State of Water Resources in Iran

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Introduction

In Iran, water resources management is a challenging issue due to some problems such as limited power of Iran Department of Environment (IDOE) and Ministry of Energy (MOE) in controlling water withdrawal and pollution sources especially when the pollution source is related to a governmental sector, uneven distribution of population and economic activities, inadequate monitoring of pollution sources and water bodies, lack of suitable cooperation among relevant governmental and non-governmental organizations and inadequate guidelines and standards. Also, climate change and periodic droughts can worsen the quantity and quality condition of water resources. In this paper, by using available data and information and employing a Driving force-Pressure-State-Impact-Response-Outlook framework, general state of water resources in Iran is evaluated.

Methodology (the driver-pressure-state-impact-response (dpsir) framework)

The DPSIR framework, is completed form from an earlier Pressure State Response (PSR) structure, was introduced by the European Environment Agency in the 1990s. It is a frame work is used to connect environmental issues to social and economic driving forces. The DPSIR framework consists of 5 elements which have causal effects on each other as follow:[1]

A. Drivers which are mostly defined as global, regional or local social, demographic and economic factors, which act as causal links to exert Pressures on the environment.

B. These pressures can lead to intentional or unintentional changes in the State of the environment.

C. Changes in the state will lead to changes in the quality and functioning of the environment causing Impacts on the different parts of the environment.

D. The Impacts will affect the welfare or well-being of natural systems and human communities.

E. Responses are actions taken by groups or individuals in society to prevent, compensate, ameliorate or adapt to changes in the state of the environment by changing drivers or pressures through actor driven shifts in behavior, prevention, mitigation or regulation.

In this study the general state of water quantity and quality in Iran is evaluated using DPSIR logical frame work.

State of water balance

The average rainfall height of Iran in the period of 1994-2014 is 228 mm/year, which is 6% less than the long term average (242 mm/year). The average surface run-off in this period is 52 billion cubic meters which is 42% less than the long-term average. The descending trend in water table level of groundwater resources has been intensified and the cumulative groundwater shortage has increased from 65 to 109 billion cubic meters. Due to overexploitation of aquifers, water withdrawals in 291 out of 609 main aquifers of Iran have been banned. The agriculture sector, which uses 90% of the total allocated water, is still the water user in Iran. The total area of agricultural lands has significantly increased in this 10-year period while this sector is not economically efficient. According to existing data, 11 mega cities in Iran with a population of 37 million people are suffering from water stress. For example, most of the active water storage capacities of the dams supplying water demands of Tehran have been empty in recent years. Negative water balances of aquifers due to overexploitation of groundwater, diversion and use of surface waters and recent droughts have put a severe water stress on Iran's wetlands. The dried wetlands are sources for dust, which can significantly affect the people health in adjacent cities and villages. According to the Falkenmark water stress index, countries with per capita renewable water less than 1700 cubic meters per year are subject to water stress. Therefore, Iran with as per capita renewable water equal to 1560 m^3 is under water stress. Besides, 80% of the renewable water in Iran is used by different sectors. It shows that Iran's water resources have a critical condition based on the UN water scarcity index. Figure 1 shows spatial variation of water stress index related to 30 main river basins in Iran.

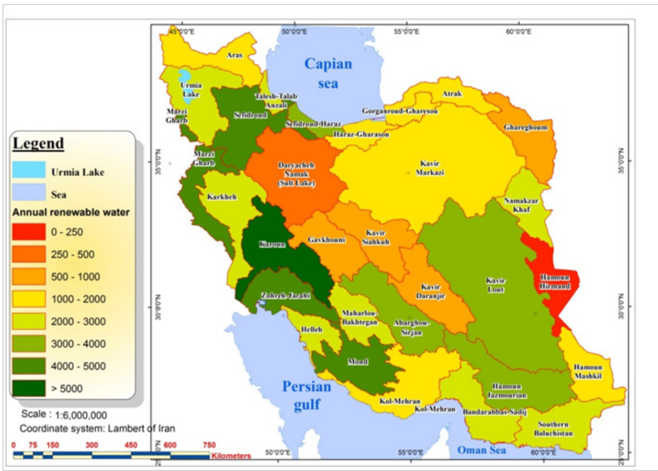

Figure 1 Annual renewable water per capita in 30 second order basins in Iran (cubic meters per year).

State of iran internal virtual water trade

The virtual-water content of a product (a commodity, good or service) is defined as "the volume of freshwater used to produce the product, measured at the place where the product was actually produced. It refers to the sum of the water use in the various steps of the production chain. In Iran, the Kerman Province, which has very limited water resources, exports virtual water. On the other hand, some provinces such as Gilan, Mazandaran as well as provinces located in western part of Iran, which have plenty of water, usually import virtual water or export limited values of virtual water. It shows that uneven investment and development exist in water and agriculture sectors in Iran.

