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ЖАҢА ЖӘНЕ ҚАЗІРГІ ЗАМАН ТАРИХЫ

NEW AND MODERN HISTORY

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WATER RESOURCES OF CENTRAL ASIA: CHALLENGES AND DEVELOPMENT STRATEGY, KAZAKHSTAN'S EXPERIENCE

Abstract. Water resources of Central Asia play a crucial role in ensuring regional security, socio-economic development, and ecological balance. The shortage of fresh water is becoming more acute due to global climate change, population growth, and the intensification of economic activities. The article examines the natural, social, and politico-legal aspects of the problem in Central Asia, including Kazakhstan, identifies key threats, and proposes possible solutions. Particular attention is paid to forecasts of climate change and hydrological regimes, as well as to the prospects for interstate cooperation. The main objective of the research is to analyze the historical evolution of water resources in Central Asia, to determine their socio-economic and political significance, and to reveal their role in the development trajectory of the regional states. At the same time, the study emphasizes the historical lessons of water resource management based on Kazakhstan's experience and addresses current challenges. In terms of methodology, historical-source analysis, comparative-analytical, and systemic approaches were applied. Statistical data, scientific literature, and materials of international organizations were used. The comparative-historical method made it possible to consider the water use practices of Central Asian countries and to identify the peculiarities of the Kazakhstani model. In addition, a historical-ecological analysis was conducted to explore the impact of climate change on water systems and its social consequences.

Keywords: Central Asia, Kazakhstan, water resources, climate change, ecological balance, regional security, water scarcity, hydrological regime.

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Орталық Азиядағы су ресурстары: өзекті мәселелер, даму стратегиясы және Қазақстан тәжірибесі

Аңдатпа. Орталық Азияның су ресурстары өңірлік қауіпсіздікті қалыптастыруда, әлеуметтік-экономикалық дамуда және экологиялық тепе-теңдікті сақтауда ерекше орын алады. Таза судың тапшылығы жаһандық климаттың өзгеруі, халық санының өсуі және шаруашылық қызметтің артуы жағдайында күшейе түсуде. Мақалада Орталық Азиядағы, соның ішінде Қазақстандағы мәселенің табиғи, әлеуметтік және саяси-құқықтық қырлары қарастырылып, негізгі қатерлер айқындалады және оларды еңсеру жолдары ұсынылады. Климаттың өзгеруі мен гидрологиялық режимнің болжамдарына, сондай-ақ мемлекетаралық ынтымақтастықтың болашағына айрықша назар аударылған. Зерттеудің негізгі мақсаты – Орталық Азиядағы су ресурстарының тарихи эволюциясын, олардың әлеуметтік-экономикалық және саяси маңызын айқындау, аймақ елдерінің даму траекториясындағы рөлін көрсету. Сонымен бірге Қазақстанның тәжірибесін негізге ала отырып, су ресурстарын басқарудың тарихи сабақтарын айқындап, қазіргі кезеңдегі өзекті мәселелерді талдау. Зерттеу барысында тарихи-деректанулық, салыстырмалы-талдау және жүйелік әдістер қолданылды. Статистикалық деректер, ғылыми әдебиеттер мен халықаралық ұйымдардың материалдары пайдаланылды. Салыстырмалы-тарихи әдіс арқылы Орталық Азия елдеріндегі су ресурстарын пайдалану тәжірибесі қарастырылып, Қазақстан үлгісінің ерекшеліктері айқындалды. Сондай-ақ тарихи-экологиялық талдау негізінде климаттық өзгерістердің су жүйесіне ықпалы мен оның әлеуметтік салдары зерделенді.

Түйін сөздер: Орталық Азия, Қазақстан, су ресурстары, климаттың өзгеруі, экологиялық тепе-теңдік, аймақтық қауіпсіздік, су тапшылығы, гидрологиялық режим.

