

## CHALLENGES TO EFFICIENT WATER USE IN AGRICULTURE IN AZERBAIJAN

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**Abstract:** Sustainable food production increasingly depends on water resources and their rational and efficient use. Due to global climate change and desertification, freshwater shortages will become even more acute. Azerbaijan is a country extremely vulnerable to water shortages due to limited internal water resources, high dependence on transboundary rivers, growing climate risks, and the inefficiency of existing water infrastructure. Water scarcity is a key obstacle to agricultural development in the country, and existing irrigation systems are characterised by significant water losses and low efficiency. Given the above, the aim of our study is to identify problems of inefficient water use in agriculture and propose solutions. To assess the level of rational water use in agriculture, we examined indicators such as water withdrawal and consumption, water use for irrigation and agriculture, water losses due to economic activities, the impact of changes in average annual temperature on crop water needs, and the distribution of water resources by region. The results showed that significant water losses pose a serious problem for the agricultural sector and require immediate solutions.

**Key words:** water resources, agriculture, irrigation, climate change, water losses, efficiency.

### Introduction

In the current context of demographic challenges, climate change, and intensifying competition for land and water resources, sustainable agricultural production increasingly depends on water resources and their rational and efficient use and conservation. This primarily involves the development and management of irrigation, including the efficient use of water resources in agriculture and the provision of water supply. Achieving food security is a priority in many countries, and agriculture must conserve water resources not only to feed a growing population but also for other purposes.

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Global forecasts indicate that demand for freshwater will increase significantly in the coming decades due to population growth, changing diets, economic development, urbanisation, and climate change. According to the FAO, 3.2 billion people worldwide currently live in agricultural areas experiencing severe or very severe water stress, with 1.2 billion living in areas of severe water stress (FAO, 2020). Increasing competition for scarce water resources leads to tensions and conflicts between stakeholders, exacerbating inequalities in access to water, particularly for vulnerable groups.

Agriculture accounts for 70% of total global freshwater consumption, but in some developing countries this figure can reach 90% (UN, 2024). With global food demand expected to grow by 60% by 2050, agricultural water demand is only set to increase (FAO, 2017). Water scarcity poses a serious threat to life, livelihoods, and business stability (World Resources Institute, 2019). Over the past 50 years, global agricultural production has nearly tripled, and the area under cultivation has increased by 12%. More than 40% of this increase in food production comes from irrigated land, the area of which has doubled. Research indicates that the area of irrigated land increases by 0.6% per year (FAO, 2011).

Factors contributing to water scarcity include population growth and socioeconomic development, which increase demand for this valuable natural resource. The situation is exacerbated by the expected impacts of climate change, such as unpredictable rainfall and water supply. Income growth and urbanisation are leading to increased demand for water from industry, energy, and services, as well as changing diets, leading to greater demand for water-intensive foods such as meat and dairy. It is estimated that growing 1 kg of grain requires 1 to 3 tonnes of water, while producing a kilogram of beef requires up to 15 tonnes of water. The FAO estimates that providing a person with their daily food supply requires 2,000 to 5,000 litres of water (FAO, 2017).

The relevance of this study stems from the fact that Azerbaijan's water resources are limited compared to other countries in the South Caucasus, accounting for only 15% of the region's total. Approximately 70% of the country's annual water resources originate outside its borders, posing a high risk to water security. Climate change, increasing water consumption in neighbouring countries, and unstable river flows are weakening the resilience of agriculture. Under these circumstances, improving the economic efficiency of water use is becoming a strategic imperative.

In recent years, Azerbaijan has experienced longer droughts, uneven precipitation distribution, and rising temperatures. These factors, along with increasing agricultural water demand, are increasing irrigation costs and threatening farmers' incomes. Agriculture accounts for 80–85% of the country's freshwater resources. However, most irrigation systems are outdated, losses are high, and the yields of many crops are below potential (Smita, 2024). This

demonstrates the economic inefficiency of water use and highlights the need to increase the cost of production per cubic metre of water.

In this regard, a quantitative assessment of the economic efficiency of water use, regional differences, and the economic impact of water-saving technologies is relevant. Taking this into account, the aim of our study is to identify problems related to the irrational use of water resources in agriculture and to determine ways to address them.

