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Restoring the Qanats as a Traditional Water Transfer System: A Sustainable Approach

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ABSTRACT: In a wide range of the central boundaries of Iranian plateau, encompassing an important part of the arid areas in Asia, the phenomenon of desertification is a long history. In this arid and waterless expanse, living conditions are fully dependent on access to water due to the supremacy of the Kavirs and deserts. The most important and oldest ways for obtaining water has been Qanat or Kariz (underground water canal). Here, we show that Qanat is one of the most important environmental sustainable tools in the local-regional environments of the Iranian plateau. Qanat improves the unfavorable conditions of earth and the natural bed of the region along with its path and helps the ecological duration of the environment. At the end of its path, in the place of its rising (emergence), Qanat is regarded as one of the most original factors in shaping, formating and duration of microclimates. However, in view of the dependency on the biological, economic and occupational (vocational) activities, the presence of Qanat and its entry to the boundary of the flourishing conditions affects the durable formation and shaping social and economic activities in its habitats along with the preparation of the groundwork for durable ecological aspects. As a result, by collecting and classifying library documents through a qualitative analysis, this study tries to present solutions concerning the sustainable use of Qanat at present and in future through the emphasis on the effect of Qanat on various ecological and social aspects of its surrounding environment and the necessity of preservation and revival of this important human innovation as a historical heritage.

Keywords: *Qanat, Sustainablity, Irrigation system, Water.*

INTRODUCTION

Qanat is one of the main water resources in most of the desert places in Iran and has been the main concern of humankind in making villages and cities in the stated areas. Access to healthy and qualified water is always needed for producing food, striking ecologic balance, and living off animals and plants. Choosing Qanat over other methods of securing water has several advantages including the absence of poisonous substances in water, the futility of fossil fuel consumption, and the reduction of air pollution. Therefore, it is apparent that by regeneration of Qanat, deserted villages and cities could continue their life in a more sustainable manner.

This study focuses on “Qanat” as an Iranian sustainable traditional system and tries to answer the following research questions:

What are the sustainable benefits of Qanats?

How do Qanats have effect on its surrounding environment?

Whether is it necessary to preserve and revive the Qanats or not?

How can we preserve and revive Qanats?

Definition of Qanat

Qanat is one of the oldest structures made by man and has been used for carrying water flow in deserted plateaus of Iran. As it can be seen in figure 1, Qanat is defined as “a structure including a number of vertical shafts (bars and main shaft) and a slightly sloped subterranean canal which carries the water to lower lands without a need of any mechanic tools or electric energy, [and simply] by using gravity energy” (Ghazi, 2002, 122).

In practice, a qanat consists of a series of vertical shafts in sloping ground, interconnected at the bottom by a tunnel with a gradient more gentle than that of the ground. The first shaft (mother well) is sunk, usually into an alluvial fan, to a level

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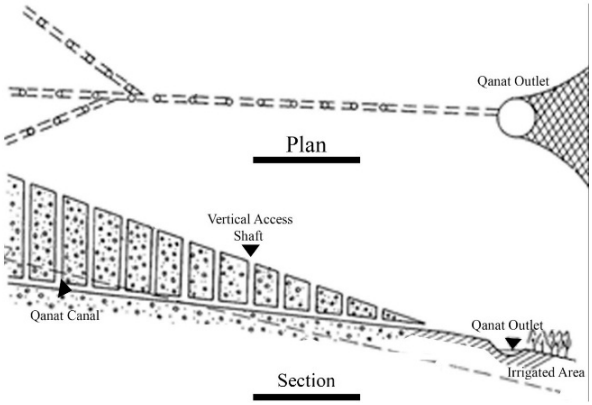

Fig .1: General Schematic for a Qanat. (Source: Waterhistory, 2016)

below the groundwater table. Shafts are sunk at intervals of 20 to 200 meters in a line between the groundwater recharge zone and the irrigated land. From the air, a qanat system looks like a line of anthills leading from the foothills across the desert to the greenery of an irrigated settlement. (Hamidian et al., 2015) Qanat is a symbol of Iranian endeavor and sustainable planning. Iranian indigenous people used to dig the shafts with lots of problems and then block its entrance with soil to prevent any contamination. Pitmen occasionally faced problems such as encountering massive cliffs, and the downfall of the shaft's walls, etc (Fig .2) (Rashedi, 2016, A). Therefore, using tools like windlass, Bookan[1], Dabil[2], Chapar[3], and Kaval[4] has extremely been the requisite. (Fig .3)

Digging was usually operated in a way that water flow was from aquiferous location to non-aquiferous location. For this aim, Qanat used to be operated in 3 different lands, including mountainous, colluvial, and flatland. Usually, flatland Qanats are the long ones which are not depended on annual rainfall. Mountainous Qanats, on the other hand, are short ones which are more depended on annual rainfall (Mostafa pour, 2012). Therefore, a sustainable planning could be done for flatland Qanats, but a precise scrutiny on rainfall graphs of the place is needed for implementing other types of Qanats.

