

Integrating International Practices to Develop a Sustainable Water Resource Management Model for Azerbaijan

Natig H. Pasha
Department of Chemical Technology,
Recycling and Ecology
Azerbaijan Technical University
Baku, Azerbaijan
0000-0002-5666-6835

Rashail Ismayilov
"Water and Amelioration Scientific
Research Institute" public legal entity
Azerbaijan State Water Resources
Agency
Baku, Azerbaijan
0000-0002-3944-355X

Isa Gasimov
Department of Industrial Engineering
Baku Engineering University
Baku, Azerbaijan
0009-0008-5760-5314

Abstract— Water management has become a critical issue worldwide, especially in regions such as Azerbaijan that face arid climates and dependency on transboundary water resources. This study proposes an integrated water management model that combines the principles of the European Union Water Framework Directive (EU WFD) and new Israeli water management practices. Pilot studies show that the implementation of this model can improve irrigation efficiency by 25% and reduce water losses by 20%.

Furthermore, this study is in line with the Sustainable Development Goals (SDGs 6 and 17) by promoting access to clean water, protecting ecosystems and strengthening international cooperation. Challenges such as technological adaptation, financial investment and transboundary water management are also discussed, and effective recommendations are provided to overcome these barriers.

The results highlight the potential of integrating international best practices in water management, offering scalable solutions that can be replicated in similar contexts around the world. This study not only contributes to the academic discourse but also provides policymakers and stakeholders with a practical basis to address pressing water resources management issues.

Keywords— *Integrated Water Management, Sustainable Development Goals (SDG 6 and SDG 17), European Union Water Framework Directives (EU WFD), Israel Water Innovations, Transboundary Water Management, Agricultural Water Efficiency.*

I. INTRODUCTION

Azerbaijan faces critical challenges in water resources management due to its arid climate, limited internal water resources, and heavy dependence on transboundary water flows from the Kura and Araz rivers (1). These rivers, shared with neighboring countries, are significantly influenced by upstream activities, such as excessive water withdrawal and pollution, exacerbating water scarcity and environmental degradation in Azerbaijan (2). The country's aging infrastructure and inefficient water use further compound the problem, particularly in agriculture, which accounts for over 70% of total water consumption (3).

To address these challenges, this study explores the potential integration of two globally recognized frameworks: the European Union's Water Framework Directives (EU WFD) and Israel's innovative water management practices. The EU WFD provides a robust legal and operational

framework for sustainable river basin management, emphasizing ecological protection, water quality improvement, and stakeholder involvement (4). Meanwhile, Israel's advancements in water reuse technologies, drip irrigation systems, and water governance offer scalable solutions for arid and semi-arid regions (5).

This research aligns with the Sustainable Development Goals (SDG 6 and 17), focusing on improving access to clean water and sanitation, fostering international partnerships, and promoting sustainable water management practices (6). By tailoring these international best practices to Azerbaijan's specific context, this study aims to develop an integrated water management model that enhances agricultural productivity, ensures ecosystem sustainability, and strengthens regional water governance (7).

II. CURRENT STATUS OF WATER RESOURCES MANAGEMENT

The Kura and Araz rivers are the main water sources of Azerbaijan. These rivers play an important role in water supply of Azerbaijan. Both rivers are transboundary and have strategic importance in water resources management (8).

In Azerbaijan, both surface and underground water sources are used for drinking water supply of the population and water supply of agriculture. The country's water resources, their use and protection are characterized by the following indicators (Table 1).

TABLE I. WATER RESOURCES AND THEIR USE IN THE REPUBLIC OF AZERBAIJAN

Types of water resources		Water resources, km ³	Объем забора воды из природных источников, km ³
Surface waters	Local	10,6	10,1
	Transboundary	20,3	
Groundwater		4,38	1,40
General		35,3	11,5

Based on state water use accounting data (2000-2020), an analysis of the volume of water withdrawal from water sources by sector was conducted. Thus, during this period, the volume of water withdrawal from natural water sources fluctuated within the range of 9.91-12.59 km³ (14). The largest volume of water withdrawal from water sources was in 2019, the smallest - in 2002 (Figure 1). In general, over the past 21 years, an average of 11.5 km³ of water was

withdrawn from natural water sources. During this period, an increase in the volume of water withdrawal from natural water sources by 1.8 km³ (17%) was noted (14).