The study examined a large number of articles and reports on the topic. Among the researchers' works are studies on the impact of climate change on water availability (Liu et al., 2022), the rational use of water in rural areas (Turan et al., 2023), the implementation of sustainable irrigation, the potential use of accumulated water reserves for irrigation (Schmitt et al., 2022), and issues related to the efficient use of virtual water (Yawson et al., 2013). The reviewed works predominantly focus on either global assessments of water scarcity, behavioural aspects of water use, or the technological potential for sustainable irrigation. However, the economic efficiency of water resource use in Azerbaijan's agriculture, taking into account climatic factors, institutional reforms, regional differences, and the dynamics of SDG 6.4.1 indicators, remains insufficiently studied.

Current water management problems significantly hinder agricultural development. Due to global warming and desertification, the freshwater shortage will become even more acute. Water scarcity reflects a shift from an engineering perspective, aimed at increasing supply to meet demand, to an economic perspective, that is, the efficient use of available water resources (Frone et al., 2012). To mitigate and address these issues, it is necessary to transition to managed water consumption and use water resources more efficiently. The objective of this study is to provide a comprehensive assessment of agricultural water use efficiency in Azerbaijan during 2010–2024, with particular attention to irrigation losses, climatic pressures, and structural constraints in water management.

### **Material and Methods**

This study is based on a comprehensive analysis of secondary quantitative and qualitative data related to water resource use in agriculture in Azerbaijan. The empirical database includes official statistical data from the State Statistical Committee of the Republic of Azerbaijan, sectoral reports from the Ministry of Agriculture, and international datasets provided by the Food and Agriculture Organization of the United Nations (FAO), including the AQUASTAT – FAO's Global Information System on Water and Agriculture, as well as analytical materials from the World Bank and the World Resources Institute.

The study also incorporates national legal and policy documents regulating water management, with particular attention to the National Strategy on the Efficient Use of Water Resources (NSEUWR, 2024) and institutional reforms in the water sector. These documents are used to assess the regulatory and strategic framework governing agricultural water use.

The comparative analysis, based on national statistical data, covers the period 2010–2024, allowing us to identify medium- and long-term trends in water withdrawal, consumption, and water efficiency under changing climatic and economic conditions. A regional perspective was applied to capture spatial disparities in water availability and irrigation efficiency across the main economic regions of the country.

To assess the rationality and efficiency of water use in agriculture, a system of key indicators was employed, including: total water withdrawal from natural sources, water consumption by sector, with a focus on agriculture and irrigation, water losses during abstraction and transportation, water use efficiency indicators, and irrigation water supply per hectare of cultivated land. The agricultural water efficiency indicator was calculated using the internationally accepted SDG 6.4.1 methodology. To assess the impact of climate change on agricultural water demand, data on temperature anomalies and precipitation trends were analysed based on graphical and percentage comparisons in relation to irrigation volumes and crop water requirements. This enables identification of linkages between rising temperatures, increased evapotranspiration, and growing pressure on the irrigation system.

The methodological approach combines descriptive statistical analysis, comparative analyses, and trend analyses. Descriptive statistics were used to characterise the structure of water use and losses by sector. Comparative analyses were applied to evaluate differences in water availability, dependence and stress between Azerbaijan and other South Caucasus countries, as well as between regions within the country. Trend analysis was employed to examine temporal changes in water withdrawal consumption, irrigation demand, and water use efficiency indicators. The integrated use of statistical, comparative, and climate-related analyses provides a multidimensional assessment of water use efficiency in agriculture and allows identification of key structural and institutional factors contributing to water losses and inefficient water management.

## Results and Discussion

Azerbaijan is among the countries with high water vulnerability, which is due to limited internal water reserves, high dependence on transboundary rivers (up to 70% of water resources are generated outside the country), as well as increasing climate risks, and the inefficiency of existing water infrastructure (World Bank, 2024). Azerbaijan's renewable freshwater reserves amount to 26.2 billion m<sup>3</sup>, of

which 8.4 billion m<sup>3</sup> come from groundwater, 4.6 billion m<sup>3</sup> from local river flows, and 13.2 billion m<sup>3</sup> from transboundary surface waters. Of the renewable freshwater reserves 17.8 billion m<sup>3</sup> come from surface freshwater resources (NSEUWR, 2024).

Surface water resources are concentrated primarily in rivers. Seventy-five percent of Azerbaijan's territory lies within the Kura River basin. Approximately 70% of river water resources originate in neighbouring countries, while the remainder (local runoff) comes from internal rivers. During dry years, transboundary water resources sharply decline. At the same time, the water resources of the Kura and Araz rivers are significantly reduced as a result of their absorption by water intake structures in neighbouring countries. This creates serious difficulties in meeting the country's water needs.