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Introduction

Central Asia is one of the regions most closely linked to water security challenges. Water resources represent a key factor in the socio-economic development and ecological stability of the region. However, the problem of efficient water use has deep historical roots and became particularly acute during the second half of the twentieth century, especially in the Soviet period, when large-scale irrigation projects and industrial policies significantly transformed the hydrological balance. After the dissolution of the USSR, each newly independent state began to formulate its own policy regarding transboundary rivers and lakes. The absence of a coherent regional management system has since intensified interstate disputes over water distribution.

In the present era, climate change, population growth, and the expansion of agriculture and industrial production are aggravating water scarcity. Land degradation and desertification processes further weaken ecological equilibrium and complicate the allocation of transboundary water resources such as the Syr Darya, Amu Darya, Ili, and Irtysh rivers. Consequently, ensuring fair and efficient water distribution has become a central factor in regional security and sustainable development.

According to international forecasts, by 2050 freshwater scarcity in Central Asia may reach a critical level [World Bank, 2023]. Such conditions necessitate new strategic approaches to water resource management. In this regard, Kazakhstan's experience is of particular importance, as the country's geographical location and water system play a crucial role in determining the effectiveness of regional cooperation.

This study is aimed at a comprehensive analysis of the current state of water resources in Central Asia, tracing their historical evolution, identifying the key challenges, and outlining strategic directions for sustainable development. Furthermore, it examines Kazakhstan's water management experience and assesses its relevance as a potential model for regional cooperation.

Materials and Research Methods

Relying on a multidisciplinary approach, this study employed a set of complementary research methods that made it possible to examine the issue of water security in Central Asia and Kazakhstan in its historical, ecological, social, political, and legal dimensions. The methodological framework was structured on three analytical levels. At the macro-level, global water security was considered through international data and reports; at the meso-level, transboundary rivers and regional threats in Central Asia were analyzed; and at the micro-level, Kazakhstan's water policy, management practices, infrastructural challenges, and case-based examples grounded in statistical evidence were examined.

Given the comprehensive nature of the study, several research methods were applied in an integrated manner. First, the historical-source analysis method was employed to investigate the historical evolution of water resources formation and management. This approach enabled the comparison of water use practices across different historical periods and revealed the deep-rooted origins of contemporary challenges. Complementing this, the comparative-analytical method was applied to compare water management practices across Central Asian countries, which allowed for the identification of both the strengths and weaknesses of the Kazakhstani model.

Building upon these approaches, the systemic analysis method was utilized to examine water security not solely from an ecological perspective but also through its social, economic, and politico-legal interconnections. This method provided a holistic understanding of the issue within its multidimensional context. In parallel, the historical-ecological analysis method was adopted to assess the long-term impacts of climate change on water resources. By combining historical evidence with climate data and hydrological forecasts, this method allowed for an evaluation of the social consequences of water scarcity.

To substantiate these findings with empirical evidence, the quantitative-statistical method was employed. Data from Kazhydromet and international organizations were used to evaluate indicators such as water balance, annual runoff, irrigation losses, and shifts in climatic temperature regimes. Finally, the content analysis method was applied to official policy documents, including presidential addresses, UN statements, and other government texts, which

enabled the identification of the place of water resources within national policy priorities.

Overall, the application of these methods enabled the synthesis of diverse sources and the production of a comprehensive analysis. Kazakhstan's experience was assessed as a potential regional model, with its specific characteristics highlighted. Thus, water security was examined as a systemic phenomenon encompassing historical evolution, climatic drivers, and current politico-legal frameworks in an integrated manner.

Water security issues in Central Asia and Kazakhstan have been comprehensively addressed in international reports, regional studies, national documents, and contemporary scientific articles. The United Nations World Water Assessment Report (2019) analyzes the state of global water resources and their importance for economic, ecological, and social development. From this source, information was drawn on how water scarcity in Central Asia is interconnected with global trends. The IPCC (2014) report highlights the impacts of climate change and adaptation mechanisms, pointing out that disruptions in the hydrological cycle reduce water availability. In the article, this source served as the basis for analyzing the direct influence of climate on water security. The works of Kundzewicz et al. (2008) and Collins et al. (2013) describe the changes in freshwater resources under climate scenarios, with an emphasis on long-term projections.

