Challenges and development perspectives of water supply system in Syrian governorates

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Abstract. Human demands on water resources are increasing unsustainably at a time when the effects of climate change on the aquatic environment are worsening and, unfortunately, the world is not on the right track to achieve sustainable water and sanitation management. Water is increasingly demanded to feed growing populations, meet growing energy needs, provide services in expanding urban areas, and meet the needs of industry. To improve water security in the context of growing demand, water scarcity, increasing uncertainty, intensifying extreme weather events and fragmentation challenges, countries will need to strengthen institutional frameworks, manage information and develop infrastructure (both natural and man-made). Institutional instruments such as legal and regulatory frameworks, water pricing and incentives to improve water allocation, regulation and conservation are important. It is also necessary to have information systems for monitoring and tracking this resource, making decisions under uncertainty, conducting network analysis, making forecasts and issuing warnings related to hydrometeorology.

1 Introduction. Emergence of the need for water resources organization

Surface water scarcity in the Arab region, in addition to other growing challenges such as climate change, high dependence on transboundary water resources and increased water use by the agricultural sector, requires the establishment of successful cooperation and partnership initiatives. Syria, like most Arab countries, relies heavily on rivers and groundwater aquifers that are shared with neighbouring countries for water supply. Over the past decade, water management has contributed to the economic and social well-being of the region by providing basic water, sanitation and hygiene services, improved food production, industrial development and ecosystem services. However, there is still a long way to go before the Sustainable Development Goal targets are met. Syria still faces unequal access to water. Other critical challenges and constraints at the regional level include inadequate exchange and health services, as well as the spread of pollution and shortcomings in transboundary cooperation. It is critical to strengthen existing partnerships and networks, and promote existing platforms to increase stakeholder engagement at all levels. Today, Syria
is growing and changing rapidly. Modern, bustling, with a young population, it is now home to more than 20 million people [1]. An economy previously largely dependent on income from agriculture and traditional manufacturing industries is becoming increasingly diversified, with a growing private sector and a thriving tourism industry. And crucial to all these people, cultures, industries and services is water. Syria, located in an arid and semi-arid climatic zone, is characterized by a wide variation in rainfall: more than 1000 mm per year in the mountainous coastal areas and less than 200 mm per year in the southeastern desert areas [2]. The country's water supply comes from three sources: rainwater, groundwater and surface water. See Figure 1. Average domestic renewable water resources are estimated at 8 billion m³/year, of which 5 billion m³/year is groundwater. In addition, Syria receives about 6 billion m³/year from the Euphrates River in the northeast of the country.

![Figure 1: Multiple water sources supply different governorates in Syria.](image)

Together with discharges from agricultural, domestic and industrial sources, the actual total renewable water resources are about 16 billion m³/year. Syria's water resources are under increasing pressure due to massive population growth and high rates of urbanization. In addition, the prevailing policy of self-sufficiency in agricultural food, industrial development and tourism are placing increasing demands on the resource. As in many other countries in the region, the main water consumer is the agricultural sector, which uses 88.5% of Syria's water resources. Due to the use of old and sometimes deteriorated water networks, potable water losses average about 25 percent of the total water pumped into the networks, and this figure rises to about 50 percent in the rural province of Damascus [3].
Over the last 15 years, annual water consumption has exceeded total renewable water resources by about 14%, and declining groundwater supplies are a major problem in many parts of the country [4]. Furthermore, water supply is unevenly distributed throughout the country, with major urban centres such as Damascus located in areas with low rainfall.

In addition to water scarcity, pollution from untreated domestic sewage and agricultural runoff is an increasing problem. This not only affects the quality of drinking water in rural and urban areas, but also contaminates irrigation water, posing a serious threat to human health.

Water scarcity and low per capita water levels represent major obstacles in any economic recovery process and particularly affect agricultural food production and the well-being of the population. In Syria, this is occurring alongside other factors, including shortages and high energy prices (fuel oil, gas and electricity). The outbreak of conflict has exacerbated and created new problems that already existed before 2011. The destruction of sanitation centres and water infrastructure, widespread water contamination, water restrictions in areas in the northeast of the country have led to severe shortages and problems with local people's access to water. In addition, power shortages have become a major constraint to water resources and water supply management. Infrastructure and water supply systems have been severely damaged or destroyed during the conflict by various actors. A UN investigation reported 46 attacks on water facilities in Syria in 2019 alone [5].