Groundwater in Azerbaijan is of high quality. Namely, 16–17% of the water entering rivers ends up in groundwater. More than 2 billion m<sup>3</sup> of groundwater are used annually for agricultural irrigation and residential water supply. The total capacity of usable groundwater is estimated at 8–9 billion m<sup>3</sup> per year.

It should be noted that Azerbaijan is the most vulnerable country in the South Caucasus in terms of water resources. For comparison, Table 1 presents the main indicators of water resources in the countries of the South Caucasus, providing a reliable description.

Table 1. Distribution of water resources among the countries of the South Caucasus.

Indicators	Azerbaijan	Georgia	Armenia
Area	86,600 km <sup>2</sup>	69,700 km <sup>2</sup>	29,800 km <sup>2</sup>
Population	10.3 million people	3.7 million people	3.09 million people
Renewable water resources	26.2 billion m <sup>3</sup>	63 billion m <sup>3</sup>	8 billion m <sup>3</sup>
	8,359	26,060	9,480
Number of rivers including	850 (number of rivers longer than 5 km) 24 (number of rivers longer than 100 km)	16 (number of rivers longer than 100 km)	379 (number of rivers longer than 10 km)
Large rivers	Kura (length 1,515 km), Araz (1,072), Samur	Kura, Rioni	Araz, Akhuryan
Groundwater reserves	8–9 billion m <sup>3</sup>	18 billion m <sup>3</sup>	4 billion m <sup>3</sup>
Number of reservoirs	140	43	74
Water resources per capita	1,313 m <sup>3</sup> /person/year	16,189 m <sup>3</sup> /person/year	2,652 m <sup>3</sup> /person/year
Water dependence	70%	8.2%	11.7%
Water stress	57.53%	4.21%	61.97%

Source: Authors' elaboration based on data from National Statistical Committees of countries and AQUASTAT – FAO's Global Information System on Water and Agriculture.

According to the data, Azerbaijan, despite its larger territory and population, has limited renewable water resources compared to Georgia, resulting in low per capita water availability (1,313 m<sup>3</sup>) and high water dependence (70%). Although Azerbaijan has many rivers, only a few are large and abundant, and groundwater reserves are limited. In contrast, Georgia is characterised by the most favourable water availability in the region: a high volume of renewable water resources, low water dependence (8.2%), and a minimal level of water stress (4.21%) create a sustainable water management system (AQUASTAT, 2025). Armenia occupies an intermediate position, but has the highest level of water stress (61.97%) despite relatively modest resources and a highly vulnerable water sector. Overall, the data confirm that the issue of rational water use, particularly in agriculture, is structurally and strategically significant for Azerbaijan.

The Kura and the Araz are the largest rivers in the Caucasus and the main sources of fresh water, irrigation, and hydroelectric power. The Kura River originates in Turkey, flows through Georgia, and then through Azerbaijan. It passes through the Kura-Araz Lowland and empties into the Caspian Sea. The total length of the Kura River is 1,515 km, of which 906 km are within the territory of the Republic of Azerbaijan. The main reservoirs, dams, and hydroelectric power plants are built on the Kura River (Figure 1).

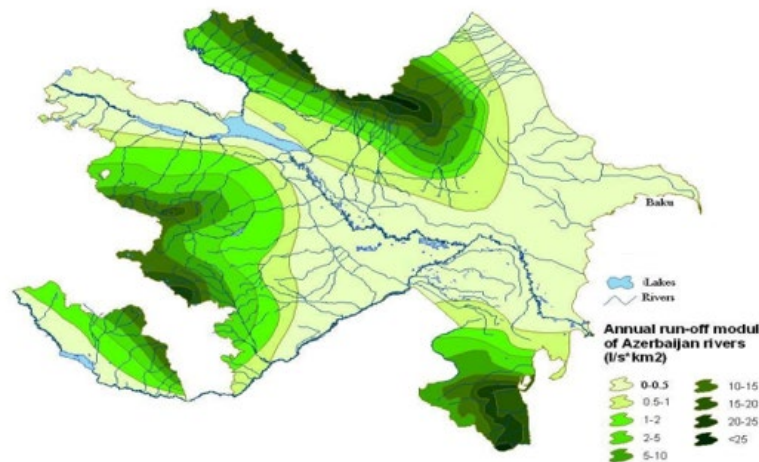


Figure 1. Annual run-off module of Azerbaijan rivers.

