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EVALUATION OF DIFFERENT TRADITIONAL WATER MANAGEMENT SYSTEMS IN SEMI-ARID REGIONS (CASE STUDY FROM IRAN)

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SUMMARY - In semi-arid regions, where rainfall is scanty, many water management systems were developed to provide irrigation water for agricultural through the centuries ago. In many part of Iran, the water requirements of most crops are not fully met by precipitation. Whereas, rural communities mostly subsist on farming and animal husbandry. To overcome the water scarcity in these regions traditional water management systems were locally developed. These practices traditionally used by local people made the best possible use of the scarce water resources and difficult conditions created by the aridity of the climate. In this paper three different traditional water management and harvesting systems in Iran, including Qanat, Khooshab and Bandsar were evaluated. Socio-economic and environmental aspects of these methods were discussed. In this article, it will be discussed why some traditional water management systems still are using properly in arid and semi-arid regions and some are not. The most important issue to use traditional method is to understand how we can adapt and integrate indigenous water management practices into modern technologies of water resources systems successfully.

Key words: Water management, traditional method, Qanat, Iran.

***RESUME** - En tenant compte de peu précipitation dans la zone semi-aride, les systèmes de gestion de l'eau pour assurer l'eau d'irrigation, sont bien développés depuis les derniers siècles en Iran. Dans la plus part de l'Iran, la précipitation n'est pas suffisante pour la culture, et Puisque la société rurale est très attachée à l'agriculture et à l'élevage, a défaut de l'eau, les habitants utilisent les différentes méthodes de l'exploitation de l'eau d'après leurs expériences. Ces approches, dans la condition autant dure, sont toujours assez satisfaisantes. Dans ce recherché, 3 méthodes traditionnelles d'exploitation de l'eau, Qanat, Khooshab et BandSar, in différentes partie de l'Iran ont été évalues. Les aspects socio-économique et environnemental de ces méthodes ont été discutes. D'après ce recherche on est arrive a distinguer; quelle est la raison pour laquelle certains de ces traditionnels méthodes sont encore acceptes et appliqués par les habitants. L'adaptation des méthodes traditionnelles avec les techniques modernes est le plus important but de ce recherche.*

***Mots clés**: Gestion de l'eau, Méthodes traditionnels, Qanat, Iran.*

INTRODUCTION

Innovative traditional approaches that have a very high potential for use in arid and semi-arid regions of the world have been developed during last centuries. Water harvesting and management approach is a method of collection and storage of rainwater that can be used to meet household, agricultural and other needs. Runoff management techniques are often applied to increase the water infiltration and supply as well as productivity in arid regions. Some other systems deal with underground water resources. These traditional water management systems date from ancient times. As Todds and Mays (2005) stated the Old Testament contains numerous references to groundwater, springs, and wells. Other than dug wells, groundwater in ancient times was supplied from horizontal wells known as Qanats. There are some 22,000 Qanats in Iran supplying about 75% of all water used in the country (Todd and Mays, 2005).

As early as 4,000 years ago people of the Negev Desert stored rainwater for household and irrigation use. As Barah (1996) pointed out water tanks were dug in rainfed areas of South India as early as 230 B.C. Ancient Romans used cisterns and paved courtyards to collect rainwater to augment water from aqueducts. Also, water management methods are still practiced by the Tohono O'odham and Hopi tribes of the southern US, who traditionally plant after the onset of summer and winter rains (TWD, 1997). There are several reports about floodwater management from Asia, Africa and America. Flood spreading systems and flood irrigation also have been practiced in Iran for many years.

Floodwater spreading systems with different size in area were constructed on the intermediate zone of debris cone in some regions in Iran. The systems were planned for the artificial recharge of groundwater, range improvement, moving sand stabilization, afforestation, etc. (Kowsar, 1991). Nowadays, some of traditional water management practices are diminishing with the introduction of mechanized irrigation and agriculture. However intensive agriculture in semi-arid regions is not sustainable in the long-term and it may prove to be extremely harmful to the local ecosystems. On the other hand, in this area, large-scale rainfed agriculture is impracticable because the erratic nature of the arid environments and lack of the water sources. Therefore, innovative local water management systems could be considered as some of sustainable approaches that will ensure the local needs and facilitate reaching to sustainable development purposes.

