American Journal of Environmental Engineering 2016, 6(4): 123-128
DOI: 10.5923/j.ajee.20160604.03

Challenges of Water Resource Management in Iran

Abolfazl Fani[1,*], Iran Ghazi[1], Arash Malekian[2]

[1]Research Institute of Shakhes Pajouh, Esfahan, I.R. Iran
[2]Faculty of Natural Resources, University of Tehran, Karaj, I.R. Iran

Abstract As stated by the United Nations, after burgeoning population growth, issues related to water scarcity and management are the second main global challenges. Global fresh water resources are scarce so that from 100% existing global water volume, 97.5% is saline and unusable, and merely 2.5% is fresh. Iran is characterized by an arid and semi-arid climate. Long-term average annual rainfall of the country reaches to as much as 252mm, equaling just to one third of the global level. One the other hand, average evaporation rate exceeds 179 mm (i.e. 71% of the total precipitation of the country) which is three times the global measure. Approximately 70% of precipitation occurs in the form of rain and the rest as snow. The methodology applied in the current study is descriptive-analytic. Required data for the assessment of current status of water resources of the country was collected by library method from domestic and foreign original papers. This study strives for the evaluation of Iran's water resources, distinguishing its fundamental challenges and providing suggestions to decrease the current challenges in the field of water management. Reviewing domestic and foreign literatures on the issue, suggest that Iran is mainly confronted by Seven major issues in the field of water management including: mismanagement, inclement weather, unfavorable geographical conditions, lack of law enforcement, low water productivity, climate change phenomenon and Drought, pollution of water resources and improper urbanization. In the following, after identifying the main problems in the field of water, strategies will be put forward to reduce these problems, the most important of which are: Development of an integrated water resource management scheme, as water is a multi-sectoral commodity, and although it should be managed under one authority, but its management should encompass all producing and consuming sectors; otherwise, proper management of this critical resource is not possible in a one-dimensional view.

Keywords Water management, Strategy, Challenge, Integrated management, Urbanization, Renewable water resources

1. Introduction

As stated by the United Nations, subsequent to the population growth, our planet second most challenging issue lies in the field of water crisis and management. Fresh water resources of the earth are so scarce, so that from the 100% water on the earth, 97% is salt water and only 3% is fresh water, of which 70% is frozen in glaciers, 29.7% in groundwater and 0.3% in rivers and other inland water bodies. Freshwater resources are also unevenly distributed and allocated to human populations. Unfortunately, the share of this country from the total fresh water resources is further limited due to the hot and arid climate. Water issue is quiet complicated as the total volume is constant while it is found in different forms. Furthermore, climate change and global warming are intensifying the retreat of snow frontiers and permanent snow covers in the South Pole. The snow storage of the Mount Kilimanjaro has retreated at an alarming rate of 2.3% which is a sign post of the crisis for water management [7].

* Corresponding author:
fani48@gmail.com (Abolfazl Fani)
Published online at http://journal.sapub.org/ajee

It is predicted that by 2025, about 3.5 billion people will suffer from water crisis. From this population, only 1.2 billion will have access to safe drinking water. Moreover, by 2050, more than 4.5 billion people will encounter the consequences of water shortage and pollution. This will undoubtedly intensify global competition over water and render management of water resources into a real challenge. Hence, water resource planning will find its position in the political, economic and social dialogues, ruling nations and governments [11].

Across the Arc of Crisis, from Somalia, Sudan and Egypt in Africa to Yemen, Iraq, Pakistan, and Afghanistan in West Asia, water scarcity in the region has already lead to drought and famine, loss of livelihood, the spread of water-borne diseases, forced migrations and open conflict [5].

Water resources scientists predict that in the near future, national, regional and international conflicts over water will be heightened, and it is not far from reality, that the next generation of wars will take place over limited water resources.