Source: National Water Strategy of the Republic of Azerbaijan.

The specific features of Azerbaijan's water resources include their limited size, the uneven distribution of internal rivers, the formation of approximately 70% of surface water resources in neighbouring states, and the serious pollution of river waters already flowing into the country (Verdiyev, 2012).

The main indicators reflecting the level of efficient use of the water resources

A comparative analysis of water consumption indicators in Azerbaijan for the period 2010–2024 reveals a number of persistent structural trends and emerging challenges in national water resources management (Figure 2). According to statistics, water withdrawal from natural sources has generally increased, rising from 11.6 billion m<sup>3</sup> in 2010 to a peak of 13.8 billion m<sup>3</sup> in 2022. This growth reflects growing demand driven by population dynamics, agricultural expansion, and economic activity. However, a significant decline in 2023 followed by a partial recovery in 2024 indicates the increasing sensitivity of water withdrawal to climate variability and hydrological constraints, highlighting the growing pressure on available water resources. Total water consumption shows a similar upward trend until 2021–2022, increasing from 7.7 billion m<sup>3</sup> in 2010 to over 10.5 billion m<sup>3</sup> in 2022 (SSC, 2025). After this peak, consumption declines slightly and stabilises in 2023–2024. The divergence between water withdrawals and consumption in recent years suggests improved reuse, reduced losses, or demand adjustments, but may also reflect supply constraints rather than simply improved efficiency.

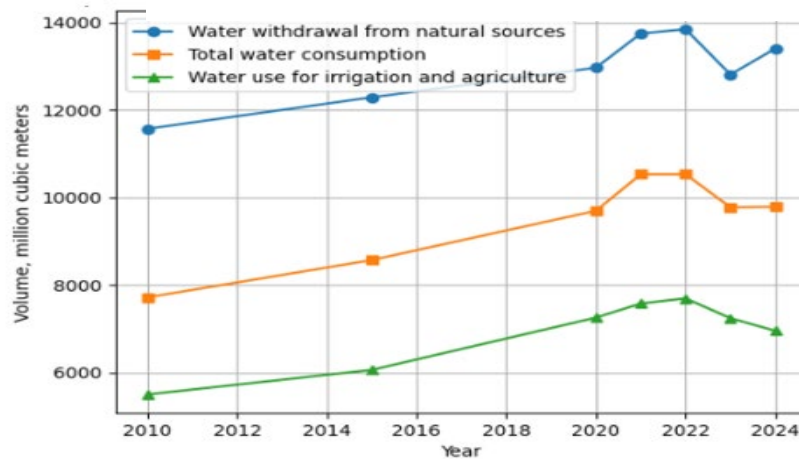


Figure 2. Comparative dynamics of water use indicators in Azerbaijan (2010–2024).

Source: The State Statistical Committee of the Republic of Azerbaijan  
<https://www.stat.gov.az/source/environment/?lang=en>

It should be noted that water use for irrigation and agriculture remains the dominant component of total water consumption throughout the period. Its share consistently exceeds two-thirds of total consumption, increasing from 5.5 billion m<sup>3</sup> in 2010 to a peak of 7.7 billion m<sup>3</sup> in 2022, before declining to 7.0 billion m<sup>3</sup> in 2024.

This confirms the structurally high dependence of Azerbaijan's water balance on the agricultural sector and highlights the crucial role of irrigation efficiency in ensuring water security. The gap between water withdrawal and effective consumption remains significant, indicating persistent losses during abstraction, transportation, and distribution. Although this gap narrowed somewhat after 2022, its overall magnitude points to systemic inefficiencies in water infrastructure and management practices, particularly in irrigation networks.

### Irrigation efficiency

Irrigated agriculture plays a crucial role in agricultural production in the country. The total area of irrigated land is 1.45 million ha, of which 77.5% is arable land, 8.6% is used for perennial crops, and 13.9% is used for other purposes such as hayfields, pastures, household plots, etc. Water resources used for irrigation amount to approximately 7.2 billion m<sup>3</sup> per year. Up to 17% of the republic's irrigated land is irrigated with groundwater, 20% with water from reservoirs built outside the riverbeds, and the remaining 63% with water from reservoirs built on the Kura and Araz rivers, as well as through canals running from the rivers themselves (Gurbanov et al., 2019). Irrigation water in agriculture comes primarily from two sources: 1) water supplied through canals; 2) water obtained from subartesian wells. Namely, 83% of the country's arable land is irrigated from surface sources (NSEUWR, 2024). Since groundwater is close to the surface in the main irrigated areas, irrigation systems with drainage networks are used in intensively cultivated areas to prevent soil salinisation and maintain soil fertility. The introduction of innovative irrigation systems in predominantly irrigated areas is rare.

