TRADITIONAL WATER MANAGEMENT; AN INSPIRATION FOR SUSTAINABLE IRRIGATED AGRICULTURE IN CENTRAL IRAN

Majid Labbaf Khaneiki[1]

ABSTRACT

Central Iran is an arid area where all agricultural systems as well as human civilizations have always depended on the groundwater mostly obtained through *qanats*, but lack of an integrated management has thrown our groundwater resources into disorder. This paper investigates the ways through which we can incorporate some traditional methods into our modern water management. In fact there are two important things we might learn from the tradition:

1- accurate systems for division of water
2- preservation of groundwater resources

In central Iran, traditional knowledge provides informal education on water management that is passed from generation to generation. It concerns knowledge on division of water, maintenance of qanats and preservation of groundwater resources. This gives hope for the future, where both tradition and modernity can live side by side to promote our new water management.

Key words: Traditional water management, modernity, division of water, preservation of water, water resources, qanat, sustainable agriculture

INTRODUCTION

Central Iran is an arid area, so that its average rainfall does not exceed 250 millimeters a year. Therefore in central Iran all agricultural systems as well as human civilizations have always depended on the groundwater mostly obtained through qanats[2], some

1-International Center on Qanat and Historic Hydraulic Structures, P O Box: 89176-575, Yazd, IRAN
Tel: 0098-351-8250553, Fax: 0098-351-8250052, Mobile: 0098-9132586196,
Email: Labbaf_majid@yahoo.com

2- There are 32164 qanats in Iran and an estimated the total length of their galleries is about 310800 kilometers (Papoli Yazdi & Labbaf Khaneiki, 2003). A qanat consists of a long horizontal tunnel which directs water toward the surface as well as lots of shaft wells in order to ventilate the tunnel and provide a way through which the excavated materials can be pulled up. To construct a qanat, first of all, an area near a mountain slope is usually chosen in order to dig the first well. The qanat practitioners continue to dig the first well as long as they come across the aquifer seeping into the bottom of the well. Then they stop digging the well because of the level of water coming up, but start digging a long tunnel crossing bottoms of all the wells, from the surface of earth to the last and deepest well. The tunnel is roughly horizontal, with a slop to allow water to drain out. The discharge rate of a qanat depends on its extent in the aquifer. Qanat has been an important part of a sustainable productive system, consistent with the environment of Iran, and used during the past centuries without damaging aquifer reserves.

gently sloping subterranean conduits, which tap a water-bearing zone at a higher elevation than cultivated lands. But lack of an integrated management has thrown our groundwater resources into disorder. About fifty years ago, the total discharge rate of the qanats was approximately 18 billion cubic meters a year, which was 2 times more than the present amount. This problematic decline is attributable to the extensive pump extraction of groundwater and many wells drilled in the past few decades. Without regulation on water resources management this practice often depletes aquifers. The pumps are threatening our groundwater in central Iran and putting some economical-social systems in a real crisis, which make us think of other ways to improve our water management.

This paper investigates the ways through which we can incorporate some traditional methods into our modern water management. In central Iran, traditional knowledge provides informal education on water management that is passed from generation to generation. It concerns knowledge on division of water, maintenance of qanats and preservation of groundwater resources. This gives hope for the future, where both tradition and modernity can live side by side without doing any damage to our water resources. Before getting to the point, I would like to bring the historical aspects of water management to the readers' attention.