According to statistics presented at the Fifth International Conference on Agricultural Economics of Asia, after the year 2050, Iran will return into one of the thirsty countries of the world [6]. Yang et al. (2003) believe that since 2000, Iran has become a water scarce country, and by 2030, its per

capita renewable water resources will decrease to 1500 m^3. Based on the proposed water critical value calculated from water abstraction over access to water, Alcamo et al (2000) calculated this index to be 0.8 for Iran. They suggest that this country will fall in the water stressed category by 2025. Smakhtin et al (2004) define water stress as the human consumption of renewable water resources (After deducting the environmental needs of the total water resources) and classify Iran in the high water stress category.

Thus assessment of the status of Iran's water resources, identifying the main challenges followed by a proper strategy development can delay entering the phase of water stress. Or even, with proper management these challenges can be eliminated one by one and a stable condition can be achieved. Accordingly, in this study it is sought to express the main problems and offer solutions in order to achieve better management of water resources.

2. Methodology

The method applied in this paper is descriptive - analytic. In this study, the Delphi method was used in three steps for obtaining and collecting opinions of the experts. In the first step, a cohort of 53 respondants (due to the loss of some samples) of academic members, experts and managers of water sector were considered. Finally, 30 people participated in the survey.

In the first round, a list of the main challenges of water sector in Iran was drafted. Participants in the survey were given complete discretion to retain, edit or remove any of the items of the list.

At the end of the first round, after retrieving the forms from the participants, all forms were carefully evaluated and with regard to all matters listed and the applied changes, a comprehensive form, reflecting the opinion of all experts, were prepared. In order to determine the importance of each factor, the list was sent again to the members.

In the second phase, the significance of the factors were calculated based on the Likert scale, including a range of very low, low, medium, high and very high options. Furthermore in order to determine the importance and priority of the views of the experts, Delphi method was deployed. Mathematical relationships, percentages, and factor weightings are as follows [4]:

n: number of people who chose each of the options (score)

N: the number of respondents

Adjusted weight $(y_i) = \frac{x_i}{\sum x_i}$

Weighted score $(z_i) = y_i \times n$

Relative importance of criterion $= \frac{\sum z_i}{N} \times 100$

Importance of criterion = $\frac{\sum (x_i \times n)}{N}$

In the third phase, all the experts were informed on the obtained average scores for each criterion, and then they were asked to reconsider and score again the list based on the average values representing the views of all experts. The goal was to create the conditions to achieve more consensus among the experts in the field of various factors.

In the first stage, a total of 11 main challenges was suggested by the experts. These factors were judged by experts in two extra stages. At the end of the second stage, the number of cases dropped to 7 and those who had low score or those that were left unscored by the experts were removed from the list. Finally, given that the difference in the scores was negligible in the third stage compared with the second phase, survey was accomplished.

3. Results and Discussion

As mentioned in the methodology of this study, expert's opinions were collected for this research. According to the results (Table 1) it was identified that seven major challenges in the management of water resources in Iran, were identified as mismanagement of water resources by 29.1%, inclement weather condition and unfavorable geographical conditions by 25.8%, lack of law enforcement by 24.9%, low water productivity by 24.1%, climate change and droughts by 23.5%, pollution of water resources by 19.5%, and finally indiscriminate urbanization by 18.1%. Table 1 provides the percentages and the importance of water resource management challenges in Iran using the Delphi method.

In order to better and more precisely evaluate the existing challenges in the field of water resources management, a more detailed analysis of each of the challenges will be discussed.

3.1. Mismanagement

From the main causes of the improper and inefficient performance in water sector, one could point out to the mismanagement of water resources. This poor management boils down to multiple reasons, from which political interventions, the lack of an integrated and holistic management scheme, the lack of expertise could be mentioned. One of the main issues, here, is improper use of well utilities, so that by the end of 2013, 455 running wells were producing 49.8 bcm water. In addition to licensed wells, unofficial estimations show that between 100 to 150 thousand wells are operating in the country. In sum, 60 thousand unlicensed wells have been detected by the ministry of energy [11].