Figure 3(a) shows that agriculture, forestry, and fisheries are the primary water consumers, accounting for the vast majority of total water withdrawals (over 11.4 billion m<sup>3</sup>). This confirms the high water intensity of the agricultural sector, largely driven by irrigation needs. The industrial sector is the second largest water consumer, with particularly large volumes generated by electricity, gas, and steam production, reflecting the need for cooling and industrial processes. However, water withdrawals from industry remain significantly lower than those from agriculture.

Water losses during transportation are strongly sectoral (Figure 3(b)). Agriculture, forestry, and fisheries are the dominant sources of losses, accounting for the overwhelming majority of total water losses during delivery. In agriculture, water losses during transportation amount to 3.6 billion m<sup>3</sup>, accounting for 30% of the total water used in agriculture and 25% of the water withdrawn from reservoirs. This indicates the high deterioration of irrigation canals, significant seepage and evaporation losses, and the low level of technological modernisation in water management infrastructure.

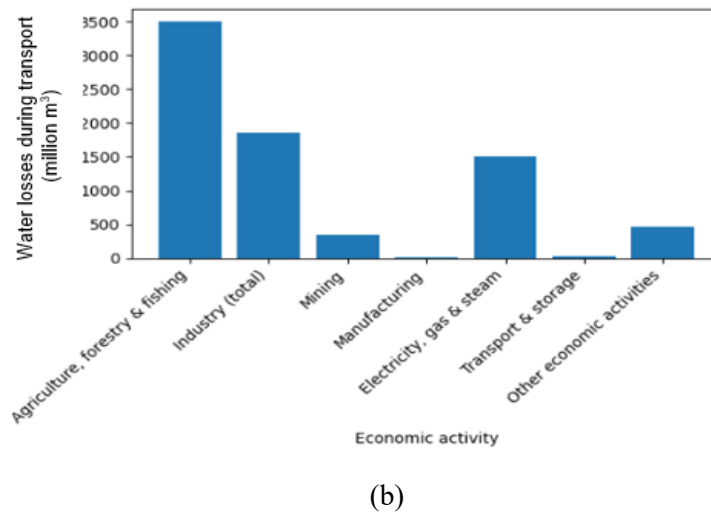
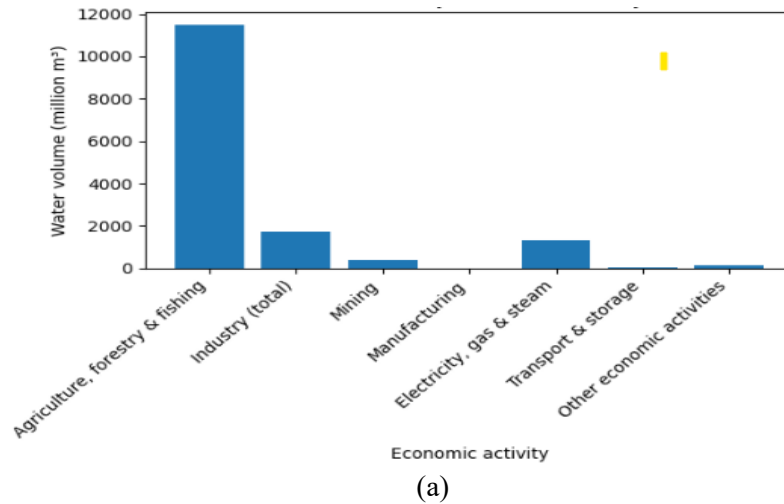


Figure 3. Water withdrawal (a) and losses (b) by economic activity, 2024.

Source: The State Statistical Committee of the Republic of Azerbaijan.

<https://www.stat.gov.az/source/environment/?lang=en>.

Water losses in other economic activities are insignificant. Overall, the loss structure highlights that improving water use efficiency in agriculture is a key resource for reducing water losses and strengthening the country's water security. Priority measures should include reconstructing irrigation networks, implementing water-saving technologies, and strengthening water loss monitoring. The

government supports this approach and provides subsidies. Currently, these subsidies are available to farmers with large land holdings, but they should be expanded. Improving water resource management is fundamental to increasing agricultural production.

