AB-ANBAR, THE ANCIENT UNDERGROUND WATER HOUSES OF KHORASAN

J. Tabatabaee Yazdi[1]

ABSTRACT

Through out history, the people of Khorasan have battled the dryness by innovations to preserve every drop of water that lands from the rare clouds, or from a stream flowing out of distant springs. Water is precious and held with highest respect, whether stored for drinking at an Ab-Anbar, or for washing and farming at the Houz in the middle of their oasis homes and orchards, or sourced at a Qanat spring or Jooy under ground.

How it is that drinking water as cold as a mountain fall is found in desert of Khorasan? Ab-Anbar is an ancient means of water preservation and cooling through an underground building structure. These underground structures have been present in Khorasan and other desert provinces of Iran as public or private water storage facilities, widely used before the installation of public plumbing systems in the late 1950s. Although today many of these structures are still functional most have been protected by the Historical Heritage Society, for restoration or viewing by the public as museums.

Khorasan natural dry climate and the massive surrounding deserts have been a breeding ground for many designs of Ab-Anbars. Today the existing number of such facilities stands in the province of Khorasan. Usually these structures are built in populated areas, also there are some forms of such structures on old trade routes and roadways leading to and from populated towns.

The proposed paper is to be considered the history of Ab-Anbars in Khorasan as well as other aspects such as types, components, construction methods and materials together with water supply and withdrawal systems.

1. INTRODUCTION

The term ab-anbar is common throughout Iran as a designation for roofed underground water reservoir.

The ab-anbar was one of the constructions developed in Khorasan (north east of Iran) as part of a water management system in areas reliant on permanent (springs, Qantas) or

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on seasonal (rain) water. A settlement's capacity for storing water ensured its survival over the hot, dry season when even the permanent water supply would diminish. Private ab-anbar*s* were filled from Qantas (man-made underground channels), while surplus flood water could often be stored in open tanks, as well as in the large, public, covered cisterns. Water was brought to the ab-anbars by special channels leading from the main quanta or holding tanks and was controlled by sluice gates. The ab-anbar, with a proper ventilation system, could then provide cool water throughout the summer months. Often rooms or pavilions were built within the complex of the ab-anbar to provide a comfortable resting place as well.

Two types of structures have been noted, a cylindrical reservoir with a dome and a rectangular one supported by piers or pillars each was marked by a portal. The portal opened into a steep, barrel-vaulted passageway, leading down to the reservoir.

The prime objective in constructing an ab-anbar is to provide a totally waterproof container for a large volume of water while allowing for proper ventilation and access. The excavation was lined with overfired brick and it was then covered with a layer (about 3 cm) of waterproof mortar (sarooj). Larger ab-anbar*s* were often lined with an additional double layer of bricks, covered with another layer of sarooj of slightly different composition, and finished with a hard plaster coat.

Ab-anbar*s* are built in towns and villages throughout Khorasan, as well as at crossroads, caravan series. While town ab-anbar*s* may be filled with rain water or from Qantas, most ab-anbar*s* along caravan routes are filled from the spring torrents of nearby streams; during the dry season gradient weirs are constructed in the stream bed in order to divert water to the ab-anbar*s* when the winter snows melt and the streams rise.

2. MODE OF CONSTRUCTION

Ab-anbar*s* built inside private dwellings are usually square or rectangular; public ab-anbar*s* in towns or along the caravan routes are generally round. While the former have a flat roof and are often built into the foundation of the house, the latter have a distinctive hemispherical or almost conical roofing.