Dukhovny & de Schutter (2011) provide an overview of the history of water in Central Asia and possible future development paths. This source was used in the introduction of the article to illustrate the historical evolution of water resources. Bernauer (2012) discusses potential conflicts over transboundary rivers in the region and reveals the geopolitical significance of water policy. This was applied in the analysis of the political and legal aspects. The OECD (2019) report outlines reforms in water resource management and international support, underlining the need for institutional changes in Kazakhstan. Kazakhstani researchers Medeu & Tursunova (2016) systematized the main ecological threats at the regional level and emphasized the role of local factors. This source served as a key reference for analyzing internal risks in Central Asia.

National-level data included the National Environmental Report (2016), hydrological bulletins of Kazhydromet (2024–2025), and the Kazhydromet Climate Review (2024). These materials were used as the statistical basis in the "Results" section of the article. In addition, President Kassym-Jomart Tokayev's Address (2025) and his statement at the UN General Assembly (2025) defined water resources as an integral part of national security and development strategy. These sources were applied to reveal Kazakhstan's policy priorities.

Reports from The Astana Times (2024–2025) highlighted the modernization of Kazakhstan's water infrastructure. The Business Perspectives (2024) article described the features of Kazakhstan's water security policy. Data from Earth.Org (Tussupov, 2025) provided concrete figures that supplemented the statistical evidence in the article. Publications by Reuters and the Financial Times (2024–2025) on the declining Caspian Sea level were used to illustrate regional ecological challenges. Materials from TimesCA / Waterdiplomat (2025) on the recovery of the Northern Aral Sea were introduced to demonstrate regional best practices.

Recent scientific articles such as Court et al. (2025) and Samant et al. (2023) emphasized the sharp decline in the Caspian Sea level due to climate factors. These studies were employed in the article to analyze the ecological and social consequences of the Caspian problem. Finally, Svensmark & Calder (2007) presented an alternative theory on the impact of cosmic rays on climate change. This was used to introduce additional perspectives on the different interpretations of climate drivers. Taken together, the body of literature employed in this research enabled a comprehensive examination of water security in Central Asia and Kazakhstan. International reports provided the global context, regional studies revealed transboundary and climatic risks, national documents demonstrated state policy, while contemporary scientific articles and media materials offered concrete statistics and up-to-date developments.

Discussion and Results

The Central Asian region includes five states: Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan. Its total area is about 3.9 million km², with a population of over 53 million people [World Bank, 2023]. More than 70% of the territory is covered by deserts, semi-deserts, and dry steppes. The main water resources are concentrated in the mountainous areas, where the glaciers of the Tien Shan, Pamir, and Altai are located. The total glaciated area reaches 17.9 thousand km², which is several times greater than the glaciation scale of the Caucasus. Glaciers play a crucial role in sustaining the flow of the region's largest rivers: the Amu Darya, Syr Darya, Ili, Chu, and Talas.

Climate change has already had a significant impact on the hydrological cycle of Central Asia. Since the late 19th century, global average temperatures have risen by approximately 0.8°C, while in Central

Asia the growth rate has exceeded the global average [Micklin, 2000: 49]. In Kazakhstan, the average annual temperature increased by 1.4°C over the last 50 years, and by 1.6°C in Kyrgyzstan. Projections indicate a further increase of 2–7°C by the end of the 21st century [UNECE, 2020].

These changes have led to glacier shrinkage: according to glaciological studies, their total area has declined by more than 25% over the past 50 years. In the short term, this may increase river runoff, but in the long term it will cause a sharp decrease. By 2050, runoff in the Syr Darya is expected to decrease by 6–10%, and in the Amu Darya by 10–15% [World Bank, 2023]. Such transformations will aggravate water scarcity, threaten food security, and intensify migration processes.