THE HISTORY OF WATER MANAGEMENT IN IRAN

Since the dawn of the Iranian civilization, water division system has played an important role and often lain behind the social and political processes. According to Wittfogel's theory, the water division system led to oriental despotism. In this arid region which has always been short of precipitation, people had to irrigate their lands, because they could not leave their cultivated lands only to such a little rainfall. On the other hand, the amount of water obtained through either rivers or qanats might not be quite sufficient for everyone to use without any need to economize on it. Therefore, some individuals gradually emerged to regulate water consumption and took charge of other water related affairs. In this region, whoever could take control over water would be able to gain a high social position and finally power to organize a political dictatorship or oriental despotism somehow.(Naghib zadeh A. 2000)

One can place a great importance on water division system during the history of Iran. As an instance, water authorities or water organizations trace back to Sasani era, about 1900 to 1400 years ago. That ancient water authority was responsible for managing water ownership, recording water shares, and calculating the amount of tax the farmers had to pay for their shares of water. Later, Abbasid caliphs reestablished the same water authority named *Divan al-Ma'*, and assigned some experts named *hassab/accountant* to all water related affairs (Papoli Yazdi M. and Labbaf Khaneiki M. 1998). All the Iranian governments used to place a high value on water, so they tried to do their best to look after water affairs. The more perfect water distribution and management, the more profit the governments could make. I would like to draw your attention to the fact that in some cases the taxes were only calculated based on the amount of water (Khosravi Khosrow. 1969), because our historical governments had derived from a traditional economical

context which was quite different from the recent one resulting in some political systems that often fasten their hopes on some natural resources like oil. In the past, the Iranian governments used to intervene in water management to avoid any disorder in agricultural production systems which had something to do with the amount of taxes the government expected to charge people. Aboodalaf, an Arab historian, reports a fascinating dam in Damghan (in central Iran) constructed by Sasani kings in order to divide water into 120 shares each of which belonged to a village, then he admits that "he has never seen such a clever and accurate technique to manage water". (Aboodalaf. 1975) Also, what Maqdasi, an Arab geographer, reports on the Marv dam, in fact shows how much the Iranian governments were concerned about the irrigation systems and water management. According to Maqdasi's report the Marv dam was run by a staff of ten thousand persons who were hired to protect the dam or be in charge of its water management. To measure the amount of water, the dam had a special tablet in a standing posture with some horizontal lines cut into it. Should the level of dam water could reach the sixtieth line, it would imply that the coming year would be so wet and fruitful that the staff of dam no longer needed to be quite strict about the water division. But, it could be a bad omen predicting an upcoming drought, if the level of water could not exceed the sixth line. There were some main outlets in the dam each of which belonged to a separate village to distribute water among them as fairly as possible, and then there were other outlets in every village to divide water among the quarters, and more outlets in every quarter, so on. If the dam would become short of water, the staff would do their best to decrease all the shares alike (Meftah E. 1992). Note that whatever we know about the water related techniques or management in the course of history come from only the existing historical records that in a way seem exaggerating. For example it is mentioned that there was such a huge dam able to supply water to 120 villages in Damghan an arid region where today the existence of such an amount of water is incredible. Also Maqdasi refers to a staff of ten thousand running the dam of Marv, but it may flash through everybody’s mind that such a staff is out of proportion to the population of a medieval city like Marv. Meanwhile, we have no idea how they could predict the scarcity of water just by means of a tablet, and do not know anything more about the scientific basis of such a prediction what is so difficult and complicated even with the aid of modern technological devices. Here I do not want to track down the mechanism of the dam of Marv or to find out whether the number of ten thousand is true or not. My purpose is to indicate that how important water management has been in the Iranian political-economical structures attracting the attention of those rulers and writers, even though the historical records are partly exaggerating.

Sometimes rulers and writers teamed up to find a remedy for water related problem. For example a book entitled “extraction of hidden waters” was written by Aboobakr Mohammad Al-Karaji whose patron was the minister of Manoochihr Voshmgir. Al-Karaji states in his preface that he had referred to various books by earlier writers on the exploitation of subterranean water (Lambton A. K. S. 1989). In fact if any problem threw the water division systems into disorder, the government was also in charge of solving it, as king Tahir did about 1000 years ago. A terrible earthquake struck Khorasan province and destroyed many qanats so that their flow completely ceased. After renovation of the

qanats, some serious disputes broke out between the owners of the qanats for more shares of water. Finally king Tahir mediated between the owners and settled the problem by means of calling in all the clergymen and lawyers from all over Khorasan to compile a book on the water division and water related laws (Salimi M. S. 2000).

