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Institutional mechanisms for transboundary water resource management and their impact on agricultural sustainability in Kyrgyzstan in the context of climate change

Ainura Batykova*

PhD in Technical Sciences, Associate Professor
Kyrgyz National Agrarian University named after K.I. Skryabin
720005, 68, Mederov Str., Bishkek, Kyrgyz Republic
https://orcid.org/0000-0001-9173-3151

Abstract. The Kyrgyz Republic occupies a strategic position in the hydrological system of Central Asia as an upstream state controlling the formation of the flow of the region's largest transboundary rivers, the Amu Darya and Syr Darya. Climate change, which increases interannual variability in river flow, poses critical challenges to the sustainability of the region's agricultural sector and the implementation of regional water management policies in Central Asia. The structural conflict between the energy interests of the upper reaches (water storage in winter for hydroelectric power stations) and the agricultural needs of the lower reaches (maximum water supply in summer for irrigation) threatens the region's food security. The aim of the study was to analyse institutional mechanisms for transboundary water management and their adaptive potential to ensure agricultural sustainability. Critical deficiencies in the current institutional system have been identified; the analysis showed that the Interstate Water Management Coordination Commission (IWCCC) has limited regulatory powers, and the commission's decisions are advisory in nature. Basin organisations do not have mechanisms to enforce water consumption limits. In conditions of low water availability, the effectiveness of the system is sharply reduced, and there is no formal system of sanctions for violations of water distribution agreements. The study examined ways to harmonise Kyrgyzstan's national water policy with regional initiatives on transboundary water management, as well as the possibilities for adapting existing contractual mechanisms to climate risks and creating a system for monitoring the implementation of intergovernmental obligations. A model of adaptive water resource management was proposed, and a three-level system was developed: (1) seasonal redistribution of flows through reservoir storage; (2) a flexible quota mechanism that takes climate forecasts into account; (3) a system of economic incentives for water conservation in the agricultural sector. The results of the study fill a gap in understanding the link between the institutional architecture of water management and agricultural vulnerability and allow for the formulation of scientifically sound recommendations for the creation of a more sustainable and institutionally effective system of transboundary water management, contributing to the minimisation of conflict potential and stimulating integrated regional development in Central Asia

Keywords: water security; water-energy nexus; hydropower potential; climate change adaptation

Introduction

In the context of global climate change, water management issues are becoming particularly relevant due to increasing water shortages and growing competition between different economic sectors and states in Central Asia. The region's geoclimatic characteristics make its hydrological systems highly vulnerable to

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*Corresponding author

anthropogenic climate change. The observed transformations are manifested in the accelerated degradation of the mountain-glacier complexes of the Pamir-Alai and Tian Shan Mountain systems in Kyrgyzstan and Tajikistan, modifications in the intra-annual distribution of river flow, an increase in the frequency of extreme hydrometeorological phenomena, and progressive climate aridisation. Together, these factors pose systemic risks to the economic stability and food security of the states of the Central Asian region, requiring the development of comprehensive adaptation strategies for water management.

Global climate change is having and will continue to have a significant impact on water resources in Central Asia (Issakov *et al.*, 2025). The consequences are already being felt, such as more frequent and severe floods and droughts, reduced water reserves, accelerated erosion and sedimentation, and a reduction in glaciers and snow cover. The impact of these factors leads to seasonal instability in water supply, which is particularly critical for the country's agriculture and energy sectors. In addition, pressure from neighbouring states on transboundary water use makes water resource management not only a national but also an international issue. All these phenomena have a direct impact on water quality and the state of ecosystems (Carec, n.d.). In the near future, almost all Central Asian countries will face negative consequences that will affect not only natural but also social and economic systems. Urgent measures are needed to integrate water resource management into climate change adaptation strategies. This should become a key element of any country's policy in order to minimise the consequences and protect the future of the region.

Water resources in Central Asia are not only economically important, but also geopolitically significant. Since all five countries in the region depend on shared water sources, effective water resource management is key to the stability and prosperity of the entire region. Kyrgyzstan, with its significant hydropower potential, plays a strategic role in the transboundary management of water resources in Central Asia. However, climate change, increasing water consumption and the need for transboundary water management require a comprehensive approach to their rational use and protection. The region's main waterways, the Amu Darya and Syr Darya, which originate in the mountain ranges of Kyrgyzstan and Tajikistan, play a crucial role in sustaining life, agriculture and the economies of these countries, and also serve as the main sources of fresh water for the downstream countries, in particular Uzbekistan, Kazakhstan and Turkmenistan. The strategic importance of water resources in Central Asia, as noted in the work of A. Prniyazova *et al.* (2025), extends beyond national borders, necessitating transboundary cooperation to prevent conflicts and ensure sustainable development. The experience of other regions, including North America, confirms the critical importance of institutionalising mechanisms for joint water resource management (Potekhin & Fesenko, 2022). According to G. Borankulova *et al.* (2025), agriculture, energy (especially hydropower), healthcare, and tourism all depend on a stable water supply, and climate change will lead to a deterioration in the conditions for their development. As a result, such changes will have a cascading effect on the health of the population and the economy of the region as a whole.

The aim of this study was to identify the institutional prerequisites and constraints affecting the effectiveness of regional water management mechanisms and to propose ways of adapting them to changing climatic conditions. The scientific hypothesis of the study was that reforming the water sector in Central Asia, taking into account both national and regional interests, could strengthen the sustainability and security of the entire region.

Literature Review

All major rivers in Central Asian countries are transboundary in nature. The main sources of water are the Amu Darya and Syr Darya rivers, which flow through the territory of several states – Tajikistan, Afghanistan, Uzbekistan and Turkmenistan. Their annual flow is about 77 km^3, of which about 96% is used for irrigation. In addition, such significant transboundary rivers as the Chu, Talas, Tarim and Irtysh flow through the region (Kukushkina & Sodikov, 2018). Among the five countries in the region, only Kyrgyzstan has water resources that are formed mainly on its own territory, which gives it strategic importance in ensuring water and energy security in Central Asia. The other states depend to varying degrees on water inflows from neighbouring territories. The most vulnerable are Uzbekistan and Turkmenistan, more than 90% of whose renewable water resources are formed outside their borders. Similar to other Central Asian states, the Kyrgyz Republic bases its water policy on the Constitution. Article 16 of the Constitution of the Kyrgyz Republic (2021) states: "The land, its subsoil, airspace, waters, forests, pastures, flora and fauna, and other natural resources are the exclusive property of the Kyrgyz Republic".

However, Kyrgyzstan does not fully implement this constitutional right due to persistent stereotypes. According to estimates by A. Sokeyev (2023), Kyrgyzstan directly uses only about 15-20% of the total water flow formed on its territory, while the majority is consumed by neighbouring states in the region. Historically, Kyrgyzstan has adhered to the principles of good neighbourliness, sharing its freshwater resources with neighbouring countries. This approach formed the basis of the strategic concepts formulated in the works of T. Usubaliev (1998), who was one of the first to identify the need to develop a national water strategy in balance with regional interests. His works emphasise that water for Kyrgyzstan is not only a natural resource

but also a geopolitical resource that requires rational use, modernisation of irrigation systems and the search for fair mechanisms for inter-state distribution of water flow. Thus, T. Usubaliev's ideas remain relevant: he pointed out that only through fair regional cooperation and respect for the interests of Kyrgyzstan as a source country is it possible to achieve sustainable management of transboundary water resources in Central Asia.

In 2001, the Jogorku Kenesh of the Kyrgyz Republic adopted Law of the Kyrgyz Republic No. 76 (2001), which established the legal basis for the fair and mutually beneficial provision of the country's water resources to interested neighbouring states. The law regulates the use of water resources, taking into account market economic relations, and complies with international legal norms and the practices of other states. Despite this, neighbouring countries periodically misinterpret the provisions of the law, suggesting that all watercourses originating in Kyrgyzstan should be completely blocked. In fact, the law provides for the establishment of fees only for water accumulated in interstate reservoirs and supplied to countries downstream, and not for the entire natural flow.

