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# An Assessment of Groundwater Crisis in Iran Case Study: Fars Province

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***Abstract*—**Groundwater is one of the most important water resources in Fars province. Based on this study, 95 percent of the total annual water consumption in Fars is used for agriculture, whereas the percentages for domestic and industrial uses are 4 and 1 percent, respectively. Population growth, urban and industrial growth, and agricultural development in Fars have created a condition of water stress. In this province, farmers and other users are pumping groundwater faster than its natural replenishment rate, causing a continuous drop in groundwater tables and depletion of this resource. In this research variation of groundwater level , their effects and ways to help control groundwater levels in some plains of Fars were evaluated .Excessive exploitation of groundwater in Darab, Jahrom, Estahban, Arsanjan, Khir and Niriz plains of Fars caused the groundwater levels fall too fast or to unacceptable levels. The average drawdown of the water table in Arsanjan, Khir. Estahban and Niriz plain plains were 12,8, 9 and 6 meters during 16,11,11 and 13 years ago respectively. This not only reduces available water resources and well yields but also can saline water intrusion, reductions in river flow and in wetland areas , drying springs, and ground subsidence, considerable increase in pumping costs and a significant decline in crop yields as a result of the increasing salinity. Finally based on situation and condition of the aquifer some suggestions are recommended.

***Keywords*—**Fars province ,ground water overdraft , water table

## I. Introduction

IRAN is a country in southwestern Asia, located on the eastern side of the Persian Gulf. Covering an area of 1,648,000 square kilometers and is one of the largest countries in southwest Asia. Such factors as the height and direction of mountains disparity of plains and existence of desert, the proximity of seas (in the north and south), as well as directions of seasonal winds have is mainly desert, and most of the places (except northern and north western regions) have less than 300 mm rainfall per year. Average of Iran annual precipitation is about 240 mm. The rainy period in most of the country is from November to May. In the dry period between May and October, rain is rare in most of the country. In other words, it seems that the temporal and spatial distribution of precipitation in Iran is volatile, as 90% of total precipitation occurs in cold and humid seasons and in northern and western parts of the country and only 10% occurs in warm and dry seasons and in central, southern and eastern parts. About 52% of precipitation occurs in 25% of the area of the country, hence some parts of the country will suffer a lack of water resources and water crises in the near future. In many localities of Iran, there is no rainfall until sudden storms, accompanied by heavy rains, dump almost an entire year's rainfall in a few days. These torrential rains cause floods and local damages. One of the critical concerns of Iran is the evaporation and acute transpiration of surface water under solar radiation.

According to the water comprehensive plan of the Iran country, the total annual precipitation throughout the country as the main water resources in Iran is equal to 413 billion cubic meters, of which 93 billion cubic meters flows as the surface water, 25 billion cubic meters penetrates to the mobile aquifers and the rest becomes un accessible in the form of evapotranspiration from the surface of the land, forests, pastures and dry farming areas. Besides , water resources supplied through precipitation, about 12 billion cubic meters enters our country via rivers which makes the total surface water resources reach 105 billion cubic meters. Considering the 25 billion cubic meters of the underground mobile aquifers, the total renewable water resources of the country reaches 130 billion cubic meters. The studies reveal that about 89.5 billion cubic meter of the total renewable water resources is used for the sectors of agriculture, industry, mines and home usage as the following[1].

- 83 billion cubic meters, that is 93 percent for agriculture;
- 5.5 billion cubic meters, that is 6 percent for home usage;
- The rest for the sector of industry and the other ones.

Water is an essential component of Iran's history and the success of its economy moving forward [2]. While the average rainfall in dry region of the world is 860 mm, in Fars province average of annual precipitation is about 323 mm. Annual precipitation is 41,000,MCM that 27,000 MCM is evaporated and 8,000 MCM becomes ground water and 6 MCM flow as surface water. Water consumption in Fars is about 10.5 billion cubic meters that 2.5 billion cubic meters of it is provided by surface water resources and 8.0 billion cubic meters is provided by the ground water resources . According to this research, 95 percent of the total annual water consumption in Fars is used for agriculture, whereas the percentages for domestic and industrial uses are 4 and 1 percent, respectively.

