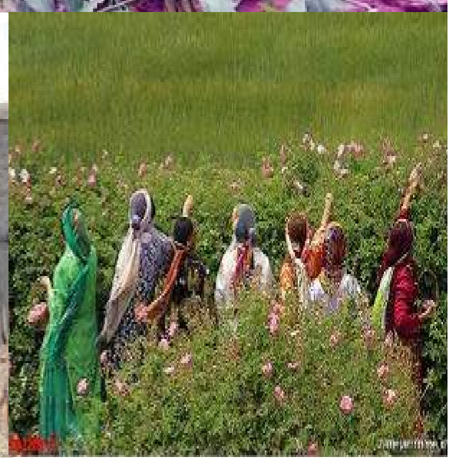
Proposal for a
Globally Important Agricultural Heritage System (GIAHS)

Qanat Irrigated Agricultural Heritage Systems
of
Kashan, Isfahan Province
Islamic Republic of Iran

April 2014



SUMMARY INFORMATION

Name/Title of the Agricultural Heritage System : Qanat Irrigated Agricultural Heritage Systems
Requesting Agency/Organization: Ministry of Jihad-e-Agriculture
Country/location/Site: Kashan Township, Isfahan Province, Islamic Republic of Iran
Accessibility of the site to capital city or major cities: Kashan is located 240 km south of Tehran, and with almost the same distance in the north of Isfahan. A highway connects Kashan to each of these two major cities in about two hours.
Approximate Surface Area: 4,650 square kilometers
Topographic features: The western and southwestern parts of Kashan are mountainous, whereas the eastern and northeastern parts are desert. A vast plain connects these two parts.
Climate Type: Dry and arid, with moderate winters, and dry and warm summers.
Approximate Population: 350,000
Main Source of Livelihoods: 50% industries, 25% agriculture, 25% services.
Summary Information of the Agricultural Heritage System: The most important agricultural systems such as Pomegranate, Pistachio, and Saffron farming systems are irrigated by Qanat. The geographical regions around the Central Desert of Iran which is also one of the most traditional agricultural areas have been using the Qanat technology for providing water for agriculture and human consumption for thousands of years. The Qanat Irrigation technology and related knowledge system have developed in Iran as early as 800 BC and the Kashan region is the land of one of the oldest human habitat in Iran and is also one of the origins of Persian agricultural civilization irrigated by Qanat system. Qanats have sustained food and livelihood security over millennia by providing reliable source of water to traditional family farms in most dry areas where agriculture and farming would be impossible otherwise. By making it possible for humans, plants and animals to survive in the harshest climatic conditions, Qanats have supported important biodiversity particularly ancient varieties of pomegranate, figs, pistachio, apples, apricots, and other fruits and vegetables, medicinal plants as well as many livestock breeds. Ingenious water distribution and management systems as well as social and cultural practices have allowed the development of the most ancient agricultural civilizations in Iran, Central Asia, China and elsewhere around the world. The community participatory water management schemes have brought cohesiveness, solidarity and strong sense of fraternity to the local communities. It is an efficient system that optimizes water use, providing quality water and crop diversity. Underground tunnels following aquifers in surrounding mountain areas collect water from different layers of earth by relying only on gravity. The Qanats minimize evaporation loss and ensure an efficient use of the available water resources. The construction and maintenance of Qanats requires skilful workers and cooperation among the community members. Farmers select diverse crops that complement each other in terms of water requirement for the best water use efficiency. Not only for agricultural developments, Qanats have and represents a unique and integrative system illustrating the use of indigenous knowledge and wisdom in sustainable management of land, water, and agricultural biodiversity. The Qanat Irrigated Agricultural Heritage Systems are uniquely designed, demonstrating a close relationship with nature, culture, and the capacity of the environment that surround it and more importantly, the underlying sustainability and productivity principles.

Table of Contents

I. CHARACTERISTICS OF THE PROPOSED GIAHS

The geographical regions around the Central Desert of Iran, including Yazd, Kerman, Bam, Birjand, Ghabel, Ferdows, Gonabad, Tabass, Kashmar, Sabzevar, Semnan, Damghan, Garmsar, Kashan, and the old Tehran, have been using the technology of Qanat for thousands of years. Kashan is an important site in relation to qanat for the following reasons:

- Historical importance: Kashan is the site of one of the oldest human settlements in Iran, as discovered in the archaeological surveys of the ancient (7,000 years old) Sialk Mound. This settlement relied on Chesmeh Suleimanieh, which is the outlet of the Fin Qanat. Human habitation in Kashan still depends on groundwater resources.
- Potential for revival: To date, a large proportion of the water requirements for agricultural and other purposes in this region are still met by about 473 active qanats.
- Accessibility: Kashan is well connected by both highway and railway to the capital city Tehran and the Isfahan metropolitan. It is less than three hours distance from each of these two large cities.
- Kashan is in the middle of an area where some of the most impressive qanats in terms of architecture, structure, indigenous knowledge, etc. examples are the Moon two-staged Qanat, the Qanats of Telkabad, Abuzeidabad and Vezvan (with underground dam).

Kashan Township is situated in a climatically dry and arid region. The annual rainfall is 153.1 mm and the annual rate of evaporation exceeds 2,800 mm. Kashan has moderate winters, and dry and warm summers. Kashan lies between two extensive areas, pertaining to agriculture and underground irrigation: The northern and northwestern parts comprise the desert. The mountainous region, extending to the southwest, is the main source of water from springs and qanats. The topographical conditions are well suited to the construction of qanats. The plains on the foothills, on the edge of the desert, have been the site for human habitation for several centuries. There are 473 qanats in the Kashan region, which vary in type, size, flow, and water source. The depth of the mother well in Kashan's qanats varies widely from 5 meters to over 45 meters. A short description of the Qanat technology is provided in Annex 1.

The Qanat water is fresh water with low content of salts and undesirable minerals. There are two main reasons for better quality of water delivered by qanats, as compared to other systems, including pump wells:

- Qanats do not draw water from the bottom of aquifers, but from the top. Whereas, deep wells with pumps are normally constructed to maximize water output from aquifers, and normally reach close to the bottom of aquifers (That's why the life span of wells are less than 20 years while there is no time limitation for life span of a Qanat). The force used in pumping water needs fossil fuel energy and takes the soil and fertility along with the water. The natural gravity system used in Qanat has resolved this issue.
- Water flowing over long distances in qanats results in gradual sedimentation of suspended matter, and therefore self-purification.

Crops irrigated with qanat water are of better quality and more resistant to drought. Qanats in the Kashan region are associated with growing a variety of fruits and crops, some of which are unique and famous in the whole country for their special quality, flavor or other unique characteristics: The *Fin* and *Zaghe Yaghuti* pomegranates, *Qamsar Muhammadi* rose flower, *Lat-hor* cucumber, *Majdabad* tobacco (also known as *Kashan* Tobacco), pears, almonds, plums, cherries, walnuts and apricots. About 100 percent of cherries, 95 percent of the *Muhammadi* rose flower, 95 percent of walnuts and almonds, 95 percent of berries, 70 percent of plums, and 35 percent of pomegranates produced in the region depend on qanat irrigation system.

Qanat irrigated agriculture in the Kashan region have formed, over millenniums and is a system that has brought about food and livelihoods security to the people living in the region, while supporting the conservation of the resource base and enriching the biodiversity. This system is evolved through the collective and individual indigenous knowledge of the local people built up over time.

1. Food and livelihood security

Shortage of water in the eastern and central parts of Iran is a major limitation for development of agriculture and livelihoods. This has been overcomed by the construction of qanat systems. In the absence of adequate rainfall and reliable permanent rivers and surface waters for complementary irrigation, qanat acts as the source of food security and livelihood for the local communities. They are the main source of water for both rural and urban uses, ranging from agriculture to household consumption.

About 75 percent of the water requirement in Kashan is supplied from qanats (127 million cubic meters) and springs (23 million cubic meters). The rest is supplied from 432 pump wells. This signifies the critical role of qanats in the food security of the region even today. In total, about 100,000 tons of field crops are produced in Kashan, in an area of about 7,350 hectares. The total production of fruits in the region amounts to 32,000 tons, in an area of about 7,000 hectares. Figures on the area and production volumes of the fruits and crops grown in the region are presented in Annex 3.

Animal husbandry, too, is an activity in the Kashan region that largely relies on qanats. There are about 230,000 small ruminants, such as sheep and goats, 23,500 head cattle, 200 camels, and 15,000 honey bee hives in the region. Many of the animal breeds and races are indigenous and unique from dryland areas of Iran with outstanding resiliencies to drought and climatic variability. Additionally, as they are free range befitting from rich natural agro-pastoral systems, they provide high quality and organic products. Post-harvest grazing of the farms that brings natural fertilization to crops is a long established pattern in Kashan.

There are about 20,000 farmers in Kashan, who are linked to qanat directly or indirectly. The dominant farming system in the region is small holdings and family farmers. The average farm size in the region is about 0.7 hectares per farmer family. The qanat irrigated agriculture system is evolved in way that typically the farm size seldom becomes large. The reason is mainly due to the fact that qanat technology was based on collective work, which in turn determined the amount of water and land available for each member of the community. Therefore, the livelihoods brought about by the qanat irrigated agriculture systems is inclusive and covers a relatively large number of people.

The Suleimanieh spring of Fin Qanat alone supports 3,000 farmers holding 10,000 shares. The water discharge of this qanat is currently 200 lit/sec, down from 400 lit/sec in the past. An interesting fact about the Fin Qanat is that almost all fruits and field crops existing in the region are grown on the farms covered by the irrigation from this qanat. In fact the agro-ecosystem of this qanat is a miniature of the whole agricultural facet of the Kashan Township.

Besides directly contributing to food security by providing reliable irrigation water, qanat irrigated agricultural heritage system helps to sustain food security through retaining and protecting the resource base. Qanats collect water from distant and different layers of earth, and keep the underground water level at a reasonable balance, never depleting its source, which is unfortunately the case with deep wells using pumps. When using qanat water, lower amounts of water are needed. For example, for cultivation of one Jerib (625 $m^{2)}$ of hay, only 2 kg of seed is needed whereas if the same crop was to be irrigated using pumping water, 12 kg seed would be needed. Well pumping water has higher salinity, which affects the quality and productivity of crops (especially those that are cultivated in spring).Therefore, with qanat, depletion of underground water resources is prevented even during frequent severe droughts.