For the Kyrgyz Republic, as an upstream country, it is strategically important to strike a balance between using water for hydropower generation and providing downstream countries (Kazakhstan, Uzbekistan, Turkmenistan) with water resources for irrigation. Geographical location and geopolitical factors objectively determine the need for regional integration and joint management of river basins based on the principles of international law. The difference in interests between upstream and downstream countries (Kyrgyzstan and Tajikistan – electricity generation; Kazakhstan, Uzbekistan and Turkmenistan – irrigation and agriculture) exacerbates regional tensions. This requires the formation of sustainable mechanisms for water diplomacy and the development of a comprehensive regional water strategy. Research by Ya. Pulatov & H. Mukhabbatov (2021) and I. Abdullaev *et al*. (2025) shows that a comprehensive basin-wide approach based on international legal norms and joint management mechanisms can mitigate conflicts and ensure water security in Central Asia. Comprehensive study of the institutional foundations of water diplomacy in the context of the Kyrgyz Republic allows to view it not only as a source of energy and water security, but also as a key element of regional stability and cooperation in Central Asia.

In the hot and arid climate of Central Asia, this is already reflected in the intensive melting of glaciers in mountain systems, leading to a decrease in river water flow. According to Kyrgyzhydromet (n.d.), over the past 70 years, the area of glaciers in Kyrgyzstan has decreased by 60%, indicating a significant reduction in freshwater reserves in the country's high-altitude regions and reflecting the effects of regional warming and changing climatic conditions. According to the Tajik Agency for Hydrometeorology (2025), 15 glaciers, each 4 to 5 km long, have disappeared in the Pamirs over the past 20 years. There are a total of 1,085 glaciers in the Pamir Mountains, including the largest, the 77 km long Fedchenko Glacier, while the area of glaciers in some parts of the Tian Shan Mountains is rapidly shrinking. The total volume of water contained in the Tian Shan glaciers is about 650 km^3. These trends underscore the need to protect Kyrgyzstan's glaciers, which are key sources of fresh water for Central Asia, and also highlight the task of widespread and rational use of the country's hydropower potential. The development of hydropower not only contributes to energy security, but can also be an important tool for mitigating the effects of regional warming and stabilising water resources.

The lack of a comprehensive mechanism for regulating the distribution of water resources among Central Asian countries significantly limits the potential for regional economic integration, including trade, transport and the labour market. This leads to increased transaction costs and hinders the achievement of sustainable development goals (SDGs) (ESCAP, 2017). Kyrgyzstan has experienced significant fluctuations in water resources due to changes in temperature, glacier melt and changes in precipitation. The impact of these factors leads to seasonal instability in water supply, which is particularly critical for the country's agriculture and energy sectors. Water resources in Central Asia have been significantly depleted in recent decades and are now almost exhausted. Per capita water availability in the region is declining rapidly: over the past 40 years, this indicator has fallen from 8.4 to 2.3 thousand cubic metres per year. According to A. Murzakulova *et al*. (2019), the reasons for this decline are population growth, climate change and irrational water use, especially in agriculture. According to forecasts by the Ministry of Finance of the Kyrgyz Republic (2025), if current trends continue, this figure could fall below the critical level of 1.7 thousand cubic metres per capita per year by 2030. At the same time, an additional 500-700 million cubic metres of water are required annually to support the region's population.

For the Kyrgyz Republic, located in the upper reaches of Central Asia's largest transboundary rivers, the Amu Darya and Syr Darya, the issue of water resource management takes on strategic importance. On the one hand, the country has significant hydropower potential, but on the other hand, it faces limited freshwater resources and conflicting interests between upstream and downstream countries. Kyrgyzstan and Tajikistan use water resources primarily for electricity generation, while Kazakhstan, Uzbekistan and Turkmenistan focus on irrigation and agricultural production. The mismatch between the seasonal needs of the energy and agricultural sectors creates the conditions for inter-state conflicts. Additional challenges include inefficient water use, deterioration of irrigation

infrastructure, and insufficient integration of water-saving technologies. The issue of water resources and water and energy security has been the focus of researchers' attention over the past decade. Canadian scientist T. Homer-Dixon (1999) studied the relationship between environmental factors and conflicts over resources. The works of M. Zeitoun & J. Warner (2006) and M. Zeitoun & J. Allan (2008) emphasise the role of control over water resources as a key factor in regional stability. Russian researchers focus on a wide range of issues, from the legal basis for transboundary water use to the rational use of water by end users. Particular attention should be paid to the studies by O. Boyarkina (2015) and N. Rogozhina (2015), which consider water security as a crucial element of modern international relations, analysing problems at the inter-state, national and regional levels. Uzbek researchers V. Dukhovny & J. de Schutter (2011) and M. Rakhimov *et al.* (2024) justify the need for an integrated approach to water resource management and the development of comprehensive methods for solving local problems, while forecasting the prospects for regional cooperation. Thus, an analysis of the scientific literature shows that for the Kyrgyz Republic, as a key sector in the upper reaches of Central Asia, the urgent task remains to find a balance between its own national interests and the requirements of regional stability, which requires strengthening the institution of water diplomacy and integrating water management into the context of sustainable development of the agricultural sector.

Kyrgyzstan's research discourse also demonstrates a significant contribution to the development of the concept of transboundary water cooperation, viewed through the prism of national and regional interests. At the same time, it is important to emphasise that international political processes have had a significant influence on the formation of scientists' approaches to the problem in different historical periods. In the context of rapidly changing global and regional relations, Kyrgyzstan in particular needs to modernise its water management and diplomacy at both the national and intergovernmental levels. Transboundary river basins have a number of common characteristics that are of interest to all riparian states. Basin water management requires the coordination of political and technical, national and regional interests. Most researchers conclude that in order to achieve environmental, economic and political security goals, riparian states must jointly address water-related issues (Akunova, 2024). Kyrgyzstan performs a strategic function in ensuring regional water security in Central Asia by maintaining stable transboundary flows and the functioning of irrigation systems in downstream countries, while incurring significant economic costs. This highlights the need to further improve water diplomacy mechanisms and the equitable distribution of water resources at the regional level.

Materials and Methods

This study of institutional mechanisms for managing transboundary water resources in Kyrgyzstan was based on a comprehensive methodological framework combining qualitative and quantitative approaches to analysing water and agricultural issues in the context of climate change. The main methodological tool used was the structural-functional method, which allows identifying the interaction of various socio-legal institutions in the transboundary water use system. This method made it possible to analyse the architecture of institutional links between national water management bodies, international organisations and regional cooperation structures, as well as to determine the functional roles of each element in the water resources management system.

The study was based on institutional analysis, which examines the formal and informal rules governing access to water resources and their distribution. Particular attention was paid to studying the evolution of institutional mechanisms from the Soviet system of centralised management to modern forms of multilateral regional cooperation. The application of this method made it possible to identify institutional gaps and dysfunctions in the existing transboundary water management system. The historical-legal method was used to study the genesis of the regulatory and legal framework for water use in the Central Asian region and to analyse the continuity and transformation of legal norms in the post-Soviet period. The synthesis of historical perspectives made it possible to trace the evolution from a unified Soviet hydrotechnical infrastructure to a fragmented system of national water strategies and to identify the roots of contemporary transboundary water conflicts. A comparative (comparative legal) method was used to compare different models of institutional regulation of transboundary water resources in Kyrgyzstan and neighbouring Central Asian states (Kazakhstan, Uzbekistan, Tajikistan, Turkmenistan). This approach made it possible to identify best practices in regional water cooperation and determine the possibilities for their adaptation to the conditions in Kyrgyzstan.