The dominance of structural to non-structural remedies such as analysis of consumer behavior, increase public and specific awareness in the field of water, is the real problem in water management. Even though in the recent decades, water management has focused on hydrological aspects; hence, nowadays water engineering and health do not suffice and there is a pressing need for scientific and management disciplines such as water economy and sociology. It is necessary to understand better all the issues of quality,

quantity, political, economic, legal and institutional, social, financial, and environmental education, in shaping water policy in the next century.

3.2. Inclement Weather and Unfavorable Geographic Conditions

Iran, due to the low precipitation and its unfavorable spatial and temporal distribution, is among the arid and semi-arid countries of the world. Long-term average annual rainfall of the country reaches to as much as 252mm, equaling just to one third of the global level. One the other hand, average evaporation rate exceeds 179 mm (i.e. 71% of the total precipitation of the country) which is three times the global measure. Approximately 70% of precipitation occurs in the form of rain and the rest as snow. This precipitation provide 413 bcm (billion cubic meters) of water to the country with is augmented by 13 bcm from the Transboundary River and reaches 426 bcm. From this, 295 bcm is lost directly to evaporation. Simply put, total water resources potential of the country is equal to 130 bcm [12]. In Iran, temporal and spatial distribution of rainfall is heterogeneous. Even poor distribution of rainfall during normal years is a serious constraints of water resource of Iran. The position of the Zagros and Alborz Mountains have caused 91% of rain fall in only 25 percent of the country.

3.3. Lack of Law Enforcement

One of the most important problems of Iran and perhaps the most important one, is the lack of enforcing ratified legal cases in the field of water. With a glimpse of the laws of the country such as upstream documents, the policies conveyed by the supreme leader and five-year development plans, it is clear that we will be facing far fewer shortcomings in the application of our laws. As in most cases the existing laws are not fully implemented, law enforcement could completely obviate the need for new guidelines in this arena.

3.4. Low Water Use Efficiency

Water use efficiency indicates how gross domestic production changes per each cubic meter of consumed water. To calculate the indicator, gross domestic product is divided by the quantity of water consumed and the obtained number is used as an index. The index varies based on economic structure of different countries. Comparison of this indicator between different countries demonstrate clear differences between developed and developing countries. This indicator fluctuates, proportional to the gross domestic production per cubic meter of water consumed, in a range of 39.1 to 2.1 between high-income to low-income countries, respectively.

In developed countries due to the high proportion of manufacturing and services sectors from GDP and utilization of higher technologies in the use of water resources, water productivity index has been greater than the developing countries. This means that for every unit of water consumption, more added value is achieved compared to the less developed countries.

In 2011, the water productivity in Iran has been reported 3$ GDP per cubic meter of water consumption (in USD of 2005) that compared with the average productivity of water in the world (14$ GDP per cubic meter of water) is at a much lower level [11].

Table 1. Percentages and the importance of water resource management challenges using the Delphi method

NO	Criterion	Level of importance						Total number	Σzi	Importance (%)	Level of importance
		Xi	1	2	3	4	5				
		yi	0.07	0.13	0.2	0.27	0.33				
1	Mismanagement	n	0	1	2	12	15	30	8.72	29.1	4.37
		Zi	0	0.13	0.4	3.24	4.95				
2	Inclement weather and unfavorable geographical conditions	n	0	3	7	11	9	30	7.73	25.8	3.87
		Zi	0	0.39	1.4	2.97	2.97				
3	Lack of law enforcement	n	3	0	9	8	10	30	7.47	24.9	3.73
		Zi	0.21	0	1.8	2.16	3.3				
4	Low water use efficiency	n	3	2	6	12	7	30	7.22	24.1	3.6
		Zi	0.21	0.26	1.2	3.24	2.31				
5	Climate change phenomenon and Drought	n	2	5	6	9	8	30	7.06	23.5	3.53
		Zi	0.14	0.65	1.2	2.43	2.64				
6	Pollution of water resources	n	3	11	4	9	3	30	5.86	19.5	2.93
		Zi	0.21	1.43	0.8	2.43	0.99				
7	Improper urbanization	n	9	3	8	8	2	30	5.44	18.1	2.7
		Zi	0.63	0.39	1.6	2.16	0.66				