In this paper three different traditional water management systems in some parts of Iran were evaluated. Socio-economic and environmental aspects of these methods were discussed. In this research, it will be discussed why some traditional water management systems still are using properly in arid and semi-arid regions and some are not. It has shown that how we can adapt and integrate indigenous water management practices into modern technologies of water resources systems successfully.

TRADITIONAL WATER MANAGEMENT SYSTEMS

A water management or harvesting system may have four components, including an area for management rain, a system of conveying water for storage, storage tank or reservoir and a distribution system to deliver water to the point of use. In following parts of the paper, three different traditional water management and harvesting systems, including Qanat, Khooshab and Bandsar, were evaluated. These three methods have been practiced for a long time in some arid and semi-arid regions of Iran. In the results of the article, socio-economic and environmental aspects of these methods will be discussed.

Khooshab

In arid regions shortage of water resources forces people to use floodwater for crop production, water supply and other uses. In some arid and semi-arid regions in Iran (i.e. Sistan-Balouchestan province), which precipitation is less than 150 mm, an innovative traditional method has been used named Khooshab to utilize flood water with area about 1-10 ha (Filekesh, 1993). This system could be used for cultivation wheat, maize, barely and dates. Khooshab is a system of water management specifically designed to provide agricultural water to a community. In this system, water is controlled at the end of a small natural stream with the help of a small dam.

The best location for Khooshabs is plateaus and flood plains. These constructions are built to use the runoff-generated form Monson rainfall during summer. According to the results the benefit of runoff management in traditional techniques depends on natural situation. Additionally they acts as an erosion and flood as well as desertification control, preventing immigration of population, increasing productivity and ground water and sustainable development of rural areas.

Fig. 1 has shown a longitude section of a Khooshab practiced in Sistan-Balouchestan province. This is a kind of cross-dam that is constructed across a small hill creek or at the junction of ephemeral streams to collect water for the dry season. As can be seen in Fig. 1 core of the dam is made of earth, supported on both downsides by rocks. Stone pitching is provided at drainage outlet to protect it from scouring. It has a basin to trap sediment and an outlet to allow excess water to flow to the next system or to flow in the stream for downstream water uses. Water stored behind the dam infiltrates to the soil, which can be used for agricultural practices. Implementation of khooshab as a farm-pondbased water management system has changed the whole socioeconomic situations of the area including availability of water for agriculture, horticulture, increasing in overall agricultural production and creation of rural employment. These systems have been used for protective irrigation for crops, horticulture and to satisfy water requirements of local and small enterprises. The streams receive water mostly through seepage from the catchment and from ephemeral streams in different size. Improved moisture and surface water availability means that farmers are motivated to introduce more profitable agricultural crops.

The rate of loss of water from the system by evaporation could be very high, with respect to the climate of the area. Hence in the absence of rains, ponds in the recharge areas dry up. In other words, water is available for protective irrigation for a few days. But the most important point is that system will increase the moisture of the lands, which will be utilized using farming and horticulture. Nowadays, this approach has been adopting by several communities group under support of some governmental organizations and NGOs in similar area. Therefore, Khooshab have become one of the largely accepted activities for water saving and management purposes in the region. Theses system could be used in order to address water demand of individual farmers located in different reaches of the streams, recharging the groundwater for overall improvement in water availability within region and for improvement of soil conservation and fertility.