Overall, the observed dynamics indicate that although Azerbaijan has managed to expand water consumption to meet economic and agricultural needs, this expansion has increased pressure on natural water resources. The predominance of agriculture in water consumption makes digital water management technologies, modernisation of irrigation systems, and demand-driven regulation key priorities for improving economic efficiency and ensuring the long-term sustainability of water use.

#### Impact of rising temperature

The data shows a steady seasonal increase in average temperatures during the spring–summer period and a decrease in autumn and winter. In recent years, there has been a trend toward higher summer peaks and warmer springs. The maximum temperature occurs in July–August (25–27°C), and the start of the growing season is shifting to an earlier date (Figure 4). According to the latest research, the average temperature in Azerbaijan increased by 1.40 degrees between 1991 and 2017, while the amount of precipitation in Azerbaijan decreased by an average of 14%. The number of hot days (with maximum temperatures above 35°C) per year has increased from 10 to 15 over the last 30 years.

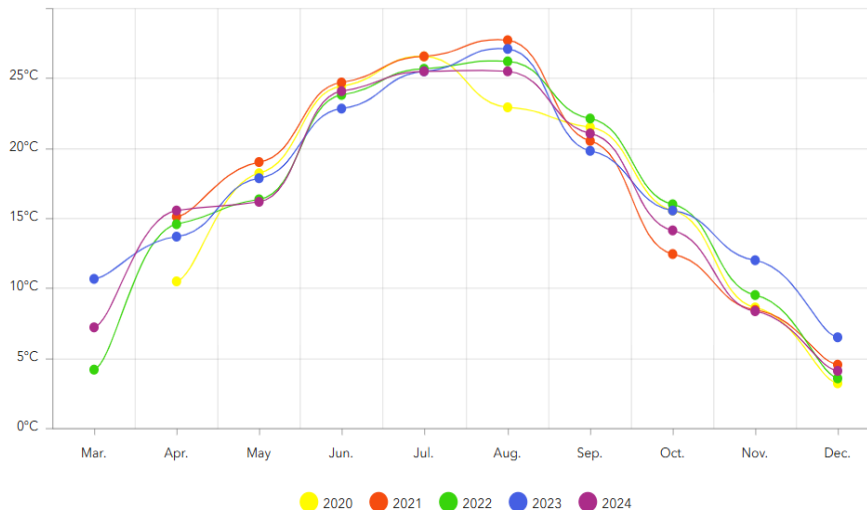


Figure 4. Temperature anomalies for the years 2020–2024 (CR, 2025).  
Source: Space Monitoring of the Effects of Global Climate Change Climate Report.

A descriptive interpretation of the parallel trends reveals that rising temperatures directly increase evaporation and transpiration, reducing available surface and soil water resources and increasing crop water demands, especially during critical summer growth phases. If the irrigation patterns remain unchanged, this leads to increased water losses and reduced water use efficiency. At the same time, the risk of drought, soil overheating, and reduced yields increases due to insufficient water supply. Drought completely destroyed 68,600 ha of crops in 2020, 42,200 ha in 2021, 101,400 ha in 2022, and 178,300 ha in 2023 (SSC, 2025). Under these conditions, the following measures are crucial:

- transition to water-saving irrigation methods (drip irrigation, sprinkler irrigation with controlled irrigation);
- adjustment of irrigation schedules to account for earlier warming;
- introduction of drought-resistant varieties and digital water management systems.

The distribution of the water resources in the country

The distribution of water resources in the republic is extremely uneven. Many regions experience severe water shortages because the distribution of productive forces does not correspond to the natural water supply. Ninety percent of crop yields are achieved through irrigation. The majority of irrigated land is located in the Central Aran (30,699 ha), Guba-Khachmaz (17,180 ha), Mil-Mugan (16,162 ha), and Shirvan-Salyan (16,257 ha) economic regions. The highest irrigation efficiency rates in the country are observed in the Mil-Mugan, Nakhchivan, and Shirvan-Salyan economic regions (SSC, 2025).

According to research, fruit orchards are the most water-intensive crops in our republic, requiring an average of 4,400 m<sup>3</sup> of water per hectare. Other crops, such as forage crops and cotton, require 3,250 m<sup>3</sup> of water, while wheat and barley require 1,320 m<sup>3</sup>. Obviously, these figures can vary depending on the crop and climate conditions, and water consumption increases in arid regions.