3.5. Climate Change Phenomenon and Drought

Climate is described as the average weather conditions in a certain area. Climate change is significant change in average weather data over a period of time [10]. It has developed from natural and human origin. It is naturally dependent to astronomical periods and changes in the energy output of the sun (solar anomalies). From the anthropogenic standpoint, climate change mainly arise from the emission of greenhouse gasses.

Climate change is different from climate fluctuations. Climate fluctuation is cyclical and expresses deviations from the mean of climatic parameters and can occur at different times. However, climate change is broad and extensive change in the climate of a region. Current trend of global warming is considered part of climate change [9].

Drought is a recurrent feature of climate that is characterized by temporary water shortages relative to normal supply, over an extended period of time – a season, a year, or several years. The term is relative, since droughts differ in extent, duration, and intensity [5].

Consequences of climate change in recent years, especially due to the rise in the emission of greenhouse gases, have influenced different parts of Iran. One of the most important effects is increased occurrence of natural disasters such as floods, droughts etc. In recent years, occurrence of droughts have caused many challenges in various sectors, especially water resources and agriculture. Drought is not an abnormal phenomenon, but its extent and harmful consequences are heavily dependent on geographical location. Occurring in Periodic manner, drought phenomenon, more than ever, expose Iran's water resources to the external threats.

3.6. Pollution of Water Resources

Water pollution issue is a considerable problem from two perspectives: ecological and health-threatening pollutants. Growing introduction of human sewage, industrial effluent and agricultural runoff to streams, wetlands, beaches and coastal waters has increased nutrient pollutants in the environment. Indiscriminate discharge of human sewage and industrial wastewater into absorption wells and surface water in residential areas and industrial sectors, on the one hand has led to the increase of harmful substances in the aquatic environment excessive to the environmental standards, and on the other hand, improper use of such wastewater in agriculture, finally leads to the arrival of the contaminants in food sources of the population.

3.7. Improper Urbanization

The population has been steadily increasing over time and this has been concomitant with a growing demand for water. Urban population growth and the formation of large cities is not a new phenomenon, as cities like London or New York began to grow in the 19th century. But the difference is, unlike developed countries, developing countries along with urbanization, grew their water and sewage system and applied appropriate and sound management in their own metropolis. In this context, two important factors must be noticed here: a gradual process of urbanization and the economic growth rate.

The rapid system complication has brought a wide range of complex problems, and hence has imposed heavy costs on government bodies. Material and immaterial costs caused by heavy traffic, water supply, municipal facilities and municipal infrastructures in recent years testifies the subject [14]. Obviously, spontaneous and undirected continuation of this trend will exacerbate the adverse effects, and centralization and densification, further marginalization of less developed regions, adverse environmental effects, regional inequalities and lack of optimal utilization of the land and facilities will follow. In addition, based on the increase of urban population, the growth of cities and their population more vicissitudes will come up such as disparate urban systems, the emergence of primate cities and subsequently further problems in the region and the country [8]. Evidence shows that in the approaching years and decades, the per capita water consumption will rapidly increase. This is due to improved welfare and hence diversified water uses. Thus, urbanization, industrial development and its maturity, and the development of agriculture for food production by cropping patters capable of meeting rising level of human welfare has caused water consumption to rapidly approach the level of global available renewable water resources.

4. Conclusions

Given what we have concluded, from the standpoint of the experts and specialists in the field of water resource management, seven major challenges exist, some of which are affected by geographic location and natural condition of Iran and some of the challenges are related to anthropogenic and management issues.

According the judgement of the experts, piecemeal water resource management can not be part of the solution, instead a comprehensive and integrated vision has to be put into practice. In support of this, one can be referred to expert opinions. As is clear, the main challenges presented (seven challenges) involve all cases of natural, anthropogenic, and management aspects.

