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Review on current status and challenging issues of land subsidence in Iran

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A B S T R A C T

Land subsidence in Iran is one of the environmental issues of recent years in Iran, which is mostly due to shortage of the groundwater resources. Iran is considered as the country with the most land subsidence. The amount of land subsidence in Iran is believed to be far more than the average of developed countries. Presently, over 300 plains of Iran are suffering from land subsidence and in some plains of Iran, the conditions have passed the subsidence and the ground has entered the critical stage of creating sinkholes. This paper presents an overview of the current status and challenging issues of land subsidence in Iran.

1. Introduction

Water crisis is the primary cause of land subsidence (Ashraf et al., 2021). In Iran, due to the shortage of rainfall during the past few years and the decrease of water behind the dams, in order to supply water, it was necessary to draw water from the underground aquifers, which resulted in the loss of the underground water and the loosening of the soil and subsidence (Messerklinger, 2014). The reason for subsidence is that, in natural equilibrium, the hydraulic pressure of the groundwater in the pores of the aquifer supports some of the weight of the earth (Amin et al., 2019). When groundwater is overdrawn by humans, pore pressures in the aquifer drop and compression and compaction of the aquifer happen (Salehi Moteahd et al., 2019). When the aquifer is compressed, it causes the ground to subside, to go down, or to drop (Abbasnejad et al., 2016). One of the aggravating factors of water shortage, which is the main cause of land subsidence, is the high consumption of water by Iranian citizens (the average water consumption in Iran is 300 liters per day at its peak, which is twice the world average), the lack of modification of the consumption pattern in the industry (Madani et al., 2016). Land subsidence is the main reason for having deep cracks in the ground surface, tilting of well pipes, damage to buildings, and tube formation of wells (Lachenbruch, 1961). Tubing is a phenomenon in which a part of the well pipe is pushed out of the ground due to land subsidence (Galloway et al., 2008; Khorrami et al., 2020).

Land subsidence is a global phenomenon, and the most important factor is the land and water crisis. According to statistics, 150 countries and hundreds of cities are subsiding by about 10 cm per year, and the gradual sinking of the earth can affect 19% of the world's population by 2040. For example, 45 US states and more than 95 Chinese cities are at risk of subsidence with an area of more than 17,000 and 79,000 square kilometers, respectively (Li et al., 2020). Drought and lack of rainfall, on the other hand, indiscriminate extraction and extraction of water from underground aquifers, exploitation and extraction of oil, gas, coal mines and deposits, sinkholes and tension caused by the creation and construction of large structures are among the causes of land subsidence (Bagheri-Gavkosh et al., 2021). In general, about 77% of the subsidence in the world

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is due to human factors, and 60% of these factors are related to the extraction of underground water (Minderhoud et al., 2017). Of course, according to the reports of the Mapping Organization, this ratio is higher in Iran and about 90 hundred subsidence phenomena are due to the withdrawal of underground water.

2. Land subsidence in Iran

Land subsidence in Iran is 5 times as big as the world average (Motagh et al., 2008). Iran has the fourth lowest subsidence in the world and 29 provinces of the country are involved in it (Motagh et al., 2007). These are all statistics that indicate the criticality of the subsidence situation in Iran. Although it is a global phenomenon and more than 150 countries are involved in it, it has been increasing in Iran and its effects have attracted the attention of public opinion in the form of collapse in recent years (Negahdary, 2022). These events have also had many reflections in the virtual space and have caused many concerns in the society.

Fig. 1. Land subsidence in Iran (Source: IRNA)

The highest subsidence record in the world was 32 cm belonging to the state of New Mexico (Cigna & Tapete, 2021); In the 18 years since the 21st century, Iran broke this record twice, one in 2010 in Tehran with 36 cm and the second time in 2015 between Dasht Fasa and Jahrom with 54 cm (IRNA). Iranians consume more water than the global average in drinking water, agriculture and industry (Alizadeh & Keshavarz, 2005). For example, in order to increase the temperature of iron from 450 degrees to 50 degrees in order to be able to produce steel, Isfahan's Mubarake steel used to consume 1000 cubic meters of fresh water every hour, while the average figure is 10 cubic meters per hour, in the agricultural sector the Iranian use 10,000 cubic meters of water per hectare, while the average figure in the world is below 5,000 cubic meters (Sadighi, 1998). Even in some regions of the country, such as Khuzestan, Iranian use up to 35,000 cubic meters of water per hectare for sugarcane (IRNA).

2.1 Land subsidence in Tehran

In the whole world, the permission to access water resources is between 3 and 20%, and when it reaches 40 to 60%, it is referred to as tension, and between 60 and 80% is a crisis, while in Iran, sometimes more than 80% of the resources are (Rezaee et al., 2021). According to some statistics, there is one well in every two square kilometers in Iran, that is, there are more than one million and 400 thousand wells in this country, of which 700 thousand and the rest are illegal. According to Ali Baitullahi, director of the earthquake and hazard department of the Road, Housing and Urban Development Research Center, there are 50,000 wells in Tehran province alone, of which 40,000 are illegal. This indiscriminate mining has led to land subsidence, which has turned into collapses in different areas of Tehran. According to some reports, 25 centimeters of ground subsidence occurs in some areas of Tehran every year, the land subsidence in Tehran is about 1 mm per day, equivalent to 36 meters per year. Therefore, according to these statistics, Tehran has a world record in terms of land subsidence.

