

SURFACE WATER RESOURCES OF AZERBAIJAN

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Abstract. This article analyzes the current status of Azerbaijan's surface water resources, their formation characteristics, the major river basins, and the challenges associated with water resources management. The study evaluates Azerbaijan's water security based on official statistical data, international reports, and recent scientific literature. The findings indicate that the country's heavy dependence on transboundary rivers for the formation of its water resources, together with the impacts of climate change, water losses, and pollution, poses significant risks to future water security. The article highlights the importance of Integrated Water Resources Management (IWRM), adaptive management approaches, the implementation of water-saving technologies, and the application of international best practices. The results of the study provide valuable scientific support for the development of a sustainable water policy in Azerbaijan.

Keywords: surface water resources, water security, Kura–Araz River Basin, climate change, adaptive management.

1. Introduction

At present, water resources are regarded as one of the most important natural resources of strategic significance worldwide. Population growth, urbanization, industrialization, and climate change are placing increasing pressure on available water resources. In particular, in countries located within arid and semi-arid climatic zones, water security is considered one of the fundamental prerequisites for sustainable socio-economic development [1].

Azerbaijan is also among the countries with limited water resources. A significant proportion of the country's total water resources is supplied by transboundary rivers originating in neighboring countries. This situation creates certain challenges in terms of both water resources management and environmental security [2].

The principal surface water resources of Azerbaijan are associated with the Kura and Araz River Basins. These rivers are of strategic importance for agriculture, industry, energy production, and the supply of drinking water to the population. However, in recent years, climate change, declining precipitation, increasing temperatures, and the intensification of drought events have adversely affected the country's water resources [3].

Reports published by international organizations also indicate that water scarcity and the deterioration of water quality will pose serious challenges in many regions in the future [4]. Therefore, the sustainable and integrated management of water resources has become increasingly important.

The main objective of this study is to analyze the current status of Azerbaijan's surface water resources, identify the major challenges, and evaluate future management perspectives. The article also examines issues related to water security, the impacts of climate change, and modern water management approaches.

General Characteristics of Azerbaijan's Water Resources

1.1. Formation of Water Resources

The formation of Azerbaijan's water resources is mainly attributed to atmospheric precipitation, snowmelt, groundwater, and river runoff. The country's geographical location and topographical characteristics result in an uneven distribution of water resources. While mountainous regions receive relatively high amounts of precipitation, water resources are considerably more limited in lowland and semi-desert areas.

A substantial proportion of Azerbaijan's renewable water resources originates outside the country's borders, indicating its high dependence on transboundary water resources [5].

The Greater Caucasus, Lesser Caucasus, and Talysh Mountains play a crucial role in the formation of the country's river network. Snow and glacier meltwater constitute one of the primary sources of river recharge during the spring and summer seasons.

1.2. Major River Basins

The majority of Azerbaijan's surface water resources are concentrated within the Kura–Araz River Basin. The Kura River is the largest river in the South Caucasus and plays a vital role in the country's economy. The Araz River, one of the principal tributaries of the Kura, is likewise of strategic importance for regional water supply.

The Kura Basin serves as the primary source of water for agriculture and irrigation systems. In addition, the Mingachevir Reservoir is of particular significance for the country's water management and hydropower sectors.

The Samur River plays an essential role in supplying drinking water to the Absheron Peninsula. Through the Samur–Absheron Canal, water is delivered to Baku and surrounding areas.

Other regionally important rivers include the Tartar River (Tartarçay), Ganikh River (Qanix), Vilash River (Viləşçay), and Astara River (Astaraçay).

1.3. Volume of Surface Water Resources

The average annual surface water resources of Azerbaijan vary depending on climatic conditions. During drought years, significant reductions in river discharge are observed. According to statistical data, the risk of water scarcity has increased in several regions in recent years [6].

The uneven spatial distribution of surface water resources has resulted in considerable regional disparities. In particular, water supply conditions are more challenging on the Absheron Peninsula and in the country's lowland regions.

The volume of Azerbaijan's surface and groundwater resources, as well as the country's water use indicators, are presented in **Table 1**.