On various occasions, water sources were deliberately contaminated, rendering the water unfit for consumption; in addition to direct attacks, pumping stations, pipes, and wells were often caught in crossfire and damaged during intense bombardment.

2 Water resources in Syria

Groundwater is used in parallel with surface water, and in some places, groundwater may be the only water resource. See Figure 3. As the total volume of available water resources cannot meet the growing demand for water due to a mismatch in the distribution of available volumes and demand, this has led to aquifer depletion beyond natural recharge.
The concept of water resources management

Water resource management is defined as the ability to utilize and harness all natural, chemical, biological and social resources to provide crops with the water needed for food and feed production to achieve predetermined objectives without compromising the environment [6]. The amount of water required and timing of irrigation depends on the prevailing climatic conditions, the type of crop and its growth rate.
Taking care of water resources is vital to fulfill all human needs including drinking water, industrial needs and irrigated agriculture. Water is seen as a commodity with economic value that can be traded internationally, exported and imported like any other commodity.
The economic concept of water can lead to the creation of reciprocal world and regional markets for this important strategic commodity.

Fig.3 Distribution of feed water sources in the governorates of Syria.

Water management methods

Water management methods in aquatic ecosystems include:
1. Management of water consumption and supply: it consists of informing water users about the importance and limitations of these resources, publishing awareness-raising materials aimed at rational water use, eliminating losses, and working to increase the amount of available water and improve its quality.
2. Improving water use efficiency: consists in the efficient and wise use of water and includes the application of methods that facilitate the use of water.
3. Surveillance: consists of tracking and analyzing water data to study water use and determine water demand.
4. Storage: involves (annual) regulation of water management facilities and reservoirs to meet water demands in different seasons such as winter-autumn (storage), summer-spring (consumption).
5. Protection and conservation of water resources: involves protecting the water basin from pollution, terrorism and willful negligence, and ensuring environmental safety and sustainability of water resources, by identifying safe and reliable methods for the disposal of waste and water pollutants, promoting healthy lifestyles to reduce waterborne diseases.
6. Regional transboundary basin management: involves planning human activities on lakes and rivers, preserving marine ecology and protecting water resources.
7. Land Management: involves determining groundwater levels, updating databases and promoting sustainable use practices.
8. Coordination Unit: involves the coordination of all parties responsible for water management in the aquatic ecosystem, in accordance with the laws and regulations of the regional basin and local authorities.
9. Water as an instrument of political influence: the problem of transboundary resources allocation and use is one of the most complicated in relations with neighboring countries.

5 Dependencies of water objects on neighbouring states

Turkey contributes 90% of the flow of the Euphrates River, as water flow from Turkey has declined from 1,800 cubic meters per second before 2010 to 200 cubic meters per second in 2021[7]. The unprecedented low levels of the Euphrates River and its dams have severely affected at least a third of the more than 190 water intake stations that rely solely on river water to supply drinking water to most of the population in Aleppo, Al Raqa and Deir Ezzor governorates. The outbreak of conflict exacerbated problems that already existed before 2011 and led to the emergence of new problems, such as the loss of water security as a result of dependence on external water sources and the control of upstream countries over the amount of water available. Haphazard management and allocation of water from available resources increases the suffering of the population.

![Fig.4 The amount of water available for human use varies from one governorate to another in Syria.](image)

6 Water management of international rivers in Syria

Due to the dependence of many Syrian governorates on external sources of water supply, in order to maintain the sustainability of water supply to these governorates, it is necessary to organize the process of water management of international rivers and this through:
1. Monitoring and evaluation: the quantity and quality of water in the rivers are constantly monitored and evaluated by the responsible authorities of the country represented by the Ministry of Water Resources and the water harvesting directorate, which helps to make the right decisions on water management.
2. Flow control: flow and river flows are monitored to ensure that sufficient water is available for various purposes.
3. Increased access to groundwater: access to groundwater is increased to meet water needs in areas suffering from surface water scarcity.
4. Reducing environmental pollution: measures are taken to reduce environmental pollution from industrial, agricultural and residential enterprises in order to maintain water quality in rivers.
5. Incentivizing the use of recycled water: the use of recycled water is incentivized to meet water needs in water scarce areas.
6. Cooperation and Coordination: Cooperation and coordination is carried out between governments, communities, companies and other organizations to achieve optimal river water management.

