the shares of qanats in Meibod are endowed. The endowed waters are divided into private endowments³ and public endowments as follows:

1. Private endowment: benefits of which belongs to special group of people.
2. Public endowment: the benefits belong to the public.
3. Endowed to the mosque: the benefits are spent for repair, maintenance and administration of the mosque.
4. Endowed to water reservoirs (Abbanbar): the benefits are spent for maintenance and repair and filling the reservoir with water.
5. Endowed to the Shiite Imams.
6. Endowed to Hosseinias (special places for mourning on Imam Hossein): the benefits are used for repair and maintenance, supply of light, distributing cold water among the mourners during the mourning ceremonies.

1. The unit of area in Meibod is gafiz. Before 1966, each qafiz was equal to 900 square meters, but today, each gafiz is equal to 1000 square meters.

2. At present, one of the main neighborhoods of Meibod City.

3. Endowment (Vagt) is to devote a property, building or water for charity works and gratis use.

7. Endowed to public bath: the benefits are spent on repair and maintenance, supply of fuel and cleaning drugs to the bath.
9. Endowed to religious rituals: the benefits are spent on religious occasions in mosques or at homes.
10. Endowed to pilgrims: the benefits are used for supply of expenses, clothing and shoes for pilgrims.

In the irrigation system of Meibod, the administration of order in use of water by the farmers was enforced by a person called Sartaqi. In some cases, the position of Sartaqi was a hereditary post and sons inherited this post from their fathers. Sartaqi is responsible for division of water only from Nov. 16 through Feb. 14. In the other months of the year, Mirab is responsible for supervision on water. Mirab is the person in charge of regulating the rotation and fair

division of water among the farmers and is elected by majority vote of the shareholders. For this purpose, 5 or 6 people from among the elderly and the trusted local people who own more shares in the qanat, choose the Mirab. When their election is confirmed and endorsed by the shareholders, it becomes formal. Each Mirab has an assistant who is called Taq-Salar, i.e. “the person who goes after water”. Taq Salars should be physically strong and honest. They work for 24 hours and rest the next 24 hours. In the past, the remuneration of Mirab and his assistant was given in kind, but at present they receive money. Mirab has two books for calculations of water, one big and one small (daily ledger book). In the large book, lie records the name of shareholders and their rights in using water. In Meibod, sale or purchase of qanat water is also common and Mirab does in the process.

Regularities of the Traditional Water Supply Network

In Meibod, land has been divided into rectangular pieces between 500 to 1500 square meters in area. Each of these pieces is called “Kort”. Each kort is irrigated through soil ditches drawn as required by the form of land. These ditches are called Juda or Ju. There are three types of ju in Meibod:

1. Juda-Shaju: which is the main ditch transferring water from mouth of qanat to the place where water is being divided.
2. Juda-Nira: which is the public juda and the main water supply network to the farms, but not everybody is allowed to use it directly.

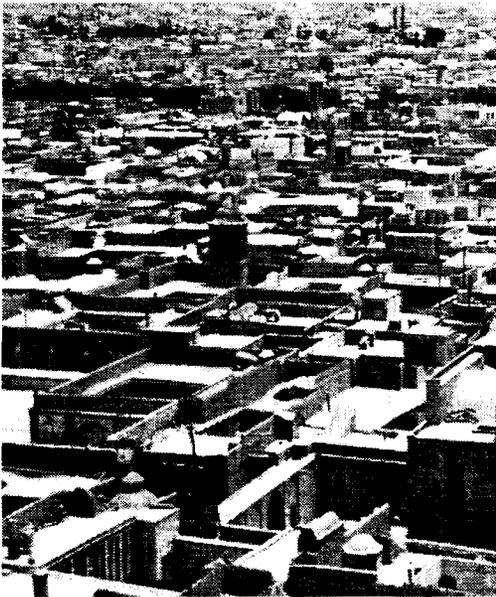


Fig. 4 Meibod City

3. Juda- Shorbi: which is a branch of main network and is divided into different private subsidiary branches.

When the farms are transformed into garden or house, shaju and juda nira change into main alleys and juda shorbi into blind alleys. The place where water enters the kort is called Galla that changes into the entrance door to the garden or the house. Irrigation is carried out through the breadth of the kort that is less wide. As the slope of Meibod lands is from south to north, for easier irrigation, the length of kort usually has the direction of northsouth as far as possible. Usually, water enters into the kort from the southern side. If the kort is rarely of east to west direction, it is irrigated through the smaller eastern or western side. If the juda nira is placed on the breadth of the kort, galla (or the entrance gate in case the farm had changed into garden or house) is opened there. But if it is placed along the length of the kort, nobody has the right to open galla thereon and in order to irrigate such kort, subsidiary juda (juda shorbi) should be used, the same as the kortes placed far from the juda nira. Everybody can have galla only in the place where water reaches his land earlier.