The empirical basis of the study was a comprehensive analysis of international official documents, including The Helsinki Convention (1992), the Alma-Ata Agreement (1992), the Convention on the Protection... (1992), as well as an analysis of the national regulatory framework of the Kyrgyz Republic. To assess the impact of institutional mechanisms on agricultural sustainability, an analysis of national statistical data and international databases was conducted. Indicators of water supply for agriculture, dynamics of irrigated areas, and water use productivity were studied. Climate models and forecasts for the Central Asian region were used to assess the potential impact of climate change on water resources and the agricultural sector. Content analysis was used to systematise the provisions of international and national legal acts, identify trends in

the evolution of legal regulation of transboundary water use, and study scientific publications on water resources issues in Central Asia in the Scopus and Web of Science databases and regional scientific journals. The study was based on an interdisciplinary approach integrating methods from jurisprudence, environmental economics, hydrology and agricultural sciences. This synthesis allowed for a comprehensive assessment of the interrelationships between institutional mechanisms, hydrological processes, climate change and agricultural sustainability. Geopolitical analysis was used to assess the positions of upstream countries (Kyrgyzstan, Tajikistan) and downstream countries (Kazakhstan, Uzbekistan, Turkmenistan) on the distribution of transboundary water resources, to study the strategies of these states and their influence on the institutional framework of regional water cooperation.

Particular attention was paid to key stages in the transformation of the regional water cooperation system and the impact of climate change, which has become particularly noticeable in the last two decades. The geographical scope of the study covered the territory of the Kyrgyz Republic, with a particular focus on transboundary river basins (Syr Darya, Amu Darya, Chu, Talas, Ili) and their catchment areas, as well as the territories of neighbouring Central Asian states with which water resources are shared. This methodological framework provided a scientifically sound basis for developing recommendations to improve institutional mechanisms for transboundary water resource management and enhance Kyrgyzstan's agricultural sustainability in the context of global climate change, which is of practical importance for the development of state policy in the field of water resources and regional cooperation.

Results and Discussion

Hydrology and geographical location of the region

All Central Asian states are characterised by their inland location, which limits their direct access to the world's oceans. At the same time, Uzbekistan is one of only two countries in the world with "double landlocked" status, i.e. it has no access to the sea even through neighbouring states, as it is surrounded by at least two countries. From a hydrological point of view, Central Asia is divided into three main zones: mountainous, foothill and flat. Mountainous areas form the bulk of underground and surface waters, which are mainly of a transit nature and determine the water supply of the lower-lying territories. This factor determines the special importance of mountain ecosystems for the sustainable functioning of the region's water management complex and for transboundary water cooperation.

The geographical location of the region is determined by the predominance of vast arid territories, where desert landscapes occupy a significant part of the area. Another important factor is that Central Asia does not receive any external inflow of water resources, which increases the dependence of the water balance exclusively on internal sources. The territory of Central Asia is located within the closed Aral-Caspian basin and covers significant inland areas. All states in the region are landlocked countries. Geographically, Central Asia is characterised by a predominance of inland deserts, significant plains and steppe areas, as well as high mountain ranges and ridges. The region is home to large mountain systems: the Altai and Sayan, Tian Shan and Pamir-Alai in the south-west. The area of mountainous territories is about 800,000 km², or approximately 20% of the total territory of the region (Vinokurov *et al.*, 2022). More than 90% of the territory of Tajikistan and over 90% of the territory of Kyrgyzstan are occupied by mountain ranges (Fig. 1). Eastern Kazakhstan (Kazakh Lowlands, Dzungarian Alatau, Tarbagatai and Altai) also has a pronounced mountainous relief. The south-eastern part of Uzbekistan (Western Tian Shan and Gissar Mountains) stretches to Afghanistan and China. The mountains act as a climatic regulator and are the main source of river flow. In Turkmenistan, mountains cover only about 1% of the territory. Glaciers cover approximately 4% of the area of Kyrgyzstan and 6% of Tajikistan; individual glaciers are also found in Kazakhstan and Uzbekistan. The total area of glaciation in Central Asia is 12-14 thousand km². Freshwater reserves in glaciers are estimated at 1,000 km³, which is comparable to the ten-year flow of the region's largest rivers, the Amu Darya and Syr Darya (Borisova, 2012). The melting of snow, glaciers and perennial ice provides a significant part of the water balance of the region's river flow. As can be seen in Figure 1, the Amu Darya and Syr Darya rivers flow through several countries in the region, playing a key role in water supply. Both rivers feed the Aral Sea, which has shrunk to 10% of its original size due to excessive water withdrawal. This is the result of the irrational use of the Amu Darya and Syr Darya rivers for irrigation. From a geographical point of view, the territory of Central Asia can be divided into several large water basins, including the Aral Sea basin, the Balkhash Lake basin, the Caspian Sea basin (with the Ural and Emba rivers), and the Kara Sea basin. This division reflects the specific nature of the region's hydrographic network and its strategic importance for transboundary water use.

Historical experience shows that water resource management is a critical factor in the sustainability of socio-economic systems. As the source of the Syr Darya and Amu Darya rivers, the Kyrgyz Republic functions as the "water tower of Central Asia", providing water to downstream countries. Kyrgyzstan has unique hydrological potential, being the headwaters of major rivers in Central Asia, such as the Naryn, Talas and Chu. Their strategic importance extends beyond national borders, providing water supply and irrigation in Kazakhstan, Uzbekistan and Tajikistan. This geographical location necessitates the formation of effective institutional

mechanisms for water resource management, as the sustainability of water supply throughout the region directly depends on Kyrgyzstan's water use policy. At the same time, existing systemic challenges – degradation of irrigation infrastructure, low energy efficiency of hydropower complexes and limited financial resources – highlight the need to develop innovative approaches to transboundary water management. In this context, water diplomacy is becoming a key institutional tool for ensuring national and regional water security.

Figure 1. Physical map of Central Asia

Source: Free World Maps (n.d.)

Transboundary rivers and population growth in Central Asia

The need for rational use of water resources based on mutually beneficial inter-state cooperation appears to be a key factor in the sustainable development of the region, political stability and security in Central Asia. In this context, international water law plays a special role, providing an institutional framework for building sustainable cooperation between basin countries and developing fair mechanisms for transboundary water management. Recognition of the social importance of water in the context of realising the human right to access safe and clean water forms the basis for water security policy. For the Kyrgyz Republic, finding ways to improve the efficiency of transboundary water resources and water bodies management is becoming a key priority on the regional agenda, aimed at preserving limited and valuable water resources for current and future generations. Some rivers in Central Asia are transboundary, including the Amu Darya and Syr Darya, which flow through Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan; the Talas and Chu, which flow through Kazakhstan and Kyrgyzstan; the Ili, which flows through Kazakhstan and China; the Tarim through Tajikistan, Kyrgyzstan and China; the Irtysh through China, Russia and Kazakhstan; and the Tobol, Ural and Ishim through Russia and Kazakhstan. These waterways play a key role in the regional water balance and require coordination of transboundary water management.

On 22 December 1993, the UN General Assembly adopted Resolution 47/193, which declares 22 March of each year as World Water Day (General Assembly, 1993). This resolution was adopted in response to the fact that many countries are facing water shortages as their populations grow, which in turn leads to economic underdevelopment. Water resources in Central Asia are under enormous pressure due to rapid population growth, climate change, inadequate management and transboundary disputes. About 90% of all water is used in agriculture, primarily for irrigation, making water management critical to food security and stability in the region. According to Worldometer (n.d.), the population of Central Asian countries will reach approximately 82.2 million by December 2024, having increased by almost one and a half times over the past 24 years (Table 1). It is expected to reach 95 million by 2050. As a result, if current water use trends continue, the region may face water shortages: water availability could fall to less than 1,000 m^3 per person per year by 2040, which corresponds to the water stress threshold. Rapid population growth, combined with a high proportion of the population employed in the agricultural sector, puts additional pressure on the region's water and land resources, challenging Central Asian states to ensure sustainable economic development, create jobs and increase agricultural productivity. The data in Table 1 show significant asymmetry in the distribution of the population of Central Asia: the upstream countries (Kyrgyzstan and Tajikistan) account for only 22% of the region's population, while the downstream countries (Kazakhstan, Uzbekistan and Turkmenistan) account for 78%. The largest

population is in Uzbekistan (36.5 million people), and the smallest is in Kyrgyzstan (7.2 million people). According to data from the World Population Review (n.d.), the region's population continues to grow at an average rate of about 1.75% per year. The total area of irrigated land in Central Asia, according to the FAO, is approximately 9.85 million hectares, which highlights the critical importance of water resources for regional agriculture (Frenken, 2013). However, these figures also point to an urgent need to modernise water management infrastructure and improve water use efficiency in the context of population growth. During the growing season, this figure reaches about 74%, while in the autumn-winter period it is approximately 26% (Carec, n.d.).