The predominance of small farms in the country's agriculture results in the low adoption of modern technologies. The problem is that traditional surface and flood irrigation methods are primarily used. Most irrigation and drainage networks run along earthen channels and are open-air systems, leading to significant water losses, the rise of mineralised groundwater in the crop layers, and salinisation of adjacent lands. More than a third of irrigated land (565,000 ha) is mechanically irrigated, including 349,400 ha by electrified systems, 68,200 ha by diesel pumping stations, and 147,700 ha by subartesian wells.

The efficiency of irrigation systems in Azerbaijan is low – approximately 37% (reflecting inefficient canals and water losses due to outdated infrastructure) (Smita, 2024). According to the Ministry of Agriculture, innovative irrigation

systems have been implemented on 126,000 ha of land in the country to date, accounting for 12% of the total area.

To accelerate this process, the government is increasing its support, and from this year, the subsidy level for locally produced equipment has been increased to 60%. This will make modern systems more accessible to farmers, expand the country's production potential, create new jobs, and reduce dependence on imported technology.

In addition to underutilisation, water quality is deteriorating. Intensive water use in agriculture leads to surface and groundwater pollution. Chemically contaminated water percolates through the soil, affecting the quality of rivers and reservoirs. Azerbaijan faces the challenge of optimising water use to ensure sustainable development with limited water resources. Water consumption, particularly in agriculture, remains high, and the country is working to improve water management and reduce environmental risks (Suleymanov, 2023). Active development of water conservation programmes, including modernising infrastructure and improving irrigation systems is necessary. Cooperation with international organisations enables the country to apply modern water management methods.

It should be noted that crop production is not the only water consumer in agriculture. Livestock farming, particularly in its industrial form, requires the use of large volumes of water from rivers, lakes, and other water bodies, significantly affecting the condition of these bodies of water and the environment as a whole. Industrial livestock farming is a major water consumer: producing 1 m<sup>3</sup> of milk requires 5 m<sup>3</sup> of water, and 1 tonne of meat requires 20,000 m<sup>3</sup> of water. Furthermore, maintaining sanitary and hygienic conditions on farms consumes significant amounts of water. Consequently, the continuous growth of agricultural production, on the one hand, leads to increased consumption of natural resources, and on the other hand, to the generation of large quantities of waste and wastewater on livestock farms and complexes, poultry farms, and other agricultural facilities (Ibragimov et al., 2021).

#### Measures for improving the efficiency of water resources use

Water resources in Azerbaijan are state property. At the national level, various organisations are responsible for the regulation, monitoring, exploitation, and scientific research of water resources. The Ministry of Ecology and Natural Resources is responsible for water policy and water resource protection. The Ministry of Ecology and Natural Resources carries out quantitative and qualitative monitoring of surface water, ensures protection from pollution, and is also responsible for the use and protection of groundwater.

To improve the efficiency of water resource management, water management activities, and land reclamation, as well as to improve the organisation of land reclamation and irrigation work, the State Agency for Water Resources of Azerbaijan was established in 2023. The Agency is the central executive body responsible for organising activities in the fields of water intake, treatment, transportation, and water supply in Azerbaijan. It also oversees the operation of state drainage and irrigation systems.

To introduce digitalisation into the country's annual water resource management balance, improve the efficiency of water resource assessment in key water management systems and facilities, and improve water resource use, accounting, and management, a decision was made to transition to "Electronic Water Resources Management". This system includes the implementation of real-time electronic monitoring mechanisms, including continuous monitoring of subartesian and artesian wells, strengthening data-driven decision-making and promoting sustainable water resource management.

The adoption of the National Strategy for the Efficient Use of Water Resources (until 2040) has become one of the main stages in the system of measures for the efficient use of water resources, with an emphasis on irrigation and land reclamation (NSEUWR, 2024).

According to calculations, water use efficiency in agriculture shows a steady and consistent upward trend over the period 2016–2024. The indicator increased from 0.52 USD/m<sup>3</sup> in 2016 to 1.09 USD/m<sup>3</sup> in 2024, more than doubling over nine years (Figure 5). This positive trend indicates a gradual increase in the economic value generated per cubic metre of water withdrawn.