Without the qanat irrigated agriculture, the very existence of many villages would not be possible andmany villages were built in areas where there is a Qanat. That is why there are numerous villages in Iran that take their name from qanat (*Kariz*), eg. Kahrizak or *Kariz*-ak, *Kariz*-abad and *Kariz*-no.

2 Biodiversity and ecosystem function

The qanat system has made it possible to grow an astonishingly number of species, biodiversity and genetic resources of importance to food and agriculture in an area which is supposed to be barren or very sparsely vegetated. Indigenous and important biodiversity species, high value crops, fruits and trees have developed and survived thanks to qanat technology, and still are widely maintained and cultivated: the pomegranates, rose flowers, almonds, plums, walnuts, apricots, vines, pistachios, quince, olives, apples, cherry, figs, sour cherry, saffron, pears, peaches, and date plums. Surrounding these agricultural heritage gardens are the cultivation of variety of field crops i.e. maize, wheat, pulses, cereals, pea, beans, potato, alfalfa, clover and other forage crops, eggplant, okra, onions, tomato, melons, water melons, cucumbers and other summer crops as well as cotton, tobacco and other industrial crops (See Annex 3). In total, about 32 types of different field crops and 20 types of fruits are produced in the region.

One of the most important biodiversity cherished in the history is the pomegranate, called the "*fruit of paradise*", "*the seeds of hope*", and many other known phrases, whose legends and myths were told and transferred from generation to generation. The pomegranate is cultivated in Iran since ancient times. In Kashan, there are about 2,100 hectares of pomegranates of superb local variety. Due to the quality and special characteristics of the Kashan pomegranate, the majority of the annual production is exported. The livelihoods of about seven thousand families in Kashan rely on pomegranates.

Pomegranates are not just fruits, they are highly valued and indispensable, and have several uses, i.e. variety of dishes, cooking, baking, juices, dye for the famous Persian carpet, medicinal purposes, etc.

Figure 1. The pomegranate varieties and fruits

The role of qanats in sustaining this biological diversity of Kashan in particular, and the country in general, can also be illustrated with the example of the Qanat Qazi. The diversity of crops cultivated by the farmers in the downstream of Qanats Qazi was reduced by 75 percent when the water discharge of the qanat declined to one-third. Hence, the key to crop diversity in the region is attributed to the traditional knowledge of the qanat system management, which links irrigation water distribution to agricultural management, ensuring continuous biodiversity conservation and management according to indigenous knowledge of dry and wet year season forecasting.

Figure 2. A forage crop farm on Qanat Qazi

Kashan is also rich in the flora of wild species. Some of the species found in the region are endemic, rare or botanically important. As its name shows, *Cousinea kashanensis* (Asteraceae) is introduced to the world from Kashan. Some of the species endemic to the area, the Central

Deserts, or Iran include: *Anthemis gayana*, *Aphanopleura breviseta* (type specimen collected from Yazd to Isfahan), *Ducrosia anethifolia* (type from Kashan-Tehran road), *Echinophora platyloba* (type from Tehran), *Echinops cephalotes*, *E. elymaiticus Euphorbia malleata, Ferula Hirtella* (type from Yazd to Kerman), *Linaria michauxii* (type from Delo), *Nonnea suchtelenioides, Onosma demawendicum, Paracaryum cyclhymenium (*type from Shahroud*), P. Persicum* (type from Persepolis*) Pycnocycla spinosa* (type from Isfahan), *Anabasis, calcarea*, *Anthochlamys multinervis, Nepeta prostrate, Benth sessilifolia, Salvia eremophila*, *Samoliflorum Heliotropium* (type from Kashan-Qom), *Reseda buhseana*, *Tanacetum lingulatum* (type from Isfahan). About 240 selected plant species recorded from the Kashan region are enlisted in Annex 4.

The local sheep races differ in the plains and the mountainous areas. In the deserts, mainly the local Baluchi and Naeeini races are reared, while in the mountainous areas, the Lori, Afshari, and Qomi (also called Kabude Shiraz) are dominant. Due to the region's diverse flora, the honey produced in Kashan is of a very high quality.

Figure 3. Transhumant and nomadic pastoral systems in desert areas

Qanat waters are also inhabited by about 25 different species of fish, crabs, aquatic plants, invertebrates, and aquatic insects. In 2009, a new species of fish, named *Albominoides qanati* was reported from the Kerman qanats to the fauna of the world. The blackfish species *Gambusia holbrooki* is unique to the qanats of the Eastern Iran.

The suitable water quality (in terms of EC and hardiness) and the currency of the qanat waters are influential in sustaining the diversity of the aquatic life.

Recently, a number of aquaculture projects were initiated to use qanat waters to produce fish. Trout fish proved to be highly productive in qanat waters. The manure produced by the fish helps in fertilizing the farmlands. In Qamsar area of Kashan, the farmers stir the water in the ponds before their turn of irrigation so that more nutrients are conveyed to their fields.

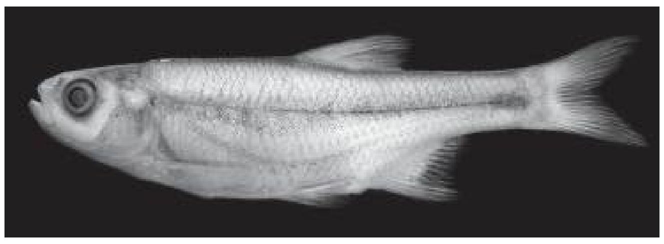


Figure 4. Albuminoides qanati

Figure 5. Cousinea kashanensis

3. Knowledge systems and adapted technologies

3.1. Participatory water distribution and management system

The Participatory approach to qanat water distribution and management system is an example of how carefully the local communities can design and operate land and water utilization systems incorporating all the economic, legal, ecological, social, and technical aspects in a way that the resiliency and the sustainability of the system are assured for centuries.

The basis of the qanat water distribution system is that the water is used according to the share that each farmer owns. In other words, one can only use as much water as he owns the right to do so based on the land area he is cultivating. In general, the right to water varies from few minutes to few hours. The main point is that the cultivation system is very dependent on the water distribution system and thus, every farmer only cultivates the area of land that he is able to irrigate with his share of water. As a result, no crop is left without being adequately irrigated.

Until the recent years, when the ecological carrying capacity of the region started to be violated, there was always a balance between the right of water and the cultivated land area. With division of water shares from generation to generation, this balance has been preserved throughout centuries. Fairness of this water distribution system is due to the fact that every land owner depending on where his land is located (distance from the spring of qanat, quality of the land itself, etc.) will get his share of water. In fact this is the reason behind the division of land into smaller pieces and their fair distribution (every farmer might get a mixture of good and bad quality lands).

The informal but highly respected community organizations, mechanisms, and arrangements established over centuries by the local communities for distribution of the qanat water are the basis for a fully functional water distribution system.

Figure 6. Consultation among the members of the local community is the basis of the qanat irrigation water management system

In this system, a *Sartagh* is in charge of distributing water between owners during the 12 hours of his supervision. This position is inherited from father to son and in general *Sartagh*s are well respected by the farmer community.

The *Sartagh* together with the *mirrab* (water distributor of the entire qanat) divide and control the intensity of the water flow into the downstream on a pool at the source of the qanat, known as *salkh* in Kashan, or *talkh*, in some other areas. A *sartagh* represents the interests of his community in the allocation of their *tagh* or 12 hours of water. The *mirrab* is responsible to all users and is well trusted and respected also.

The unit for water division is called *sereje* (which equals approximately 9.6 minutes) and 72 *sereje* forms a *tagh*. Every 12 hours is called a *Tagh-ab*. Each *tagh* is a unit for irrigation that is supervised by the *Sartagh*. People of the same *tagh* usually also help each other with the cultivation on a rotation basis.

Within each *Tagh-ab* the rights to water are equally divided such that the turn for irrigation at each rotation (or *Madaar*) will shift.

Such collaborative work can be observed not only in the irrigation system but also in other activities related to agriculture and rural societies. There are strong relationships between people of the same *tagh,* which also affect their daily life together.

Every two days and nights or every four *tagh*s forms a *Blook*. In the past there used to be a person in charge of each *Blook,* called *Sar-Blook* but now the unit for collective irrigation is *tagh* which consists of a system of *Boneh* between owners and farmers.

Normally farmers belonging to the same *tagh* respect the decision of the *Sartagh* regarding the kind of crops to be planted. The *Sartagh* is also responsible for collecting the cost of dredging and renovation of the qanat. Description is provided below:

Sar– Blook		Basic Unit of a Blook (48 Hrs)	
(24 Hours) Day & Night		(24 Hours)Day & Night	
Tagh (12 Hours)	Tagh (12 Hours)	Tagh (12 Hours)	Tagh (12 Hours)

Figure 7. Irrigation water rotation applied in Qazi Qanat

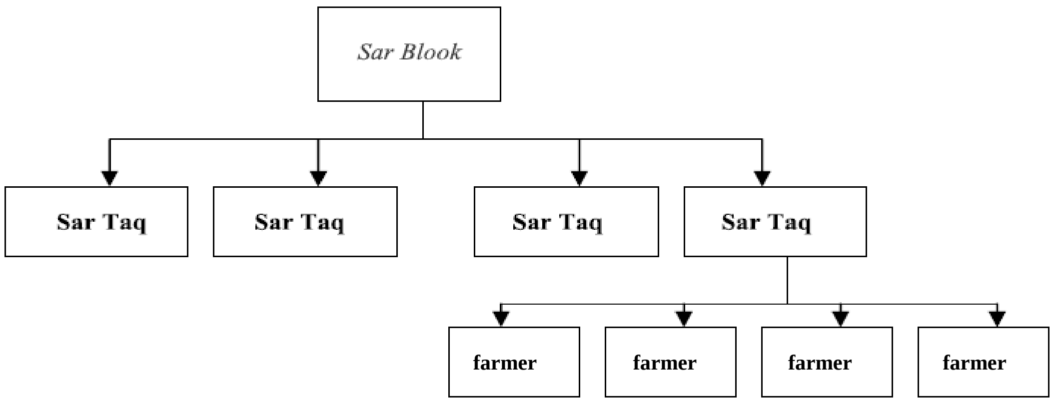


Figure8. The relationship between Sar Taq, Sar Blook and farmers

3.2 Enhancing participatory region-wide agricultural decision making – the role of the Qanat Irrigated Agricultural Heritage Systems

A very important service brought about by the Qanat Irrigated Agricultural Heritage Systems is the formation of a highly prestigious, respected and intelligent *region-wide participatory agricultural decision making system* capitalizing on the holistic management system of land and water.