Table 1. Population of Central Asian countries as of the end of 2024

Country	Area of irrigated land in 2024	Population	Share of the region's population, %
Kyrgyzstan	1.05 million hectares	7,224,195	9
Kazakhstan	2 million hectares	20,676,707	25
Tajikistan	0.85 million hectares	10,637,645	13
Turkmenistan	1.75 million hectares	7,031,200	8
Uzbekistan	4.2 million hectares	36,469,203	45
Total	9.85 million hectares	82,038,950	100

Source: compiled by the author based on Worldometer (n.d.)

In total, there are more than 89,000 rivers in Central Asia, but the largest rivers, the Amu Darya and Syr Darya, are of key importance for the region's water supply. In addition to these, the Ili River, which flows into Lake Balkhash, also plays an important role. The Amu Darya and Syr Darya, in turn, flow into the Aral Sea, providing its main source of water. In recent years, all Central Asian countries have adopted new water management programmes with the aim of improving water supply and reducing water consumption. However, there are external factors that can affect regional water resources. These include Russia and China, as transboundary rivers (e.g. the Caspian Basin, Ili, Irtysh) are shared by these states. In addition, Afghanistan should also be considered part of the upper reaches of the basins, as there may be disputes over the rights to use the Amu Darya River in the future. More than 18% of the Amu Darya's water resources come from Afghanistan, which is not a party to the diplomatic agreements between the Central Asian countries. In the northern part of the country, a large canal, Kush-Tepa, 285 km long and about 100 m wide, is under active construction, which creates a risk of drought for the lower reaches of the Amu Darya in Uzbekistan (including Karakalpakstan) and Turkmenistan. Experts note the absence of international legal mechanisms for settlement and the high probability of escalating conflicts. It is expected that about one-third of the Amu Darya's water resources will be used for the construction of the Kush-Tepa canal, which will become a problem for the lower reaches countries, especially Uzbekistan and Turkmenistan (Saida, 2023). The conceptual basis of environmental and water security assumes regional interdependence and cooperation between states to ensure their viability. The concept of water diplomacy is based on international relations arising from water security issues. International water law is directly related to the protection and use of transboundary rivers, lakes and groundwater aquifers. More than 150 countries in the world have transboundary water resources, which makes it critically important to define water use rights and volumes in a transparent and predictable manner. The problem of water resource distribution between upstream countries (Kyrgyzstan, Tajikistan) and downstream countries (Kazakhstan, Uzbekistan, Turkmenistan) of the Amu Darya and Syr Darya rivers remains one of the most sensitive aspects of inter-state relations, requiring the development of long-term compromise solutions based on the principles of sustainable development and equal use of transboundary water resources.

Institutional architecture of transboundary water management and international legal position

The Kyrgyz Republic is implementing a strategy of integrated water resources management based on the basin principle, with the gradual involvement of non-state actors in decision-making processes. The institutional architecture includes water user associations, and the country is divided into five large river basins, for each of which basin councils are established to identify basin problems, plan measures to address them, and coordinate water sector activities. The National Water Strategy of the Kyrgyz Republic until 2040 (2023) focuses on the rational use of water resources and reducing water losses. The programme provides for the modernisation of water and irrigation systems, as well as the construction of hydraulic structures for water accumulation and storage. One of the key tasks is the use of renewable energy sources in water management, such as small hydropower, in accordance with the Water Code of the Kyrgyz Republic (2005). In accordance with Law of the Kyrgyz Republic No. 257 (2009), Kyrgyzstan plans to increase the area of irrigated land from 1.0 million hectares to 1.7 million hectares. These programmes, designed for the period up to 2030-2040, include plans to expand irrigated land and introduce water-saving technologies.

The ratification of the Helsinki Convention (1992) by a number of states in the region (Kazakhstan, Turkmenistan, Uzbekistan) creates the conditions for harmonising national water legislation with international principles of fair and reasonable use of transboundary waters, which demonstrates a desire to harmonise national legislation with international water law and strengthen transboundary cooperation in the Central Asian region. However, Kyrgyzstan actively cooperates with UNECE (n.d.) within the framework of various water management programmes and participates in National Policy Dialogues on Integrated Water Resources Management, but the republic has not formally ratified the Convention. UNECE plays an important role in the region in the field of water cooperation, as it is the secretariat of the Convention on the Protection... (1992). The Commission conducts technical assistance programmes, national policy dialogues and promotes the exchange of experience in the field of transboundary water resources management. In 2021, the Kara Darya-Syr Darya-Amu Darya Basin Water Resources Management Authority was established, and in March 2024, the Issyk-Kul-Tarim, Naryn-Syr Darya, Talas and Chui Basin Management Authorities were established. However, the system faces serious challenges. After the transfer of internal irrigation canals to the balance sheet of water user associations in 2004, many of these organisations faced a lack of funding to maintain large-scale infrastructure, which led to a deterioration in the technical condition of the canals.

In accordance with the Alma-Ata Agreement (1992), the Interstate Water Commission of Central Asia (IWC-CA) was established. The institutional structure of the commission initially included three key executive bodies: the ICWC Secretariat, the Syr Darya Basin Water Management Association (BWMA) and the Amu Darya BWMA. Subsequent institutional development led to the creation of the ICWC Scientific and Information Centre (ICWC SIC) and the Energy-Water Coordination and Dispatch Centre, which contributed to strengthening regional cooperation in the field of hydrological monitoring, data exchange and water policy coordination. Nevertheless, the political and economic heterogeneity of the states in the region continues to hinder the formation of an integrated strategy for transboundary water resources management. According to the typology of transboundary basin organisations, the ICWC belongs to the category of coordination bodies with limited regulatory powers. Under the Alma-Ata Agreement (1992), the commission is vested with the functions of establishing and approving water use limits for member states and the region as a whole.

Despite their institutional mandate, the Amu Darya and Syr Darya River Basin Organisations have not acquired the status of supranational regulatory bodies with enforcement mechanisms. In conditions of hydrological deficit, the problem of ensuring compliance with agreed water consumption limits is exacerbated, as the ICWC and subordinate basin organisations do not have effective control instruments at their disposal. Critically important is the fact that the ICWC's jurisdiction does not cover the entire territory of the river basins, and its decisions are advisory rather than mandatory in nature. The most significant institutional gap is the lack of a mechanism for legal liability for violations of water distribution obligations and exceeding established limits. Despite the declared need to create a system of sanctions, formalised enforcement measures have not yet been developed. The diagram in Figure 2 illustrates the three levels of functioning of a transboundary basin organisation, reflecting the gradation of powers and the degree of integration in the management of shared water resources. The structure is organised according to the principle of increasing institutional complexity and depth of intergovernmental cooperation.