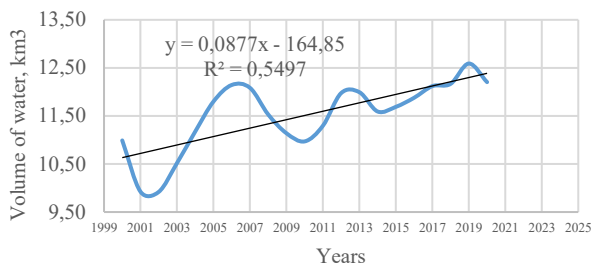
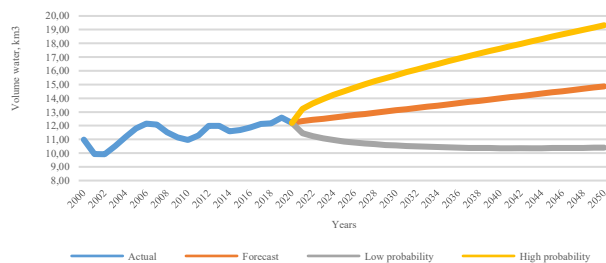


Fig. 1. Figure 1. Change in the volume of water withdrawal from natural water sources.

If the volume of water withdrawal from water sources remains at the same rate, it is predicted that in 2030 it will be 13.2 km³, in 2040 – 13.99 km³, and in 2050 – 14.86 km³ (Figure 2).



The analysis was carried out separately for both the volume of water taken from surface sources and the volume of water taken from underground sources. Over a long period, a decrease in the volume of water taken from surface water sources and an increase in the volume of water taken from underground water sources has been observed (2,14).

Analysis of water intake by sources shows that such use of the resource will lead to serious problems in the region's ecosystem in the future. In this regard, the use of underground water sources should be reduced and priority should be given to the use of surface water sources.

Although some steps have been taken recently to increase water production and reduce water losses, as well as to create modern irrigation systems that ensure efficient delivery of water to plants (9, 10), there are a number of problems and shortcomings in water resources management in Azerbaijan (11, 12). These problems hinder the efficient use and conservation of water resources.

The main problems are mainly related to transboundary water resources management, solving water discharge and distribution problems, integrated water use in industry and agriculture, uncertainties in the current legislation related to water resources management, as well as climate change related problems in water supply. (13, 2).

Water is wasted due to problems of improper management and distribution of water resources in Azerbaijan. Inefficient use of water in agriculture and industry, as well as outdated irrigation systems, make it difficult to manage water resources properly (15). Inefficient

use of water leads to a reduction in water resources in the country and an increase in the economy's demand for water.

The current legislation on water management in Azerbaijan is sometimes vague and does not cover the necessary requirements. This leads to ineffective water management. At the same time, poor coordination between government agencies hinders effective water management (16).

Climate change can have a serious impact on water resources. Climate change affects water cycles and flows, as well as the availability of water resources (17). Drought and deterioration in water quality can cause difficulties in agriculture and drinking water supply (18).

III. GLOBAL EXPERIENCE: INTEGRATED WATER RESOURCES MANAGEMENT

The European Union Water Framework Directives, which propose principles for river basin water management and water protection in accordance with environmental requirements, can be an important step towards effective and sustainable water resources management in Azerbaijan.

These principles cover all sources of water resources and are aimed at protecting ecosystems and improving water quality.

Experts studying ecosystem-based water management methods (19, 4) emphasize the importance of water resources for ecosystems and the possibility of ensuring ecological balance by developing effective water management strategies to protect ecosystems.

In studies related to climate change adaptation and water resources management in Azerbaijan, researchers (20, 21) note that positive results can be achieved in integrated water resources management for adaptation to climate change by implementing the European Union Water Framework Directives (WFD).

Israel's experience in using advanced technologies and strategies in water resources management can serve as an example for water resources management in Azerbaijan (22).

Israel has built an extensive infrastructure for water recycling, using the world's largest desalination plants, thereby ensuring water security and water recycling. At the same time, Israel is also implementing various measures to adapt to climate change (23). Israel's achievements in water management (24) serve as important examples for water management in Azerbaijan. Measures such as drip irrigation technologies and water recycling will ensure efficient water use and conservation of water resources (25).

IV. ADAPTABLE PRACTICES FOR AZERBAIJAN

The water legislation of Azerbaijan differs from the EU Water Framework Directives in several respects and at the same time requires integration in some respects (26). The water legislation of Azerbaijan is based on the principles of water basin management and water protection in accordance with environmental requirements, in accordance with the EU directives (27). However, in some respects, the water legislation of Azerbaijan differs with more precise and gradually implemented rules (22).

In terms of water resources management: Incorporate the principles of integrated water basin management of the European Union into the water legislation of Azerbaijan. It is necessary to develop measures to ensure the efficient and sustainable use of water resources.

In the field of environmental requirements and safety issues: Further improvement of the principles of water protection in accordance with environmental requirements in the water legislation of Azerbaijan. Implementation of measures to ensure the sustainability of ecosystems.