Water remains quite cool inside the ab-anbar, since it is generally built beneath ground level and is insulated by very thick walls. In the south of Iran, most particularly in Yazd province, one or more ventilation towers (*badgir*) is built along the edge of the ab-anbar′s roof, directly on the tank wall and connected by a duct to the upper part of the ab-anbar chamber under the domed roof. Fresh air entering through these ducts keeps the air inside the ab-anbar chamber circulating and the water cooled. In the case of ab-anbar*s* with domed or conical roofs, the center of the roof is sometimes pierced, and a short ventilation chamber made of brick is built directly over the ab-anbar chamber. A duct inside the ventilation chamber leads from the openings or slats (that catch the breeze on top) directly inside the roof, again circulating air inside the ab-anbar chamber. The height of these ventilation chambers is generally about one meter, though some can occasionally be seen that reach a height of two or even three meters (Fig. 1)

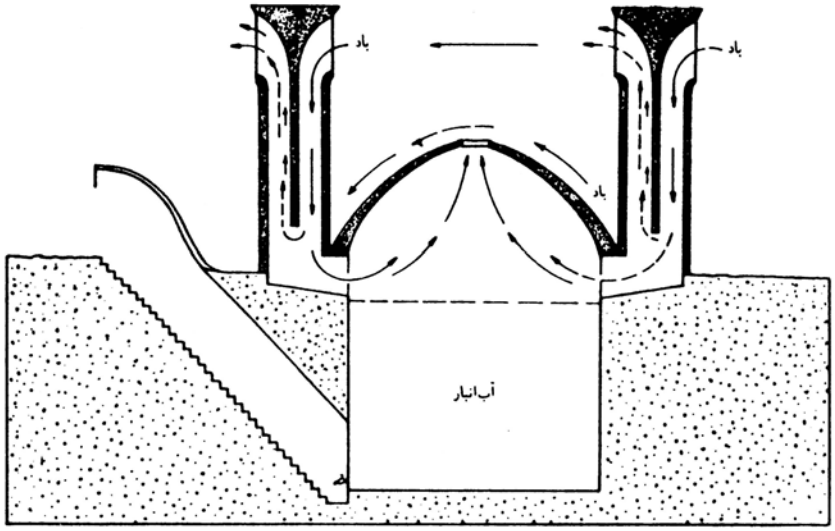

Figure 1: Cross section of Ab-anbar with ventilation tower

3. CONSTRUCTION MATERIALS

Materials used consist essentially of stone or baked brick with lime-mortar and plaster. After the pit that will house the ab-anbar has been hollowed out, the bottom is covered with slaked lime-mortar. When this floor hardens, the builder erects the tank's walls, made of baked brick or stone. The bricks are generally plunged in water before being laid. The filling between bricks or stones consists of lime-mortar. After the roofing of brick and slaked lime is laid, the tank's floor and walls are finished with a coating of plaster.

A type of ab-anbar, made of poured lime-plaster, is considerably cheaper to build. First the perimeter of the tank's walls is marked out, and the earth within the wall area is dug out to the desired depth. Next lime-mortar is poured into the square or rectangular trench until it is filled nearly to the ground level. This is left for a week or two until the mortar settles and is solidified. Then the area of earth bounded by the mortar walls is dug out down to the prescribed floor level. The floor is built by pouring lime-mortar; and, finally, when the walls and floor are dry, they receive a coat of plaster.

Plaster is an indispensable material in the construction of the Iranian ab-anbar, since the essential function, containment of water, is achieved by the watertightness of the plaster. The type of plaster most commonly used, called *sarooj*, is a compound from six parts clay, four parts lime, one part ash, and an amount of seed's pod sufficient to keep the compound from cracking. The first step in the preparation of this plaster is the mixture of the clay and lime, to which water is added. All of this is made into a relatively hard, clayey substance which is worked for one or two days. Next the ashes and pods are poured into this mixture until the various components have been thoroughly blended. This pounding is done with wooden sticks about 10 cm in diameter and one meter long, one end of which has been tapered to serve as a handle. This last step is important, because the more the mixture is pounded and kneaded, the more durable it is. When the plaster compound is ready, it is spread on the walls and the floor

of the ab-anbar with a trowel. The next step is to score the plaster surface with a stone that fits in the palm of the hand. This scoring goes on for several days until the walls and the floor of the tank begin to perspire, a sign that the components in the plaster are holding together fast. Only then is the ab-anbar filled with water.