Natural factors such as the lack of precipitation, are those that cannot be manipulated by humans, but with proper management, most of the shortcoming can be obviated. For example, even though precipitation, or in other words the entrance to the area, is scarce in Iran, but this scarce level can be utilized properly through the introduction of watershed management activities, and be protected against evaporation.

In the field of law enforcement it should be mentioned that: with a glimpse of the laws of the country such as upstream documents, the policies conveyed by the supreme leader and five-year development plans, it is clear that we will be facing far fewer shortcomings in the application of our laws. As in

most cases the existing laws are not fully implemented, law enforcement could completely obviate the need for new guidelines in this arena.

In the discussion of water efficiency, it should be noted that be incorporating new and updated techniques as well as by using proper water transmission and distribution systems, water productivity, especially in the agricultural sector which is the largest consumer, might be raised to an acceptable level.

As mentioned, in Iran, greatest water consumption occurs in the agriculture sector. However, agriculture sector suffers from the following issues: high water losses in the agricultural fields, improper operation of existing irrigation facilities, water loss from channels, Inappropriate form and size of farms in relation to the amount of water and irrigation method, farmers Lack of awareness on the importance of optimized irrigation and water use efficiency, lack of proper irrigation techniques, Inappropriate water pricing, Poor land quality, Inappropriate use of water resources particularly groundwater quality (threatening quantity and quality of the resources), inappropriate pattern and density of crops, improper crop selection with respect to their water demand, lack of appropriate tariff for water consumption for various products, and inappropriate water pricing system [11]. Application of a holistic management approach, selection of strategic crops and better water management could be some remedies for these difficulties.

In the field of climate change it should be noted that: Consequences of climate change in recent years, especially due to the rise in the emission of greenhouse gases, have influenced different parts of Iran. One of the most important effects is increased occurrence of natural disasters such as floods, droughts etc. In recent years, occurrence of droughts have caused many challenges in various sectors, especially water resources and agriculture. Given the current situation of Iran, precautionary measures must be taken for reducing the emission of these anthropogenic gases.

But the problem of water shortage is not limited to the water volume, but water resources quality lack necessary qualities due to the contamination by human and industrial wastes. Even countries exist with already abundant water resources which are concerned with the water supply for its population in the near future [2].

Establishing an appropriate balance between capacity expansion on one hand, and water supply and demand management on the other, could incorporate numerous benefits such as delaying the high cost of water supply and its environmental impact, reduction in operating costs, waste production, water consumption and energy costs [3].

One of these which is in desparate need to be balanced is the increased urbanization and expansion of urban areas, where a proper link has to be established between these areas and their water demand (especially water of appropriate quality).

Next, in order to minimize the problems facing the management of water resources following suggestions are made.

4.1. Implications

1- Since water is a multi-sectoral factor and although it should be managed in one place, however, its management must be such that all consumption sectors (economic, social, and environmental) have constructive interactions and it necessitates integrated management of water resources.

2- Set of rules of countries have emphasized the move towards sustainable development; still, the lack of appropriate procedures for the implementation and coordination for all concerned executive agencies, lack of hydrological databases and inadequate attention in the evaluation of water cost and value, has slowed the operationalization of recommendations.

3- Due to the continuing population growth and increasing demand for water and constant elasticity of renewable water resources, it is necessary to study, within the framework of a comprehensive study in present and desired scenarios, status of water resources, population growth, agricultural production, trade balance in agriculture sector and food security of the country in the coming years. Appropriate strategies and programs have to be developed to balance the water and food resources.

4- In the field of agriculture, with regard to the share of more than 90% of this section by, implementation of land use policies need to consider the application and enforcement of each region according to the strategic policies.

5- In the field of domestic consumption, raising water consumption culture through mass media, the investment for the rehabilitation of water transmission lines, applying tiered pricing systems and analysis of water crisis in the country and its management are required.