Groundwater and water resources management plays a key

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role in conserving the sustainable conditions in arid and semi-arid regions. Groundwater is one of the most important water resources ,making it fundamental to people life and economic development in Fars province. There are many reasons why society has found it so useful to develop groundwater, but among the most important are:

- aquifers are very convenient sources of water because they are natural underground reservoirs
- many aquifers are also able to offer natural protection from contamination ,so untreated groundwater is usually cleaner and safer than its untreated surface water equivalent;
- groundwater is relatively easy and cheap to use. It can be brought on-stream progressively with little capital outlay and boreholes can often be drilled close to where the water supply is needed;
- it is a resource that is organizationally easy to develop; individuals can construct, operate and control their own supply, often on their own land.

Land surface deformation associated with groundwater overexploitation is a serious challenge for plain aquifers of Fars province and other regions of Iran , particularly in semiarid and arid region. For example in the Greater Tehran area, the capital of Iran with a population of 14 million people, groundwater discharge has exceeded natural recharge over the last decades, causing significant drawdown of groundwater level and land subsidence.

Table 1 provides an overview of how water resources were used generally in Fars province [3].

TABLE I
A GENERAL VIEW OF WATER RESOURCES AND USES IN FARS PROVINCE (MILLION M 3)

| Sources of use | SURFACE WATER | groundwater | total |
|---|---|---|---|
| Agriculture | 2549 | 6657 | 9206 |
| Industry | 21 | 54 | 75 |
| Residential | 30 | 295 | 325 |
| Total | 2600 | 7006 | 9606 |

Source: Fars water corporation [3,10]. (2005-2006)

As shown in table 3, over 70 percent of total water used in the province are withdrawn from Groundwater aquifers.

There are some 180 small and large aquifers in the province. Based on data collected from 1346 wells during period 1994-2006, average annual decline of water table in 80 percent of aquifers is 0.5 meter, ranging from 0.03 to 1.97 meters annually. Accordingly, groundwater decrement due to over pumping has been estimated at 258 million cubic meters.

As indicated, groundwater overdraft has deteriorating effects on water quality. Based on analysis of water quality in 57 plains, water salinity in 37 plains is increasing. Table 2 shows Electrical conductivity (EC) of groundwater in critical aquifers of Fars province.

Water salinity is measured by electrical conductivity of (EC) Saturated extract of soil of root zone. For practical purpose however, EC of irrigation water is measured first, then EC of saturated soil is obtained by dividing EC of irrigation water by 1.5. It is reported that if EC of saturated extract of soil reaches 14000 µ micromohs/cm (or) 14 (mmhos/cm), relative yield of wheat falls by 50% [4].

TABLE I I
ELECTRICAL CONDUCTIVITY OF GROUNDWATER IN FARS PROVINCE

| Aquifer | Number of years | Δ EC µ MOHS/CM | Situation |
|---|---|---|---|
| Kavar-Maharloo | 6 | + 376 | Fairly critical |
| Sarvestan | 6 | +563 | Critical |
| Farrash band | 11 | +692 | Critical |
| Nimah | 6 | +1227 | Very critical |
| Khasuyeh | 8 | +1518 | Very critical |
| Dasht khak | 8 | +1459 | Very critical |

Source: Fars water corporation[3,4,10].

## II. MATERIALS AND METHODS

Fars province is located in the south part of I. R. of Iran, at 50o30′ to 55o38′ longitude and 27o3′ to 31o42′ N latitude, with 124000 km2 area and it includes almost 7.5% of Iran's area. Mean elevation of Fars Province is 1,350 m above the sea level. It's the 3rd largest province in Iran. The climate in north of this province is cold, while in central part it has mild and rainy winters and dry summers, and in south and south-east winters are mild and summers are hot.

The majority of the rain producing air masses enter the region from the west and the north-west, yielding relatively high precipitation amounts for those areas. Towards the south and south-east, rainfall is decreases. Furthermore, winter precipitation in the north-west area is in the form of snowfall, but for other areas it is mostly in the form of rain. The mean annual precipitation for the province ranges from 50 to 1000 mm [5,6]. Therefore, most of the parts of this province is arid or semi arid. Also, the shortage of water resources for agriculture usage are existed in the most of plains of this province.