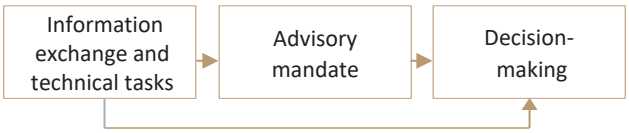

Figure 2. Structure of a transboundary basin organisation

Source: developed by the author

This three-level scheme reflects the evolutionary path of transboundary water cooperation institutions from the simplest forms of information exchange to complex joint management mechanisms. In the context of Central Asia, existing institutions, such as the Interstate Water Commission, are mainly at the first level with elements of the second, while the transition to the third level remains a strategic prospect requiring a significant strengthening of political will and institutional trust between the states of the region. The first level does not involve the transfer of sovereign powers and is limited to providing information for national decisions on water use. Interaction is mainly horizontal in nature between technical specialists from water management agencies in different countries. The second level, "Advisory mandate", is characterised by the formation of expert platforms for discussing strategic issues of transboundary basin management. At this stage, the basin organisation is granted the right to develop recommendations on the optimal distribution of water resources, propose scenarios for the development of water infrastructure, and formulate proposals for the harmonisation of national water policies. However, the final decisions remain the prerogative of national governments, which may accept or reject the recommendations of the basin organisation. The third level, "Decision-making", represents the most advanced form of institutionalisation of transboundary water cooperation, in which the basin organisation is vested with

real management powers. Decisions are made on the basis of agreed criteria for the fair and reasonable use of water resources, taking into account the interests of all riparian states and environmental requirements.

The financial support for the activities of basin organisations is characterised by an asymmetrical distribution of obligations: the Amu Darya Basin Organisation is mainly financed by Uzbekistan and Turkmenistan, while the Syr Darya Basin Organisation is financed by Kazakhstan and Uzbekistan. However, the existing financing model does not comply with the principle of proportional parity and equity participation, which creates additional institutional imbalances in the regional water management system.

Conceptualisation of adaptive water resources management in the context of transboundary cooperation

Effective management of transboundary water resources in the context of increasing climate variability and demographic pressure requires the introduction of innovative institutional mechanisms based on the principles of adaptability and flexibility. Within the framework of the modern water management paradigm, a three-level system of adaptive management is being developed, integrating technological, institutional and economic instruments for regulating water use (Fig. 3).

Figure 3. Adaptive management system for transboundary water resources
Source: developed by the author

The first level of the system involves optimising the seasonal redistribution of water flows by creating a cascade of reservoirs with different functional purposes. This approach is based on hydrological modelling of intra-annual flow variability and involves the accumulation of excess water resources during periods of high water availability (spring and summer floods) with subsequent controlled release during low-water seasons. Technical implementation includes the modernisation of existing reservoirs and the construction of new multi-purpose hydraulic structures that simultaneously provide irrigation water supply, hydropower generation and flood protection functions. A critically important aspect is the integration of automated systems for monitoring and forecasting the hydrological regime, allowing real-time adjustment of reservoir regulation parameters in accordance with current hydrometeorological conditions.

The second level is represented by a mechanism of dynamic (flexible) water management quotas, adapted to the predicted climate scenarios and the actual state of the basin's water resources. Unlike the traditional system of fixed water abstraction limits, this model provides for annual adjustment of water use quotas based on long-term meteorological forecasts, data on snow accumulation in high-altitude areas where runoff is formed, and actual water availability indicators for the previous period. The institutional mechanism for implementation is basin commissions, which are empowered to approve adjusted plans for the distribution of water resources among different categories of water users and administrative-territorial units. The methodological basis is probabilistic hydrological forecasting using ensemble models of climate scenarios, which allows assessing the range of possible water availability conditions and forming alternative options for water management balances. It is fundamentally important to establish differentiated water use priorities that guarantee the satisfaction of priority needs for drinking water supply and the maintenance of ecological flow under any hydrological scenarios.

The third level of the system includes a set of economic incentives aimed at improving water use efficiency in the agricultural sector as the main consumer of water resources in the region. The key instruments are: (1) a progressive tariff policy providing preferential water rates for economic entities that meet the established standards for specific water consumption per unit of production; (2) a system of subsidies for the introduction of water-saving irrigation technologies (drip irrigation, sprinkler irrigation, precision farming systems), compensating for up to 50-70% of the initial capital costs; (3) a mechanism for trading water use rights within established basin limits, allowing water resources to be reallocated to the most efficient agricultural producers; (4) insurance instruments that minimise the risks for farmers when switching to less water-intensive crops in conditions of water scarcity.

The integrated application of a three-level adaptive management system provides a synergistic effect, creating the institutional prerequisites for improving the region's water security in conditions of climate uncertainty. At the same time, successful implementation of the model requires a significant transformation of the existing regulatory framework for water use, the development of hydrometeorological monitoring and forecasting infrastructure, and the formation of institutional capacity for basin organisations. Ensuring transparency in decision-making processes and involving a wide range of stakeholders, including non-state actors, in the development and implementation of adaptive water management strategies remains a critical factor.

Water, energy and socio-economic potential of Central Asian countries

The main problem in the distribution of water resources in Central Asia is related to hydropower. Both

mountainous republics, Kyrgyzstan and Tajikistan, are heavily dependent on electricity supplies. The development of the hydropower sector requires consideration of the interests of all countries through which the Amu Darya and Syr Darya rivers flow, as water is vital not only for energy but also for agriculture in the region. The desire to develop hydropower, especially in Tajikistan and Kyrgyzstan, is driven by low energy independence, despite the significant potential of water energy sources. According to the United Nations (2025), Central Asia uses only 6% of its renewable hydropower potential. For example, electricity generation per capita varies greatly: in Kazakhstan – 4,730 kWh, in Kyrgyzstan – 1,375 kWh, in Tajikistan – 2,004 kWh, in Turkmenistan – 2,403 kWh, and in Uzbekistan – 1,650 kWh. For comparison, this figure is 8,400 kWh in Japan and 15,140 kWh in Canada. Tajikistan, which ranks eighth in the world in terms of hydropower potential, faces a problem of electricity shortages, especially in winter, when up to 70% of the population experiences shortages. The commissioning of the Rogun HPP, planned for the coming years, could increase the country's annual electricity production to 31-33 billion kWh (Ministry of Energy..., n.d.). Kyrgyzstan also plans to significantly increase its hydropower capacity by building a cascade of hydropower plants on the Naryn River, which could generate more than 25 billion kWh per year with an installed capacity of 6,450 MW.

The initial stage of cooperation between the Kyrgyz Republic and the Republic of Uzbekistan in the context of hydropower infrastructure development was characterised by a conflict of interests. Uzbekistan expressed concern about the potential negative impact of the Kambar-Ata-1 (1,900 MW) and Kambar-Ata-2 (360 MW) on the hydrological regime of the Naryn River and water supply to agricultural areas in the Fergana Valley. A shift in positions occurred in 2016-2017 as part of the intensification of bilateral dialogue at the highest level. In 2017, a Memorandum of Understanding was signed between the joint-stock company (JSC) Electric Power Plants (Kyrgyzstan) and JSC Uzbekhydroenergo, establishing the institutional framework for the joint development of the Kambar-Ata-1 project. This agreement marked the transition from a confrontational model to a cooperative approach in the field of transboundary water and energy cooperation. The conceptual basis for this transformation was Uzbekistan's new foreign policy strategy, initiated after 2016, which prioritises regional integration and the building of constructive relations with neighbouring states. Tashkent's recognition of the legitimacy of Kyrgyzstan's hydropower interests, while taking into account the water management needs of downstream countries, was of fundamental importance. This approach represents a departure from the traditional "zero-sum" paradigm in favour of a model of mutually beneficial cooperation based on the principles of sharing the benefits of transboundary water resources. This joint assessment mechanism is an innovative tool for preventive diplomacy in the region, aimed at minimising potential disagreements at the early stages of project design. The evolution of the legal framework for transboundary water use is characterised by a gradual transition from Soviet regulations to modern international legal standards. At the same time, the absence of a universal regional agreement regulating the use of transboundary water resources in the Amu Darya and Syr Darya basins remains a significant institutional gap. Table 2 shows the water and energy potential of Central Asian countries, with Tajikistan leading in terms of energy potential.