History of Qanat

Iranian culture has always put emphasis on the importance of water. This liquid is considered holy in ancient history of Iran. It is believed that water has been created after the sky and before animals were on the earth. A symbol of this respect to water could be seen from paintings left from ancient civilizations (Wilber, 2004, 12).

In the Ashkanian period in Iran, digging Qanat was a business,

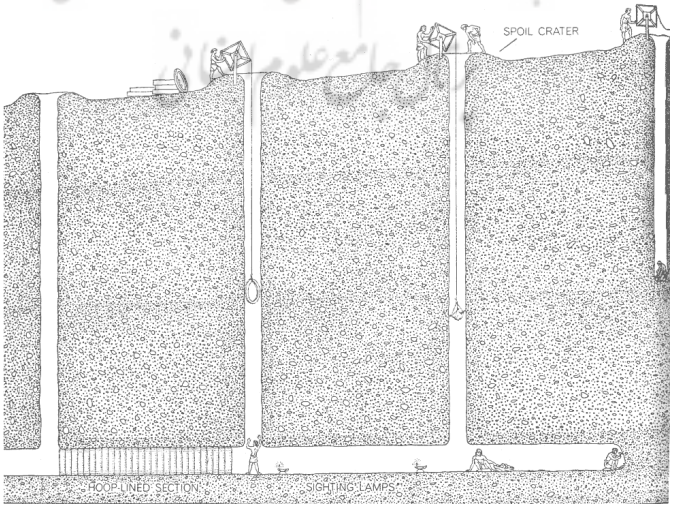

Fig .2: Constructing a qanat using reinforcing rings. (Source: Waterhistory ,2016)

Fig .3: Windlass as a main implement of shaft digging. (Source: Rashedi, 2016 A)

especially around Silk Road. People in Sasani dynasty brought Qanat's industry and technology to western parts of Persian Gulf. They also created an official system for managing water resources. After Islam's initiation, the first signs of digging Qanat could be traced in Mecca, which is repeatedly cited by "Hamdollah Mostofi[5]" in his book "Nazhatol gholoob". A book was written by an Iranian engineer, i.e., Aboobakr Mohammad Ebn Taleb Karaji, on Qanats' structures in the 4th century (on Persian Calendar), which is a masterpiece in its own field. Afterwards, in all dynasties, Qanat played such an important role, and you can find out that there were offices and organizations with the responsibility of managing water resources (Bagheri, 2000).

In Ilkhanian dynasty, there were certain authorities for this aim. Sharden, famous French rubberneck, has written about this fact in his book.

In all these periods, Qanat has been quite versatile; it was used to carry water, water the farms, gardening, and permanent housing. Qanat has also changed the structure and appearance of some cities like "Tabas[6]" and "Meybod[7]". To sum it up, we have to admit that Qanat has played a significant role in all social and ecological aspects and brought about environmental sustainability.

Spread of Qanat in the World

Researchers have approved the existence of Qanats in 33 countries, including:

Asia: Jordan, Afghanistan, UAE, Pakistan, Turkey, China, Syria, Iraq, Saudi Arabia, Oman, India, Yamane, and Iran.

Africa: Aljazeera, Tunis, Libya, Marrakesh, and Egypt.

Europe: Germany, Russia, England, Spain (Carrión, & Antonio, 2016) , Czech, Slovakia, Cyprus, and France.

America: Peru, Chile, Mexico. (Behnia, 2005)

According to the last statistical data from 1998, there are 32,164 active Qanats discovered, from which a total amount of 9,823,000,000 m^3 is being produced in Iran. About 77.7% of these Qanats are situated in eastern part and 22.3 in the western part of Iran. Biggest centralization of Qanats could be seen in these provinces: Khorasan, Kerman, Yazd, Isfahan, and Azerbaijan. (The Persian qanats, 2016)

MATERIALS AND METHODS

This is a qualitative study in which a combination of analytical-descriptive research method and citation research method has been used. Therefore, using a library method and authoritative writings and the internet resources, a wide range of sources related to Qanat was studied. By comparative study, deductive and inferential methods were used to analyze Qanat aspects.