Agriculture is the largest consumer of water in the region. More than half of all water resources are used for irrigation, yet a significant share is lost due to deteriorated infrastructure. Losses in irrigation canals reach 50–70% [FAO, 2012]. Soil salinization is among the most pressing issues: in Uzbekistan, up to 50% of irrigated lands are salinized; in Turkmenistan, up to 37%; and in Kazakhstan, about 66% of the territory is degraded [UNECE, 2020].

Population growth (2–3% per year) intensifies the pressure on water resources, increasing demands for food and drinking water (World Bank, 2023). Hydropower also plays a crucial role: in Kyrgyzstan and Tajikistan, it accounts for up to 90% of electricity generation, while in Kazakhstan, Uzbekistan, and Turkmenistan the share does not exceed 15% [Micklin, 2014: 121]. This creates a conflict of interests between upstream and downstream states, which is a major factor of regional tensions.

Effective water management is complicated by the lack of a developed legal framework and coordinated interstate agreements. For instance, in the United States dozens of legislative acts regulate water relations, while in Central Asia the legal system remains extremely limited [Abdullaev, Rakhmatullaev, 2014: 95]. Kazakhstan has adopted the Water Code, Kyrgyzstan has its basic "Law on Water," but regional agreements remain fragmented. The principle of state sovereignty prevents the elaboration of a common strategy. Attempts to introduce Integrated Water Resources Management (IWRM) have produced only partial results [UNECE, 2020].

Global practice demonstrates that only interstate cooperation allows for effective resolution of transboundary water issues. Examples include the Rhine Convention and agreements on the Danube and Nile River basins. Central Asia requires a similar model that would include unified tariffs, joint monitoring, and harmonization of legislation. The experience of Kazakhstan and Kyrgyzstan in managing the Chu and Talas rivers, as well as the Small Aral Sea restoration project, show that positive results are achievable given sufficient political will [World Bank, 2023].

Table 1 – Water Availability in Central Asian Countries

Country	Water Availability (m^3/person per year)	Key Features
Kazakhstan	7,300	High dependence on transboundary rivers (Irtysh, Ili, Syr Darya)
Kyrgyzstan	8,900	Zone of flow formation, major glaciers
Tajikistan	13,000	Largest water resources, significant hydropower potential
Uzbekistan	1,646	High level of soil salinization, severe water deficit
Turkmenistan	4,681	Dependence on Amu Darya, intensive irrigation

[World Bank, 2023]; [UNECE, 2020].

Table 2 – Climate Change Projections in Central Asia up to 2100

Period	Temperature Increase (°C)	Change in Precipitation (%)	Consequences
1976–2016	+0.34 / decade	–5%	Onset of glacier degradation, increasing aridity
2020–2050	+1.5…+2.5	–5% to –10%	River runoff decline by 6–15%
2050–2100	+2…+7	–8% to –17%	Intensification of aridization, water resources crisis

[UNECE, 2020]; [World Bank, 2023]

The table illustrates the interdependence of rising temperatures, glacier retreat, declining river runoff, and the growing socio-economic pressure on water resources [UNECE, 2020]. These factors increase the risk of interstate conflicts.

Overall, two main scenarios for future development can be identified. The first is the inertial scenario, under which current trends continue. In this case, by 2050 water scarcity will worsen, agriculture will degrade, and interstate conflicts will intensify [World Bank, 2021]. The second is the innovative scenario, which implies the introduction of Integrated Water Resources Management (IWRM), modernization of irrigation systems, development of desalination technologies, utilization of groundwater, and integration into international programs [Abdullaev, Rakhmatullaev, 2014: 78]. The choice between these scenarios depends on political will, the readiness of states to compromise, and the ability to ensure long-term cooperation.

