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FULL EXPLOITATION OF GROUNDWATER AND ITS ECONOMICAL-SOCIAL BACKLASHES

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Abstract. About fifty years ago, the total groundwater withdrawal rate of *qanats* (gently sloping subterranean conduits) in Iran was approximately 18 billion cubic meters a year, which was 2 times of the present amount. This problematic decline is attributable to extensive pump extraction of groundwater and many wells drilled in the past few decades. Iranians had not faced such a problem during their history, while using *qanats* to supply water. But all *qanats* are going to dry one after another because of the wells and their pump extraction which take the water table away from the access of *qanats*.
In fact, pump extraction is not applicable to the environmental conditions of Iran. These wells gradually make both soil and groundwater salty and consume lots of energy. *Qanats* are supplying water without any use of energy. The pumps are threatening groundwater in Iran and putting her economical-social systems in a real crisis. Iranian authorities must think of some indigenous ways and refer to some sustainable systems such as *qanats*, otherwise the growing pumps activities can lead to the annihilation of the extractable groundwater, and then the agriculture in Iran.

Key words: groundwater, depletion of aquifer, *qanat*, pump extraction, water well.

Abstrakt. Pięćdziesiąt lat temu *qanaty* (łagodnie nachylone podziemne kanały) dostarczały w Iranie około 18 mld m^3 wody podziemnej rocznie, tzn. dwa razy więcej, niż obecnie. Spadek wydajności *qanatów* jest wiązany z intensywnym pompowaniem wód podziemnych z wielu odwierconych w ostatnich dekadach studni. Podczas całej swojej historii Irańczycy nie spotkali się z takim problemem, gdy wykorzystywali tylko *qanaty.* Tymczasem *qanaty* będą jeden po drugim wysychały, ponieważ pompujące wodę studnie wiercone obniżają zwierciadło wód podziemnych poniżej zasięgu *qanatów.*
Eksploatacja wód podziemnych metodą pompowania nie odpowiada środowiskowym warunkom Iranu, bowiem powoduje ona stopniowy wzrost zasolenia zarówno wód podziemnych, jak i gleb, zużywając przy tym wiele energii. Tymczasem *qanaty* dostarczają wodę całkowicie bez wykorzystywania jakiejkolwiek energii. Pompy głębinowe zagrażają zatem wodom podziemnym Iranu prowadząc do kryzysu społeczno-ekonomicznego. Irańskie władze muszą znaleźć lokalny, zrównoważony sposób zaopatrzenia w wodę. W przeciwnym wypadku rosnąca liczba pomp głębinowych może doprowadzić do zniszczenia zasobów wód podziemnych, a w rezultacie do upadku irańskiego rolnictwa.

Słowa kluczowe: woda podziemna, wyczerpywanie zbiornika wód podziemnych, *qanat*, eksploatacja pompami, studnia głębinowa.

QANATS SYSTEM IN IRAN

Iran is an arid area and its average rainfall does not exceed 250 millimetres a year. Therefore, all agricultural systems as well as human civilisations in Iran have always depended on the groundwater obtained through *qanats*, gently sloping subterranean conduits, which tap a water-bearing zone at a higher elevation than cultivated lands.

There are 32,164 *qanats* in Iran. and an estimated total length of their galleries is about 310,800 kilometers (Papoli Yazdi, Labbaf Khaneiki, 2003). An area near a mountain slope is usually chosen in order to dig first well of *qanat*. Some professional workers named *moqanni* are always responsible for both constructing and repairing *qanats* all over Iran. The work-

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ers (*moqanni*) continue to dig the first well as long as they come across the aquifer seeping water into the bottom of the well. Then they stop digging the well because the water level is coming up, and start digging a long tunnel crossing bottoms of all the wells, from the surface of earth to the last and deepest well. The tunnel is roughly horizontal, with a slop to allow water to drain out. The wells are used to empty the tunnel of soil as well as to ventilate the tunnel. Withdrawal rate of each *qanat* depends on its length within the aquifer. *Qanat* has been an important part of a sustainable productive system, consistent with the environment of Iran, and used during the past centuries without damaging aquifer reserves (Papoli Yazdi, Labbaf Khaneiki, 1999).