Table 2. Water and energy potential of Central Asian countries

Central Asian countries	Hydropower potential (MW)	Installed capacity (MW)
Kazakhstan	27,000	8,861
Kyrgyzstan	163,000	10,778
Tajikistan	317,000	15,086
Turkmenistan	2,000	–
Uzbekistan	15,000	7,278
Afghanistan	400	595
Total	524,400	42,598

Source: compiled by the author based on J. Granit *et al.* (2010)

In Central Asia, Tajikistan and Kyrgyzstan have a geographical advantage in terms of water resources, but economically they are weaker than the countries located downstream. For Tajikistan, water resources are practically the only external political asset in its relations with Uzbekistan and Turkmenistan. According to Worldometer (n.d.) data on the gross domestic product (GDP) of Central Asian countries, the Republic of Kazakhstan will have the largest GDP in 2024, estimated at approximately USD 261.42 billion. At the same time, the lowest GDP figures among the countries in the region are observed in Tajikistan, where it is forecast at USD 12.96 billion, and in Kyrgyzstan, at USD 13.6 billion (Table 3). The highest GDP growth among the countries in the region at the end of 2024 was demonstrated by Tajikistan (7.2%), Uzbekistan (6%) and the Kyrgyz Republic (5.8%). At the same time, Kazakhstan and Uzbekistan, given their population size, economic potential and geopolitical position with major international transport corridors passing through them, can be considered

key regional players, and all neighbouring states are in constant interaction. However, the existence of multiple institutional mechanisms does not always translate into effective solutions to regional problems.

Table 3. Gross domestic product (GDP) of Central Asian countries

Country	GDP 2024, USD
Kyrgyzstan	13,600,000,000
Kazakhstan	261,420,000,000
Tajikistan	12,960,000,000
Turkmenistan	64,080,000,000
Uzbekistan	97,960,000,000
Total	450,020,000,000

Source: compiled by the author based on Worldometer (n.d.)

Recommendations for improving water diplomacy in Central Asia

Effective intergovernmental cooperation in the field of water use is becoming a decisive factor in ensuring sustainable development, political stability and security in Central Asia. A new intergovernmental compromise is needed to ease existing tensions. This would equally recognise the needs and interests of all Central Asian countries and lead to unified regional water resource management. Such an approach requires consideration of the economic and social interests of countries and takes into account the ecological balance in Central Asian water basins (Janusz-Pawletta & Gubaidullina, 2015). However, water shortages caused by climate change, population growth, increased demand for water and inefficient water management are exacerbating the region's problems. According to J. Sehring (2006), the water resources of Central Asia are of strategic importance that goes beyond the borders of individual states, making regional cooperation a necessary condition for preventing conflicts and achieving sustainable development goals.

An analysis of the current state of water diplomacy in Central Asia allows for formulating a set of strategic recommendations aimed at strengthening the institutional foundations of transboundary cooperation and establishing sustainable water resource management mechanisms. The proposed measures cover the legal, institutional, technological and diplomatic aspects of water cooperation, taking into account the special role of the Kyrgyz Republic as an upstream country and the need to balance the interests of all states in the region. The implementation of these recommendations will facilitate the transition from a confrontational model to an integrated approach to transboundary water resources management.

1. The role of water diplomacy as a tool for regional cooperation in Central Asia. The author believes that it is time for the states of Central Asia to move towards joint and coordinated management of water and energy resources, using the prism of water diplomacy. This could be facilitated by the creation of a commercial organisation, such as an international water and energy consortium, and the revival of a regional resource management organisation based on modern market mechanisms.

2. Sustainable water resource management in transboundary river basins. Countries located in transboundary river basins share a common culture, language, history and experience of joint water resource management. This aspect is a powerful factor for further unification and strengthening of cooperation between neighbouring countries.

3. Institutional and legal mechanisms for management. The author points to the weakness of the institutional framework for water resources management. It is necessary to strengthen and modernise institutional cooperation that will reflect the interests of all countries in the basin. Central Asian states should strengthen and improve the implementation of the existing legal framework by adding principles and improved cooperation mechanisms to it. In this context, there is a need to move away from declarative positions and develop legally binding documents on basin management based on international law. These documents should be aimed at adapting to climate change.

4. The importance of the "Central Asia as One Regional Voice" platform. It is expected that the creation of such a platform, which will include representatives of the Central Asian states and Afghanistan, will also contribute to the formation of experience in creating an institutional foundation.

5. A comprehensive approach to solving water problems. Not only professional water resource specialists, but also scientists and experts from various fields should be involved in solving water issues. Analytical platforms should be created and comprehensive studies conducted, including political, technical and environmental forecasts.

6. Kyrgyzstan's role in transboundary river management. Given that Kyrgyzstan is the source country for major transboundary rivers such as the Syr Darya and Chu, its role in water resource management in Central Asia is particularly important. Kyrgyzstan's position and its policies on water resource management and hydropower development have a direct impact on the entire hydrological situation in the region. Therefore, any strengthening of institutional cooperation and

development of water-energy consortia must take into account the interests and contribution of Kyrgyzstan as a key player in this system. Kyrgyzstan, along with other countries in the region, needs to participate in the creation of sustainable mechanisms that will ensure the equitable distribution of water resources and minimise the risks associated with climate change. This includes not only technical solutions, but also active participation in water diplomacy aimed at building trust and long-term partnerships with neighbouring countries.

7. The development of agreed criteria and methodologies for resolving inter-state water issues, the conclusion of bilateral and multilateral agreements related to new inter-state water sharing, compensation for damage caused by violations of inter-state water distribution agreements, and the creation of a modern information system.

8. It is necessary to develop cooperation between research institutes and universities in Central Asia to solve water problems in the region.

The implementation of these recommendations requires the political will of all Central Asian states and a willingness to compromise based on the principles of mutual benefit and sustainable development. Of particular importance is the creation of effective institutional mechanisms, backed by legally binding agreements and modern technological solutions. The Kyrgyz Republic, occupying a key position in the region's hydrological system, has the opportunity to initiate the formation of a new paradigm of water diplomacy based on the principles of equitable water use, environmental responsibility and long-term regional partnership. The successful implementation of these recommendations will not only ensure water and energy security in the region, but will also lay the foundation for broader economic and political integration among the countries of Central Asia.

Conclusions

The study of institutional mechanisms for transboundary water resources management in Kyrgyzstan has identified key factors determining the effectiveness of regional water cooperation and its impact on the agricultural sustainability of the republic in the context of climate change. The analysis showed that the existing institutional architecture for transboundary water management is fragmented and insufficiently adapted to the modern challenges associated with climate change and increasing competition for water resources in the region. It has been established that the transformation of the water use system from a centralised Soviet model to independent national strategies has led to institutional gaps that hinder the effective distribution of water resources between upstream and downstream states. The conflict between the energy interests of Kyrgyzstan as a mountainous country and the irrigation needs of neighbouring states remains a central problem for regional cooperation, requiring the development of compromise institutional solutions.

The study demonstrated that climate change exacerbates existing institutional problems, increasing the instability of water resources and creating additional risks for Kyrgyzstan's agricultural sector. The observed reduction in glacial runoff, changes in river regimes and the increasing frequency of extreme hydrological events require a review of traditional approaches to water resource management and the introduction of adaptive institutional mechanisms. It has been found that Kyrgyzstan's bilateral agreements with neighbouring states, although providing a legal basis for cooperation, do not contain sufficient mechanisms for flexible response to climate-induced changes in the water balance. An analysis of the impact of institutional mechanisms on agricultural sustainability has shown that uncertainty in the distribution of water resources negatively affects the country's food security, reducing the predictability of agricultural production and hindering long-term investment planning in irrigation infrastructure. There is a need to develop integrated institutional approaches that synchronise water, energy and agricultural policies at the national and regional levels.

Prospects for further research are linked to a detailed study of the economic mechanisms for compensating for water ecosystem regulation services provided by the mountainous areas of Kyrgyzstan, the development of institutional design models for adapting water management systems to different climate scenarios, and analysis of the role of international organisations and donor institutions in shaping regional water policy. In-depth research is needed on the potential of digital technologies and remote monitoring to increase transparency and objectivity in the distribution of transboundary water resources. A relevant area of research is the study of the social aspects of water use and the participation of local communities in water management decision-making, which can contribute to the legitimacy and effectiveness of institutional mechanisms.