Table 1. Main Water Resources and Water Use Indicators of Azerbaijan

Type of Water Resource	Water Resources (km ³)	Water Withdrawn from Natural Sources (km ³)
Surface water – domestic	10.6	10.1
Surface water – transboundary	20.3	—
Groundwater	4.38	1.40
Total	35.3	11.5

Source: Prepared by the authors based on data from the State Statistical Committee of the Republic of Azerbaijan (2024).

International assessments indicate that, as a consequence of climate change, river discharge is expected to continue declining in the coming years [7].

2. Experimental Section

2.1. Impacts of Climate Change

In recent years, global climate change has had a significant impact on Azerbaijan's water resources, as observed in many other regions of the world. Rising temperatures, changes in precipitation patterns, increasing frequency of droughts, and intensified evaporation have contributed to the reduction of surface water resources. These effects are particularly pronounced in some regions of Azerbaijan characterized by semi-arid climatic conditions.

Studies have shown that the increase in the country's average annual temperature over recent decades has resulted in reduced river discharge and alterations in the national water balance [8]. The reduction in snow cover and the depletion of glacier reserves negatively affect river recharge during the spring and summer seasons. These impacts are particularly evident in rivers originating from the Greater Caucasus and Lesser Caucasus mountain ranges.

Climate change also has significant consequences for the agricultural sector. Increasing demand for irrigation water places additional pressure on existing water resources. At the same time, the intensification of drought periods increases the risk of reduced agricultural productivity.

International reports indicate that the risk of water scarcity in the South Caucasus region is likely to increase further in the coming years. Therefore, strengthening climate change adaptation measures and ensuring the sustainable management of water resources are of paramount importance.

2.2. Water Scarcity and Regional Disparities

The uneven distribution of water resources across Azerbaijan has resulted in considerable regional differences in water availability. While mountainous and foothill regions possess relatively abundant water resources, water scarcity is much more severe in the Aran (Kur–Araz Lowland) region and on the Absheron Peninsula.

The high population density and concentration of industrial enterprises on the Absheron Peninsula substantially increase water demand. The region's limited local water resources are supplied mainly through the Samur–Absheron Water System, creating additional technical and economic burdens.

One of the major challenges in the Aran region is the substantial loss of irrigation water used in agriculture. Open irrigation canals, aging infrastructure, and inefficient irrigation practices contribute to the inefficient utilization of water resources. According to FAO data, agriculture accounts for the largest share of water consumption in Azerbaijan [5].

Regional disparities also influence socio-economic development. Water scarcity reduces agricultural productivity, exacerbates environmental problems in certain areas, and limits the prospects for sustainable development of local communities.

2.3. Water Pollution Issues

One of the principal challenges facing Azerbaijan's surface water resources is the pollution of water bodies. Industrial activities, domestic wastewater, and agricultural practices have contributed to the deterioration of water quality in a number of rivers and reservoirs.

Since the Kura and Araz Rivers are transboundary watercourses, their pollution is not solely associated with domestic sources. Industrial and agricultural activities located in the upstream sections of neighboring countries also affect water quality [2].

Another significant problem is the discharge of untreated or inadequately treated domestic wastewater into rivers and other water bodies. In particular, the insufficient development of sewage systems and wastewater treatment facilities in some regions has led to increased biological and chemical pollution of rivers.

Furthermore, fertilizers and pesticides used in agriculture are transported into rivers through surface runoff, adversely affecting ecological conditions. The pollution of water bodies represents a serious threat not only to aquatic ecosystems but also to the safety of drinking water supplies.

2.4. Transboundary Water Issues

The fact that a significant proportion of Azerbaijan's water resources originates outside the country's borders makes transboundary water management a strategic issue. A large share of the flow of the Kura and Araz Rivers is generated within neighboring countries, making Azerbaijan's water security highly dependent on regional hydrological and political processes.

According to UNECE reports, effective coordination and information exchange are essential for the management of transboundary river basins [7]. Regional cooperation is considered crucial for the sustainable utilization of water resources, the prevention of pollution, and the maintenance of environmental flows.