EFFECTS OF APPLYING WELLS PUMPING TO GROUNDWATER EXTRACTION IN IRAN

Pump extraction began to replace *qanats* since about 1945, because some farmers needed more water to develop their lands. They just preferred to dig deep well and use pump extraction which took them less time than *qanat*, and it was also easy to dig such wells, unlike *qanats,* in either confined or karst aquifer (Aqasi and Emami Meybodi, 1999).

The first well with extractive pump was drilled in Neyshaboor region (the northeastern Iran), in 1958. The number of such wells reached 14 in 1960, and then amounted to 286 in 1970. These wells finally increased from 1514 thirteen years ago (1990) to 1580 today. A massive groundwater extraction causes depletion of total aquifer reserves and dramatically reduces the water table of the whole surrounding area. As estimated, in the Neyshaboor region the water table goes down about 0.2 meters a year on average because of the massive groundwater extraction (Velayati, 1999).

In effect, most *qanat*s was drying one after another due to the wells and their pumps, which took the water table away from the *qanats* access. Depletion of aquifer not only makes *qanat*s dry, but also causes desertification of the area, especially in the central Iran in which some plants, such as Salsola Sp. and Seidlitzia Sp. usually grow on the water table (Ekhtesasi, Daneshvar, 1999).

When we worked for Amirkabir institute in 1996, we came across an amazing adventure explaining the role of pump extraction in some social-economical problems. There were some villages in southern Khorasan region, located in the eastern Iran, in which some peasants traditionally earned their living by camel husbandry. A governmental company made a decision to help them to start cultivate their pastures, in hopes that they could improve their economical situation. Therefore, the company persuaded them to give up camel husbandry that could waste their capabilities. They started to drill many deep wells to pump water for lands allocated for production of pistachio, instead of camel husbandry.

The extracted water contained some salt, and irrigation water that was not probably drained, has left a salt residue. The salt has built up and finally led to transformation of soil condition into unusable for farming. According to the Blue Gold book, salinity has affected a fifth of the world's agricultural land, and each year it forces farmers to abandon a million hectares of farmland (Barlow, Clarke, 2003).

Eventually, the aforementioned farmers had to stop planting the pistachio trees, because the salty soil did not allow the pistachio growing. They intended to return to the camel husbandry, but the environmental condition had changed as well. The pumps have caused such depletion of aquifer that roots of plants such as Alhaji (the main camels food) could not reach the water. Therefore, there is not enough plants on which peasants camels graze. That way, farmers lost both agriculture and animal husbandry, and they had to emigrate to principal cities becoming a community of poor suburbanites (Fig. 1).

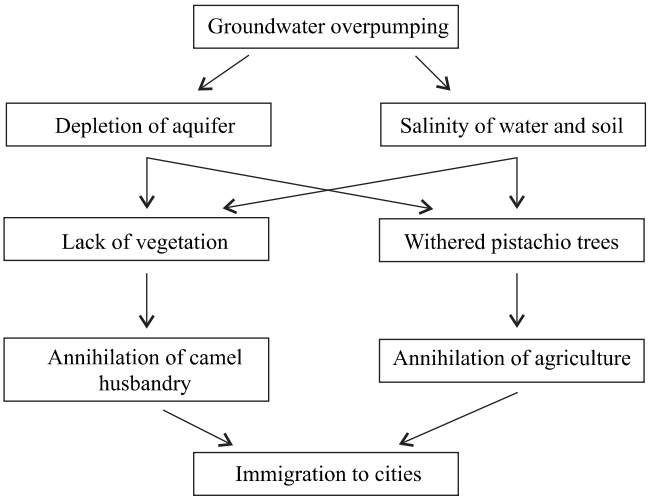

Fig. 1. Scheme of groundwater overexploitation impacts

THE LAND REFORM IMPACT

The land reform law, approved in 1960, aggravated the problem of drying *qanats*. Before the land reform, most of the Iranian population resided in rural regions. Each village consisted of agricultural units named *boneh*, cultivated by 8 to 12 farmers. The duty of each farmer was perfectly specialised. Everybody worked and lived under the management and authority of a lord, who owned the whole village. According to the Law of Land Reform, villages were purchased from lords