Qanats' Sustainable Influences

Development was generally considered to be an economical factor until the late 1970s, but from 1980 other factors such as politics, culture, and environment started to gain importance and soon transformed to become requisites for development. There has never been a fixed solution to sustainable development for the whole world. These solutions are set depending on the environmental and cultural status of that country. The main purpose of sustainable development is to obtain the basic needs of people (Ebizadeh, 2011). Paying attention to natural settlements and enhancing the living quality are also among very important specifications of sustainable development.

Therefore, these kinds of planning could lead to sustainable

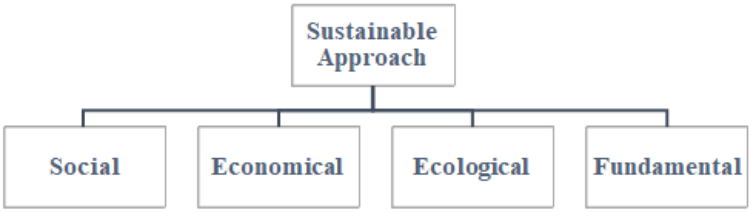

Fig .4: Dimention of Sustaiablity approach.

development:
The ones that have independent prospect;
They're inductive to important matters like housing and food and water security for everyone;
They're based on man's creativity and important inventions.
They help indigent people, who are deconstructive for their environment International Union for Conservation of Nature (IUCN) defines sustainable development as enhancing quality of life with the support of the ecosystem and addressing issues such as eradicating poverty, food security, health, education, gender equality, water supply, access to energy Sustainable economic growth, flexible infrastructure, reducing inequalities between countries, sustainable consumption and production, and climate change. (Mahan, 2016,74) The definition outlined in Brentland's report covers a comprehensive overarching concept of sustainable development: "Development that enables today's needs without losing the ability to respond to future generation needs" (Soltani & Namdarian, 2011). In the above definition, special emphasis has been placed on the three key words "development", "needs" and "future generations. (Fig .4)
In the following sections, we have tried to define Qanats' sustainable influences on their environment.

RESULTS AND DISCUSSION

Social Impacts of Qanat on their Environment

Qanat is known as the main water resource in many cities and villages. And therefore cultural and social relations have been formed through the use of Qanats. Some of the most important social impacts are listed below:

Formation of new occupations: Using water resources and distributing water have been one of the main concerns of people, especially in desert rustic areas. Consequently, different jobs related to water formed. Big variety of this sort of jobs reminds us of the importance of water and Qanat in these areas (Ahmadi, 2005).

Formations of traditional co-ops: Maintenance actions are necessary for Qanat in rustic societies due to extensive use. Therefore, different co-ops have been formed for management of people's volunteer co-operation.(Irani Behbahani et al. , 2012)

Amplification of negotiation culture: In Qanat -depended societies, especially villages, people are directly relied on Qanat to run their life. So face-to-face relationships between water distribution authorities and people are very common. Also, attendance of stockholders in decision making procedure strengthens the culture of negotiation. (Ghaffari, 2005)

Amplification of parsimony culture and efficient use: Lack of raining and water resources has made people watch their consumption models more than ever. Thus, parsimony and correct usage of resources has become a part of the cultural body of people living in these areas.

Cultural independence (not allowing new people in): The amount of acquired water from Qanat is restricted and enough for a specific number of people. Qanat cannot produce enough water for any extra users or extra farms. Therefore, in large scale, it's quite impossible to take in people other than indigenous. This specification supports native culture and prevents any turmoil caused by the mixture of cultures. It also leads to more sustainability in prices (Ghaffari, 2005).

Segregation of different social levels: Streams with more amount of water are devoted to bigger farms and gardens. Quality of land and soil and also ground's slope define how qualified a garden or farm is; the reason is that the slope determines where the water goes. Therefore, people with a better financial situation own bigger fields, and are centralized in specific areas, but people in lower financial levels are gathered in other places.

Economic Impacts of Qanats

A staggering number of Qanats in Iran and the amount of their produced water remind us of a massive system, in which a big number of water networks exist. Thus impacts of Qanat in Iran are apparent. Here, some of such impacts are discussed:

Qanats, drinking and farming water supply: One of the main reasons for digging Qanat is bringing water to places with a low level of rainfall and water resources. The water produced by Qanat hasn't been used only for farming purposes, but also for drinking. For instance, since recent years, Qanats were the main drinking water resources of people living in some neighborhoods in Tehran, the capital of Iran. This water was produced from steeps of Alborz mountain range (Ahmadi, 2005). Producing water is very crucial in any place of a country, but it has much more importance in islands spread in the Persian Gulf. A part of their drinking water is produced by Qanats.