Monitoring of water use: Introduction of modern technologies and improvement of standards for monitoring and control of water resources in the water legislation of Azerbaijan. In transboundary water management: expanding international cooperation and regional agreements on transboundary water management in the water legislation of Azerbaijan.

In water supply and sanitation systems management: improving the standards for the application of water purification and reuse technologies in the water legislation of Azerbaijan and expanding measures to prevent improper use of water.

Azerbaijan can widely apply water reuse technologies, using the experience of Israel, in agriculture, which is the largest consumer of water.

Application of desalination technologies: Azerbaijan's location on the Caspian Sea coast creates ideal conditions for the application of desalination technologies. The problem of water shortage can be solved by applying these technologies. The construction of desalination plants for the purification of sea water will ensure the safety and purity of water.

Water management infrastructure and adaptation to climate change: Azerbaijan can benefit from Israel's experience in the field of water management infrastructure and adaptation to climate change. Long-term strategies should be developed to make water resources more resilient to the effects of climate change through the application of modern technologies and strategies for effective water management. Given the climatic conditions of Azerbaijan and limited water resources, it is important to encourage the cultivation of plants that consume little water and have high tolerance to salinity.

V. CONCLUSION AND SUGGESTIONS

1. Water Resources Management: Applying the principles of integrated watershed management. This will ensure protection of water quality and quantity.

2. Environmental Requirements and Safety: Further improving water protection principles in accordance with environmental requirements and implementing measures to ensure ecosystem sustainability.

3. Water Use Monitoring: Applying modern technologies and improving standards for monitoring and controlling water resources.

4. Transboundary Water Management: Expanding international cooperation and regional understanding.

5. Water Supply and Sanitation: Improving standards for the application of water purification and reuse technologies and expanding measures to prevent water losses.

Adapting International Practice to Local Conditions:

1. The Israeli Experience: Widespread Application of Drip Irrigation Technologies in Azerbaijani Agriculture, Reusing Wastewater, and Building Desalination Plants by Studying Israeli Drip Irrigation Technologies, Water Reuse, Desalination Technologies, and Climate Change Adaptation Measures.

2. The EU experience: Incorporation of the principles of integrated water resources management and water protection in accordance with environmental requirements into the water legislation of Azerbaijan and improvement of environmental requirements within the WFD of the EU.

3. Technological innovations: Application and development of water reuse, desalination and smart water monitoring technologies to prevent water losses and effectively manage water resources in Azerbaijan through innovative technologies and applications.

These results and proposals represent the main directions for effective and sustainable water management in Azerbaijan. Using these proposals, water legislation and management practices in Azerbaijan can be improved. Water quality and ecosystem health can be ensured by applying these standards and guidelines for water protection in accordance with environmental requirements in Azerbaijan.

REFERENCES

- [1] Abbasov, R. & Smakhtin, V. (2009). "Introducing environmental thresholds into water withdrawal management of mountain streams in the Kura River basin, Azerbaijan." *Hydrological Sciences Journal*, 54(6), 1068-1078. DOI: 10.1623/hysj.54.6.1068
- [2] Pasha, N. H., Zengin, E. & Baylarli, A. T. (2023). Sustainability of Water Resources of Azerbaijan, Future Prospects and Problems. *Journal of Management, Economics & Industrial Organization (JOMEINO)*, 7(2). <http://doi.org/10.31039/jomeino.2023.7.2.2>
- [3] Abbasov, R. (2020). Mainstreaming climate change related activities into the water sector of Azerbaijan. *Water 4 United Nations Development Program Report*.
- [4] Gain, A. K., et al. (2021). "Social-ecological system approaches for water resources management." *International Journal of Sustainable Development & World Ecology*, 28(2), 109-124. DOI: 10.1080/13504509.2021.1878137
- [5] Marin, P., et al. (2017). "Water Management in Israel: Key Innovations and Lessons Learned for Water Scarce Countries." *World Bank Publications*. DOI: 10.1596/978-1-4648-1060-0
- [6] Kaika, M. (2003). "The Water Framework Directive: A new directive for a changing social, political and economic European framework." *European Planning Studies*, 11(3), 299-316.
- [7] Zeitoun, M. & Mirumachi, N. (2008). "Transboundary water interaction I: Reconsidering conflict and cooperation." *International Environmental Agreements*, 8(4), 297-316.
- [8] Qurbanov, A. (2013). *Hidroböhran, hidromünaqişələr və hidrostrategiya*. Bakı: Azərbaycan Respublikasının Prezidenti yanında Strateji Araşdırmalar Mərkəzi.
- [9] Ismailova, L. F. (2021). Some Issues of the Development of the Agricultural Sector and Agricultural Entrepreneurship.
- [10] Pasha, N. & Zengin, E. Restoration and resilience strategies for sustainable urban development. *Proceedings of the 3rd International Scientific and Practical Conference «Modern Knowledge: Research and Discoveries»*, July 19-20, 2024, Vancouver, Canada. <https://doi.org/10.51582/interconf.19-20.07.2024.006>
- [11] Ahouissoussi, N., Neumann, J. E., Okan, C., Boehlert, B., & Strzepek, K. (2014). Reducing the vulnerability of Azerbaijan's agricultural systems to climate change: impact assessment and adaptation options. *World Bank Publications*.
- [12] Tosun, H. E., Zengin, E., & Paşa, N. H. (2023). Dirençli kent oluşturma sürecinde kentsel restorasyon politikaları. *Tikintinin iktisadiyatı ve menecment*, № 2 (2023) -səh.155-177, Bakı, 2023. <https://doi.org/10.58225/tim.2023-2-155-177>