Bearing in mind the importance of water management in Iran, it was only for king or his minister to confirm and sign the official proofs regarding the water division systems of big rivers. For example the proofs of Karaj River should have been authorized by Amir Kabir, Nasereddin Shah's famous minister (Enayatollah R. 1971). So, it would not be an exaggeration to say that most of the socio - political structures of Iran are still rooted in the history of water management.

Needless to say water management systems did not exist only at the level of state, but even more complicated systems were (are) practiced in rural regions. The following part examines the remains of these local systems that can be an inspiration for our new water management systems.

TRADITIONAL WATER MANAGEMENT

Here, traditional water management means all the actions the local farmers take in order to regulate water division, irrigation related subjects and preservation of water resources. They have traditionally established some complicated systems in order to divide water among the farmers or the shareholders of a water resource, and irrigation rights are based on landownership or time shares within a certain period of rotation. This water division system can match up with all likely changes in the volume of water during a year, while satisfying the farmers' irrigation needs. To measure the time every shareholder has for irrigation, they have invented a special type of water clock or clepsydra. Their clepsydra consists of two bowls made of copper one of which is so small that could freely float on the surface of water in the large one. The floating bowl has a tiny hole at its bottom through which water can enter the bowl and gradually fill it up. After being filled which may take a certain time, the small bowl sinks in the water and bumps into the bottom of the large bowl. As soon as the bump would be heard, a unit of time would be over, so the time between the two bumps equals a certain unit of time. One can also find some marks cut into the inner side of the small bowl which divide the certain unit of time into the shorter fragments. The time it may take the small bowl to be filled and sink varies from area to area in the central plateau of Iran. I examined some different types of clepsydra in some areas and summarized all the results in the following table.

Location	Time (hour: minute: second)
Kol-e Birjand	00: 24: 00
Shahik-e Qayen	00: 22: 30
Khor-e Birjand	00: 17: 00
Kadekan	00: 15: 00
Sarbisheh, Zirkooh-e Qayen, Darmian-e Birjand	00: 12: 00
Yazd	00: 11: 15
Zoozan, Boshrooyeh	00: 10: 00
Fakhrabad-e Bajestan, Eshgh abad-e Tabas	00: 09: 00
Bilond-e Gonabad	00: 08: 30
Gonabad	00: 08: 24
Dihook-e Tabas	00: 08: 00
Khanik-e Gonabad	00: 07: 30
Abiz-e Qayen	00: 07: 00
Aboojafari-e Boshrooye, Kakhk	00: 06: 00
Khosro Jerd-e Sabzevar	00: 05: 00
Serend-e Ferdows	00: 04: 44
Bajestan	00: 04: 36
Tabas	00: 04: 00
Ferdows	00: 03: 00

Sometimes, in a certain area, the unit of time may vary with the season and the period of rotation within which the irrigation rights have been defined. As an instance, In Bajestan area, the unit of time varies from 2.3 to 17.2 minutes between the months of March and February. In this area, there are three qanats named Mohammad abad, Golbid and nowkariz. Bearing in mind the location of farms and the distance between the qanats and the farms, each farmer may use either one of the three qanats or two/three of them mixed together. The joint flow of the qanats of Golbid and nowkariz is only considered as the standard flow to which all the official proofs refer. For example, if someone claims that he/she possesses ten shares of water, in fact he/she is entitled to irrigating his/her land for 46 minutes because every unit of time equals 4.6 minutes on the condition that the flows of Golbid and nowkariz are together. On the other hand, the rotation of irrigation rights may be based on 21, 14 or 10 days during a year. Within a period of rotation based on 21 days, every shareholder is allowed to irrigate only once every 21 days and so on.