by the government one after another, and then were sold by instalments to a few farmers of the same village. The mechanised farms were the exception, and having pump extraction was legally considered as a proof of it (Azkia M., 1994). So, most of the lords were encouraged to replace *qanats* with pump extraction for economising their properties (Fig. 2).

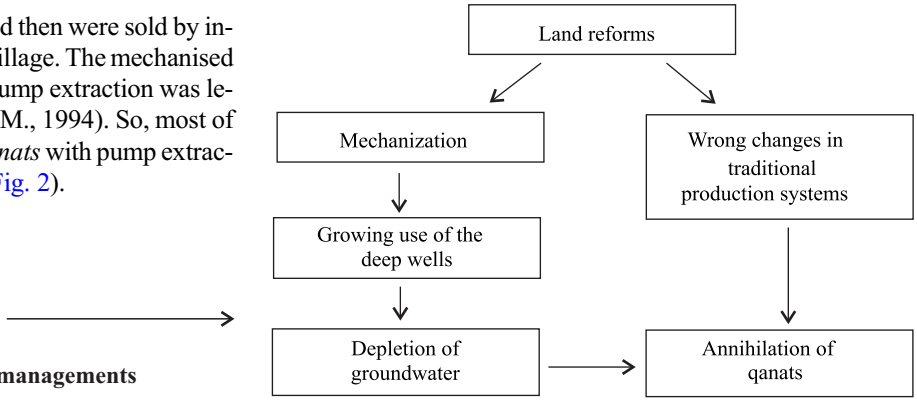

Fig. 2. The changes of water managements

HARMS CAUSED BY BIASED REPORTS

Most of the scholars and politicians tried to exaggerate the technical defects of *qanats* to convince farmers to use pump extraction instead of *qanats.* For instance, a report entitled *Economical Development of Soil and Water Resources* was prepared in 1966, assessing the amount of required water to irrigate an area equal to 10,000 m^2or a hectare. Some parts of that report discussing modern techniques estimated the amount of required water for a hectare to be about 10,000 m^3a year. On the other hand, another part related to *qanast* and traditional irrigation made contradictory statements, saying that estimated amount of water needed for a hectare was about 16,400 m^3 a year. It was a thirty percent decrease in the required water, in comparison with real estimate, when the report explained modern irrigation, and a sixty percent increase when the report dealt with *qanats* and traditional irrigation. The report concluded, based such on estimates, that a *qanat* was not be able to supply the required amount of water to irrigate our farms.

Such misleading reports resulted in thousands *qanat*s being destroyed. For instance, only in the field of Yazd (in the central Iran) there are more than 70 dried-up *qanats* which have caused many villages, and about 2,500 hectares of the rich lands, to be abandoned (Labbaf Khaneiki, 1999). The reason why *qanats* started drying out was that many deep wells were drilled on the lower slopes to extract water with pumps.

In Ghoochan plain (in the southeastern Iran), there are groundwater streams from the southeastern, northern and southern sides towards the centre of the plain. All *qanats* are located on the plain surroundings unlike the deep pumping wells that have been located in the centre. Therefore, the deep wells can extract groundwater as long as their engines work. In a nutshell: those wells caused groundwater to decline, and made a great damage to 125 *qanats* on the plain, because *qanats* depended on water table that steadily went down with continuous water pumping. The piezometric wells showed that between 1994 and 1997 there has been a decrease of 24.5 million cubic meters in the groundwater resources in Ghoochan plain (Kazemi *et al*., 2004).