The Effect of Traditional Water Networks on Development of Neighborhoods of the City

In Firoozabad of Meibod, there are two qanats (Jadideh and Mahmoodi). Jadideh

qanat has two keshtkhans. Keshtkhan is referred to the entire agricultural lands irrigated with the water of one qanat. This qanat has two keshtkhans. Each keshtkhan is divided into a few Maqams¹ and each maqam to a number of Takhta² and each takhta to a set of kortes. In Meibod, the lowness or highness of land is the factor determining the name of farm and other natural or unnatural factors such as mound, river, tower, water reservoir (Abbanbar) and garden. It specifies the name of each keshtkhan. Any part of the land of each keshtkhan which is placed in a leveled plane surface is called a takhta. The differences of level of takhtas are shown by attributes of "pit", "highland", up and down. The more strong the intervention of people in the form of the land, the more private are the names given to the land. Foreexample, the area of gardens is usually specified with the name of the persons who, for the first time, built a garden in the given area. Even if no trace were left from that garden today, the name of the garden and its owner would remain.

Sometimes, naming keshtkhan is based on its position in relation to mouth of qanat. For example, the first piece of land which is close to the mouth of qanat, i.e. is nearest to the water is called Salar³ and the farthest piece to the mouth of qanat is called Kolom. These names were aimed at specifying the limits of land and determining the turn of irrigation so that everybody could determine his time of irrigation. Most of these names have remained after development of

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1. Maqam is a section of keshtkhan with relatively levelled lands which are irrigated by a single dam. Sometimes, maqam may be called keshtkhan if too big.
 2. Takhta is referred to a section of lands of the same level.
 3. Means the first location.

Firoozabad neighborhood and change of farmlands into residential houses in the form of names of new streets and alleys. Kolom, Sar Hoze Band¹, Sar Hoze Noe, Salar, Sar Baghe Pol, and other old names are derived from the names of farmlands which used to be irrigated by qanat water. These neighborhood names created the neighborhoods inclinations and sense of belongings in the course of time. The inclination which causes inhabitants of each neighborhood feel attached to one another and to help each other in competing other neighborhoods in their development efforts and to strengthen their neighborhood sentiments.

Traditional Network of Water and Morphology of City Passageways

The regularities of traditional water network along with the shape of juda niras and juda shorbis have formed the morphology of Firoozabad neighborhood in Meibod and in the course of its development, this neighborhood expands regularly toward the farms. The farms are first turned into gardens and then into houses or houses are built directly thereupon. In any case, after fencing the house, the juda of each kort functions as the Rahpa, i.e. the road.² As the ownership of these judas is common, nobody is allowed to interfere or change then. Therefore, the form and all specifications of the road including its breadth and length, being direct or inclined, having turns and all other specifications

follow the turns and specifications of the juda.

Since 1984 onwards, due to the execution of Master plan of Meibod, the roads and streets of new residences are subject to modern urban planning regulations.

In the past, some factors interfered in determining the breadth of alleys. For fencing the land from the side where juda was located, every one was free to transfer juda into his garden if he wished so. Transfer of juda into the garden could take place under one of the following procedures:

1. In case the juda was owned commonly and this common ownership could be proved by having galla, the owner could place the fence or the wall on the band³ common between juda and kort and transfer the juda into the garden. In such a case, the half of the juda that was placed outside the garden considered embarkment of the wall. Bands that are thus placed between two kort usually function as the common border and its breadth is enough to let one person pass over.
2. If the owner is not a partner in juda, he should place the wall behind the band and juda and left the band as the soil embarkment. Therefore, the width of the alley would be either equal to the width of juda plus the width of band or equal to the width of juda alone. Since the width of juda depended on the quantity