Meanwhile, the length of the period rotation varies from season to season in order to adapt the available water to the existing climate condition. Therefore, there are 15 units of time all of which depend on the period of rotation and the source of water, as you can

see in the following matrix. The gray part of this matrix shows 15 possibilities for unit of time from 2.3 to 17.2 minutes. As an example, the unit of time would equal 4.6 minutes, if the rotation of irrigation rights would be based on 14 days as well as both the qanats of Golbid and nowkariz would be taken into account.

10	14	21	period of rotation / source of water
2.3	3.2	4.8	Mohammad abad+Golbid+nowkariz
3.2	**4.6**	6.9	Golbid+ nowkariz
8.2	11.5	17.2	Mohammad abad
8.2	11.5	17.2	Golbid
5.5	7.8	11.7	Nowkariz

Due to the complexity of the water division, there are some professionals named *mirab* who are in charge of distribution of water among the farms, and are paid a definite salary by all the shareholders. While giving water to a shareholder, *mirab* also has to consider the time it may take the qanat flow to get to the given farm. For example, if someone has a right of 46 minutes irrigation, and if it takes the flow of water 4 minutes to arrive in his/her farm, then he/she should be allowed to use the water for 50 minutes. Therefore, *mirab* does his best to distribute the water among the farms in a way that as less water as possible would be wasted in the ditches. Doing so, *mirab* should be quite familiar with the locations and characteristics of all the ditches leading water to the farms. *Mirab* has a notebook too, including all the irrigation rights in detail, so if the shareholders want to sell or buy any right they should let *mirab* know about any transaction. Unfortunately nowadays this profession is fading but nothing is replacing it, so we witness some recent conflicts over water in rural areas these years.

Preservation of groundwater resources is also a good example of traditional Water Management which could be up for discussion here. Iranians 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. They used qanats as a sustainable technique to extract groundwater, which was recharged in winters by some special dams constructed by the farmers. To prevent damaging aquifer, they designated the vicinity of qanat, which was the area defined surrounding the qanat and comprised between 1 and 3 km depending on the local conditions. The aforementioned dam is nothing but a pile of soil in upstream above the first and deepest well of qanat so that it can catch the floods in winter behind itself. The water accumulated behind the dam can gradually penetrate the earth and then seep into aquifer, so an increase in the discharge of qanat as well as the lack of erosion are two of the advantages of such dams. Nowadays, most of the dam are leveled and then cultivated with the help of pumping deep wells drilled in the vicinity of qanat. The fertile deposits of the dams tempted some farmers to change the dams into the farms at any cost, even though the qanat would dry up. As an instance, in Yazd a qanat named Chahok-e Nir was recharged by four dams which were located in the bound of another village named Pandar. The habitants of Pandar had some shares from this qanat, so not only they put up with the presence of dams in the middle of their

lands, but also they helped the main owners of the qanat with renovating and protecting the four dams. After the Islamic revolution, the farmers of Pandar started selling their shares, and after a while they completely destroyed the dams and drilled some pumping wells in order to cultivate the whole area. The lack of those dams caused the qanat to drizzle. But fortunately such traditional dams could provide inspiration for the Yazd Regional Water Authority which is very concerned about improving the groundwater resources in Yazd province. Doing so, they recently implemented some great projects to help recharge aquifer such as building 18 mud dams being able to inject more than 17 million cubic meters seasonal flood into aquifer. This gives hope for the future, where we would be equipped with both tradition and modernity to guarantee a sustainable agricultural system, though after the land reform program and the advent of modern devices, these traditional water management systems started to fade out.

Figure 1- a traditional structure named Maqsam for dividing water into four shares each of which goes to a particular village. (the province of Yazd)

Figure 2- calculating water shares by means of a traditional clepsydra

WATER MANAGEMENT IN THE REALM OF MODERNITY

Among the package of the modern reformation of the former Shah in 1963, the redistribution of agricultural lands which sheared the traditional landed elites of much of their influence has the most significant effect on water management systems in Iran. Before the land reform, most of the Iranian population resided in rural regions. Each village consisted of some agricultural units named *boneh*, cultivated by 8 to 12 farmers (share-croppers). The duty of each farmer was perfectly specialized. Two farmers were

usually in charge of plowing and preparing the field, two other farmers were responsible only for irrigation, and the rest of them were involved in seeding, protecting and harvesting. Everybody worked and lived under the management and authority of a lord, who owned the whole village. According to the Law of Land Reform, the villages were purchased from the lords by the government one after another, and then were sold to a few farmers in the same village by installments.