Fars ground water resources consist of 71315 wells, 2910 springs, and 1402 qanats and provide 79 percent of total water

consumption .Thus in different regions of Fars province groundwater plays a key role in all forms of development. In the last years, aquifers development have been continued in order to fundamental of economic development and water supplies for different usages sectors such as domestic, industrial and specially for irrigation usages.

Based on our information there are about 180 agricultural productive plains with approximately 48000km2 area in Fars province and existence of these plain have caused ,which the Fars province became the greatest producer of wheat, barn, corn and the 3rd producer of rice and the 5th producer of cotton in Iran in the recent years.

Groundwater is by far the most important sources for water supplying in agricultural sector in Fars province. Groundwater aquifer management plays a key role in conserving the sustainable conditions in arid and semi-arid regions[7] specially in Fars. According to this research, 95 percent of the total annual water consumption in Fars is used for agriculture. The agricultural sector of Fars province plays a vital role in the national economy and food products of Iran. The evaluation and monitoring of monthly groundwater level in Fars aquifers during the last years can help us to manage and control the groundwater crisis. In this research, monthly groundwater level fluctuations of a lot of observation wells in different parts of Fars province were evaluated between 1993 t0 2006. Unit hydrograph of groundwater aquifers were provided and the trend of groundwater level and their fluctuations were determined.

Growing Fars people population causes more use of fresh water resources in order to more crop production. Crop production in the arid regions of Fars consumes large quantities of water. While the production of 1 kg of grain in the temperate zone takes less than 0.5 m3 of water, 1.5–2.5 m3 is normal in the arid zone. Irrigated crop production in the arid zone therefore exerts a heavy toll on the available scarce fresh water resources [8]. Groundwater is, however, the main and more reliable resource of irrigation. Both over-exploitation from aquifers to address the irrigation needs, and drought events have caused severe water table level drop in many areas. Where groundwater is used for irrigation, aquifers are also being depleted at an alarming rate. In Iran, the current groundwater abstraction exceeds the safe yields by some 15%–20% and water tables in some irrigated areas are falling at 0.5– 1.0 m per year [9].. The situation is equally alarming in some parts of the Indo-Gangetic plains in India, the North China Plain and in the south-west of the USA [8]..

The data and other information of monthly groundwater level of some observation wells , which was recorded continually during 1994 to 2006 were evaluated ,then has been used in this study. These wells are distributed among the study area to indicate the trend and fluctuations of groundwater level all over the Fars plains. The data recorded for each well consisted of average monthly water table level ,with totally 168 data measurements for each well during the 14 years [2,5,6,10].

Beside the stress on groundwater aquifers, the other important factors that affecting on the water crisis in Fars is low irrigation efficiency particularly in agriculture. That is reported which ,irrigation efficiency rate is variable from approximately 20 percent in the traditional rice fields to 75 percent in the sprinkle system types ,also surface irrigation efficiency is usually lower than the other advanced methods. Based on previous study , Fars irrigation efficiency is estimated near to 30 percent, which is really low and should be increased in future.

Notwithstanding groundwater shortage in Fars aquifer, the rate of water loss in the irrigation networks and farming areas is so high, meanwhile there aren't enough developed irrigation networks in this province. The improvement in the irrigation efficiency is one of the methods, which compensate water deficiency. For example, one percent increase in water efficiency causes to save 800 million cubic meter of water in Iran, which results in the irrigation of additional 8000 hectare of the agricultural areas [1].

## III. RESULTS AND DISCUTIONS

In the recent years, a dramatic increase in discharge of aquifers were observed ,because the population growth and economic development needs to supply of water more and more in different sectors of water usages for instance domestic, industrial and specially for irrigation purposes.

Population growth, urban and industrial growth, and agricultural development in Fars have created a condition of water stress. In Fars province, farmers and other users are pumping groundwater faster than its annual natural recharge rate, causing a continuous drop in groundwater tables and depletion of this resource. In this research variation of groundwater level , their effects and ways to help control groundwater levels in some plains of Fars were evaluated .