In this holistic system, the *mirrab*, who constitute the backbone of the qanat irrigation water management system, are also given the task to plan the cropping pattern. Each one or two years of cultivation the land is left for fallow. A part of the land adjacent to crops is reserved for orchard in alternate plots. One crop may be cultivated by everyone one year and varied the next year. When there is adequate supply of water, two or three types of crops may be cultivated annually.

This collective system of agricultural planning also compensates for the disadvantages of having multiple but small and highly distributed pieces of land. The water rights for each *sereje* are for one Jarib (625 $m^{2)}$ of land. Each owner has one or several, normally small, plots of land distributed in the plain for irrigation by qanats. The plots are divided into three parts, based on their distance from the spring of qanat. Every year one section of the plain (or one *jarib*) is allocated for cultivation in autumn and another *jarib* for spring. The third *jarib* is left uncultivated (*Ayesh*). Autumn cultivation runs from 9 October to 5 May each year and includes barley and wheat. Spring cultivation includes crops such as melons, onions, turnips, sugar beet, tobacco, cotton, and alfalfa. Part of the upper plain that is closer to the spring of qanat or *Mazhar* is allocated to orchard keeping.

Apart from the water division and distribution system, farmers and *sartagh* are all aware of what is being cultivated and where, thereby protecting crop diversity. This is part of their traditional knowledge, which has taught them through experience that, for example, the best tobacco grows in hard soil whereas loose soil will produce average quality tobacco; or in distinguishing which watermelon and melon seeds grow faster or slower.

Factors that cause weakening or depreciation in agriculture are monitored and controlled through consensus. For example, old owners are 'retired' in lieu of the upkeep and protection of qanats, division of water, or even where a share from cultivation is to be distributed. Each plot is irrigated and cultivated by those who 'own' the land, in turns or with the help of one another. Plots belonging to an owner may be scattered, but are dealt with as one. Crops are cultivated in plots next to one another.

3.3 Adaptive farming technologies – the case of growing water melon in the middle of the desert (Chaleh Sombak)

Qanat has taught, over time, the farmers of Kashan how to live with the desert. Through experience built up by generation after generation, they have developed highly efficient farming technologies that overcome the climatic limitations. An interesting example of the extension of indigenous knowledge of qanat to develop other types of sustainable irrigation is the technique for planting watermelons in the middle of the sandy deserts.

This method of cultivation is called *Sombak* (named after Sombak Plain of Ghazi area in Kashan). The farmers plant watermelon by digging holes that are 1 m deep and 30 cm wide and then cover them with different layers of soil and manure. The top layer of soil most heated by the sun is poured in first, then covered with 10 cm of manure, and finally covered with the most humid layer extracted from the hole. They place the watermelon seeds inside the soil and prepare some kind of barrier against the moving sand and wind in the surroundings of the hole. The seeds develop and grow gradually while the water captivated in the basin. Once the root reaches the layer with manure, there is no further need for irrigation.

Figure 9. Water-melons and melon garden landscapes in the desert chaleh Sombak.

3.4 Indigenous knowledge of biodiversity conservation and management

Every year the best crops are selected by farmers to extract the seeds. Seeds are collected as soon as the crop is harvested. Farmers believe that if the crops are left or stored for more than two days, the seeds will lose potency. In the selection of seeds for farming, species are examined and selected with a variety of factors, such as their requirement for water, cropping season, resistance to pests and quality of production. Selection of a diversity of species helps to reduce risks and enhances sustainability.

For example, farmers use each watermelon species for a specific purpose. They carefully select the seeds and believe that watermelon seeds are best four days after harvest. This is how agriculture using qanats has survived and adapted to the desert environment in Kashan area, while preventing desertification and establishing a sustainable system. Even today, about 50 percent of the seeds are produced locally.

Figure 10. A Kashani farmer showing his domestic seeds in a community gathering

4. Cultures, value systems and social organizations (Agri-Culture)

4.1. Qanat Irrigated Agricultural Heritage Systems and the institution of Vaghf (endowment)

Like many other properties, such as farms, estates, markets, schools, books and mills, qanat has been associated with *Vaghf* (Endowment) over the history in Kashan region and the rest of Iran. Pious people, who put their properties on *Vaghf*, may make qanat a *benefactor* or *beneficiary* of the public good. In the first case, the owners of a qanat would endow all or part of the income from the use of the qanat to charity purposes or to meet certain needs of the local community. In the second case, the owners of other properties, such as a market place or a farmland would endow all or part of the income to be used for repairing and maintaining qanats.

4.2. Qanat Irrigated Agricultural Heritage Systems and Cultural beliefs

Over history, the local communities in Kashan and other parts of Iran have built up different cultural beliefs on qanats heritage.

The services provided by qanats in various aspects is so dear for the local communities, and qanats are intermingled with the life of the local communities so deeply that sometimes they are considered as a member of the community even in the present day. A prominent example of such beliefs is "gendering qanat". That is, qanats would be personified as masculine or feminine, often masculine, by the local people. Qanat with torrential and noisy currents would be usually believed to be 'male', and those with tranquil currents, 'female'. In some areas, the gender of the qanat would be identified with an examination of the hand palm skin of the *muqhanni* after digging the qanat. If the hands had become coarsened, bruised and crinkled, the qanat would be named as 'male'. But if the hand skin was still soft, the qanat would be believed to be 'female'. Once the gender of the qanat is identified, the community would start finding a suitable 'bride' or 'groom' for the qanat to make a 'marriage'. The 'wedding ceremony' of the qanat was a full-fledged one, like the wedding of a young couple.

Another example is '*Mourning for the death of qanat'*. In some areas, when a qanat dries up, it is as if the community has lost one of its members. As a recent case, when the 1,000 years-old Upper Armak Village qanat in Kashan dried up in 2009, the local people erected mourning banners announcing to the public attention the demise of their qanat.

4.3. The customary management, the sanctioned buffer (Harim)

The local communities sanction a buffer zone along the route of each qanat. This buffer zone is respected by the local people. No farmer would use the buffer zone for farming. Qanats are placed such that they are next to each other but this arrangement avoids the infiltration of water from one Qanat system to another. The distance between Qanats pertains to the relative legal and customary laws and regulations. If an owner finds another person encroaching on his rights where the Qanat is concerned, he has the authority to stop the progress as it could bring forth problems of water output due to infiltration. Moreover, the distance between Qanats varies according to the regional layout. For example in well drained areas, the distance between Qanats should at least be 500 meters, in dry areas the distance increases to 1500 meters and in the mountainous regions and valleys this distance has been determined to be 500 meters.

4.4. Qanat as a source of social esteem

Large parts of the social system in areas that rely on Qanats were directly or indirectly related to this phenomenon. In such regions the importance and value of people were judged according to their ownership rights to the amount of water. No matter how small a share was in this aspect, the person was held in high esteem. In cities too, this was held as social hierarchy, as the vicinity of a person's premises (that is whether it was upstream or downstream in relation to the qanat) was a factor to be considered. No matter how small a share, the owner of water is held in high esteem. The control of water rights determines the power hierarchy.

5. Remarkable landscapes, land and water resources managements

Besides supporting food production, the Qanat irrigated agriculture system has contributed to enrichment of the landscape in the Kashan region which otherwise should have been a desert.

The most beautiful farms and gardens were created and maintained through Qanat irrigation techniques that are also sources of aspiration for Persian literature, poetry as well as important tourist destination. In the other words, the system has acted as a strong element of de-desertification by diversification of the landscape. Over thousands of years, genuine solutions have been introduced by the local communities to manage the landscape based on the available land and water resources. Capitalizing on the services of qanats, they have innovated various technologies, architectures, tools and styles, which have brought about better conditions for them to live, work, and have recreation under unfavorable climatic conditions and water scarcity. Some of the remarkable landscapes and innovative architectures of the region are as follows.

5.1 Rose Gardens and Rose Water Extraction in Ghamsar Kashan

Ghamsar Kashan is the main production center for the highest quality rose water. The essence of Muhammadi rose flower of Ghamsar has a concentration of 35 mg per 100 ml or 350 ppm, which makes it one of the finest and highest quality brands of its kind. Every year during the second half of May to mid-June, the Rose and Rose Water Festival are held in Kashan. About 80,000 tourists from different parts of the country and abroad visit Kashan every day to participate in this festival.

The rose water is made from a very sweet smelling kind of rose and is used in various traditional dishes and sweets. It is also used as a perfume. Since a long time ago, this plant was used in healing medicine to treat various diseases including chronic diarrhea, rheumatic pains, blood abnormalities, and sore throat.

Although a number of modern industrial processing plants have been established recently for rose extraction, the traditional methods are still widely used in Kashan and the equipment used for extraction of rose water in Ghamsar is almost traditional and has hardly changed over decades. The people of Ghamsar collect roses, boil them in special pots and collect their water in beautiful containers. It is a pride for the region that each year, the sacred Kaaba (Mecca), is washed with rose water from Ghamsar Kashan.

The production of about 95 percent of the rose flower in the Kashan region relies on qanat water.

Figure 11. The rose garden landscape in desert environment (above) the extracted water from the rose.

5.2 The pomegranate gardens

The *Fin* and *Zaghe Yaghuti* pomegranate gardens of Kashan are spread across the region. These gardens provide sceneries in the form of pockets of green spaces in contrast with the dusty texture of the desert. The notion of pomegranate gardens in Kashan has turned into a proper name "Anarestan" (the pomegranate place), which signifies the people's appreciation of the role of these gardens in enriching the landscape.