When villagers would lose their *qanats*, they would have to purchase or rent required water from the deep wells owners. But in fact, the water they have to pay for it is the same water they used to obtain through their *qanats* free of charge. As Bonine reports, if one or a few individuals have financed a deep well, water might be used only for themselves or it may be rented by hours (Bonine, 1982). It is an unfairly transaction that the villagers' water is being sold to themselves. As a result, lots of villagers have not afforded the cost of water and preferred to leave their farms for cities. This is another problem we always face (Fig. 3).

Comparison of *qanat* with well (extractive pump) can shed a light on the fact that in many cases such wells are not suitable for Iranian agricultural systems. Extractive pump empties a porous layers of water and causes subsidence which do lots of damage to soil structure and even to buildings. If extractive pump emptied karstic holes with water and destroyed them,

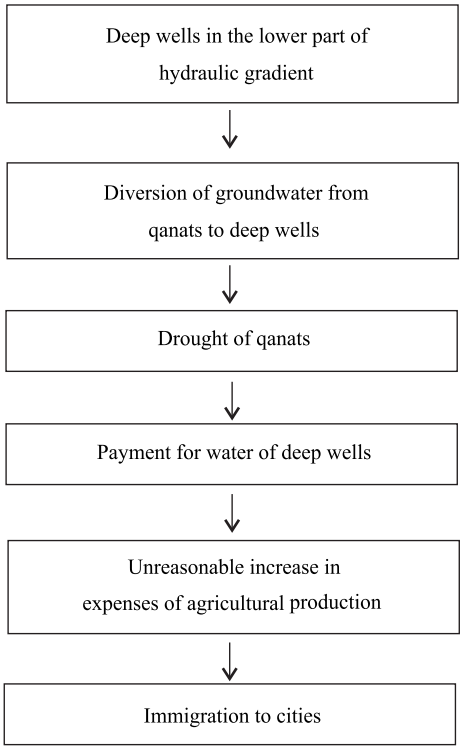

Fig. 3. Results of water supply changes

then a circular hollow appears within a radius of 100 meters on surface of earth. But *qanat* never makes such a problem. Loss of fresh water, which makes salt water moves upwards, is attributable to extractive pumps, whereas *qanats* never change the water quality.

According to some information on Iran, wells with extractive pumps could last no more than 30 years, unlike *qanats* which last more than 2000 years without any defects.

In fact, water flows out of *qanat* only due to the gravity force, which is free of charge, whereas the extractive pumps consume an enormous amount of fuel per year. For example, in Yazd area there are 4,340 wells with extractive pumps, which totally consume 205,854,880 litres of oil a year in order to obtain 926,350,000 m^3 of water. But in the same area, there are 2,948 *qanats*, which withdraw 329,870,000 m^3 of water a year without any fuel (Baqeri, Roozbeh, 1999). Therefore, such extractive pumps replacing *qanats* can do damage to our economy.

Contrary to such shocking facts, Iranian authorities seem unwilling to stop the extractive pumps from growing. For instance, Pumpiran Company is one of the most important companies in Iran that is producing more extractive pumps for wells than ever. Pumpiran was just a small company established in 1973, but now the company has 550 employees, more than 30,000 square meters of workshops and auxiliary buildings. In 1991, the company became a public utility and belongs now to thousands of shareholders in Tehran stock market (URL Pumpiran).

Also the number of drilling companies, responsible for most of the massive groundwater overpumping, is still increasing. According to the report of Iranian Water Organisation, in 2003 there were 347 companies with 1389 drilling machines, involved in exploiting aquifers all over Iran. It is estimated that the aforementioned companies drill about 1000 kilometres a year in total in order to establish many deep wells allowing them to pump groundwater (URL Water News Network).

CONCLUSIONS

Nowadays, environmental and economical disorders resulting from modernisation processes have made us think of other ways of production. On the other hand, we have been equipped with modern technology while trying to retain the traditional production techniques. We need to think more of a return to indigenous techniques without ignoring the effectiveness of modern technology. Doing this we will able to develop an appropriate agriculture system consistent with the social--economical conditions of Iran.

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