Climate change is expected to further increase the risk of reduced river discharge in transboundary rivers, which may intensify challenges related to water allocation and utilization.

Modern approaches indicate that the effective management of transboundary water resources requires not only technical solutions but also the development of institutional frameworks and diplomatic mechanisms [8].

3. Results and discussion

3.1. State Programs and Water Resources Management Mechanisms

The management of water resources is considered one of the strategic priorities at the state level in Azerbaijan. In recent years, various state programs and projects have been implemented to ensure water security, reduce water losses, and modernize water infrastructure.

One of the principal institutional bodies responsible for water resources management is the State Water Resources Agency of the Republic of Azerbaijan. The Agency plays a key role in water resource utilization, reservoir management, the operation of land reclamation and irrigation systems, and the implementation of water security measures.

One of the major priorities of the national water management programs is the improvement of drinking water supply and the enhancement of water availability for agriculture. In recent years, considerable efforts have been made toward the construction of new reservoirs, the rehabilitation of major canals, and the modernization of irrigation systems.

At the same time, contemporary water resources management extends beyond purely technical approaches. International experience demonstrates that effective water governance

requires strong institutional coordination, efficient information exchange, and the integration of environmental considerations into management practices [9].

3.2. Modern Water Management Approaches

The concept of **Integrated Water Resources Management (IWRM)** has become widely adopted in modern water management systems. This approach considers the social, economic, and environmental dimensions of water resources in an integrated manner.

According to the IWRM concept, water resources management should not be carried out by a single sector alone but should involve the active participation of all relevant stakeholders. Such an approach enables more efficient allocation and sustainable utilization of water resources [10].

In recent years, the application of digital technologies has also become increasingly important in water management. Satellite monitoring, hydrological modeling, automated measurement systems, and integrated databases facilitate more effective monitoring and management of water resources.

Adaptive management approaches have likewise gained increasing importance in recent years. The primary objective of this approach is to implement flexible management mechanisms capable of responding to climate change and environmental uncertainties. Studies have shown that adaptive management systems play a significant role in reducing water security risks [11].

3.3. Future Solutions and Directions for Sustainable Development

The sustainable management of Azerbaijan's water resources requires the implementation of comprehensive measures in the coming years. First and foremost, reducing water losses should be regarded as one of the highest priorities. Significant water losses within parts of the existing irrigation infrastructure lead to the inefficient utilization of available water resources.

The introduction of modern drip irrigation and sprinkler irrigation technologies can substantially reduce agricultural water consumption. These technologies are particularly important in regions experiencing water scarcity.

Another promising direction is the reuse of treated wastewater. In many countries, reclaimed wastewater is widely utilized for agricultural irrigation and industrial applications. The adoption of modern wastewater reuse technologies in Azerbaijan should therefore be considered an important priority for the future.

Furthermore, optimizing reservoir operation and improving hydrological forecasting systems can significantly enhance national water security. Under conditions of increasing climate change impacts, the development of long-term adaptation strategies is of particular importance.

Modern scientific approaches indicate that the establishment of a sustainable water policy requires not only technical measures but also institutional reforms, active public participation, and strengthened international cooperation mechanisms [11].

4. Conclusion

The analyses conducted in this study demonstrate that Azerbaijan's surface water resources are of strategic importance for the country's socio-economic development. The Kura–Araz River Basin constitutes the country's principal water supply system and plays a vital role in agriculture, hydropower generation, industry, and the provision of drinking water.

The study findings indicate that the substantial dependence of Azerbaijan's water resources on transboundary water sources makes the country's water security highly dependent on external factors. At the same time, climate change, increasing drought risks, water pollution, and inefficient water use further exacerbate existing challenges.

The study emphasizes that the implementation of integrated and adaptive water management approaches is essential for the sustainable management of water resources. The adoption of modern irrigation technologies, the development of digital monitoring systems, the reuse of treated wastewater, and the strengthening of institutional coordination should be regarded as key priorities for the future.

In conclusion, ensuring Azerbaijan's water security will depend not only on the conservation of existing water resources but also on the development and implementation of a comprehensive long-term strategic water management policy.

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