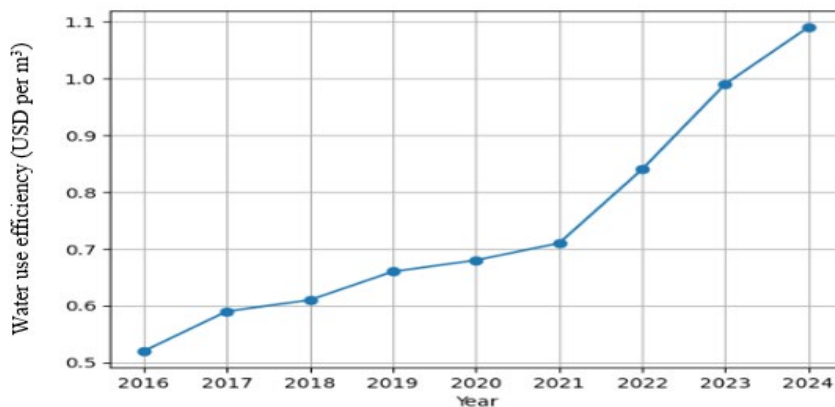


Figure 5. Water use efficiency in agriculture (2016–2024).

Source: Authors' calculations.

The improvement is attributed to structural shifts in agricultural production, partial modernisation of irrigation infrastructure, improved water management practices, and institutional reforms in the water sector. Overall, the results confirm an improvement in water productivity. However, given the still low absolute level of USD/m<sup>3</sup> compared to water-efficient economies, further modernisation and efficiency-enhancing measures remain necessary.

### **Conclusion**

The country's shortage of freshwater resources, climate change, and the observed increase in average temperatures in recent years, along with significant reductions in surface water resources, river water content, and precipitation, primarily from neighbouring countries, as well as rapid population growth, rising living standards, and economic development, including agriculture, have led to increased water demand. These processes require urgent measures to ensure water security in the country.

The findings of the study confirm that water use remains one of the most critical constraints on sustainable agricultural development in Azerbaijan. Limited internal freshwater resources, high dependency on transboundary rivers, increasing climate variability, and outdated irrigation infrastructure collectively intensify water consumption, while substantial losses occur during water abstraction, conveyance, and field application, indicating persistent structural inefficiency in the water management system.

The analysis demonstrates that rising air temperatures and more frequent drought events significantly increase crop water requirements and exacerbate pressure on already limited water resources. Under existing irrigation practices, these climatic changes lead to higher evaporation losses, declining water productivity, and increased vulnerability of agricultural output. Although recent investments in canal rehabilitation, pipeline systems, and modern irrigation technologies have improved water efficiency, their overall impact remains constrained by uneven adoption, institutional weaknesses, and limited access for small and medium-size farms.

The study highlights that further improvement in agricultural water use efficiency requires an integrated approach combining physical modernisation of irrigation infrastructure, wider dissemination of water-saving technologies, and the expansion of digital water management and monitoring systems. Strengthening economic incentives, improving governance and coordination among water management institutions, and aligning regional water allocation with natural resource availability are equally important. Ensuring the efficient use of water resources is not only a technical necessity but also a strategic condition for enhancing agricultural resilience, food security, and long-term water sustainability in Azerbaijan under increasing climate and resource pressure.

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## IZAZOVI EFIKASNOG KORIŠĆENJA VODE U POLJOPRIVREDI U AZERBEJDŽANU

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### Re z i m e

Održiva proizvodnja hrane sve više zavisi od vodnih resursa i njihovog racionalnog i efikasnog korišćenja. Usled globalnih klimatskih promena i dezertifikacije, nestašica slatke vode postaće još izraženija. Azerbejdžan je zemlja izuzetno ranjiva na nestašicu vode zbog ograničenih unutrašnjih vodnih resursa, velike zavisnosti od prekograničnih reka, rastućih klimatskih rizika i neefikasnosti postojeće vodne infrastrukture. Nestašica vode je ključna prepreka razvoju poljoprivrede u zemlji, a postojeće sisteme za navodnjavanje karakterišu značajni gubici vode i niska efikasnost. S obzirom na navedeno, cilj našeg istraživanja je da identifikujemo probleme neefikasnog korišćenja vode u poljoprivredi i predložimo rešenja. Da bismo procenili nivo racionalnog korišćenja vode u poljoprivredi, ispitali smo pokazatelje kao što su zahvatanje i potrošnja vode, korišćenje vode za navodnjavanje i poljoprivredu, gubici vode usled ekonomskih aktivnosti, uticaj promena prosečne godišnje temperature na potrebe useva za vodom i raspodela vodnih resursa po regionima. Rezultati su pokazali da značajni gubici vode predstavljaju ozbiljan problem za poljoprivredni sektor i zahtevaju hitna rešenja.

**Ključne reči:** vodni resursi, poljoprivreda, navodnjavanje, klimatske promene, gubici vode, efikasnost.

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