Main pressures on iran water resources

Agricultural water use has increased from 44 billionm^3 in 1961 to 80 billionm^3 in 2001 and 86.5 billionm^3 in 2011.[2,3] About 92% of allocated water in Iran is used by agriculture sector. This percent in the World and Asia are respectively equal to 70% and 81%.[4] In 2020, the total volume of wastewaters and return flows would be about 30% of the total renewable water. Therefore, one of the issues in future would be solving problems related to low water quality from the institutional, structural, legislation and capacity building points of views. Total area of agricultural lands has also increased from 7 million ha in 1991 to 8.8 million ha in 2011.

Main impacts

Impact on river discharges: Data obtained from hydrometric stations show that river discharges have remarkably reduced during the past 20 years. The long-term discharge of rivers in Iran is about 89 billion cubic meters (Figure 2). This value has decreased to 53 billion cubic meters in the period of 2005-2013 (i.e. 42% reduction).

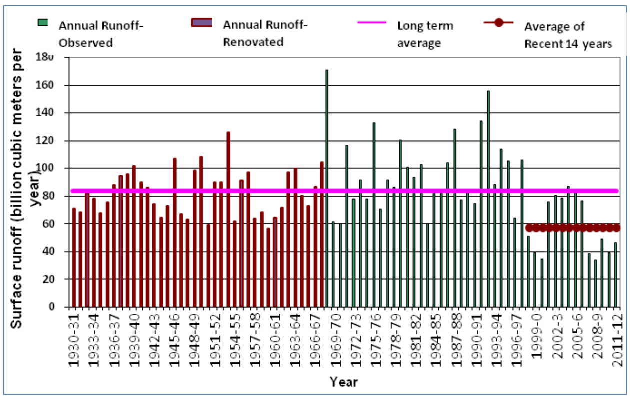

Figure 2 Variations and average values of surface runoff in Iran.[2]

Impact on groundwater resources: According to available data, about 650 thousand wells (legal or illegal), 39000 qanats and 146000 springs exist in Iran. The number of forbidden aquifers (aquifers with no permission for water withdrawal) has increased from 25 aquifers to 300 during past 40 years.

Land subsidence: Land subsidence is a gradual settling or sudden sinking of the Earth's surface owing to subsurface movement of earth materials. Subsidence is a global problem and, in Iran many aquifer have been directly affected by subsidence. The principal causes are aquifer-system compaction, drainage of organic soils, underground mining, hydro-compaction, natural compaction, sinkholes, and thawing permafrost. Most of the identified subsidence in Iran is a consequence of our exploitation of underground water, and the increasing development of land and water resources threatens to exacerbate existing land-subsidence problems and initiate new ones (Figure 3). Subsidence causes permanent inundation of land, aggravates flooding, changes topographic gradients, ruptures the land surface, and reduces the capacity of aquifers to store water and cause stability and functionality problems for infrastructures.

Figure 3 Land subsidence in Kerman region in Iran.

Dust propagation: Based on satellite data, about 529 dust storms have been identified in western part of Iran during the period of 2001-2011. There are 6 main sources for dust in Iran's neighbors and also in Iran dried wetlands than can cause dust storms in western part of Iran. Construction of many dams in Turkey (GAP project) and other countries, diversion of river flows and drying wetlands are main causes of dust in Iran.[2]

Increase in conflicts among water users: Groundwater resources are considered as common pool resources. Therefore, water users can have conflicting utilities and their non-cooperative behaviors can cause some environmental issues such as over water exploitation from aquifers and land subsidence. In Iran, because of inadequate supervision, there are many illegal wells in aquifers and there is no control on their water withdrawals. There are also some political pressures on decision makers to get permission for new well in aquifers with negative water balances. When an aquifer recharges a river, overdraft of aquifer can affect the river discharge and water rights of water users of the river. In drought conditions, pressures on aquifers are increased and overexploitation of aquifers can cause more conflicts.

Decrease in discharge of wells and their life expectancy: By decreasing in groundwater table elevation in an aquifer, discharges of wells are usually decreased. Owners of wells try to increase the wells depths or relocate wells to improve water withdrawal efficiency of wells. It can significantly reduce the life expectancy of wells. Intrusion of saline water can also cause erosion of wells equipment or increase salt sedimentation on the wells casings. Besides, the required energy for pumping water would increase. In Iran, the number of wells has increased in the past decade, but increase in groundwater withdrawal has been limited because of groundwater table drawdown in most of aquifers (Figure 4).