4. DRAWING WATER

Ab-anbar*s* may be provided with a tap. When the place for the tap is reached in the course of construction, an additional pipe for it is built into the wall; and a plaster compound (half clay and half lime) called “batard” is pounded into the space above the pipe. Water is taken from this type of ab-anbar by means of a separate chamber, containing a staircase, about as deep as the adjoining tank chamber. The stairs are wide enough so that persons going up and down with buckets, gourds, or leather bottles will not get in each other's way. Two, three, or even more taps are sometimes installed. A few ab-anbar*s* have been observed to have two separate stairs on opposite sides. In the case of the ab-anbar*s* built alongside roadways, however, the normal procedure is to construct the staircase within the ab-anbar chamber itself, so that the water is drawn directly from the tank.

5. CAPACITY

The capacity of the traditional cylindrical ab-anbar varies generally from 300 to 3,000 cu m. This upper limit is dictated by the fact that the maximum diameter allowed by the method of construction is about 20 m. If the depth of the tank is up to 10 m, its capacity would be about 3,000 cu m. In a few localities the ab-anbar*s* have an even greater capacity, and some exceptional examples have been cited as able to hold up to 100,000 cu m. These are not round tanks, however, but square or rectangular ab-anbar*s* with columns placed in the middle of the tank chamber in one or two rows. These support a roof consisting of a series of domes or barrel-vaults.

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INVESTIGATION ON HISTORICAL LESS- IRRIGATION MANAGEMENT METHOD UTILITY IN AGRICULTURAL PRODUCTION IN YAZD PROVINCE

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ABSTRACT:

Water is one of the important basements in the agricultural production. Shortages of water quality and quantities from the ancient in the kavir area of Yazd province caused utility of specific management method to increase profitability of irrigation .less-irrigation is one of the methods which has been used from the ancient . In this management method, its tried to maximize the profitability of pure profit due to unit volume of water, considering conditions and effective elements.

Biography of agricultural activities in Yazd province shows that less-irrigation method was used for the old times in surface irrigation. This method mainly include providing the best planting pattern and agricultural activities such as vegetation density , fallow and alternation for using precipitation and storing humidity, changing plant time to shorten growth period, planting resistant and tolerable plants to drought.

The quality of using this method in different parts of Yazd was studied. In Abarkooh to keep and preserve pistachio gardens, farmers take the latest water of wheat and irrigate pistachios. In Sadoogh to plant summer crops farmer use the latest water of wheat or barely.

Investigation showed that using this method may increase profitability and exceeding valuation of whole agricultural productions, because agriculture is mixed of different activities.

Keywords: Historical study, agriculture, kavir, less-irrigation (few-irrigation)

INTRODUCTION:

Due to dry and ultra dry climate in Yazd province and little precipitation (mean annual about 105 mm) agricultural activities are difficult .Ground waters resources are the only resources which used for agricultural production. Despite of extended area of province which include 4.5% of whole country but agricultural lands are only 0.74%. This

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percentage of agricultural lands is based on utility of dry land agricultural methods using less irrigation and Qantas water. Basically less irrigation is a technique for irrigated vegetations (Faryab) to use maximum profit of water volume unit and maximum benefit of land unit to obtain maximum pure benefit. Shortage of water resources in agricultural section of province caused extension of using this method before drilling deep wells and 3000 Qantas are constructed.

This article is based on investigation as: Collection and record of native knowledge in agricultural section in Yazd province during 1382-1383(2003-2004)

In this study historical resources around water and irrigation water used .In addition , field study has been done anal , query forms was filled by qualified farmers and experts .Analysis of data and information fulfilled by SPSS software.