The land reform law was finally carried out, without caring about the majority of the villagers who had no share in the agricultural units (*boneh*), not profiting from the land reform at all, and without caring about the complicated relationships between the production systems, environment and water management in Iran. So, the land reform law could lead to annihilation of many qanats which were only resources to supply water to central Iran, by means of a blind mechanization and confusing water management systems. Even if the motive for the land reform was making the lords' capitals move to the principal cities to be invested in the industrial section, the government should not have distributed the lands between the peasants yet. But, it was better for the government to retain the purchased lands and reconfigure the traditional management in a modern context by means of setting up some organizations in the rural regions being able to take the landlords' place. Doing so, the agricultural units *(boneh)* which could optimize irrigation so perfectly that sometimes the irrigated fields could be extended 1.5 times (Safinejad. 1989), would be left untouched.

In fact the land reform removed the lord's traditional position, because those agricultural systems carrying such a position were ruined, but anyone or any kind of organization did not exactly replace the lord's role. Therefore many qanats were abandoned for a while or even for ever. Because, within the agricultural system of *boneh*, the lord used to look after his qanat, and if a qanat would need to be repaired, the lord did not hesitate to call in the qanat practitioners and finance the whole project. After the land reform, the qanat practitioners could no longer work for any lord who used to finance the qanat and give them an opportunity to earn a living, so they were encouraged to immigrate to the cities or other regions. In central Iran, qanat practitioners were a professional community having no right to work on the lord's lands as some official and permanent farmers. In the rural regions, the society was divided into two casts locally named *Nasaqdar* and *Khoshneshin*. *Nasaqdar* meant the groups who had the right to work for the lord as his farmers on his fields, so they had priority over the second cast (*Khoshneshin*) who had nothing to do with the agricultural activities, and their jobs would only satisfy the other needs of the rural community such as masonry, carpentry, handicrafts and qanat-related activities. According to the land reform law, the lord's lands should have been distributed just among the *Nasaqdars* the people who worked on the lord's fields, so this program did not bring any profits to the qanat practitioners and made them let go of the agricultural areas.

On the other hand, the land reform raised a great demand for irrigation water because of a bad management. Before the land reform, whoever worked in an agricultural unit (*boneh*) was responsible just for a particular job such as plowing, seeding, irrigating or harvesting, and the farmers rarely interfered with each other's job. Therefore, each farmer could not be as good at all jobs as his own job, so most of them were not capable of irrigating the fields. In a traditional manner, someone who was not expert at irrigation might waste some water in many ways, so after the redistribution of the lands

the consumption of water increased, and the demand for water quickly surpassed the supply of qanats mostly due to misusing water. Therefore, the farmers had to drill some deep well to pump the aquifer to provide the required water, doing so lots of qanats fell into decay.