The observation wells network of 82 plains in Fars province have completed yet .The fluctuation and changing trend of ground water level in some of important plains were evaluated during 14 years. Based on evaluation of aquifer unit hydrographs which provide for this plains ,it is evidence that there are 68 plains with negative groundwater balance and they were showed a considerable decrease in the groundwater level.

This research shows that the groundwater level has dropped as a result of Rapid population growth , the increase in number of wells and pumping rate and is extremely lowered over 14 years ago . Excessive exploitation of groundwater in Darab, Jahrom, Estahban, Arsanjan, Khir and Niriz plains caused the groundwater levels fall too fast or to unacceptable levels. The figures 1, 2,3, and 4 give information about amount of monthly rainfall (mm) on left vertical axes and groundwater level fluctuation(m) on the right vertical axes in Arsanjan, Khir. Estahban and Niriz plain respectively during 11 to 14 years. The figures shows the average drawdown of the water table in Arsanjan, Khir. Estahban and Niriz plain plains were 12,8, 9 and 6 meters during 16,11,11 and 13 years ago respectively.

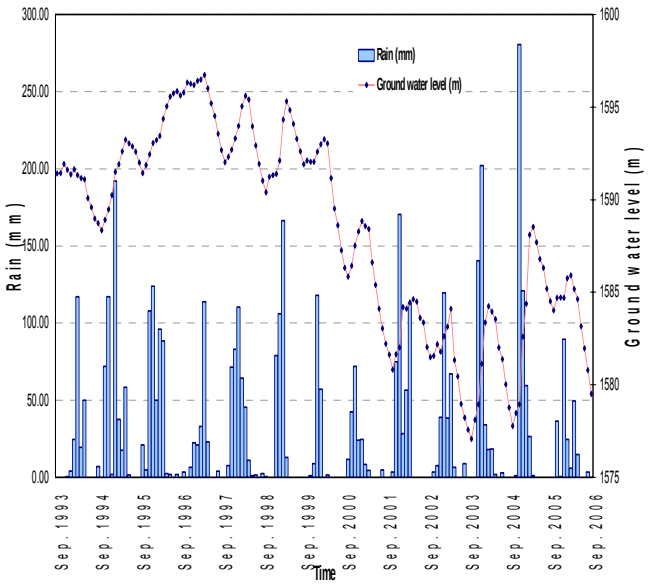


Fig. 1. The rainfall(mm) and groundwater hydrograph(m) of Arsanjan plain.

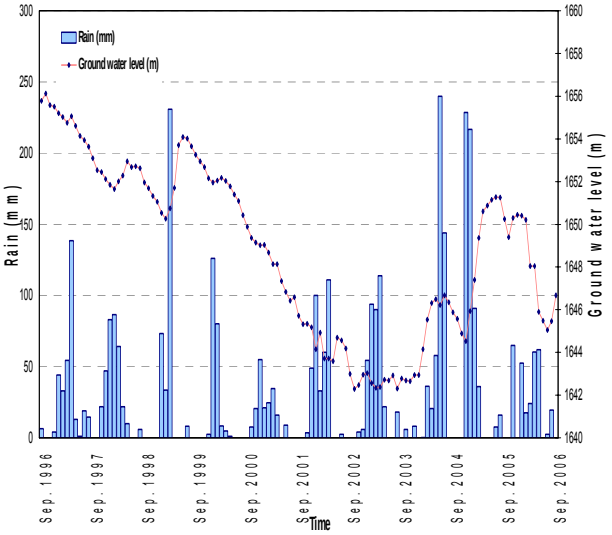


Fig. 3. The rainfall(mm) and groundwater hydrograph(m) of Estahban plain.