5.3 Tourism facilities

Qanats irrigated agriculture system has indirectly served tourism in many ways. In Kashan, the internationally popular Fin Garden, which is visited by hundreds of domestic and foreign tourists every day, would not have been set up and survived without the Fin Qanat.

Figure 13. Fin Garden, long shot and close up

But qanat as a direct tourism is a subject that is gaining attention only recently. A number of very interesting projects have already been implemented in other parts of the country. In these projects, the qanat is renovated, the facilities are installed for receiving and entertaining tourists inside the galleries or around the open outlet ponds of the qanat.

A very interesting example of such projects is the construction of the *Shahre-Kariz* (Qanat City) in Kish on the site of the 2,000 years-old qanat of the Kish Island.

Figure 14. The Kish Island Qanat as a tourist's site

Similar projects have been initiated in Kashan. A tourism site is under renovation on the world's only two-staged qanat, which is located in Ardestan. Other distinctive qanats in the Kashan area include: Ghazi, Abuzeidabad, Jafarabad, Armak, Cheshmeh Khorshid and Cheshmeh Suleimani (supporting Fin Garden, a representative of centuries-old Persian Gardens). They can be used as suitable sites for tourism development while in operation for agricultural and other uses.

Figure 14. The Ardestan two-staged Moon Qanat

5.4 Soil conservation, an environmental service of qanats

Qanats play an important role in balancing the salinity of water and protecting agricultural lands downstream. Furthermore, the local communities have learned over the years, how to use the qanat system to separate the flow of fresh water from saline water flows. The Ghazi Qanat of Kashan provides an example of applying this indigenous knowledge.

An ingenious: the Ghazi qanat of Kashan

The Ghazi qanat is located 10 km northeast of Kashan in the desert area. This qanat irrigates a plain under the same name near the town of Bidgol.

The qanat has two branches, with two mother wells. The reason for this is that the qanat earlier had saline water, but eventually the muqannis discovered that parts of the qanat were drawing freshwater, while other parts were drawing saline water. A second branch was developed to reduce and eventually stop the flow of saline water into the qanat, and for the last thirty years instead of being a source of saline water, the qanat has yielded excellent quality potable water.

Qanats also play the role of a groundwater drainage system, especially during flash floods which are a phenomenon specific to arid zones. Drainage of water through qanats has prevented a rise in groundwater levels.

II. OTHER SOCIAL AND CULTURAL CHARACTERISTICS

Ab-bandan (traditional dams)

Since qanat water is available all year long, with varying flow in different seasons, water reservoirs were built to store water for lean periods, to meet urban and rural needs. In rural areas, small natural and semi-natural dams and pools, called *ab-bandan* (dams) were built for agricultural purposes and are still in use in the region. These small dams normally stored both qanat water and rain water. In urban areas and along main communication routes, covered water reservoirs called *ab-ambars* (cistern) were in use to store and provide potable water.

Water mills

Another qanat related water structure is the water mill or *Asiyab-Abi*, for milling flour. The qanats of the Fin Garden (*Bagh-e-Fin*) in Kashan have 75 water mills distributed along the stretch of the qanat towards the city and surrounding countryside, some of which are still working.. A water mill is normally located on a qanat's direction, when there is a total drop of about 5–6 m between the point of collection (*sarab*) and the point of water discharge (*zirab*). A higher level difference was considered unsuitable for operating the water wheel which acted as a turbine. The wheel is undershot by the force of flowing water.

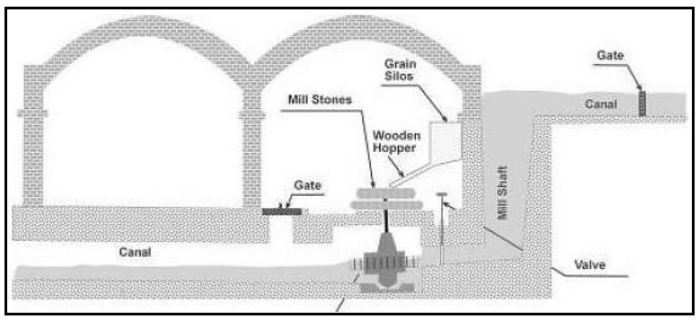


Figure 15. Qanat (Kareez) and water mills, the scheme and the photo of an operational mill in Kashan

Wind-tower

A wind-tower (*bâdgir*: *bâd* "wind" + *gir* "catcher") is an architectural indigenous knowledge to create natural ventilation in buildings. Wind-tower comes in various designs: uni-directional, bi-directional, and multi-directional. Wind-towers are also used in combination with a qanat. In this method, the open side of the tower faces away from the direction of the prevailing wind (the tower's orientation can be adjusted by directional ports at the top). By keeping only this tower open, air is drawn upwards.

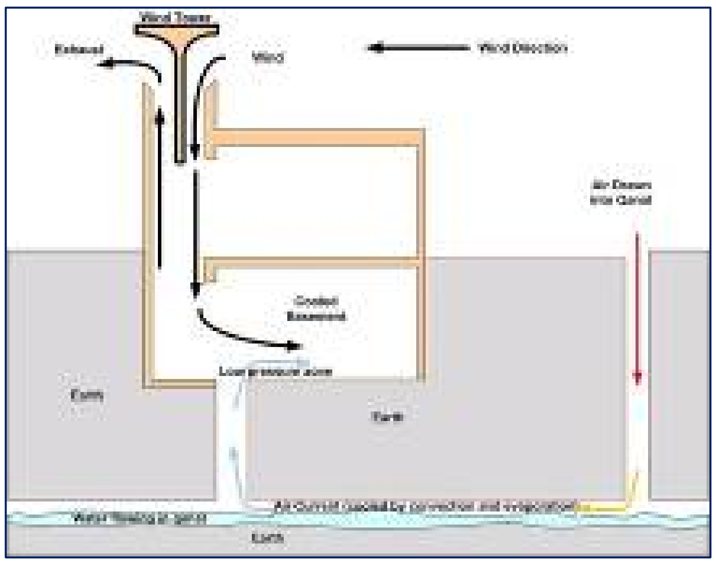


Figure 15. The scheme of a wind-tower operated with qanat water

Figure 16. The wind-tower in the Brujerdis House in Kashan

Supply of drinking water

Until about 40 years ago, part or most of the water in larger cities, such as Yazd, Kazeroon, Esfahan, Tabriz, Shiraz, Ghazvin, Zanjan, and Kashan was provided solely or significantly by qanats, thus demonstrating that they are not uniquely an agricultural/rural phenomenon, but have also had an important role in the formation of cities. Each neighborhood has an assistant for capturing and distributing water from urban cisterns called *Ab-anbaar* to residents. The name of this man was *Sagha* . Kashan has 80 *Ab-anbaars*. This system is still in operation.)

III. HISTORIC/CONTEMPORARY RELEVANCE OF QANAT IRRIGATED AGRICULTURAL HERITAGE SYSTEMS

Although deeply rooted in the history of Iran, qanat is not history. It lives on and will live on. According to official statistics, there were ۳۲,۱۲۴ qanats in Iran in Iran, with a total annual output of 8 billion cubic meters of water, which constituted about approximately 8 percent of the total water supply in the whole country. Figure 9 shows the current distribution map of qanats in Iran. About 14 percent of Iranian agricultural production still relies on the water supplied from Qanats. About 800,000 ha of farmlands are irrigated from the Qanat irrigation system.

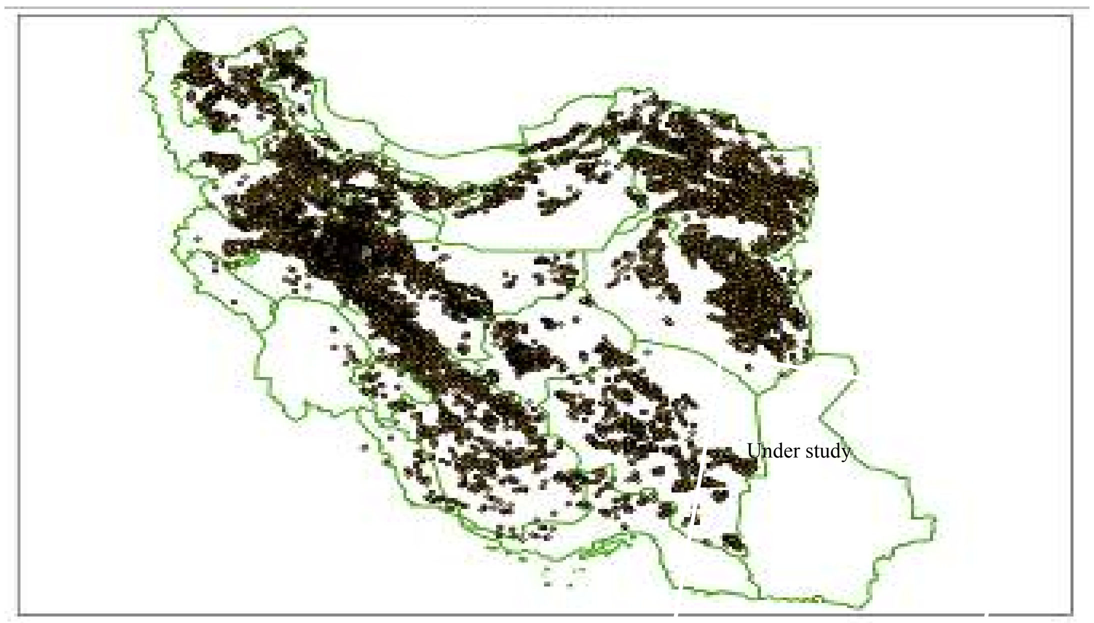


Figure 17. Distribution map of qanats in Iran

IV. THREATS AND CHALLENGES

Depletion of the aquifers

Over the past few decades, the aquifers have experienced a declining trend due to low rainfall, the excessive use of the groundwater resources and other reasons. In particular, the introduction of pump wells has contributed to this unsustainable trend. The declining groundwater table is accompanied by higher waters salinity.