Fig 1- Situation of Yazd province in Iran

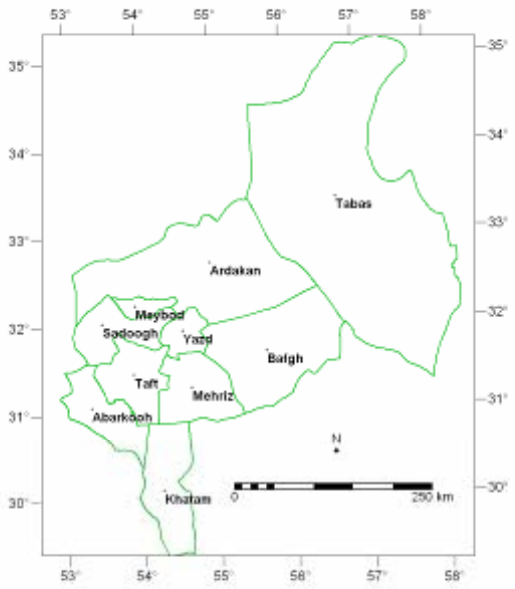

Fig 2- Map of Yazd province

LITERATURE REVIEW:

Sharifi (2003) studied influence of minerals such as bentonite and soil mixture with mineral cartridge (5%) on little irrigation of vegetation and introduced them as increasers of vegetation tolerances facing drought. [9]

Dehgani Tafti (2005) introduced sand as mulch for preserve soil wetness and conserve root and curb. [4]

Silspour reported that applying of plastic mulch may improve efficiency of used water from 4.77 to 6.26 kg/m3. [8]

Solimani poor et al (2004) studied plastic mulch influences on cucumber production and found that benefits coefficient is 3.19 to normal production which is 2.11.

Campos et al (1992) studied red soil mulch effectiveness on cucumber production and report that production increased to 60 ton/ha rating to 47 ton/ha in normal way. [15]

Amiri Ardakani (2002) reported the using of khake-sokhteh (burned soil) in Vashanaveh of Kahak (Qom) to reinforce hazelnut gardens.

Naraya Nasami (2002) reported using of clay, red soil, salt and calcium carbonate in ancient India. [17]

Amiri Ardakani (2002) reported a kind of irrigation management to combat crack at pomegranates [1] which is confirmed by Hydary (2003). [2]

1-LITTLE IRRIGATION IN LIGHT LANDS DURING WINTER AND SPRING TO PREVENT DRYNESS IN SUMMER:

Since, irrigation on level lands is more easy and exact, farmers tried to shape slope lands as small trusts and fix them with rocks (boulders), which prevent to soil leaching and waste of water(fig 1). Channel slope and erosion of walls and bed is decreased by constructing pads (clappers) to conserve more water in dry times. Karts (land section or partition) in village of Taft are around 25 to 35 m2 and in slope lands 10 m2, length of karts normally decreased to 7 m (fig2).

2-LITTLE IRRIGATION CONSTRUCTING SMALL SINK AROUND TREES (AGENE BANDY) TO DECREASE TRANSPIRATION OF SOIL SURFACES:

In drought times or dry seasons, farmers are concentrated to irrigate trees. In this condition just trees are watered. Due to canopy cover area of each tree, circular basins (karts) are made and filled with water. The other parts of land are cultivated to conserve the soil wet and absorbed by trees. This kind of irrigation is named as Jabieh Bandy. Irrigation Jabieh is ploughed and fertilized by animal manure to minimized surface transpiration (fig3).

In this innovation, water need of garden is minimized according to: Te= Eterop [Ps + 15(1-Ps)]. Which:

Te= need water in critical condition (Volume/ area unit)

ET= need water in normal condition (volume/ area unit)

PS: wet percentage of land

3-LITTLE IRRIGATION USING DIFFICULT MULCHES TO PREVENT SOIL SURFACE TRANSPIRATION:

For old times , wind sand was used to conserve soil wet in Taft for production of cucumber and the other summer crops in Taft.(Yazd province),(fig 4,5,6).To conserve wet in farm, decrease soil surface transpiration and prevent grounding when harvesting of alfalfa and so keeping of its root. For small saplings which need more wet washed sands are added around the root to conserve wet in early years.