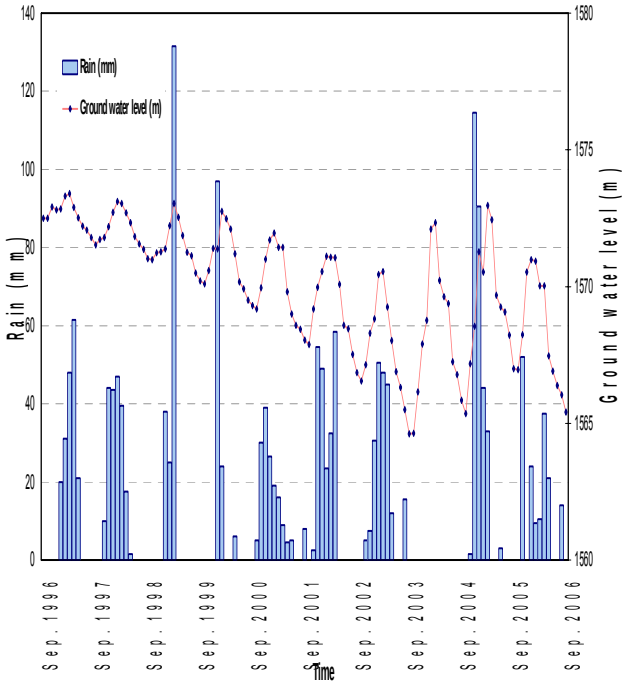


Fig. 2. The rainfall(mm) and groundwater hydrograph(m) of Khir plain.

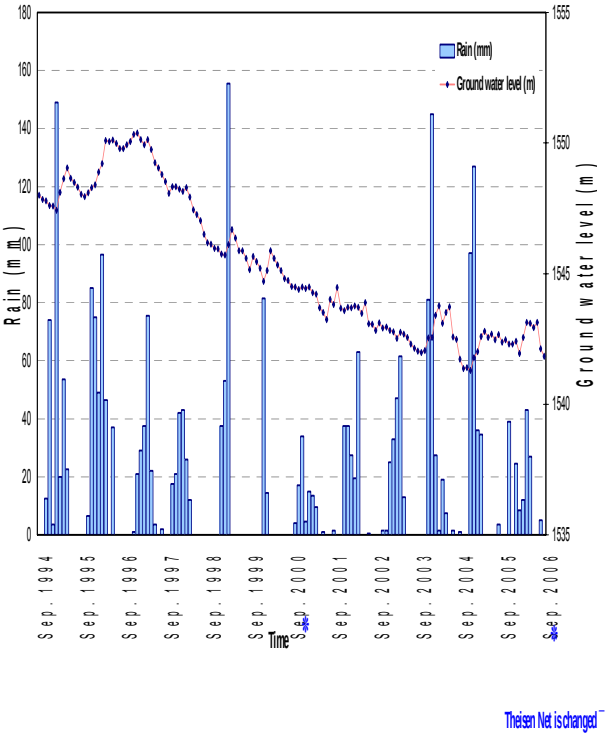


Fig. 4. The rainfall(mm) and groundwater hydrograph(m) of Niriz plain.

## IV. CONCLUSIONS

Excessive exploitation from aquifers in Fars plains , specially where groundwater levels fall too fast or to unacceptable levels not only reduced available water resources and well yields but could cause some other negative effects as follow as :

- Continuing the dramatic decrease in important plains such as Arsanjan, Khir. Estahban and Niriz caused result in the drying-up of shallow wells, increased pumping costs, reduced borehole yields and efficiencies, the need to deepen or replace boreholes and, in coastal areas, saline intrusion in Fars province especially around the lakes. For example declining groundwater levels in Kor basin also caused a considerable reductions in Kor river flow and in Bakhtegan and Tashk wetland areas.

- Groundwater pumping has effected on the pore water pressure in porous media beneath the ground surface and thus increasing the effective stress from the overlying strata on the matrix of the aquifer. When the increase in effective stress is greater than a critical value, known as the pre consolidation stress, the sediment compaction becomes irrecoverable or inelastic and sedimentary aquifer systems can be compacted groundwater subsidence can occurred. There were some land subsidence in Fasa, and Darab plain.

- Saline water intrusion is an important consideration for aquifers adjacent to the coast of Bakhtegan and Tashk likes in Arsanjan and Niriz plain .

The following suggestion are recommended for ground water management and aquifer improvement in Fars province:

1-promote the water productivity in the plains

2-Design and construction of artificial groundwater recharge projects can change the trend of groundwater level especially in Arsanjan, Khir. Estahban and Niriz plain.

3- Control and measuring of wells discharge.

4- Establishment of groundwater user associations in the plains.

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