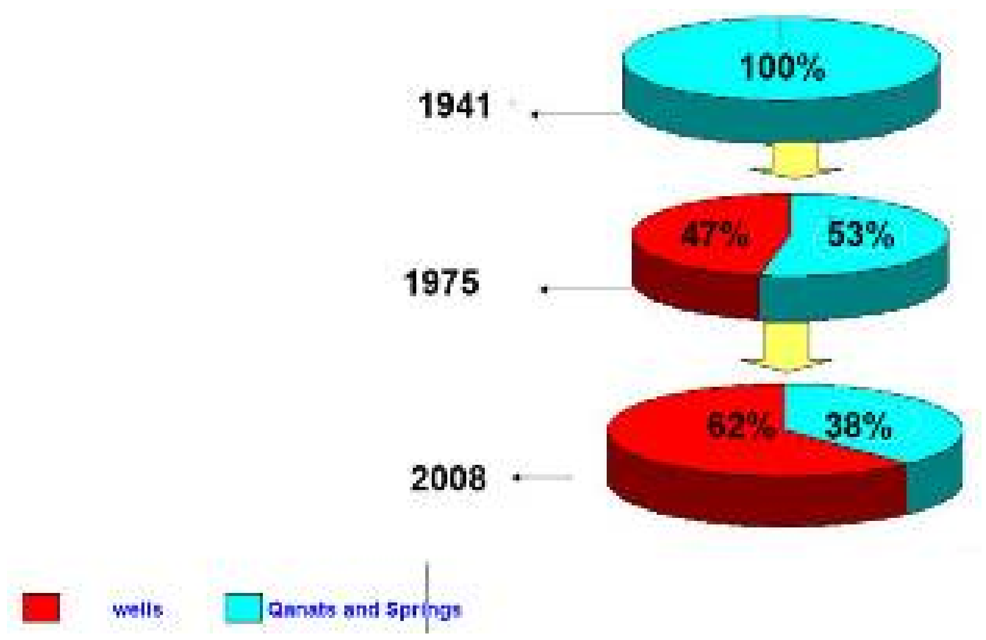


Figure 18. The increasing share of pump wells in groundwater supply as compared to qanats, aggregate of Iran.

The changing agricultural land ownership and management system

The community-wide participatory decision making system which was particularly efficient in adjusting the cropping pattern according to the availability of water is giving way to a mode of production mainly governed by individual farmers making decisions based on the signals of the market.

The Declining number of professional muqannis

The number of skilled qanat drillers (*muqannis*) has reduced in the last few decades, mainly due to the following reasons:

- The introduction of pump wells, which are drilled with machinery. Unable to find year-round full time jobs, many *muqannis* have to leave the job or to accept less delicate drilling projects such as sewage wells.

- Low wages compared to other job opportunities. Problems related to the access of *muqannis* to insurance coverage and other social security services
- Diminishing of the traditional apprenticeship system, while an efficient alternative is not introduced yet.

Figure 19. A Muqanni at work on his wheel

V. PRACTICAL CONSIDERATIONS

An overview of the ongoing efforts

Recognizing the key role of qanat agricultural heritage systems in sustainable management of land and water resources, the Government initiated a National Programme for the Renovation and Maintenance of Qanats in 1998. Until 2008, the funds for implementing this Plan were supplied from the regular national or provincial budget. The total approved funds amounted to 1,000 billion rials for 22,000 projects. Since 2008, this Plan was further strengthened by its entitlement to utilize budgets from the national Drought Mitigation Funds. In 2011 the High Water Council allocated further amounts of funds for the revival and renovation of qanats, which contributed significantly to improving the situation qanats in the country.

The main activities of the Ministry of Jihad-e Agriculture in the field of renovating and the maintenance of Qanats during the last two decades may be summarized as follows:

- Formulation of the detailed Terms of Reference of studies for reconstruction of qanats, which were published in the official journal of the Presidential Department of Strategic Studies and Monitoring in three volumes, and updating the cost breakdown of qanat reconstruction projects in 2013. In the development planning system of Iran, this is considered as an important step to make qanat reconstruction projects an integral part of the regular development activity.

  - Implementation of the Programme for the Renovation and Reconstruction of Qanats. According to 2013 National Budget Act, specific funds were allocated to initiate reconstruction projects through tender bids for consultants, contractors, and *muqannis* (real and legal persons).
  - Development of a GIS-based national databank on qanats, containing data on the location, annual discharge, the ownership and farming system for each qanat.
  - The implementing agencies and collaborators of the Programme for the Renovation and Reconstruction of Qanats have been organized in coordination with Provincial Governor Offices throughout the country.
  - Introducing a degree programme on Qanat at Bachelor's level at Scientific-Vocational University, Taft Township Branch, Yazd Province, in collaboration with the Ministry of Energy. A High School Diploma Course has also been introduced on qanats.
  - Signing of MOUs with the Cultural Heritage Organization, Minister of Energy, and Fisheries Organization on multi-purpose use of water resources and an MOU with the Forests and Rangeland Organization for the management of the watershed in upper parts of Qanats.
  - Cooperation of the Ministry of Energy in the establishment of the International Center of Qanat and Water Historical Structures covered by UNESCO in Iran, and holding two international conferences in this regard in Kerman (2005) and Yazd (2011).
  - Appointment of the joint working group for Qanats in collaboration with the Ministry of Energy and the International Center of Qanat and Water Historical Structures.

Concrete lining of the qanat gallery

Reconstruction of the qanat outlet

Poly-ethylene pipes for lining the qanat gallery

Applying geo-membrane on the gallery

Concrete lining of the open canals

Polyethylene lining of wells

Artificial recharge of aquifers by surplus qanat water

Qanat water storage in the winter

Figure 20. The increasing use of industrial products in renovation and maintenance of qanats.

The envisage activities

The implementation of the National Programme for Renovation and Reconstruction of Qanats, with the attraction of additional funds under the Fifth Five Year National Development Plan (2013-2017). The following activities are also in the relevant agencies:

- Revising the exiting legislation or convening fresh laws, rules and regulations concerning qanats; decoupling qanats from wells in the legislation, as recommended in Article 51 of the Act on Fair Distribution of Water and the resolutions of the 27th joint session of the Ministries of Jihad-e Agriculture and Energy.
- Delineation of the buffer zones of qanats, with a focus on:
    i. Quantitative buffer, for the protection of qanats against excessive discharge of groundwater charges.
    ii. Qualitative buffer, for the protection of qanats against water pollution
    iii. Physical buffer, to protect qanats from the impacts of rural and urban construction projects and other development activities.
    iv. Conventional buffer zones, needed for renovation and maintenance of qanats.
- Training and extension of innovations and advanced technologies for the improvement and revival of qanats.
- Organizing the traditional *muqannis* in terms of economic and social aspects, and interaction with the universities to introduce new courses on qanats.
- Establishment of joint working groups of the Ministries of Jihad-e Agriculture and Energy to finalize the terms of reference and other technical criteria for initiating watershed management projects upstream of qanats and for protecting qanats against floods.

The proposed GIAHS will complement the above activities by incorporating a holistic approach to promote the qanat irrigated agriculture system in the Kashan region. Specifically, the following activities were identified in consultation with the stakeholders:

(actions on agriculture, biodiversity and qanat irrigation system)

- Designing the optimal cropping pattern based on the carrying capacity of qanats, the ecology and related considerations. The e participatory region-wide agriculture management system will be the basis for this action.
- Formulating and implementing a participatory Conservation Plan to preserve and promote the use of the local varieties of fruits and crops as well as the wild species of plants (medicinal, ornamental, repellents, etc.) and animals of the region.
- Providing advice to the Government on enhancing the sustainability and comprehensiveness of the large-scale Programme for Qanat Renovation and Maintenance through incorporating the social, economic, environmental, cultural and ecological aspects and functions of qanats into the mandate of the Programme.
- The GIAHS will help in preparing a guidelines and benchmarks for studying the ecological, social, environmental and other functions of qanats, which are currently missing in the Terms of Reference and criteria for implementation of qanat renovation projects. This would be an important first step to shift the exiting approaches from civil engineering towards integrated system management.
- The proposed GIAHS will raise awareness on the need to review, and possibly adapting the recently introduced methods, such as the use of concretes and

polyethylene in lining the galleries and vertical wells of qanats, in consultation with the traditional practitioners of qanats irrigated agriculture. The purpose is to assure that they would not affect the sustainability of the system.

- Scaling up and strengthening the marketing efforts to utilize the quality of the local varieties for higher added value to the small farmers through approaches such as introducing certification systems, branding, traceability and advocacy.
- Formulating and promoting measures to address the issue of overgrazing and the existing pressure on the ecological carrying capacity of the region due to excess number of livestock.
- Promoting the qanat-fish production system through implementing pilot projects with the participation of the fishery department and the farmers.
- Promoting the Integrated Pest Management approach to retain the safety and quality of the local varieties of fruits and crops.

(actions on local community empowerment and institutional development)

- Strengthening the community-based management through facilitating and supporting the CBOs in the region. In particular, empowerment of the CBOs on the means and skills required for collective action under the existing situation, such as how to interact with the government institutions, deal with the formal legal and regulatory mechanisms, and access to funds and credits.
- The funds approved under the national budgets for renovation and maintenance of qanats are sizable. But the actually 'allocated funds' have been less that the approved amounts. The proposed GIAHS will advocate the need for full allocation of the approved funds and for extending the coverage of the budget lines from civil engineering to include socio-economic, environmental and other multi functional characteristics of the qanat irrigated agriculture system.
- By organizing participatory workshops and appraisals, the proposed GIAHS will help in reflecting the needs and expectations of the professionals and workers involved in qanat irrigated agriculture system, such as *muqqanis* and *miraabs* in the Government's recent plans to address the vocational issues of these groups who play a key role in revitalizing this system.
- Establishing the multi-stakeholder provincial and national GIAHS promotion board. The missions, functions, activities and the composition of the proposed Board is under discussion with the relevant institutions and CBOs at the local and national level.