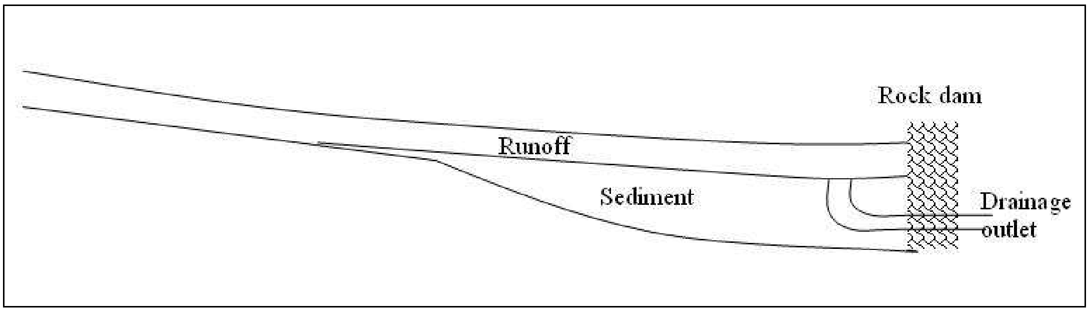

Fig. 1. A longitude cross-section of a khooshab.

Bandsar

Bandsar is a traditional water harvesting system, which is practiced where mountainous catchments and valley plains occur in proximity. The runoff from the catchment is stored in the lower valley floor enclosed by a small earthen dam. A plan of Bandsar in both possible situations, mountainous catchments and valley plains, has shown in Fig. 2. The water trapped in the Bandsar can be used during dry seasons or it can infiltrate into deeper soils layer and increase humidity of downward lands. Wheat and Barely are often planted. These crops mature without irrigation. The soils in the Bandsar are extremely fertile because of the frequent deposition of fine sediment. Small ephemeral streams and streamlets originate in them. The depth of water trapped in a Bandsar varies from 50 to 125 cm. It is gradually depleted through seepage and evaporation, and disappeared during the time, leaving the surface soil moist and fit for sowing. In these system no fertilizer and irrigation is needed.

As can be seen in Fig. 2 Bandsar has a very simple construction. It is made of a shallow water drainage, which could be an ephemeral stream, an earthen embankment made of river sediment and a waterway for overflow of flood. Bandsars covers different areas e.g. 100 square meters in valleys to 30 ha in low slope lands (Arabkhedri, 1995). Generally in alluvial fans, the land situated between two streams is suited for constructing Bandsar (Fig. 2). As Arabkhedri (1995) reported most of Bandsars are located in the central and southern parts of Khorasan province in areas where annual precipitation is less than 200 mm per year. Bandsar is a kind of water management structures that depends on rainfall and temporal runoff. Its construction consists of plots, basin and levee along contour line and dry rivers. The generated runoff from upland area will be stored in the basin to infiltrate, also proactive trapped sediment in Bandsar will be used as improving and fertile materials for sandy soil.

In the Bandsar system accumulation of salts could be observed due to evaporation and incoming sediments. The accumulation of sediment inside a Bandsar causes a gradual rise in the level of the soil. Shallow wells could be dogged outside a Bandsar to utilize water in lower layers of the soil. This increases seepage from the Bandsar and continuously removes salts. This water management system has many benefits such as increasing soil moisture's, crop production, groundwater recharge, soil protection, and preventing water loss to saline lakes.