Watermills: In some parts of Iran, Qanats are operated in steeped lands. Watermills are made in the way of canals of

these qanats in order to take advantage of water's speed and energy to operate them. This decreases their dependency on fossil fuel and helps us have a better environment.

Qanat increases the value of a property: If a property includes one or more Qanats, its price will be much higher in comparison to those having no Qanat.

Living fish in Qanats: There are fishes living in almost all Qanats in Iran. These fishes are just healthy and have a normal color. Indigenous people don't know about their originality and where they come from. These fishes are mostly seen in spring and summer.

Qanat and tourism industry: Qanat could become interesting places for people to make adventures. There are usually tales about how Qanats are made in different places and this could sound attractive to people visiting them.

Sustainable Energy Production: Utilizing the current water energy available on the channel and turning it into energy for the people can be a source of cheap energy. A large number of mills in the aqueducts will allow the aquarium to be used continuously for sustainable and cheap energy production.

Therefore, according to aforementioned items, Qanats affect different aspects of a place's economy and cause more income along with a dramatic decrease in expenses.

Ecological Impacts of Qanat on the Environment

Along with supplying healthy and pure water, Qanats cause different creatures including mankind to live more constantly, having no negative impacts, help strikes the better balance in the field of ecosystems.

Reclamation of deserts by Qanats: There exist some big deserts in Iran. In many of the cities situated in these areas, Qanat is the only way of producing water. The water produced from these Qanats helps gardens form and has made the desert life no more severe.

Striking continental balance by Qanats: According to experienced occasions, the existence of Qanat has made the farming in desert areas more balanced. Destruction of Qanat in recent years has led to the destruction of continents themselves. This sad destruction of Qanat has caused many cities or villages to become empty and has made ruins out of each. (Mohammadi et al., 2014)

Separating the salt from salty soil: Running the water streams out of the ground, Qanat also makes salty soils not containing that much salt as they used to have. In other words, Qanats help strike a balance in the salt spread (This happens in shallow Qanats) (Ghazi, 2002, 125).

Qanats affect herbaceous ecosystems: Access to water makes plants living longer in an environment. Enough farming water helps plants grow better in an area; these places are covered by more plants. As a result, herbaceous ecosystem won't leave any bad impacts on the neighbor ecosystems and will establish these natural statuses:

Makes biological diversity and keeps it;

Makes indigenous plants grow: there are very rare species with unique genetic specifications. These species grow when enough water is applied and the environment is conducive to their growth;

Prevents the extinction of some specific species: the existence of Qanat will keep the species' diversity and makes them strong. This feature especially works for herbs;

Prevents erosion: when a place is covered by varied plants, this will help the soil to become more fixed and erosion will be less likely to occur. (Rezaei, et al., 2015)

Qanats support animal ecosystems:

Qanat eases the access to water for wild and domestic animals. Therefore, Qanat supports their ecosystem. Here we address some positive influences of Qanats on the animal ecosystem;

Increase in the number of domestic and wild animals: Qanat supplies needed water without cutting their natural relationships, so they will find the opportunity to increase their population;

Qanat can become a shelter for animals against the warmth of the air. Shafts of Qanat can be good shelters for birds;

Prevention of native species' extinction: When Qanat is regenerated in a place, animals will reach water easily and get stronger and in this way their resistance will become much more than before. When they are stronger they'll be able to live longer and more sustainable. This method decreases the expenses of getting water to endangered species as much as possible;

A good place for living fishes: Settled water in Qanat is a good place for fishes to live and fertilize;

Better quality of meat and dairy products: When living place of animals has satisfactory quality, their produced meat and milk will be healthier and won't cause usual illnesses (Ghaffari, 2005).

Fundamental Impacts of Qanat on the Environment

Determination of cities and villages urban texture: Because Qanat is the main water resources of people living in desert, they have made houses near Qanats to have better and easier access to them. This will increase the aggregation of houses and decrease the size of the lands;

Determination of vulnerable houses architecture: Proximity of houses to Qanats and their compatibility for letting the water stream from inside the houses has caused a new urban architecture to form. Different structures and buildings like "Godal Baghche[8]", "Ab Anbar[9]" (Fig .5), "Padiave[10]" have been also made for easy use of the Qanats and storage of water that have unique architecture;

Determination of Iranian gardens' shape: When Qanats established in desert areas in Iran, gardens have found a new appearance; their size or location is mostly determined by the amount of produced water and slope of the ground (Fig .6). When water is passed from inside a garden, the Iranian landscape architecture has created beautiful fountains and streams to change the atmosphere of the garden.