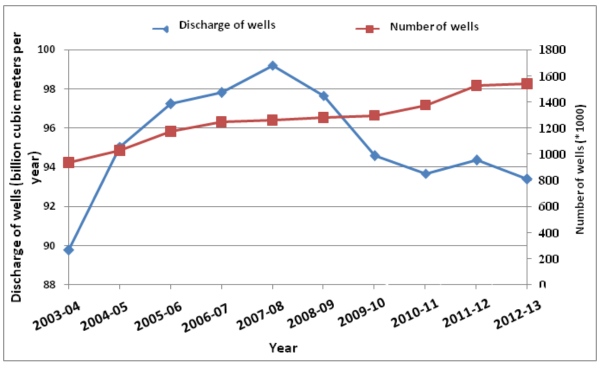

Figure 4 Temporal variations of the number of wells and groundwater withdrawal in Iran.[2]

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Responses

In the past 20 years, some strategies have been developed and ratified for water resources management in Iran. These strategies include: Iran general strategies for water resources (2000), Strategies for water resources development in Iran (2003), Iran outlook in 2025 (2003), Iran's strategies for demand management (2010). It looks that the existing strategies can provide a very good platform for acceptable water resources management in Iran. Although the items related to water sector in the fourth and fifth 5-year development plans have been prepared considering the main attitudes presented in the above-mentioned strategies, some of them have partially been applied. Some of the rules ratified by Iran's Islamic Parliament are not in line with the strategies and have caused some problems for water resource management in Iran. For example, based on an act, which was ratified in 2010, owners of several thousand illegal wells got permission for water withdrawal from aquifers which were suffering from water overexploitation. In line with the Iran's water resources strategies, the following policies are proposed for better management of water resources.

Good water governance and integrated water resources management

1. Developing master and regional plans for development considering the water resources potentials.
2. Developing action plans based on the existing strategies proposed for water sector.
3. Improving the existing cooperation among different organizations and participating stakeholders in decision making process.
4. Revising rules and developing an integrated act for water sector in Iran.
5. Institutional reform for integrated basin-scale management of water resources.
6. Balancing the water supply and demand relationship with emphasis on demand management.

Improving water supply condition

1. Optimal management of trans-boundary and shared water resources considering the existing protocols and water demands of ecosystems.
2. Desalination of sea water for encouraging people to settle near seas.
3. Utilization of unconventional water using modern treatment and desalination technologies.
4. Recycling of water and using treated wastewater in agriculture by taking into account hygienic and environmental considerations.
5. Estimating and allocating environmental water rights of rivers, wetlands and lakes.
6. Revising the required volume of under design dams considering the recent variability of hydrologic factors as well as economic and environmental criteria.

Improving water use efficiency and demand management

1. Controlling water uses considering the ecological limitations of the basins.
2. Limiting water withdrawal from aquifers to control the existing negative water balance of aquifers.
3. Reducing agricultural water demands using modern irrigation technologies.
4. Determining cropping patterns and cultivation area considering natural and environmental limitations.
5. Providing food security by cultivating strategic crops and considering the concept of virtual water trading in supplying non-strategic crops.
6. Utilizing watershed management techniques for basin-scale water and soil conservation.
7. Reducing water loss and unaccounted-for water in urban and rural water distribution systems.
8. Reducing domestic water demands using modern technologies.

Revising the economic and investment structure of water sector

1. Considering the economic value of water in decision making and establishing water markets.
2. Revising the current system of pricing water by taking into account the costs of water supply and treatment.
3. Increasing the diversity of investments sources and encouraging the private sector for investing in water sector.
4. Giving priority to non-structural and supporting projects in investments.

Improving the current system of water monitoring and conservation

1. Reducing the vulnerability of surface and groundwater resources by improving the existing monitoring systems.
2. Providing strict supervision for water withdrawal from aquifers.
3. Completing existing monitoring systems for water quantity and quality.
4. Improving the current management information systems (MISs).
5. Extending the coverage of standards and guidelines for conservation and operation of water resources systems.
6. Using the capabilities of non-governmental organizations (NGOs) for water resources conservation.

Capacity building for integrated water resources management

1. Institutional capacity building for managing and organizing different sectors.
2. Participating water users' organizations for managing water infrastructures.
3. Supporting and strengthening NGOs.
4. Public awareness and participation.
5. Training and strengthening human resources.
6. Scientific cooperation and exchange of experiences with international organizations.

Conclusion: outlook of Iran water resources

As all development plans should consider the future dynamics of population, predicting the future population growth pattern and estimating future needs are important steps for planning for water quantity and quality management. In the period of 1994-2014, population growth, migration of people to large cities as well as droughts and climate change have been driving forces for putting pressures on water resources in Iran. In addition, more than 90% of the allocated water in Iran is used by the agriculture sector which has a very low water efficiency and economic productivity. In some regions in Iran, these pressures have caused water stresses as well as many social and environmental issues such as destruction of wetlands, severe drawdown of groundwater table levels and subsidence of lands. These environmental problems are mostly due to human activities and mismanagement rather than droughts and climate change. In the studied period, water resources management strategies and polices have been inefficient and have caused an unacceptable distribution of investments and development projects in water and agriculture sectors. Without revising the current approaches for water governance and management, the existing problems would be intensified in future. But by having good water governance, improving the water management strategies and participating different stakeholders, even during drought conditions, water resources management problems can be solved and a better future would be provided for the current and next generations.

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Conflict of interest

Authors declare there is no conflict of interest in publishing the article.

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