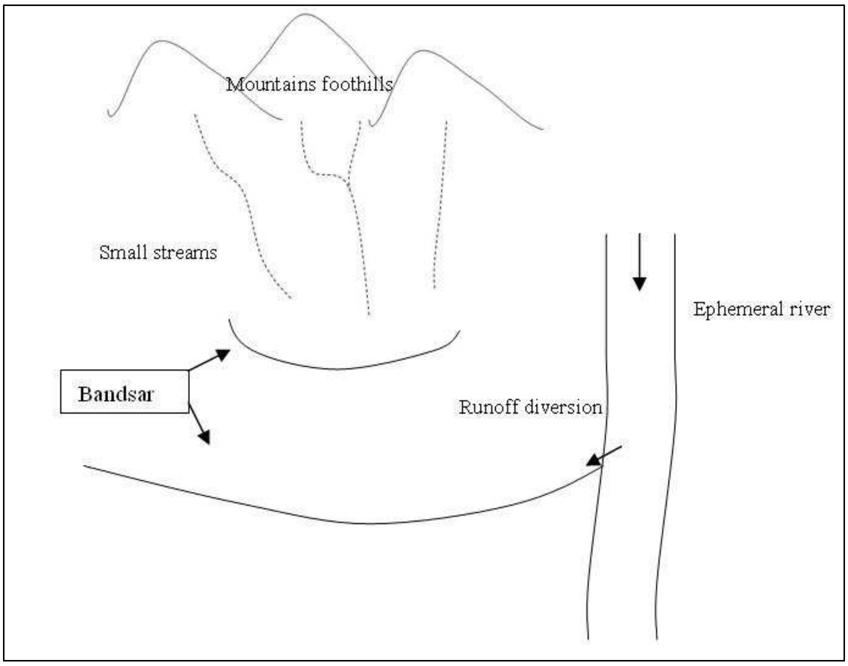

Fig. 2. A plan for different kind of Bandsar practiced in Khorasan province.

Qanat

Qanat is an ancient water utilization technology that can be described as the greatest contribution made by Persians to Groundwater hydraulics. Qanat construction must have been started at least 5000 years ago in Iran. Old Zavareh Qanat dating back to 5000 years ago and 350m depth mother well of Gonabad Qanat dating back to 2500 years ago are some existing example of traditional groundwater utilization in Iran. The longest Qanat in Iran is located near Zarand, which is 29 km long with a mother well depth of 96 m and with 966 shafts along its length (Todd and Mays, 2005).

A cross section along a Qanat is shown in Fig. 3. In this system, a sloping tunnel dug through alluvial material leads water by gravity flow from beneath the water table at its upper end to a ground surface outlet and irrigation canal at its lower end. Vertical shafts dug at closely spaced intervals provide access to the tunnel. A Qanat system is usually dug in the slope of a mountain or hillside where material washed down the slope has been deposited in alluvial fans. The first step for construction of a Qanat is to sink a trial shaft to know the presence of water table and determine its depth. When the trial shaft is sunk and reached to an impermeable stratum, this shaft could be used as mother well. Continuing of Qanat construction begins at the lower end where its water is to come to the surface. The tunnel starts to be dug back toward the mother well. At times it begins simultaneously at both ends. The gradient of the gallery must not be too steep, because the water will flow too fast and erode the walls and the tunnel will fall in. Vertical shafts are sunk from the surface to the tunnel approximately every 20 - 35 m, or are sunk first and then connected by a tunnel. Mud or stone linings at their upper parts strengthen these shafts. Usually there accumulates a ring of soil around the shaft on the surface.

The discharge of the water of Qanat varies according to ground water characteristics, the nature of the soil and season. Qanat routes need to be regularly cleaned and maintained. Damages could be the falling in of the ceiling of aqueducts or walls of shafts, the accumulation of sediments, sands or mud in the underground galleries, the blockage of subterranean waterways.