Black sand (Rig-e-Siah) which is a kind of shale is used to grow summer crops seeds in Nasrabad (Yazd).

Bentonite and minerals cartridge which is mixed with soil (5%) is introduced by Sharifi as increased of vegetation tolerance to dryness.

Straw, date's foliage, walnut leaves are used as soil wet keeper. Animal manure as a thin layer is applied to keep wet in alfalfa and orchard frees while water shortage.

In recent years, plastic foils are used to keep wet in summer crops. Before cultivation narrow partitions (kart) are formed and covered by plastic foil, then seeds are planted. In this way , water is consumed to ¼ normal volume .Tunnel cultivation using plastic foil for cucumber , tomato, water melon, marrow is normalized , which decrease water consumption and protect weed growing and so to premature of product, accelerate germination of seeds due to high temperature under the tunnels and decrease damages of storm and hail.

Using mulches of tree's leaves, decayed animal manure, mineral materials may conserve humidity and cause strengthening of soil. Several kind of weeds are applied by farmers to cover the soil in front of sunlight, wind and storm to prevent of soil surface dryness. As farmer believe, garden weed or wild millet consume little amount of water and food but it has more advantage.

4-LITTLE IRRIGATION WITH SOIL OPERATIONS TO PRESERVE SOIL MOISTURE:

In dry season, around the trees are ploughed slightly after every irrigation to prevent soil surface transpiration, in this way without any damages for trees, duration of irrigation will increase to 2 times. To keep soil moisture and grow seeds in good condition , soil is scraped by rake after planting the seeds and primary irrigation, which preserve soil humidity for a long time , this way named as: <<Rehtah kashy>> . This method may break soil and prevent capillarity and deep transpiration to combat dryness and water shortage.

Black marl and red shale which are exposed in the area were used to modify the soil texture (30ton/hec) in Nasrrabad named as :(Rige-siah) and Eslamieh, zainabad, Taft named as: (khak-e- sorkh).

Using a kind of soil by the name of khak-e-sokhteh (burned-soil) in hazelnut gardens of Vashnovah village of Kahak (Qom) is reported by Amiri Ardakani.

5-LITTLE IRRIGATION USING CANAL AND LEVEES (JOO AND POSHTEH):

Summer crops planting are done in Joo and poshteh method, because it's believed that more water would be saved. In this way, 1/3 of soil surface or canals which is covered by gravel will be drowned and levees will keep water for crops, consequently transpiration is decreased to 1/3. This method was named as :<< Moreh kary>> (fig7).

6-LITTLE IRRIGATION WITH BUILDING MOUND BETWEEN THE TREES:

Soil mound with one meter width are made in Almond and pomegranate orchards, after spring time ploughing. The other way to prevent of stress to trees is using mound with 0.5-0.7 meter height and 1 meter diameter which is named as:<< Band and pazman >>(residual soil) or (khak dehi paye derakht). The soil of mounds are exposal to the sun and changeable with land soil for next year which may reinforce fertility of soil (fig11).

This method may intense prevent of cold stroke of curb of pomegranates trees, transpiration stress in leaves before reaching water, and so crack of pomegranates [7].

7-LITTLE IRRIGATION USING MANURE PIT (CHAL KOUD OR KOUD DEHEE) IN SUMMER CROPS:

There was a method in planting of watermelon and marrow which used holes(50*40cm2) filled with soil , 1/3 decayed animal manure and 1/3 range bushes such as Peganum Harmala, Ephedra Strobilacea, Hertia Angustifolia and amount of garden leaves and chips. Using this way may preserve water in holes due to high permeability and reinforce soil fertility caused by manures which leads to prolog irrigation duration.

8-LITTLE IRRIGATION USING PLANTING MANAGEMENT:

There were found several plantation management in village of study area:

a- Discipliner plantation to adapt with drought.