- [13] Paşa, N. H., Tosun, H. E., & Zengin, E. (2023). Dirençli kentler oluşturulmasında kentsel kirilganlık ve ekolojik restorasyon. *Tikintinin iqtisadiyyatı və menecment*, № 3 (2023) -səh.15-32, Bakı, 2023. <https://doi.org/10.58225/tim.2023-3-15-32>
- [14] İsmayilov, R., & Suleymanov, F. (2024). Water Resilience Under Climate Change in Azerbaijan. *Geo Journal of Tourism and Geosites*, 53(2), 677-686.
- [15] Aliyev, V., & Suleymanov, F. (2023). The protection of water resources for sustainable tourism under climate change in South Caucasus: In the context of Azerbaijan. *GeoJ. Tour. Geosites*, 47(2), 515-522.
- [16] İbrahimova, G., & Valizade, V. (2018). Siyasi süreçler ve küreselleşme. *Atlas Sosyal Bilimler Dergisi*, (3), 150-171.
- [17] Ahmadov, E., Mehriban, S., Javadov, R., Aliyev, E., & Khalilov, T. (2019). Sustainable water resources management and its quality modeling in Azerbaijan. *Economic and Social Development: Book of Proceedings*, 1-11.
- [18] Natig, P. H. (2013). The role and strategic importance of Balkan countries in caspian basins energy diplomacy. *IBAC 2012, 2nd International Balkan Annual Conference, Tirana-Albania, October 10-13, 2012*, <https://cdn.istanbul.edu.tr/FileHandler2.ashx?f=ibac-2012-albania-volume-i-1.pdf>
- [19] Schoeman, J., Allan, C., & Finlayson, C. M. (2017). A new paradigm for water? A comparative review of integrated, adaptive and ecosystem-based water management in the Anthropocene. *Revisiting Integrated Water Resources Management*, 17-30.
- [20] Ward, F. A. (2013). Forging sustainable transboundary water-sharing agreements: barriers and opportunities. *Water Policy*, 15(3), 386-417.
- [21] Pasha, N. The impact of water security and climate change adaptation on sustainable development in Azerbaijan. *16th International Scientific and Practical Conference «Scientific Horizon in the Context of Social Crises»*, November 26-28, 2024), Tokyo, Japan. <https://doi.org/10.51582/interconf.2024.226>
- [22] Marin, Philippe; Tal, Shimon; Yeres, Joshua; Ringskog, Klas B. (2017). *Water Management in Israel: Key Innovations and Lessons Learned for Water Scarce Countries*. World Bank, Washington, DC. <http://hdl.handle.net/10986/28097>. License: CC BY 3.0 IGO.
- [23] Alatout, S. (2008). 'States' of scarcity: water, space, and identity politics in Israel, 1948-59. *Environment and Planning D: Society and Space*, 26(6), 959-982.
- [24] Tal, A. (2016). Rethinking the sustainability of Israel's irrigation practices in the Drylands. *Water research*, 90, 387-394.
- [25] Megersa, G., & Abdulahi, J. (2015). Irrigation system in Israel: A review. *International Journal of water resources and environmental engineering*, 7(3), 29-37.
- [26] Luckmann, J., Grethe, H., & McDonald, S. (2016). When water saving limits recycling: Modelling economy-wide linkages of wastewater use. *Water research*, 88, 972-980.
- [27] Sneegas, G., Seghezzi, L., Brannstrom, C., Jepson, W., & Eckstein, G. (2022). Do not put all your eggs in one basket: social perspectives on desalination and water recycling in Israel. *Water Policy*, 24(11), 1772-1795.