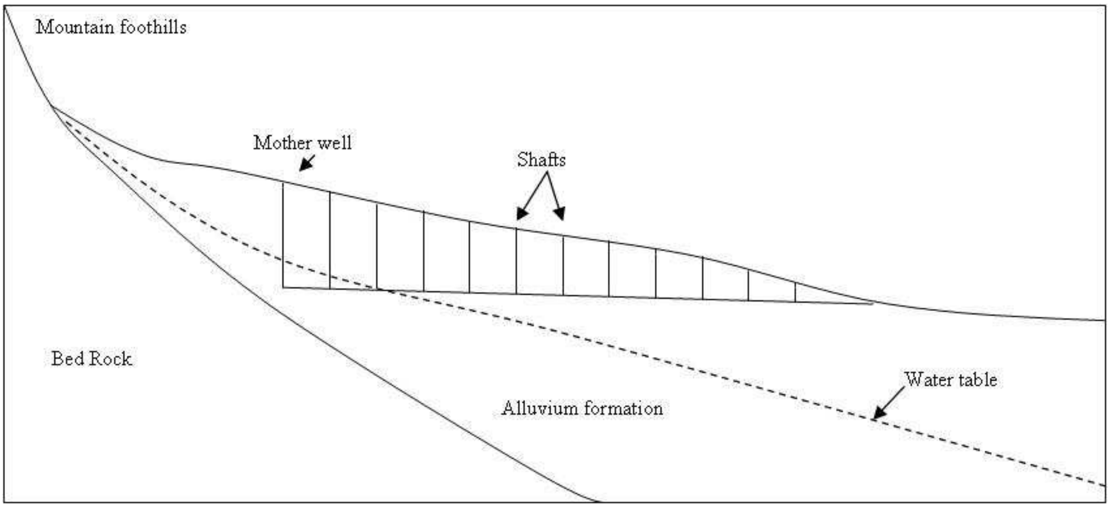

Fig. 3. Vertical cross section along a Qanat practiced in Iran.

The distribution of the water of a Qanat route is based on time as determined by the users through their representatives in downside. The distribution of the water has to be under a trustworthy person who is chosen by the community or the government and is paid a certain salary. Since ancient times, there have been laws as to how to distribute water fairly among various small and large villages on the Qanat routes to prevent any conflicts. Qanat systems could be observed in many parts of Iran like Hamedan, Qazvin, Neyshabur, Kerman, Yazd and many smaller cities and towns. In the regions mentioned, there could not be any piece of land cultivated and agricultural practices.

However, Qanat still remains to be the principal, and in some cases, the only source of irrigation and domestic water supply in many parts of Iran. But in the areas with more densely populated districts, Qanat has lost its importance as the main water provision source. Laws and common understandings that are hallowed by tradition rule the building of Qanats and the distribution of the water. There are also some traditional systems for the fair allocation of water from a Qanat between water users, which is not discussed in this paper. The agricultural production made possible by the Qanats amply repays the investment in construction and maintenance. As Haeri (1993) noted construction costs have risen in recent years as the standard of living in Iran improved and labor costs have increased. Moreover, the division of large landholdings into smaller ones under the new land-distribution policy, as well as the introduction of expensive modern machinery has made it difficult for the individual landowners to afford the expense of constructing new Qanats or maintaining old ones.

ADVANTAGES OF TRADITIONAL METHODS

Like any indigenous practice, water management methods have merits and limitations that determine where and when these methods could be used. These methods have evolved in particular socio-cultural and physical settings to serve specific community needs. With change in society and introducing of new technology, water management methods are also undergoing changes. Some of traditional methods may not be practiced at all in future and some other may have to be reintroduced to ensure environmental and ecological balance that modern methods might have overlooked. Following is a summary of important advantages of indigenous water management methods discussed in the article.

Through construction of Qanats, water present in the aquifers is drawn to the surface in order to be utilized by manipulating a series of vertical wells and one horizontal well. This method uses no electrical or fossil energy. Since fifty years ago the role of Qanats as a traditional water management system in arid and semi-arid regions of the country has been diminishing. But fortunately, the ‘age’ of

Qanat was not over. The experiences in Iran have shown that due to inadequate policies, lack of awareness about the indigenous methods, poor understanding of the interdependency between Qanat systems and the local community and its importance in agricultural productivity, the critical role of Qanats have been neglected. In comparison between Qanat systems and deep wells, it can be said that the cost of excavating a Qanat proves to be eight to nine times more than the same for a deep well. But if Qanats are regularly dredged and repaired they have an approximately prolonged and unlimited life span (Haeri, 2003). Whereas, life span of a well is about 20 years. The water output of a Qanat within a definite period of time is determined and much more reliable. Thus, Qanats prove to be a safer source of water provision safer for agriculture, except in some occasions. Low expenditure of Qanats in comparison to high maintenance charges of wells and motor pumps is a definite advantage in rural areas. Qanats do not impair the quality or quantity of groundwater. This is due to the fact that they are utilized gradually and assist in keeping the balance of ground water in various layers of ground intact. In fact even during periods of severe drought, Qanats are not detrimental to water reservoirs (Haeri, 2003).