A cultivar land is divided to: a strip around (1/3 area) for fruit trees and the inner part (2/3 area) for farming which is named as:

Derakht kary va Sadeh kary (fig 8).In wet years whole land is planted, but in dry years or summer just trees are irrigated and inner part is fallowed. Spring planting inclusive: wheat, barely, cucumber in middle, part and after harvesting would be ploughed immediately. This manner is managed to control fluctuation of water resources (Qantas and springs) and maximize water utility.

B: selection of adaptable plants

Pomegranates, Almonds, Berries, walnuts are selected trees which are adapted with dryness.

Alfalfa, turnip, carrot, summer crops and cereals are planted in wet years but irrigated spring barely or wheat and peas are cultivated in dry years. Off course in ultra drought these kind of culture are fulfilled under the shadow of trees, solely (fig…).

Considering to harvested water from Qantas or spring more area of surrounding lands of village would be selected for farming or managed to be left.

In drought, just closest gardens to water resources would be irrigated and the others would be left. In this way, peach, hazelnut, pear and cherry trees are planted in the closest gardens to the water resources, almonds are cultured in far gardens, almonds, and berry and oleaster are planted, sparsely.

Vegetables, cucumber, marrow and tomato are cultured around the pool. In some villages, every family has a small land around the pool or Qantas to be able to supply its needs.

Special irrigation duration selection is a kind of management which is allocated for vegetables and summer crops, for example if duration is 16 days its increased to 18 day , but in every 8 day one time water is used for vegetation and summer crops. This is named as : Ab-e-tar(faster irrigation) Alfaalfa,cotton.summer crops , wheat , barely and pomegranates , pistachio are cultured in separate lands in plain village which have more stable water condition oleaster ,pedeh,berry,willow are planted in

the margin of water canals. Wheat, barely, alfalfa, cotton, madder and beet are cultivated in the pistachio gardens of Ardakan, solely and marginal trees are pedeh, oleaster and tamarisk. In more dry areas, pistachio are selected to be cultured in salty and alkaline soils of Chahafzal (Ardakan).

9-LITTLE IRRIGATION USING WATER ABSORBING MATERIALS:

Red soil (Gel-e-sorkh or khak-e-sorkh), Black gravel (Rige-e-siah), salty soil (khak-e-shoreh or gel-e-yogheh) are used material to modify soil texture. These kinds of soils include marl or clay which keep water and were used with animal manure to reinforce the soil. In Taft, Nasrabad percentage of water absorption and absorbable potassium ratio of some samples were tested in lab that is 38% of weight and 292 ppm.

Salty soil named as shoreh which is a kind of clay and evaporational sediments including K,Fe an Mg were used for pomegranates, wheat, barely, cotton, alfalfa, beat and poppy , mixing 1/3 animal manure.

10-LITTLE IRRIGATION WITH ELIMINATING LAST WATER:

In dry years, farmers plant wheat and barely in fall and winter, and irrigate it. In spring that orchard trees and vegetables need water last irrigation would be eliminated. In Abarkouh, last eliminated water is given to pistachio orchards and summer crops.

SUGGESTION:

1- Publication of valuable experiments of kavir area farmers such as Yazd and as native knowledge.

2- Support of village to use native knowledge of little irrigation or providing new methods to keep village stand up.

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INDICES:

Fig 1: less irrigation with terrace building for wheat growing (Sanij)

Fig 2: less irrigation with partitioning (little partitions 3*4 m2) (Sanij)

Fig 3: less irrigation with making sinks around the trees.

Fig 4: less irrigation using sandy mulches (Aliabad).

Fig 5: less irrigation using black sandy mulches (Aliabad).

Fig 6: less irrigation using plastic mulches (Hemmatabad).

Fig 7- Little Irrigation with building mound between the trees (Nir).

Fig 8- Discipliner plantation to adopt with drought.

Fig 9-Discipliner plantation to adopt with drought, potatoes and beans within almonds garden (Sanij).

Fig 10 -Nasrabad black sand mine.

Fig 11- Ephedra Strobilacea is used in manure pit.