If we consider the water resources of Kazakhstan, they occupy a special place in the system of regional security and socio-economic development of Central Asia. The country's geographical location and its dependence on transboundary rivers make water management particularly vulnerable (UNECE, 2020). The bulk of the runoff of major rivers such as the Irtysh, Ili, and Syr Darya is formed outside Kazakhstan's territory, predetermining the country's dependence on the decisions of neighboring states. Under intensifying climate change, this dependence is becoming increasingly acute [IPCC, 2022].

Climatic shifts in recent decades have already had a direct impact on Kazakhstan's hydrological regime. Over the last fifty years, the average annual temperature in the country has risen by 1.4 °C, which significantly exceeds the global average [World Bank, 2023]. Forecasts indicate a further increase of 2–7 °C by the end of the 21st century [IPCC, 2022]. These processes are accompanied by glacier retreat, which plays a key role in sustaining river runoff: the area of glaciation in Central Asia has declined by more than a quarter, inevitably leading to a reduction in the flow of transboundary rivers [Savoskul, Smakhtin, 2013: 175]. According to calculations, by 2050 the Syr Darya runoff will decrease by 6–10%, and the Amu Darya runoff by 10–15%, creating a serious shortage of freshwater, undermining food security, and potentially increasing migration flows (UNECE, 2020; World Bank, 2023).

Socio-economic factors aggravate the situation further. Agriculture remains the largest consumer of water in Kazakhstan, while the efficiency of its use remains low. Losses in irrigation reach 50–70% due to the poor condition of irrigation infrastructure. In addition, land degradation is a serious problem: according to estimates, about 66% of the country's territory is affected by salinization and erosion [UNECE, 2020]. This situation forms a vicious cycle: land degradation reduces agricultural productivity, which, in turn, stimulates increased water withdrawal to compensate for yields, thereby exacerbating water scarcity.

The legal regulation of water use in Kazakhstan is based on the Water Code of the Republic of Kazakhstan, but at the regional level the legal framework remains fragmented (Abdullaev, Rakhmatullaev, 2014). While there are individual agreements, such as the joint management of the Chu and Talas rivers with Kyrgyzstan, the overall level of institutional coordination among Central Asian countries is low. The principle of state sovereignty continues to hinder the establishment of supranational mechanisms for transboundary water management. Nevertheless, the experience of the Small Aral restoration demonstrates that successful examples of ecological and water policy are possible when there is political will and international support [World Bank, 2023].

Thus, Kazakhstan faces a dual challenge: on the one hand, the country depends on transboundary resources influenced by the political and economic decisions of neighboring states, and on the other, internal climatic and infrastructural problems limit its ability to effectively manage its own water resources. The future of Kazakhstan's water security is largely determined by the state's capacity to modernize irrigation systems, introduce water-saving technologies, and develop regional cooperation [UNECE, 2020].

In his Annual Address to the Nation on September 8, 2025, and in his subsequent speech at the UN General Assembly on September 22–23, President Kassym-Jomart Tokayev acknowledged the already emerging shortage of freshwater in Kazakhstan, linking it to a combination of climatic factors and institutional-technological shortcomings in water management [Tokayev, 2025; UN General Assembly, 2025]. The official text emphasized that climate change (increased droughts, altered precipitation regimes, and glacier melt) has created a persistent trend of declining freshwater resources, while outdated infrastructure and weak accounting systems limit the capacity of government agencies and regions to respond promptly.

This problem was further addressed through the President's instructions to establish a unified digital information system for water accounting and moni-

toring, and to develop a National Water Balance as a systemic planning tool. Such digitalization is intended to integrate data on surface and groundwater, combine hydrogeological monitoring, and support decision-making using analytics and elements of artificial intelligence.

One critical practical aspect highlighted was reducing technological losses during irrigation water transport and distribution. Analytical and ministerial publications from 2024–2025 estimate water losses in some irrigation networks at 50–60% of withdrawals [Kazakh Ministry of Water Resources, 2025]. Reconstruction of certain irrigation networks in 2025 is expected to reduce annual losses by about 250 million cubic meters and improve irrigation efficiency, with the state's reform plan targeting a reduction of losses from the current ~50% to about 35% in the coming years.