Results

Reconsideration and Regeneration of Qanats

Fig .5: Ab Anbar. (Source: Rashedi, 2016 B)

Fig. 6: Shazdeh Mahan Garden in Kerman, Iran. (Source: Rashedi, 2016 B)

Table 1: Sustainabile Impacts of Qanat.

Sustainabile Impacts of Qanat			
Social impacts	Economical impacts	Ecological impacts	Fundamental impacts
Formation of new occupations	Qanat s, drinking & farming water supply	Reclamation of deserts by Qanat	Determination of cities and villages urban texture
Formations of traditional co-ops	Watermills	Striking continental balance by Qanat	Determination of vulnerable houses architecture
Amplification of negotiation culture	Qanat increases the value of a property	Separating the salt from salty soil	Determination of Iranian gardens' shape
Amplification of parsimony culture and efficient use	Living fish in Qanat	Qanat affect herbaceous ecosystems	
Cultural independence	Qanat and tourism industry	Qanat support animal ecosystems	
Segregation of different social levels	Sustainable Energy Production		

As it became apparent from four discussions above, Qanat is known as a sustainable and green creative complex, which has influenced the lives of people living in the central parts of Iran. This creative innovation of the mankind has made the societies culturally and economically independent from outside but has no negative aspects.

Supplying constant pure water, Qanat has increased the hygiene in these places and have prevented many endangered herbaceous species from extinction. Qanat doesn't need fossil fuel to flow the water and gravity makes it flow through the canals.

Therefore, Qanat could be considered as sustainable long-term vision, by which quality of living would increase and ecosystems will be kept. Unfortunately, nowadays deep shafts are common among methods of producing water, so using Qanat might seem to be useless. Therefore, many Qanats have been totally destructed and are no more operable. Using a big number of deep shafts is decreasing the amount of subterranean water dramatically. The profits of using Qanat because of its long-term vision must have become apparent up to now. Therefore, it seems wise to regenerate Qanats and reuse it on a big scale.

In order to make Qanats common again, upholding these principles could help:

Education: Education is the most important step to make people aware of superiorities of Qanats over other methods of producing water. People, as consumers of water, should be fully aware of challenges and threats in the field of producing water, and so they can be effective in the preservation of water resources. Experts in the fields of ecology, hydrology, landscape architecture, etc. can make people aware by forming associations to teach people;

Communion: knowing the exact definition of sustainability and sustainable development, people can form unions to make and use Qanats more efficiently. People's communion is very economical and supports ecological sustainability;

Management and planning: the government should make long-term planning for regeneration of Qanats. For making such planning, experts from fields of ecology, economy, sociology, and fundamental should cooperate but ban deep shafts. The government should also secure the needed budget to motivate citizens for co-operating; it should also involve the private sector for investing in this field. After passing courses on the regeneration of Qanats and sustainable development, the private sector can invest on one or more of these items:

Making workrooms in the way of under-construction Qanats for producing necessary materials. These workrooms can use the mechanic energy of the water;

Using the water of Qanats for fish farming;

Introducing farms and gardens;

Introducing ranches and meat producing units;

Introducing big old Qanats as tourist attractions and Iranian architecture innovation;

Introducing botanic gardens for growing plants exclusive to specific places.

CONCLUSION

Having an overall observation of discussed subjects, we can easily come up with effective answers to questions of this study: In the first place, surveying the effects of Qanats on their environment makes it transparent that: Paying extensive attention to the regeneration of Qanats will make sustainable steps toward social, ecological, financial, and skeletal goals. Furthermore, Qanats should be considered as some sustainable creations, by which desert civilizations can gain independence, healthy water, environmental hygiene, and ecological balance in long-term. Bearing in mind the bad effects of the modern method of producing water, such as deep shafts, regeneration of Qanats seem to be productive and reasonable in the current situation. In order to expand the use of Qanats in modern societies, following guidelines could appear to be effective: education, planning, effective management, incentives for private sector to invest on the regeneration of Qanats, and researchers.

ENDNOTES

1 - A space like an underground room where indigenous people live there during shaft digging

2- Digging the shafts inversely (from underground to surface)

3- A wooden umbrella that indigenous people use above their head for preventing from stone and soil slump

4- A concrete round things that use in aqueduct's walls and floor for make them safety

5- A Persian historian, geographer and epic poet (1281-1349)

6- A city that located in east of Iran

7- A city that located in centar of Iran

8- In the pattern of Iranian traditional houses, yards located downer than the surface of ground, therefore people can use water of aqueducts easier and make a green place

9- A public places for reaching cool water in residential neighborhood that located underground.

10- A place in Muslim religious building especially in Mosque for clearing themselves by water.

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