6- In the field of industrial use, environmental considerations and special attention to water as an integral part, technical and economic feasibility of projects, site selection for industrial towns and construction of industrial units should be of interest to planners in this area.

7- The effects of climate change on groundwater resources and coping and adaptation strategies as one of the most important subjects in sustainable water management must be taken into consideration. Organized programs for water management at all levels of policy-making, planning, capacity building and implementation should be provided.

8- Watershed management and soil conservation in watersheds upstream and implementation of flood spreading, aquifer recharge by prioritizing forbidden plains to produce water and reduce evaporation and transpiration

9- Education in the field of water, providing appropriate incentive packages for low-consumption households as well as modernization of distribution channels for

water to urban areas to reduce consumption and waste of water.

REFERENCES

[1] Alcamo, J. & Henrichs, T. 2002. Critical regions: a model-based estimation of world water resources sensitive to global changes. Journal Aquatic Sciences. 64, 352-362.

[2] Angelakis, A.N., L.W. Mays, and D. Koutsoyiannis. 2012. Evolution of Water Supply Through the Millennia.: IWA Publishing. 1-584.

[3] Cheng, C.L. 2002. Study of the inter-relationship between water use and energy conservation for a building. Journal of Energy and Buildings, 34(3), 261-266.

[4] Danekar, Afshin and Haddadi Nia, Somayeh. 2009. Weighting and ranking criteria for planning in desert and semi-desert ecosystems by using Delphi method. Journal of management and natural resource development. 2 (2), 21-32.

[5] El-Kharraz, Jauad., El-Sadek., Ghaffour, Noreddine and Mino, Eric. 2012. Water scarcity and drought in WANA countries. Journal of Procedia Engineering 33, 14-20.

[6] Ganjizadeh, R., Houshmand, A. 2012. Cropping pattern under irrigation and drainage network and the performance of water in crop production (Case Study: Kheirabad area, Behbahan, Khuzestan province). Third National Conference on Integrated Water Resource Management. Sari University of Agricultural Sciences and Natural Resources.1-8.

[7] Ghazi, Iran. 2015. The best way to curb the consequences of drought, and water resources is wise management of water. Journal of Water and Sewage Company of Isfahan Province, No.139,5-5.

[8] Gheibi, Mohammad, Jajarm, Kazem. 2011. Analysis of urban system developments in Tehran province from 1355 to 1385. Journal of new approaches in human geography. 3(3), 1-16.

[9] Khosravi, Mahmoud. Esmaeil Nejad, Morteza., Nazari Pour, Hamid. 2010. Climate change and its impact on water resources in the Middle East. Fourth International Congress of Islamic World Geographers. Iran, Zahedan.1-12.

[10] Mahdizadeh, Saleh, Meftah Halghi, Mahdi, Seyyed Ghasemi, Samaneh, Mosaedi, Abolfazl. 2011. The effect of climate change on rainfall in golestan dam basin. Journal of Soil and water conservation research. 18 (3), 1-16.

[11] Mohammad Jani, Ismaeil., Yazdanian, Nazanin. 2014. Situation analysis of the water crisis and management requirements. Journal of Economic Research, 21(65-66), 144-117.

[12] Sarshar, Amin., Ali, Masoumi. 2013. The impact of virtual water in water resource management. Eighth National Conference on Civil Engineering and sustainable development. 1-8.

[13] Smakhtin, Vladimir., Revenga, Carmen and Döll, Petra. 2004. Taking into Account Environmental Water Requirements in Global-scale Water Resources Assessments. Comprehensive Assessment of Water Management in Agriculture. Report 2. 1-32.

[14] Sorour, Houshang. 2009. Economic globalization and sustainable development of metropolitan areas - A Case Study of Tehran city. PhD thesis, Tarbiat Modarres University. 1-146.

[15] Yang H, Reichert P, Abbaspour K, Zehnder AJB. 2003. A water resources threshold and its implications for food security. Journal of Environmental science and Technology. 37 (14), 3048-3054.