As mentioned, according to the Law of Land Reform, the lords were forced to sell their lands to the government. But mechanized farms were the exception, and having pump extraction was legally considered as a proof of it (Azkia M.. 1994), so some of the lords were encouraged to replace qanat with pump extraction in order to save their own lands. Actually they did not want government to destroy their traditional position in the rural communities by means of removing their economical roots. The lords hurried to dig the well with extractive pump to avoid being included in the land reform law, even if their lands needed no well. Doing so, the number of the deep wells dramatically began to increase. As an instance, the first well with extractive pump, which took place in Neyshaboor region, was drilled in 1958. But the number of such wells reached 14 in 1960 just when the land reform law were approved and announced, and then amounted to 286 in 1970. Massive ground water extraction causes depletion of finite aquifer reserves, and it dramatically reduces the water table of the whole surrounding area. An estimated in Neyshaboor region the water table goes down about 0.2 meters a year on average, because of the massive groundwater extraction (Velayati. 1999). Therefore most qanats were drying one after another, due to the wells and their pumps, which took the water table away from the access of qanats. The comparison of qanat with well (extractive pump) can shed a light on the fact that such wells are not suitable for Iranian agricultural systems in many cases. Extractive pump empties the porous layers of water and cause some subsidence, which do lots of damages to the structure of soil and even buildings. If extractive pump empties karstic holes of water and destroy them, then a circular hollow appears within a radius of 100 meters on the surface of earth. But qanat never makes such a problem. The potential loss of fresh water, which makes salt water move towards up stream, is attributable to extractive pumps, whereas qanats never change the quality of water. According to some information related to Iran, the wells with extractive pumps could not last more than 30 years unlike qanats which last more than 2000 years without any defects. After all, water flows out of qanat only because of the force of gravity that is free of charge, whereas the extractive pumps consume an enormous amount of fuel per year. For example, in Yazd area there are 4340 wells with extractive pumps, which totally consume 205854880 liters gas oil a year in order to obtain 926350000 cubic meters water. But in the same area there are 2948 qanats, which withdraw 329870000 cubic meters water a year without any fuel (Baqeri & Roozbeh. 1999).

This land reform was an example and a bad experience that taught us the fact that development is not a simple concept we can import from the modern world into our own country, without taking our cultural economical and ecological conditions into account. Although the Iranian authorities tried to belittle all the traditional production systems, while carrying out the land reform program, in order to pave the way for a modern model. They believed that our country could never achieve a developed stage, unless we completely let go of the traditional sections of the society that appropriate most of our resources. Therefore, most of the Iranian scholars and politicians tried to exaggerate the technical defects in qanat and traditional water management to justify their own hasty programs and convince farmers to use pump extraction instead of qanat.

As an instance, a report entitled “Economical Development of Soil and Water Resources” prepared in 1966 explains the amount of required water to irrigate an area equal to 10000 square meters or a hectare. Some parts of that report associated with modern techniques estimate the amount of required water for a hectare to be about 10000 cubic meters a year. But another part related to qanat and traditional irrigation makes contradictory statements, so that it estimates the amount of water needed for a hectare to be about 16400 cubic meters a year. In fact there is a thirty percent decrease in the required water in comparison with real estimate when the report explains modern irrigation, and a sixty percent increase when the report engages in qanat and traditional irrigation. Then the report concludes from such wrong estimates that qanat cannot supply the required water to irrigate our farms. Such exaggerating reports resulted in thousands qanats being destroyed. As an instance, only in the plain of Yazd there are more than 70 dried-up qanats, which have caused many villages and about 2500 hectares rich lands to be abandoned (Labbaf Khaneiki M.. 1999). The main reason why *qanats* started drying is that many deep wells were drilled in lower slopes to extract water with pumps depleting aquifer.

The depletion of aquifer not only makes *qanat*s dry, but also causes desertification especially in central Iran in which some plants such as Salsola Spp and Seidlitzia Sp usually grow depending on the water table (Ekhtesasi & Daneshvar. 1999). When I worked for Amirkabir institute in 1996, I came across an awful adventure explaining the role of pump extraction in some water and land management disasters as well as social – economical problems. There were some villages in southern Khorasan lying on the edge of central desert of Iran in which some peasants had settled and traditionally earned their living by camel husbandry. An organization had made a decision to help them start to cultivate their pastures in hopes that they could improve their economical situation. So the organization encouraged them to give up camel husbandry that was supposed to waste their time and energy. They started to drill many deep wells to pump water for the lands allocated to produce pistachio instead of camel husbandry. The extracted water contained some salt, and irrigation water that was not properly drained left a salt residue. The salt built up and finally led to a type of soil unusable for farming. According to the book Blue Gold, salinity has affected a fifth of the world’s agricultural land, and each year it forces farmers to abandon a million hectares of farmland (Barlow & Clarke. 2003). As a result, the aforementioned farmers had to stop planting the pistachio trees, because of the salty soil not letting pistachio grow. So they desired to return to the camel husbandry, but the environmental condition had changed so much that no animal could feed on such poor vegetation. In fact the pumps caused depletion of aquifer as far as the roots of some plants such as Alhaji which was the main food to camels could not reach the water. Therefore, there is no enough plant in the field in which their camels were supposed to graze. Unfortunately the farmers lost both agriculture and animal husbandry, and they had to immigrate to some principal cities as a community of poor suburbanites. I believe that after water management broke up in disorder and lost its traditional function, we faced some multidimensional problems which would remain unsolved unless we would modestly learn some lessons from tradition.