7 Modern methods of organizing water resources

1. Desalination Industry Development:
The process of evaluating available and viable alternatives in the long term shows that desalinated water, [8] is likely to be the primary and main source of drinking water needed in the development process, as the desalination industry not only largely provides current water resources, but future technologies promise to be a successful solution to water scarcity. In the long term, desalination may become possible using renewable energy sources such as solar energy.
2. Development of regional and international cooperation in the field of water resources management:
The problem of limited water resources in the medium and long term is a regional problem and one of the most important challenges to economic and social development in the world in general and in the Middle East region in particular. Cooperation between neighboring countries in the development of new water sources and water resources management should be one of the main areas of regional and international cooperation in the future Research, technical development and exchange of experience in the development and management of water resources can be the most important areas of this cooperation. Strengthening the coordination, integration, exchange and participation between Syria, Iraq and Turkey will open up great opportunities for different types of cooperation in the field of water resources in the future [8].
3. Water reuse.
Advanced technologies make it possible to purify used water and return it for other uses such as agriculture or industry.
4. Water saving by smart irrigation.
Advanced irrigation technologies such as drip or sprinkler irrigation are used to reduce water wastage and improve water efficiency in agriculture.
5. Remote sensing technologies.
Technologies such as satellites and remote sensing are used to monitor and measure the quantity and quality of water in lakes, rivers and natural springs.
6. Government regulation of water demand:
It aims to improve the efficiency of water use by educating people about the importance of water and encouraging them to reduce their personal consumption.
Water storage methods such as dams and reservoirs are used to store water during times of water surplus.
8. Strategic water use planning:
Long-term strategies for the efficient management and allocation of water resources are developed to meet the future expectations and needs of the population and industry.
9. International Cooperation:
Cooperation between countries in the management of shared water resources, such as international rivers and shared estuaries, is strengthened through joint agreements and memoranda of understanding.
8 Importance of water management

1. Water management allows water to be pumped from areas where there is more water than needed to areas suffering from drought by creating a canal or distribution network that can be linked between an area with excess water at source and an area in need.
2. At 70%, agriculture uses most of the fresh water in the world. It is needed for food production. The more people there are, the more water is required. Water management also helps determine future irrigation projections, so it is very important.
3. Water management involves many issues, which means that responsible parties need to know how much water is available, how it should be used and what needs to happen to make water usable, as well as competing demands, processes.
4. The fact that water resources are often distributed across the borders of several countries is one of the problems that water governance helps to solve [9].

In addition to being complex, water governance is also challenging. Many issues make access to clean water difficult, such as pollution of available water and climate change, as climate change redistributes water to places where it is scarce, making water management increasingly important, in addition to the growing demand for water responsible for water management.

9 Proposed measures for water resources development

1. Study of surface and groundwater potential and development of water resources at the expense of surface watercourses and groundwater.
2. All planned hydraulic structures (especially for agricultural purposes) should seek to maximize the use of rainfall and surface runoff while reducing dependence on groundwater abstraction.
3. Urban needs should seek to minimize systemic water losses and adaptation measures. Conservation; this will help to conserve groundwater resources.
   It should be noted that integrated water resources management requires consideration of a wide range of social, economic and environmental aspects of resource utilization and protection, and in developing water resources management perspectives.

10 Conclusions

To improve the water situation in the governorates of the Syrian Arab Republic the following main determinants should be focused on:

1. River basin management with a focus on water supply to different end-users and the potential impacts of climate change on river flows and agriculture.
2. Groundwater and surface water utilization and management by assessing the interaction of the groundwater and surface water system and the allocation and transfer of water between basins.
3. Management of lakes and reservoirs with emphasis on pollution control, water supply and operation of reservoirs, implementation and management of irrigation systems.
4. Development of design and operation of water treatment systems.
5. Design development and operation of water supply and distribution networks.
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