President Tokayev also drew attention to the declining water levels of the Caspian Sea, which pose risks to coastal ecosystems and the economies of littoral regions. He called for interstate coordination and the initiation of high-level programs for preserving Caspian water resources [UN General Assembly, 2025]. As for positive trends, the President cited data on the Aral Sea restoration project: official reports indicate that the surface area of the North Aral increased by 36%, water volume nearly doubled, and mineralization levels dropped twofold compared to pre-restoration benchmarks. However, the Address stressed that these efforts require continuation and systemic funding [World Bank, 2023].

From the perspective of scientific methodology and practical implementation, three interrelated lines of research and policy emerge from the President's agenda. The first is the creation of an open, verifiable, and regularly updated database of hydrological and hydrogeological data (satellite observations, ground stations, operational meters), necessary for constructing a national water balance and verifying future risk scenarios. The second is the technical modernization of irrigation and water supply infrastructure (lining and straightening of critical sections, automation of regulators, installation of meters and remote sensors), which ministerial and international assessments show could save hundreds of millions of cubic meters annually. The third line concerns institutional reforms: legal regulation of water use, stricter control of illegal withdrawals, incentives for water-saving agricultural practices, and the redistribution of investments to highly water-vulnerable regions. These measures must be accompanied by transparent reporting and access for researchers to primary data [Abdullaev, Rakhmatullaev, 2014: 45].

In the context of increasing climate pressure on Eurasian water systems and the growing shortage of freshwater in certain regions of Kazakhstan, the activities of the Ministry of Water Resources and Irrigation should be viewed as an institutional response to a multifaceted challenge, where climatic, technological, and governance factors are closely intertwined.

The agency established in 2023 has assumed responsibility for coordinating the digitalization of hydrological information, modernization of irrigation infrastructure, and formalization of water use practices. The projects initiated in data integration and canal reconstruction demonstrate both political will and access to resources necessary for implementing reforms [Tokayev, 2025; Kazhydromet, 2024].

However, analysis of available operational reports and independent studies shows that in the first two years of activity the visible effect remains fragmented: several regional reconstruction projects yielded positive short-term results in terms of water delivery volumes and expanded irrigated areas, but systemic reductions in technological losses remain insufficient to neutralize the structural vulnerability of the sector [Astana Times, 2024; Business Perspectives, 2024].

In his Address of September 8, 2025, President Tokayev directly pointed to the deficit of reliable information on actual water volumes and to critically high levels of losses in networks–reaching 50–60% in some canals. He also emphasized outdated metering and the absence of modern monitoring at water intake points–factors that hinder the development of adequate distribution and adaptation measures [Tokayev, 2025; Mail.ru News, 2025].

These remarks align with hydrometeorological observations: the annual bulletin and operational data of Kazhydromet record high variability of snow reserves and surface runoff across basins, which increases uncertainty in water use planning and underscores the importance of creating a unified digital platform aggregating satellite and ground-based data [Kazhydromet, 2024; Kazhydromet Daily Bulletins, 2025].

Alongside domestic challenges, the Ministry must operate within a context of transboundary risks–above all in the Caspian basin and in coordinating measures to restore the Aral Sea. Recent scientific publications record a steady decline in Caspian Sea levels and significant transformations of coastal ecosystems, creating additional pressure on littoral regions and requiring interstate scientific-technical cooperation and investment coordination (Court et al., 2025; Samant et al., 2023). At the same

time, achievements in restoring the North Aral demonstrate that targeted programs supported by engineering solutions and transboundary agreements can produce tangible improvements in water volume and quality if sustained funding and monitoring are maintained [Times CA / Water diplomat, 2025].