(Education, information supply. documentation)

- Supporting the ongoing initiatives for introducing qanat as an academic subject at the high school and academic levels. Efforts will be made to assure the inclusiveness of the curricula of these courses.
- Providing advice to the relevant institutions to improving the existing Qanats Database of Iran. The exiting formats of the database include only records of

technical aspects of qanats rather than all the socio-economic and agro-ecological elements of the qanat irrigated agriculture as an integrated system.

- Initiating a GIAHS promotion campaign with the assistance of the mass media, the CBOs and the TV.
- Initiating a project for documentation of the multifunctional services of the GIAHS.

(actions on promoting eco-tourism agri-culture)

- Preparing the Kashan region ecotourism plan based on the Qanat Irrigated System.
- The product-based festivals, similar to the rose water extraction which has been extremely successful in Kasha, will be extended to other fruits, crops and other remarkable landscapes associated with the qanat irrigated system. Pomegranate is an immediate candidate for this purpose.
- Undertaking a study on the services of the qanat irrigated agriculture system to the enrichment of the region's cultural assets.
- Promoting the preservation of the GIAHD related landmark structures and architectures that are still operating.

The potential influence/impacts of the GIAHS

Taking into account the abovementioned points, it is hoped that the GIAHS recognition will contribute to dynamic conservation of the qanat agricultural heritage system in Iran through introducing a holistic, participatory and multi-dimensional approach for supporting qanats to continue their history-long functions with regard to food security, livelihoods, biodiversity, agricultural management, ecological resilience and social cohesion in the region of Kashan Township.

For this purpose, a GIAHS Action Plan will be prepared and implemented with the participation of the stakeholders, including the local communities, the provincial and national authorities, the NGOs, and the FAO. The Action Plan will have two phases: the Pilot Actions (Kashan Township) and the National Extension.

The GIAHS will contribute to introducing models for dynamic conservation of qanat irrigated agriculture system in Iran and other countries that this system exists.

REFERENCES

Bahadori, M. N. 1978. Passive Cooling Systems in Iranian Architecture. Scientific American, February, pages 144-154.

Beamount, P., Bonine, M. and McLachlan, K., 1989, *Qanat, Karize and Khottara* (Gallipoli House, The Cottons, Outwell, Wisbech, Cambridgeshire PE14 8TN, UK: Middle East and North East Africa Studies Press Ltd).

Behniya, Abdolkarim, 1988, *Construction and Protection of Qanats in Iran* (Tehran, Iran: University Press Centre).

Centre for Sustainable Development (Cenesta), 2003, Qanat irrigation systems: Ancient water distribution in Iran.

Cressy, G.B., 1958, Qanats, Kariz and Foggara. *The Geographical Review,* XLVXXX, n. 9. English, P.W., 1966, *City and Village in Iran, Settlement and Economy in the Kerman Basin* (London).

Farhady Morteza, 2002**,** Indigenous knowledge and traditional technique from the scientific and experimental viewpoint, *Namayeh of Pazhoohesh Magazine,* no. 13–14.

Farhady Morteza, 2002**,** Indigenous knowledge and traditional technique from scientific and experimental view. A round table conference. *Namayeh of Pazhoohesh* Magazine (Persian), no. 13–14.

Fisher, W.B., 1968, *The Land of Iran, Cambridge History of Iran, VI* (Cambridge: Cambridge University Press).

Ganji, Water Quality Engineer, 2007, Laboratory tests conducted to control water quality, Water Organisation of Kashan.

Ghayoor Hasanali, 1991, A new view of qanats in Iran and geographical region distribution. *Geographical Research Magazine,* Ferdosy University, Mashhad, Iran.

Goblot, H., 1966, *Les qanats, Une technique d'acquision de L',eau.*

Haeri, **M.R.,** 2003, An evaluation of the sustainability of qanats under changing socio-economic and climate condition in Iran, for Cenesta, Ngo, Tehran..

Hamdollah Mostofi, 1984, Nez,hatolgholoob, edited by G. Lesterenge (Tehran: Donyaye Ketab). In explaining the geography and history of regions of Iran Mostofi gives the names of the cities which used Qanats as sources of water.

Jomehpour Mahmoud, 2009, Qanat irrigation systems as important and ingenious agricultural heritage: case study of the qanats of Kashan, Iran. International Journal of Environmental Studies, Volume 66, Number 3, June 2009 , pp. 297-315(19).

Jomehpour Mahmoud, 2007, Indigenous knowledge of Qanat and its cultural aspect. *Social Science Magazine,* no. 33, Social Science Faculty, Allameh Tabatabaii University, Tehran, Iran.

Jomehpour Mahmoud, 2003, Case study in qanats of kashan: qanat of Ghazi, Sustainable Development and Environment Institute, NGOs.

Jomehpour Mahmoud, 1996, Traditional cooperation system and role of soil and water conservation. *Geographical Research Magazine,* Mashhad University, Iran.

Karaji, **Abu Bakr Mohammad ben** al-**Hassan al-**, 1966, *Astekhrage abhaye penhani,* translated by Khadiv Jam Hosain (Tehran: Institute of Farhange Iran).

Kurose, **G.R**., 1943, *Irans Kampf um wasser* (Berlin).

Kurush Gholam Reza et al., 1350 (1971), Water and irrigation technology in Ancient Iran, Ministry of Energy, Tehran

Lambton, 1969, 137–142, quoted in Moghaddam Fatemeh, 1996, *From Land Reform to Revolution: The Political Economy of Agricultural Development in Iran, 1962–1979* (London: I.B. Tauris), ISBN 1860640060, 9781860640063, p. 14.

Mahdavi Masoud, 1977, Research on water and irrigation in the rural desert region east of Kashan, BIYABANMagazine, Centre of Desert and Desertification Research, Tehran University.

Meteorological Organisation of Isfahan, 2002, Annual meteorological statistics of Kashan.

Papoly Yazdi and Labbaf e Kaniky, 2000, Role of qanat in the making of civilisation, theory of cultural sustainability and civilisation of Karizi. International session of qanats, Yazd, Iran.

Pazoosh, **Hormoz**, 1982, An overview of plans for use of water resources in Iran- past and present. Engineering Faculty, Tehran University.

Safinezhad Javad, 2000, The numinous qanats of Iran, International session of qanat, Yazd, Iran.

Safinezhad Javad, 1989, Traditional irrigation systems in Iran; Social Study and Research Institute, Tehran University. Quotations translated in English have also been used.

Safinezhad Javad, 1974, *Boneh* (Tehran: Toose Publications), in Persian. Quotations translated into English have also been used from Moghaddam Fatemeh, 1996, *From Land Reform to Revolution: The Political Economy of Agricultural Development in Iran, 1962–1979* (London: I.B. Tauris) ISBN 1860640060, 9781860640063, p. 14.

Safynezhad Javad, 2002, Indigenous knowledge and traditional technique from scientific and experimental view. A round table conference. *Namayeh of Pazhoohesh Magazine,* no. 13–14.

Shahshahani soheilla, 1998, Kashan city between desert and mountain; *Shahrdariha magazine* (in Persian), no. 7, Tehran, Iran.

Tabari, Abu Jaafar, 1867–1874, *History of Tabari* (Paris: Zotenberg).

Troll, C., 1963, Mitteilungen der osterreichischen Geographischen Gesellschaft Bd. 105, Heft III.

Wittfogel, K.A., 1964, *Le despotism oriental* (Paris: Av. Propos de P. V. Naquet. Trade de lamericain, Oriental despotism, par A. Marchland).

Annex 1. Location map of Kashan region

Annex 2. Origin, description and nature of the qanat irrigation technology

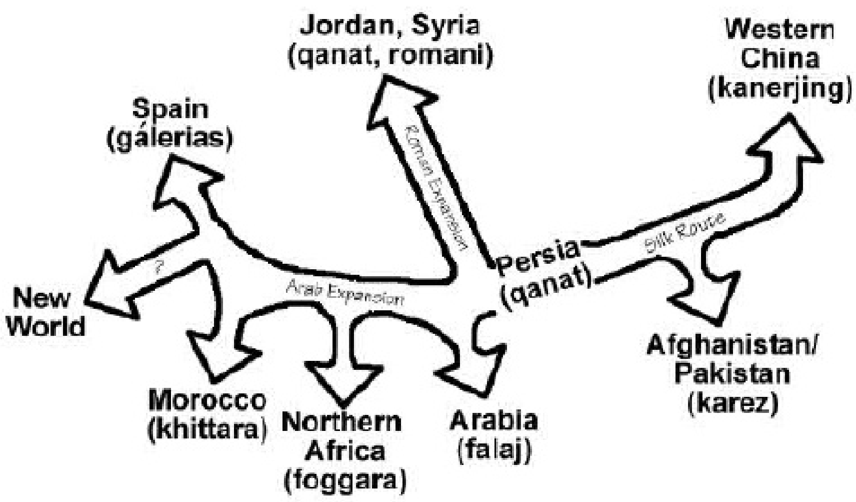
Qanats are more than just a way of using groundwater. They represent a unique and integrated system whereby sustainable management of land, water, and agricultural biodiversity is attained through a wide use of the indigenous knowledge and wisdom.

The importance of Qanats to arid regions has been well established and they maintain their importance in these regions to date. Qanats were the only means of water supply for several centuries, and they contributed to the forming of civilizations in these harsh climatic conditions. In fact, what has been termed 'the Qanat (or Kariz) Civilization' manifests unique social, cultural, economic and political characteristics and the knowledge of how to live in deserts.

The'Qanat civilization' emerged in the Central Iran watershed, particularly in areas where the following prerequisites existed:

1. A desert surrounded by high mountain chains, leading to accumulation of relatively extensive groundwater reservoirs.
2. Limited rainfall, low humidity, and distance from sea coasts.
3. The absence of permanent rivers and other surface water sources.
4. Limited rainfed agriculture and the dependence of irrigated agriculture to qanat.
5. Sustainable use of the aquifers.
6. Poor vegetative cover, low share of animal husbandry in the economy, and prosperous handicraft industry.
7. Scattered villages and urban settlements.

The qanat technology has spread from Iran to the east (Central Asia and China) the south (Arab region and North Africa) and the west including into the new world (Peru).