There are several problems that are affected directly or indirectly by overexploitation of groundwater including deteriorating quality of water supplies, land subsidence, rising salinity levels in soil, competing demands for water supplies, loss of agricultural land, decreasing crop production and loss of job opportunities. Qanat systems could be used for sustainable groundwater utilization. Qanats reflect collective and cooperative work, and in areas where Qanats are constructed labor or work opportunities are provided for the local community. Qanat systems are closely linked to the local community and the management system is such that the water is distributed equitably. As a result, water security supply and water access equity are supporting the foundations of the local community and agriculture at large. It can be concluded that Qanats is a collaborative sustainable water management systems that could be used in arid and semi-arid regions.

The indigenous and traditional water management methods like Khooshab and Bandsar are easy to implement and maintain. It costs very little to meet household needs through water management. When these structures are built, cost is shared by the community in the form of providing labor and raw material collected from the surroundings. This also serves multiple purposes and it could be considered as a multiple objective plans. These are used to produce crops, fruits and much kind of agricultural productions in addition to collecting and storing water in soil layers and aquifer. The surrounding environment is left undisturbed so it could be used as naturally friendly water management system, which can develop and coexist with the community's demand for water. The social dimension of these systems is extremely important. Most local people live in small communities and closely depend on each other. Traditional methods require participation and sharing that contributes to maintaining and improving social harmony. Increased agricultural production will ensure the food security of the watershed population. The increase in agricultural production will increase rural families incomes and improve the life style.

CONCLUSION

Small water management systems like Khooshab or Bandsar have emerged as the most appropriate technology for watershed development in rural and rainfed agricultural areas in arid and semi-arid regions. These traditional innovative methods offer a better option in many parts of Iran and similar countries for watershed development. The potential for these approaches are tremendous and detailed water balance analysis is necessary for thorough understanding of the effects of different methods on water resources in watersheds in hydrologic or socioeconomic issues.

It is evident that traditional water management methods still exist in many countries both in hilly and flat areas. Some of these technologies serve multiple purposes and have no harmful impact on the environment. However, some of these methods are being given up in favor of modern alternatives. Both traditional and modern methods have advantages and disadvantages. By incorporating beneficial elements of both into one, a water supply system can be developed that will be sustainable and environment-friendly in the long term. Finally from the results it can be drown that traditional knowledge is closely integrated with economy, environment and society. Based on sustainable cycles its operation leads to the definition of a new integrated paradigm. Application of traditional water management systems, where practically possible, provides the foundation for a profitable agriculture. As it is socially acceptable and environmentally sound, it could be practically sustainable. One of the often cited reasons for the failure of development projects in the developing countries is the lack of effective participation of the beneficiaries in decision making, planning and implementing such plans. This problem usually manifests itself when technologists, who intend to upgrade the well-being of a less advantaged community, are of different cultural background from the people whom they are going to help.

Since traditional water supply technologies have in most cases been able to meet the needs of local populations for many centuries, the systems could be clearly sustainable and benefit from the community supports. For example, Qanats have still been able to withstand governing policies, socio-economic, and climatic situations in Iran and could be used as an acceptable water management alternative. One of the reasons why some traditional methods have become less popular is that these methods usually serve a small community. With the increase in population due to growth and immigration from other parts of the country, water demand in hilly areas has grown many times. This demand can only be met with the help of mechanized water management systems.

On the other hand, these water management methods are location specific. Khooshab or Bandsar can be built across small hilly streams but this cannot be done across a medium sized river without a lot of prior planning and construction activities. Despite this issue, there are potentials for incorporating these methods into modern technologies and engineering practices. Local People should be empowered to manage and maintain water management systems. This specific opportunity could be prepared through locally based integrated planning at the strategic and tactical levels of decision-making process by collaboration between community, government and NGOs in water sectors.

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