Fig. 2. Land subsidence in Tehran (Source: ISNA)

2.2 Land subsidence in Esfahan

According to experts, the biggest deficit of water reservoirs and land subsidence in Isfahan province is along the Zainderoud river and Baghat, and with the continuation of this trend, the subsidence will cover all of Isfahan province in the next 15 years (Fatolahzadeh et al., 2022). Based on the results of the studies of the Geological and Mineral Exploration Organization of the country, the Isfahan plain, especially the areas fed by the Zayandeh River, the northern areas of Isfahan city and Rahnan region, Shahid Beheshti Airport, Kohpayeh, as well as the cities of Doman, Ardestan, Kashan, Varzaneh, Barkhar, Khorasgan, Shahreza, Sejzai and Dasht Mehyar are very affected by the subsidence phenomenon (Sorkhabi et al., 2022). Also, based on these studies, the eight open areas that have a better situation in terms of aquifer level include Anark, Nain, Khor, Jandaq, Bayazeh, Bakhtiari, Gavkhoni and Chupanan areas, but the 10 critical prohibited areas are the plains of North Mahyar, South Mahyar, Kashan, Golpayegan, It includes Isfahan-Barkhar, Ardestan, Bad-Khalidabad, Doman, Ant-Khort and Najafabad, all of which are involved in land subsidence (Rafiee et al., 2022). According to the announcement of the public relations of the Organization of Geology and Mineral Exploration of the country, according to the statistics, there are 42 thousand and 349 authorized wells in Isfahan province, which harvest 3.5 billion cubic meters of water annually, and there are about 21 thousand unauthorized wells, which are currently about 9 1,823 wells are active, about 6,000 wells are blocked, and the rest of the wells have no water and are abandoned, and according to the researchers of the Geological Organization of Isfahan, they named Isfahan the most dangerous region and a symbol of subsidence in the country. Also, according to the Director General of Isfahan Geology Center, in 2015, only 2% of the province's area of 2,900 square kilometers was involved in land subsidence, but the latest studies show that about 10,000 square kilometers of the province, i.e. 10% of it, are dangerously and very seriously involved.

Fig. 3. Land subsidence in one of the regions in Esfahan (Source: Mehrnews)

Land subsidence has recently forced some people in Esfahan to evacuate some small towns near the city, completely. According to IRNA news, subsidence is lurking in the museum city of Isfahan; Bridges in the area of Zayandeh Rood River, Safavi Government House, Naqsh Jahan Square and the concentration of historical buildings in the historical and cultural axis of Isfahan are all in the first line of the invasion of subsidence effects. Most of Isfahan's historical bridges are located on alluvium with different depths, as well as Naqsh Jahan Square with unique works such as Sheikh Lotfollah Mosque, Imam Mosque, Ali Qapu Mansion and Qaisarieh Market Gate due to the thickness and extent of the alluvium on which they were built. There are effects of subsidence and the intensity of subsidence can be a serious threat to the cultural heritage of Isfahan (Talebiniya et al., 2022).

2.3 Land subsidence in Fars

The rate of subsidence in Fars province is very critical and it is related to the Morvdasht plain, which has a very alarming situation. However, it was already announced that Fars has the first rank of subsidence in the world and measures should be taken as soon as possible to prevent the spread of subsidence in this region (Golian et al., 2021).

Fig. 4. Land subsidence in Fars (Source: Mehrnews)

Unfortunately, the use of underground aquifers for agriculture and industrial purposes in Fars province not only wastes water reserves for future generations, but also leads to phenomena such as sinkholes and land subsidence. However, the most reasonable and least expensive way to do it, which most experts recommend, is to block the wells and prevent the issuance of drilling permits for new wells (Golian et al., 2021; Rokni et al., 2019).

2.4 Land subsidence in Khorasan

According to the available information, subsidence has become critical in 6 plains of Razavi Khorasan, which include Mashhad, Neishabur, Kashmer, Bardskan, Khaf and Joyn plains (Salehi Moteahd et al., 2019). Based on the estimates, subsidence in the Mashhad plain occurs between 0 and 17 cm in different places every year, and the protrusions and outcrops of these settlements are mainly outside the residential context (Rahmati et al., 2019). Currently, 6 plains of Neyshabur, Kashmer, Bardskan, Khaf, Sabzevar and Mashhad are in critical conditions, and their studies have been finalized and the relevant report has been prepared. There are average openings of 10 to 50 cm with an average depth of one to three meters and sinkholes with an average depth of one to 2.5 meters, which are expanding rapidly (Gharechelou et al., 2021). Damage to vital structures such as high-traffic roads, railway lines, especially in the area of Neishabor to Sabzevar in the vicinity of Bishro and Ahangaran villages, and gas and oil transmission lines (the oil transmission line from Neishabor to Shahrood), electricity and telecommunications due to the wide spread of settlements in the mentioned plains is a concern.

Fig. 5. Land subsidence in Khorasan Razavi (Source: IRNA)

3. Discussion and conclusion

Land subsidence has become a critical issue in Iran and there is a need to take some serious actions to fight against this crisis. The actions should include new legislations to protect the land, new rules and regulations, increase public awareness, etc. Protecting land against some unusual incidents is the responsibility of societies, people, government, scientists, etc. Iranians consume more water than the global average in various sectors such as drinking, agriculture and industry. Iranians lose a third of the purified water due to the wear and tear of the pipes in the city network, and due to the importance of the issue, the government should take some necessary actions to reduce the damages. In cities like Tehran, Isfahan, Kerman and Yazd, grass and ornamental flowers should no longer be planted, but tree species that do not need irrigation must be planted. The country should not use thermal power plants which are extremely water-intensive to supply energy in the country, The country should expand solar panels or wind energy to produce electricity.

Although many damages caused by land subsidence and especially collapses are tangible in people's daily lives, this phenomenon also has intangible consequences. including the risks of subsidence, increased risk of flooding, damage to buildings, foundations and infrastructure, disturbance in water management and related sectors. This phenomenon has been growing in Iran in recent years. According to experts, in case of lack of attention and necessary policies to deal with it, it can become a wide-ranging crisis in the country.

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