The area of qanat civilization in the Iranian Plateau spreading in different countries

The qanat of Jopar, near Kerman city, which is associated with the worship of *Anahita (*the water goddess) is estimated to have existed as far back as 1200 BC.

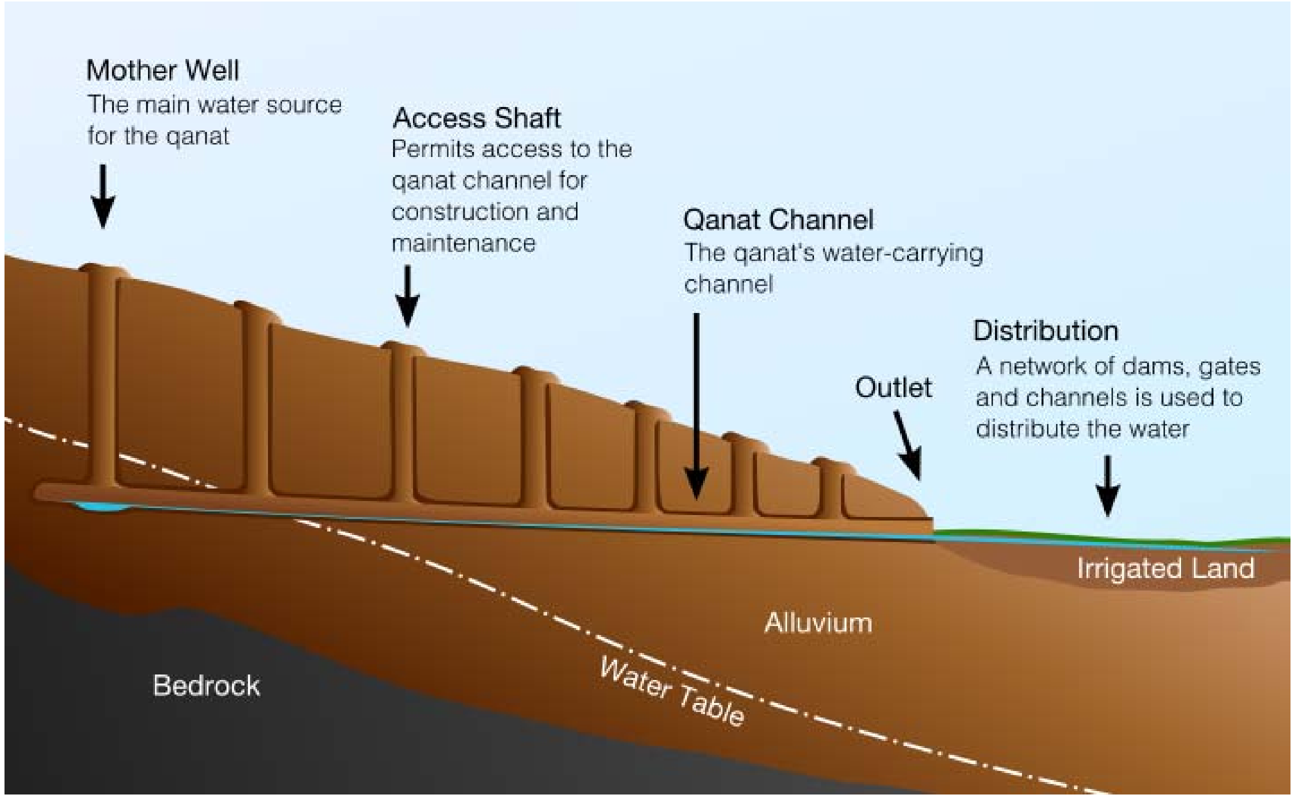
Qanats were in common use in Iran during the Achaemedian period (c. 625 BC) and the technology was then transferred to Egypt, North Africa, Spain, Cyprus, Sicily, and other countries. In 500 BC, qanats were recorded in Egypt, in 750 AD in Madrid, in 850 AD in the south of Algeria, in 1520 AD in Los Angeles, in 1540 AD in Chile, in 1780 AD in Turkmenistan and from 120 BC to 1475 AD qanats prevailed in China.

Historical records show that in the Parthian period (205–212 BC), qanats were deliberately destroyed in certain strategic points by the defending kings to hold back Roman occupation. *Tabbari* also discloses some facts about qanats in the times of the Sassanides, though the actual location has not been mentioned. In the year 828 AD, the Abbasid Caliph built a garden near Baghdad which was irrigated by qanats.

In books remaining from the Iranian scientists of the early Islamic period, including Haseb Karaji living in about a thousand years ago, the principles of the earth's gravity and flow of surface are discussed, which shows that at that time they had the knowledge of underground waters (***hidden water***). Inclined horizontal wells gradually replaced vertical wells for bringing water to the surface.

Qanats first appeared in the mountains of Kurdistan in western Iran, eastern Turkey, and northern Iraq more than 2,500 years ago. The earliest report of a *qanat* system is chronicled on a tablet narrating the destruction of the *qanats* which provided water to the city of Ulhu (modern Ula), located at the northwestern end of Lake Urmia by Sargon II in 714 BC (Laessøe 1951). Soon thereafter, Assyrian cities, particularly those located on the upper Tigris River, relied on *qanats* for drinking water. Then, the capital city of the Medes, Ecbatana (modern Hamadan) was watered by qanats as was Darius's capital city of Persepolis (Forbes 1955; Goblot 1963). Under the Achaemenids (550–331 BC), when Persian rule extended from the Indus to the Nile, *qanat* technology spread well beyond the confines of the Iranian Plateau. To the west, *qanats* were constructed from Mesopotamia to the shores of the Mediterranean as well as southward into parts of Egypt and Arabia. They became particularly important sources of water in the foothills of eastern Iraq, the Syrian Desert, and the Hadhramaut. In Yemen and in Oman, *qanats* are locally called *falaj* (plural: *aflaj*). *Qanats* are gently sloping subterranean tunnels dug far enough into alluvium or water bearing sedimentary rock to pierce the underground water table and penetrate the aquifer beneath. Water from the aquifer filters into the upper reaches of these channels, flows down their gentle slope, and emerges as a surface stream of water at or near a settlement. *Qanats* are generally constructed on the slopes of piedmont alluvial fans, in mountain basins, and along alluvial valleys. In these locations, this groundwater collection system has long brought water to the surface and supported settlement in regions where no other water technology would work. Qanat technology were developed through centuries of trial and error, gradually turned into an integrated well-established irrigation system and became one of Persian's unique knowledge system, backbone of the agricultural civilization and a vital part of the society's culture up to present time.

The structure of a qanat is simple. It consists of a horizontal tunnel (*Kooreh*) running through an incline with many chains of vertical wells (*Millehs*) that form air passages allowing for required operations such as excavation and dredging (see figure 1). This forms the basic pattern of qanats, but from a structural point of view they can be divided into different categories based on location (mountain/plain/desert), length of mother well (*madarchah*), the number of the vertical tunnels or the distance between mother well and the mouth of the qanats (*mazhar*). Qanats are synchronized with the climatic conditions of the region. If average annual rainfall is heavy, the length of the qanats is shorter and the mother wells are not deep. Where rainfall is scarce, the length of qanats increases and so does the depth of the mother well. The depth of the mother well and the length of qanats in mountain regions are shorter than those in the plains.



Vertical view of Qanat

Annex 3. List of Biodiversity grown in Qanat Agricultural Heritage Systems

Table1. Types, area and production of fruits in Kashan Township, 2013

Fruit	**Area (not fruit-bearing) ha**	**Area (fruit-bearing) ha**	**Production (tons)**
Pomegranate	145	1890	11700
Rose flower	80	1500	3599
Almond	65	620	450
Plums	43.9	516	4110
Walnuts	31.5	495	594
Apricot	4	425	656
Vines	8	367	4587
Pistachio	130	312	337
Quince	80	170	1836
Olive	245	132	135
Apple	7	128	1352
Cherry	9	83	624
Fig	1	62	520
Sour cherry	5	31	165
Saffron	5.5	24.1	0.126
Pear	0	22	356
Peach	3	20	152
Other fruits	2	18	165
Date plum و	2	14	65
Hazelnut	0	7	11

Table 2. Types, area and production of fruits grown in Kashan Township, 2013

crop	**Area (ha)**	**Production (tons)**	**Yield/ha (tons)**
Barley	1700	8670	5.1
Wheat	1200	5040	4.2
Protected Vegetables	766	11490	15
Summer crops	743	17560	2.3
Forage crops	610	8950	14.6
Industrial crops	605	2112.5	3.5
Cotton	600	2100	3.5
Alfa alfa	500	4900	9.8
Other summer crops	390	5850	15
Onion	240	9840	4.1
Tomato	200	5000	2.5
Cucumber	170	5950	3.5
Potato	120	2520	2.1
Water melon	120	1800	15
Other crops	97	290.8	3
Pea	70	126	1.8
Beans	60	120	2
Other forage crops	60	2550	42.5
melon	50	1750	35
Clover	50	1500	30
Maize	10	80	8
Tobacco	5	12.5	2.5