Based on a comparison of official instructions, ministerial reports, and peer-reviewed literature, the following integrative conclusion can be drawn: the Ministry has successfully initiated the creation of institutional infrastructure and launched projects necessary for a transition to "data-driven management." However, the implementation of these projects has not yet ensured a reduction in the sector's vulnerability to climate and infrastructure shocks at the national level.

The key bottlenecks include an outdated material and technical base (making reconstruction critically important), insufficient pace of water-saving technology adoption, fragmented monitoring and weak centralization of accounting data, as well as the absence of strong economic incentives and enforcement mechanisms to curb illegal water withdrawals and stimulate rational use in the agricultural sector. The presidential instructions of 2025–on creating a unified digital platform, establishing a national water balance, and strengthening hydrogeological monitoring–adequately reflect these problems and provide an operational vector for further research and practical measures [Tokayev, 2025; Astana Times, 2025].

For scientific support and verification of the measures taken, open publication of primary hydrological data, independent audits of implemented projects, and formalization of KPIs to assess the effectiveness of reconstruction and water-saving technologies at the regional level are essential.

Conclusion

Central Asia faces a serious challenge – to ensure sustainable water use under conditions of climate change and increasing anthropogenic pressure. The future of the region largely depends on coordinated policies among states, modernization of infrastructure, and the implementation of environmentally oriented technologies.

Water is becoming not only an economic but also a political resource. Only a comprehensive approach that combines legal, economic, and ecological measures can ensure the sustainable development of the region in the 21st century.

A complex analysis of the state of water resources in Kazakhstan and Central Asia shows that the region is in a zone of high vulnerability, where climatic and anthropogenic factors reinforce each other. In Kazakhstan, more than 40% of surface water resources are formed outside the country, creating a critical dependence on transboundary rivers such as the Syr Darya, Ili, Irtysh, and Ural [UNECE, 2022; World Bank, 2023]. The situation is complicated by the fact that intensive use of water in agriculture and energy in neighboring countries directly affects the availability of resources in downstream areas.

According to FAO (2021) and Kazhydromet (2024), water losses in Kazakhstan's irrigation systems reach 50–60%, which is significantly higher than in countries with similar climatic conditions. Studies by Business Perspectives (2024) and Tussupov (2025) indicate that low efficiency in water distribution and use in the agricultural sector is a key source of scarcity. At the same time, the introduction of water-saving technologies and modernization of infrastructure remain fragmented and do not cover all strategically important regions.

The situation in major regional water bodies confirms long-term forecasts of systemic ecological risks. The restoration of the North Aral Sea shows positive results: in recent years, water levels have stabilized and biodiversity has partially recovered (Water diplomat, 2025). However, forecasts for the Caspian Sea are much less optimistic: according to Samant et al. (2023) and Court et al. (2025), climate-driven sea level decline may amount to several meters during the 21st century, leading to large-scale socio-economic and ecological consequences.

In his 2025 Address, President Kassym-Jomart Tokayev emphasized that Kazakhstan faces a real threat of freshwater shortage, a conclusion supported by international research. His criticism of the continued cultivation of water-intensive crops under conditions of scarcity and the weak enforcement against illegal water withdrawals reflects the institutional problems also highlighted by independent experts [Earth.org, 2025; World Bank, 2023].

Thus, it can be concluded that water security in Kazakhstan and Central Asia remains one of the key challenges to regional stability. On the one hand, positive developments are evident – institutionalization of water resources management, digitalization of accounting systems, and several successful ecosystem restoration projects. On the other hand, structural problems such as worn-out infrastructure, transboundary dependence, and climatic variability continue to intensify scarcity risks.

The prospects for sustainable water use in Kazakhstan and Central Asia are linked to three strategic directions: accelerated adoption of water-saving

technologies, the creation of a unified system of digital monitoring, and the deepening of regional water diplomacy. Without a comprehensive solution to these tasks, the region risks entering a state of chronic water stress, which will entail significant economic, ecological, and social costs.

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