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Conflict of Interest

The author declares that there is no conflict of interest.

References

[1] Abdullaev, I., *et al.* (2025). Current challenges in Central Asian water governance and their implications for research, higher education, and science-policy interaction. *Central Asian Journal of Water Research*, 7(1), 47-58. doi: 10.29258/CAJWR/2025-R1.v11-1/47-58.eng.

[2] Agency for Hydrometeorology of the Republic of Tajikistan. (n.d.). Retrieved from https://meteo.tj/en.

[3] Agreement between the Republic of Kazakhstan, the Kyrgyz Republic, the Republic of Uzbekistan, the Republic of Tajikistan and Turkmenistan on Cooperation in the Field of Joint Management of the Use and Protection of Water Resources of Interstate Sources (Alma-Ata Agreement). (1992, February). Retrieved from https://online.zakon.kz/Document/?doc_id=1045698&pos=2;-121#pos=2;-121.

[4] Akunova, G.Ch. (2021). Features of water diplomacy in Central Asia. *Post-Soviet Issues*, 8(2), 229-241. doi: 10.24975/2313-8920-2021-8-2-229-241.

[5] Borankulova, G., Altybayev, G., Tungatarova, A., Yeraliyeva, B., Dulatbayeva, S., Murzakhmetov, A., & Bekbolatov, S. (2025). Development of real-time water-level monitoring system for agriculture. *Sensors*, 25(17), article number 5564. doi: 10.3390/s25175564.

[6] Borisova, E.A. (2012). Features of the water crisis in Central Asia. *History and Modernity*, 1(15), 138-146.

[7] Boyarkina, O.A. (2015). Theoretical aspects of international water conflict research. *Conflictology*, 1, 65-77.

[8] Carec. (n.d.). Retrieved from https://centralasiaclimateportal.org/ru/topics/.

[9] Constitution of the Kyrgyz Republic. (2021, April). Retrieved from https://mkk.gov.kg/%D0%BA%D0%BE%D0%BD%D1%81%D1%82%D0%B8%D1%82%D1%83%D1%86%D0%B8%D1%8F-%D0%BA%D1%8B%D1%80%D0%B3%D1%8B%D0%B7%D1%81%D0%BA%D0%BE%D0%B9-%D1%80%D0%B5%D-1%81%D0%BF%D1%83%D0%B1%D0%BB%D0%B8%D0%BA%D0%B8/.

[10] Convention on the Protection and Use of Transboundary Watercourses and International Lakes. (1992, March). Retrieved from https://treaties.un.org/pages/viewdetails.aspx?src=treaty&mtdsg_no=xxvii-5&chapter=27&clang=_en.

[11] Data from the Ministry of Finance of the Kyrgyz Republic. (2025). Retrieved from https://economist.kg/ekonomika/2025/09/01/rost-vvp-na-8-2-v-ghod-22-mlrd-tovarooborota-sriedniaia-zp-v-61-8-tysiachi-somov-chto-zhdiet-kyrghyzstan-k-2030-ghodu/.

[12] Dukhovny, V.A., & de Schutter, J. (2011). *Water in Central Asia: Past, present, future*. Boca Raton: CRC Press.

[13] Economic and Social Commission for Asia and the Pacific (ESCAP). (2017). *Achieving the sustainable development goals in North and Central Asia*. Bangkok: United Nations Publication.

[14] Free World Maps. (n.d.). Retrieved from https://www.freeworldmaps.net/asia/central/physical.html.

[15] Frenken, K. (Ed.). (2013). *Irrigation in Central Asia in figures*. Rome: FAO.

[16] General Assembly of the United Nations. (1993). *Resolution 47/193. Observance of World Day for Water*. Retrieved from https://docs.un.org/en/A/RES/47/193.

[17] Granit, J., Jägerskog, A., Löfgren, R., Bullock, A., de Gooijer, G., Pettigrew, S., & Lindström, A. (2010). Regional water intelligence report Central Asia. Stockholm: SIWI.

[18] Homer-Dixon, T.F. (1999). *Environment, scarcity, and violence*. Princeton: Princeton University Press.

[19] Issakov, Y., Sarkytkan, K., Gajić, T., Akhmetova, A., Berdygulova, G., Zhoya, K., Razia, T., & Matigulla, B. (2025). Climate-induced transboundary water insecurity in Central Asia: Institutional challenges, adaptation responses, and future research directions. *Water*, 17(12), article number 1795. doi: 10.3390/w17121795.

[20] Janusz-Pawletta, B., & Gubaidullina, M. (2015). Transboundary water management in Central Asia. *Cahiers d'Asie Centrale*, 25, 195-215.

[21] Kukushkina, A.V., & Sodikov, Sh.D. (2018). The problem of the international legal status of water resources in Central Asia. *Law and Right*, 12, 31-39. doi: 10.24411/2073-3313-2018-10258.

[22] Kyrgyzhydromet. (n.d.). Retrieved from https://meteo.kg/ru/pages/agrometerological-forecasts-and-references.

[23] Law of the Kyrgyz Republic No. 76 "On the Interstate Use of Water Bodies, Water Resources and Water Management Structures of the Kyrgyz Republic". (2001, July). Retrieved from https://cbd.minjust.gov.kg/483/edition/282586/ru.

[24] Law of the Kyrgyz Republic No. 257 "On the Introduction of a Moratorium on the Transfer (Transformation) of Irrigated Arable Lands into Other Land Categories and Types of Lands". (2009, July). Retrieved from https://cbd.minjust.gov.kg/4-4021/edition/1285841/ru.

[25] Ministry of Energy and Water Resources of the Republic of Tajikistan. (n.d.). Retrieved from https://www.mewr.tj/.

[26] Murzakulova, A., Schmidt-Vogt, D., Balla, D., Darr, D., Hamidov, A., Kasymov, U., Mendelevitch, R., & Orazgaliyev, S. (2019). Water for agriculture and other economic sectors. In S. Xenarios, D. Schmidt-Vogt, M. Qadir, B. Janusz-Pawletta & I. Abdullaev (Eds.), *The Aral Sea basin* (Chapter 7). London: Routledge.

[27] National Water Strategy of the Kyrgyz Republic until 2040. (2023). Retrieved from https://faolex.fao.org/docs/pdf/kyr229064.pdf.

[28] Potekhin, O., & Fesenko, M. (2022). Solving the Border Issues of the USA and Canada in the Field of Joint Use of Water Resources. *Foreign Affairs*, 32(2), 9-15. doi: 10.46493/2663-2675.32(2).2022.9-15.
[29] Prniyazova, A., Turaeva, S., Turgunov, D., & Jarihani, B. (2025). Sustainable transboundary water governance in Central Asia: Challenges, conflicts, and regional cooperation. *Sustainability*, 17(11), article number 4968. doi: 10.3390/su17114968.
[30] Pulatov, Ya.E., & Mukhabbatov, H.M. (2021). Water resources of the Aral Sea basin, water separation and ways to solve water scarcity. *Central Asian Journal of Geographical Research*, 1-2, 70-83.
[31] Rakhimov, M.A., Umarov, A., & Ismailova, G. (Eds.). (2024). *Central Asia and European Union: In search of sustainability*. Tashkent: University of World Economy and Diplomacy.
[32] Rogozhina, N.G. (2015). *Environmental policy of developing states*. Moscow: Aspekt-Press.
[33] Saida, N. (2023). *The Taliban's new canal threatens water security in Uzbekistan and Turkmenistan*. Retrieved from https://thediplomat.com/2023/07/the-talibans-new-canal-threatens-water-security-in-uzbekistan-and-turkmenistan/.
[34] Sehring, J. (2006). *The politics of water institutional reform in neo-patrimonial states. A comparative analysis of Kyrgyzstan and Tajikistan*. Wiesbaden: VS Verlag. doi: 10.1007/978-3-531-91377-3.
[35] Sokeyev, A. (2023). *Kyrgyzstan considers water a foundation for mutually beneficial cooperation*. Retrieved from https://news.un.org/ru/interview/2023/03/1439172.
[36] The Helsinki Convention. (1992, April). Retrieved from https://helcom.fi/about-us/convention/.
[37] United Nations Economic Commission for Europe (UNECE). (n.d.). Retrieved from https://unece.org/.
[38] United Nations. (2025). *Why are over 670 million people going hungry?* Retrieved from https://news.un.org/en/story/2025/10/1166108.
[39] Usubaliev, T.U. (1998). *Water is more valuable than gold. Kyrgyzstan's water resources are its national wealth*. Bishkek: Sham.
[40] Vinokurov, E., Ahunbaev, A., Usmanov, N., & Sarsembekov, T. (2022). *Regulation of the water energy complex of Central Asia*. Almaty: Eurasian Development Bank.
[41] Water Code of the Kyrgyz Republic. (2005, January). Retrieved from https://cbd.minjust.gov.kg/1605/edition/1201418/ru.
[42] World Population Review. (n.d.). *Population pyramids of the world from 1950 to 2100*. Retrieved from https://www.populationpyramid.net/world/.
[43] Worldometer. (n.d.). Retrieved from https://www.worldometers.info/.
[44] Zeitoun, M., & Allan, J.A. (2008). Applying hegemony and power theory to transboundary water analysis. *Water Policy*, 10(2), 3-12. doi: 10.2166/wp.2008.203.
[45] Zeitoun, M., & Warner, J. (2006). Hydro-hegemony – a framework for analysis of transboundary water conflicts. *Water Policy*, 8(5), 435-460. doi: 10.2166/wp.2006.054.