Annex 4. Selected plant species recorded from the flora of the Kashan Township

family	*genus*	*species*
Apiaceae	*Aphanopleura*	*breviseta (*Boiss.*)* Heywood & Jury
	Chaerophyllum	*macropodum* Boiss.
	Ducrosia	*anethifolia* (DC.) Boiss.
	Echinophora	*platyloba* DC.
	Falcaria	*vulgaris Bernh. Syn. F. sioides* (Wibel) Ascherson
	Ferula	*hirtella* Boiss.
		ovina (Boiss.) Boiss
	Prangos	*uloptera* DC.
	Psammogeton	*stocksii* (Boiss.) E. Nasir
	Pycnocycla	*spinosa* Decne. ex Boiss.
	Semenovia	*subscaposa* (Rech.f.) Alava
Asteraceae	*Aegopordon*	*berardioides* Boiss.
	Amberboa	*turanica Iljin*
	Anthemis	*gayana* Boiss.
		odontostephana Boiss.
	Artemisia	*aucheri* Boiss.
		scoparia Waldst.& Kit.
		sieberi Besser
	Carduus	*pycnocephalus* L.
	Carthamus	*oxyacantha* M.Bieb.
	Centaurea	*bruguierana* (DC.) Hand.-Mzt.
		depressa M.Bieb.
		gaubae (Bornm.) Wagenitz
	Cirsium	*libanoticum* DC.
		rhizocephalum C.A.Mey.
	Cousinia	*congesta* Bunge
		cylindracea Boiss.
		eriobasis Bunge
		kashanensis Rech.f. & Esfand.
		manouchehrii Rech.f. & Esfand.
		multiloba DC.
	Crepis	*sancta L.*
	Echinops	*cephalotes* DC.
		elymaiticus Bornm.
		leiopolyceras Bornm.
		leucographus Bunge
		ritrodes Bunge
	Epilasia	*acrolasia* (Bunge) C. B. Clarke
	Filago	*hurdwarica* (DC.) Wagenitz
		pyramidata L.
	Francoeuria	*undulata* (L.) Lack
	Helichrysum	*pallasii* (Spreng.) Ledeb.
	Hertia	*angustifolia* (DC.) O. Kuntze

family	*genus*	*species*
	Jurinea	*ramosissima* DC.
	Lactuca	*orientalis* Boiss.
		serriola L.
		undulata Ledeb.
		acanthodes (Boiss.) O. Kuntze
	Oligochaeta	*minima* (Boiss.) Briq.
	Outreya	*carduiformis* Jaub. & Spach
	Phagnalon	*nitidum* Fres.
	Picnomon	*acarna* (L.) Cass.
	Picris	*strigosa* M.Bieb.
	Psychrogeton	*amorphoglossus* (Boiss.) Novopokr.
	Pulicaria	*gnaphalodes* (Vent.) Boiss.
	Scorzonera	*ramosissima* DC.
		rupicola Hausskn.
		sp.
		tortuosissima Boiss.
	Senecio	*glaucus* L.
		vernalis Waldst. & Kit.
	Sonchus	*maritimus* L.
	Tanacetum	*lingulatum* (Boiss.) Bornm.
		parthenium (L.) Schultz-Bip.
		pinnatum Boiss.
		polycephalum Schultz-Bip.
	Thevenotia	*persica* DC.
	Urospermum	*picroides* (L.) Desf.
	Varthemia	*persica* DC.
Brassicaceae	*Aethionema*	*trinervium* (DC.) Boiss.
	Alyssum	*dasycarpum* Steph. ex Willd.
		linifolium Steph. ex Willd.
		marginatum Steud. ex Boiss.
	Arabidopsis	*pumila (Steph.) N.Busch*
	Barbarea	*plantaginea DC.*
	Cithareloma	*registanicum* Rech.f.
	Clypeola	*aspera* (Grauer) Turrill
		dichotoma Boiss.
		jonthlaspi L.
	Conringia	*planisiliqua* Fisch. & C.A.Mey.
	Erysimum	*sp.*
	Fibigia	*umbellata* (Boiss.) Boiss.
	Fortuynia	*garcinii* (Burm.) Shuttlew.
	Isatis	*minima* Bunge
	Lepidium	*persicum* Boiss.
	Malcolmia	*africana* (L.) R.Br.
	Matthiola	*chenopodiifolia* Fisch. & C.A.Mey.
		flavida Boiss.

family	***genus***	***species***
		ovatifolia (Boiss.) Boiss.
	Moriera	*spinosa* Boiss.
	Nasturtium	*officinale* R.Br.
	Sisymbrium	*altissimum* L.
		orientale L.
		septulatum DC.
	Sterigmostemum	-
	Torularia	*torulosa* (Desf.) O.E.Schultz
Boraginaceae	Heliotropium	*arguzioides* Kar. & Kir.
	Arnebia	*decumbens* (Vent.) Coss. & Kral.
		linearifolia DC.
	Asperugo	*procumbens* L.
	Buglossoides	*arvensis* (L.) Johnston
	Heliotropium	*arguzioides* Kar. & Kir.
		aucheri DC.
		crispum Desf.
		Dissitiflorum Boiss.
		Samoliflorum Bge.
		supinum L.
		transoxanum Bge.
	Lappula	*microcarpa* (Ledeb.) Gurke
		Semiglabra (Ledeb.) Gurke
		sinaica (DC.) Aschers.
	Anchusa	ovata Lehm.
		aucheri DC.
		dasycarpum Ledeb.
		dissitiflorum Boiss.
		samoliflorum Bunge
	Nonnea	*caspica* (Willd.) G. Don
		Persica Boiss.
		pulla (L.) DC.
		suchtelenioides Riedl
	Onosma	*cyrenaicum* Durand & Barr.
		demawendicum Riedl
	Paracaryum	*cyclhymenium* (Boiss.) Riedl
		Persicum (Boiss.) Boiss.
		rugulosum (DC.) Boiss.
		stellatum Riedl
	Rochelia	*bungei* Trautv.
	Trichodesma	*incanum* (Bunge) A. DC.
Caryophyllaceae	*Acanthophyllum*	-

family	*genus*	*species*
	Buffonia	-
	Caesalpinia	*gilliesii* (Hook.) Dietr.
	Dianthus	-
	Gypsophila	*acantholimoides* Bornm.
	Lepyrodiclis	*holosteoides* (C.A.Mey.) Fenzl ex Fisch. & C.A.Mey.
	Silene	gynodioica Ghazanfar
Chenopodiaceae	*Halothamnus*	*auriculus* (Moq.) Botsch. syn. Aellenia auricula (Moq.) Ulbr.
	Agriophyllum	*latifolium* Fisch. & C.A.Mey. syn. A.minus Fisch. & C.A.Mey. ex Fenzl subsp. *aranense* Aellen
	Anabasis	*calcarea* (Charif & Aellen) Bokhari & Wendelbo
		setifera Moq.
	Anthochlamys	*multinervis* Rech.f.
	Atriplex	
		dimorphostegia Kar. & Kir.
		griffithii Moq.
		halimus L.
		tatarica L.
	Euphorbia	*buhsei* Boiss.
		cheirolepis Fisch. & C.A.Mey.
		erythradenia Boiss.
		malleata Boiss.
		marschalliana Boiss.
		microsciadia Boiss.
		peplus L.
		petiolata Banks & Soland.
		policaulis Boiss. & Hohen.
	Mercurialis	*granulata* Forssk.
Fumariaceae	*Fumaria*	*vaillantii* Loisel.
Geraniaceae	*Erodium*	*cicutarium* (L.) L' Her. ex Aiton
		oxyrrhynchum M.Bieb.
Iridaceae	*Gynandriris*	*sisyrinchium* (L.) Parl.
	Iris	*songarica* Schrenk
	Juncus	*inflexus* L.
		rigidus Desf.
Lamiaceae	*Proveskia*	*abrotanoides* Karel.
	Acinos	*graveolens* (M.Bieb.) Link
	Hymenocrater	*bituminosus* Fisch. & C.A.Mey.
	Lamium	*amplexicaule* L.
	Marrubium	*crassidens* Boiss.
	Mentha	*sp*.
		Longifolia (L.) Gudson
	Nepeta	*kotschyi* Boiss. var. persica (Boiss.)Jamzad syn. N. persica Boiss.
		prostrata Benth.
		pungens (Bunge) Benth.
		saccharta Bunge

family	*genus*	*species*
		satureioides Boiss.
		sessilifolia Bunge
	Phlomis	*olivieri* Benth.
	Salvia	*ceratophylla* L.
		eremophila Boiss.
		limbata C. A. Mey.
		macrosiphon Boiss.
		reuterana Boiss.
Resedaceae	*Reseda*	*buhseana* Mull.-Arg. var. buhseana
		lutea L.
Rhamnaceae	*Rhamnus*	*persica* Boiss.
Rosaceae	*Amygdalus*	*lycioides* Spach
		scoparia Spach
	Rosa	*beggeriana* Schrenk.
	Sanguisorba	*minor* Scop.
Rubiaceae	*Callipeltis*	*microstegia* Boiss.
		microstegia Boiss.
	Crucianella	*gilanica* Trin. Subsp. *gluca* (A. Rich ex DC.) &subsp. *transcaucasica*
	Galium	*tricornutum* Dandy
		setaceum Lam.
	Rubia	*tinctorum* L.
Rutaceae	*Haplophyllum*	*robustum* Bunge
		tuberculatum (Forssk.) Adr.
Salicaceae	*Populus*	*euphratica* Olivier
Scrophulariaceae	*Linaria*	*michauxii* Chav.
		lineolata Boiss.
		michauxii Chav....
	Scrophularia	*frigida* Boiss.
		leucoclada Bunge
		variegata M.Bieb.
		striata Boiss.
		syriaca Benth.
	Verbascum	*speciosum* Schrad.
	Veronica	*polita* Fr.
		campylopoda Boiss.
		anagallioides Guss.
Solanaceae	*Hyoscyamus*	*pusillus* L.
		senecionis Willd.
	Lycium	*depressum* Stocks
Tamaricaceae	*Tamarix*	*hispida* Willd.
	Reaumuria	*alternifolia* (Labill.) Britten
		squarrosa Jaub. & Spach
Thymeliaceae	*Dendrostellera*	*lessertii* (Wikstr.) Van Tiegh.

family	*genus*	*species*
		lessertii (Wikstr.) Van Tiegh.
Tiliaceae	*Grewia*	*makranica* Rech.f. & Esfandiari = *G. tenax* (Forssk.) *Fiori* subsp. *Makranica*
Ulmaceae	*Ulmus*	*umbraculifera* Trautv.
Urticaceae	*Parietaria*	*judaica* L.
Valerianaceae	*Valerianella*	*dufresnia* Bunge ex Boiss.
		triplaris Boiss. & Buhse
Zygophyllaceae	*Fagonia*	*bruguieri* DC.
	Peganum	*harmala* L.
	Tribulus	*longipetalus* Viv.
		ochroleucus (Maire) Ozenoa & Quezel
	Zygophyllum	*fabago* L.
		eurypterum Boiss. & Buhse