CONCLUSION

It is not wise to give up all modern technologies and revive tradition instead, but it is quite wise to adopt the sustainable relationship which has always existed between environment and the elements of the traditional production system. In the traditional agriculture, such an accurate water management perfectly met environmental conditions to make use of every drop of water in cultivating this arid region. Therefore, there are still many things we can learn from traditional water management to promote our new water affairs. Recently, in Iran some governmental centers' attention to traditional water management is tending upward. This gives glad tidings that future is not that disappointing if we learn how to have both tradition and modernity living side by side by meeting a unique purpose, and it is the golden key of the sustainable water management.

REFERENCES

1. Aboodalaf, 1975. Aboodalaf's Travel Account. Translated by Tabatabyi A. Zavar Publication. Tehran. P; 81-82
2. Azkia M. 1994. Sociology of Development and The Lack of Development in Iranian Villages. Ettelaat Publication. Tehran. P; 70
3. Baqeri M. and Roozbeh M. 1999. Economical Value of Qanat in Comparison with Well. In: International Symposium on Qanat. P; 293-302
4. Barlow Maude and Clarke Tony. 2003. Blue Gold. McClelland & Stewart. Ontario. P; 44
5. Enayatollah R. and others. 1971. Water and Irrigation Techniques in Ancient Iran. Ministry of Energy. Tehran. P; 214
6. Khosravi Khosrow. 1969. Irrigation and the Rural Society in Iran. Social Sciences Journal. Vol. 3. Tehran. P; 49
7. Labbaf khaneiki M. 1999. Postmodern Agriculture: Convergence of Modernization and Indigenous Technology. Geographical Research Journal. Vol. 58&59. P; 101-118
8. Lambton A. K. S. 1989. The Origin Diffusion and Functioning of the Qanat. Qanat, Kariz and Khattara: Traditional Water Systems in the Middle East and North Africa. MENAS Press. London. P. 6
9. Meftah Elhame. 1992. Historical Geography of Marghab/Marv/Marry. Historical Researches Journal. Vol. 6&7. Tehran. P; 71-132
10. Naghib zadeh A. 2000. An Introduction to Sociology. Samt Publication. Tehran. P; 64-65
11. Papoli Yazdi M. and Labbaf Khaneiki M. 2003. The Qanats of Taft. Cultural Heritage Organization. Tehran. P; 18
12. Papoli Yazdi M. and Labbaf Khaneiki M. 1998. Division of Water in Traditional Irrigation Systems. Geographical Researches Journal. Vol. 49&50. Mashhad. P; 49

13. Safinejad Javad. 1989. Traditional Irrigation Systems in Iran. Astan Qods Publication. Vol. 2. Mashhad. P; 244
14. Salimi M. S. 2000. The Legend on Creation of Qanat in Shahdad District. The Book of International Conference on Qanat. Yazd Regional Water Authority. Vol. 1. Tehran. P; 158-159
15. Velayati S. 1999. Critical Factors in Quality Changes in The Aquifer of Neyshaboor Plain. Geographical Research Journal. Vol. 58&59. P; 119-134