1. Sar Hoze Band means the place where Hoze Band is Located. Hoze Band is the first place of dividing water in mouth of Jadida Qanat in Meibod.
2. Rahpa means the right of trespassing. This right is obtained only through having galla in juda nira or juda shorbi.
3. Band is the borderline specifying the central limits.

of water of each keshtkhan, the width of each alley was also related to the quantity of water of the given keshtkhan. Such a relationship can be easily seen in different parts of Firoozabad neighborhood. Each alley that is developed from the juda of the jadida qanat is wider, because the water of this qanat has been more. But the alleys which are developed from the judas of Mahmoodi qanat are less wide because this qanat had less water and its judas were narrower.

According to local custom, a donkey or a cow with a hay load should be able to pass through the main alleys built on Shaju or Juda nira. In other terms, the main alley should be Shawl-gozar¹. The width of blind alleys which are developed from juda shorbi (the subsidiary private juda) should be enough to allow a donkey or a cow with the load of Valla² pass. The blind alleys should be Valla-gozar.

One of the other elements determining the breadth of alley was the difference of level of land with its adjacent pieces. The difference in height of the given piece of land with the adjacent piece should create a sloppy surface on the common border of the two pieces which is traditionally called "Jerband". If Jerband were separated from the lower piece of land with juda nira, the water basin of juda belonged to the person whose land was on the top. But if he wanted to open a way from this side, he should have left Jerband as embankment and road while fencing or making wall and should have

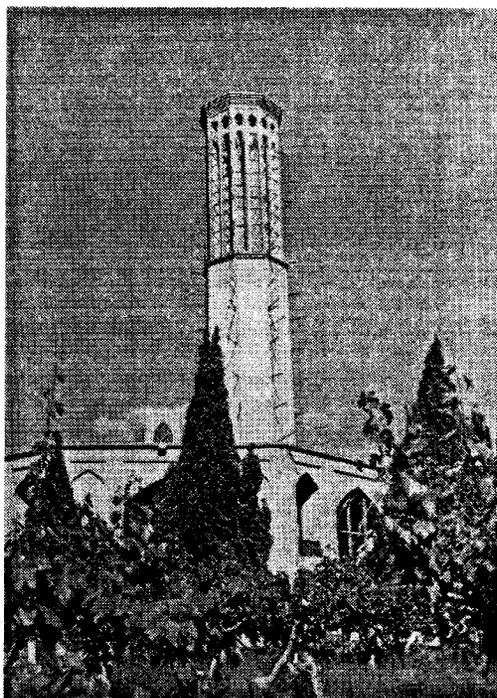


Fig. 5 Badgire

placed the wall on the last farmable point of the land. In this case, jerband was considered limits of the road and was added to the width of the alley. But if the owner of the upper land were not interested in giving a road, he should have placed the wall on the site of the basin of juda. Sometimes, jerband alone formed a road. Most of keshtkhan roads are created in this way. Due to the wider breadth of jerband, a pedestrian can easily pass over it. If the location of the land which has jerband were so that its jerband is placed in line with the road and facilitates access to the farms, jerband will be used as road. In such cases, such use may

1. Shawl-gozar is a tool used for carrying wheat or hay. It is made of wool woven in four pieces of 50 cm. Wide and 2 m. long sewn together. The shawl is filled with hay and placed on donkey back.
2. Valla is a cotton textile used for carrying manure.

gradually cause right of passing and jerbant may change into the public road of keshtkhan.

Conclusion

In the past, location of Iranian cities was in direct link with water. Access to water resources in the cities of Iran was affected by surface waters, river and the traditional water supply network of qanat. In the internal plateau of Iran and especially in Meibod city, the qanat water has been very effective in form and morphology of the neighborhoods. Residences, alleys and passageways have formed mainly based on the traditional water networks. The most essential source of water supply in Meibod has been qanat. In the perspective of the middle, traditional and historical parts of the city, elements such as mosques, water reservoirs, badgirs, ponds and old alleys can be clearly recognized. Water reservoir and payab were among the effective factors in developing neighborhoods. Meibod city as one of the ganat civilizations had specific system, legal and social rules which caused development of the neighborhoods of this city due to public and private endowments. Generally, before water piping in 1966, the texture and morphology of Meibod city was under the influence of the local rules, customs and traditional network of ganat waters.

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