Чек аралык суу ресурстарын башкаруунун институционалдык механизмдери жана алардын климаттын өзгөрүшү шарттарында Кыргызстандын айыл чарба туруктуулугуна тийгизген таасири

Айнура Батыкова

Техникалык илимдердин кандидаты, доцент
К.И. Скрябин атындагы Кыргыз улуттук агрардык университети
720005, Медеров көч., 68, Бишкек ш., Кыргыз Республикасы
https://orcid.org/0000-0001-9173-3151

Аннотация. Кыргыз Республикасы Борбордук Азиянын гидрологиялык системасында стратегиялык орунду ээлейт, анткени ал аймактын эң ири чек аралык дарыяларынын – Амудария жана Сырдариянын агымын калыптандырууну көзөмөлдөгөн жогорку агымдагы мамлекет болуп саналат. Климаттын өзгөрүшү дарыялардын жылдар аралык агымынын өзгөрмөлүүлүгүн жогорулатып, аймактын айыл чарба секторунун туруктуулугу жана Борбордук Азиядагы суу башкаруунун аймактык саясатын ишке ашыруу үчүн критикалык кыйынчылыктарды жаратууда. Жогорку агымдын энергетикалык кызыкчылыктары (кышында ГЭС үчүн суу топтоо) менен төмөнкү агымдын айыл чарба муктаждыктарынын (жайда сугат үчүн максималдуу суу берүү) ортосундагы структуралык конфликт Борбордук Азиянын азык-түлүк коопсуздугуна коркунуч туудурат. Изилдөөнүн максаты чек аралык сууларды башкаруунун институционалдык механизмдерин жана алардын айыл чарбанын туруктуулугун камсыз кылуу үчүн адаптациялык потенциалын талдоо болуп саналат. Учурдагы институционалдык системанын критикалык кемчиликтери аныкталды; талдоо Мамлекеттер аралык координациялык суу чарба комиссиясынын (МКСКК) чектелүү жөнгө салуу ыйгарым укуктарына ээ экенин көрсөттү, комиссиянын чечимдери сунуштоо мүнөзүнө ээ. Бассейндик уюмдарда суу керектөө лимиттерине баш ийдирүү механизмдери жок. Суунун азаюу шарттарында системанын эффективдүүлүгү кескин төмөндөп, суу бөлүштүрүү макулдашууларын бузгандык үчүн формалдуу санкциялар системасы жок. Изилдөөнүн алкагында Кыргызстандын улуттук суу стратегияларын трансчектүү суу ресурстарын биргелешип башкаруу боюнча аймактык демилгелер менен шайкештирүү мүмкүнчүлүктөрү, келишим-укуктук механизмдерди климаттык тобокелдикке адаптациялоонун келечектери жана мамлекеттер аралык милдеттенмелерди аткарууну текшерүү механизмдерин өнүктүрүү талданды. Суу ресурстарын адаптивдүү башкаруунун модели сунушталды, үч деңгээлдүү система ишке киргизилип чыккан: (1) резервуар сактагыч аркылуу маусымдуу агымдарды кайра бөлүштүрүү; (2) климаттык болжолдорду эске алуу менен ийкемдүү квоталардын механизми; (3) айыл чарба секторунда сууну үнөмдөө үчүн экономикалык стимулдардын системасы. Изилдөөнүн жыйынтыктары суу башкаруунун институционалдык архитектурасы менен айыл чарбанын алсыздыгынын ортосундагы байланышты түшүнүүдөгү боштукту толтурат жана Борбордук Азияда конфликттик потенциалды минималдаштырууга жана интеграцияланган аймактык өнүгүүнү стимулдаштырууга салым кошкон, туруктуу жана институционалдык жактан натыйжалуу чек аралык суу ресурстарын башкаруу системасын түзүү боюнча илимий негизделген сунуштарды түзүүгө мүмкүндүк берет

Негизги сөздөр: суу коопсуздугу; суу-энергия байланышы; гидроэнергетикалык потенциал; климаттын өзгөрүшүнө адаптация

Институциональные механизмы управления трансграничными водными ресурсами и их влияние на аграрную устойчивость Кыргызстана в условиях климатических изменений

Айнура Батыкова

Кандидат технических наук, доцент
Кыргызский национальный аграрный университет им. К.И. Скрябина
720005, ул. Медерова, 68, г. Бишкек, Кыргызская Республика
https://orcid.org/0000-0001-9173-3151

Аннотация. Кыргызская Республика занимает стратегическое положение в гидрологической системе Центральной Азии как государство верховьев, контролирующее формирование стока крупнейших трансграничных рек региона – Амударьи и Сырдарьи. Климатические изменения, увеличивающие межгодовую изменчивость речного стока, создают критические вызовы для устойчивости аграрного сектора региона и реализации региональной политики водного управления в Центральной Азии. Структурный конфликт между энергетическими интересами верховьев (накопление воды зимой для гидроэлектростанций) и аграрными потребностями низовьев (максимальная водоподача летом для ирригации) угрожает продовольственной безопасности региона. Целью исследования был анализ институциональных механизмов управления трансграничными водами и их адаптационного потенциала для обеспечения аграрной устойчивости. Выявлены критические дефициты действующей институциональной системы; анализ показал, что Межгосударственная координационная водохозяйственная комиссия (МКВК) обладает ограниченными регуляторными полномочиями, решения комиссии носят рекомендательный характер. Бассейновые организации не имеют механизмов принуждения к соблюдению лимитов водопотребления. В условиях маловодья эффективность системы резко снижается, и отсутствует формальная система санкций за нарушения водораспределительных соглашений. В исследовании рассмотрены пути согласования национальной водной политики Кыргызстана с региональными инициативами по управлению трансграничными водами, а также возможности адаптации существующих договорных механизмов к климатическим рискам и создания системы контроля за выполнением межгосударственных обязательств. Предложена модель адаптивного управления водными ресурсами, разработана трехуровневая система: (1) сезонное перераспределение потоков через резервуарное хранилище; (2) механизм гибких квот с учетом климатических прогнозов; (3) система экономических стимулов для водосбережения в аграрном секторе. Результаты исследования заполняют пробел в понимании связи между институциональной архитектурой водного управления и аграрной уязвимостью и позволяют сформулировать научно обоснованные рекомендации по созданию более устойчивой и институционально эффективной системы трансграничного управления водными ресурсами, способствующей минимизации конфликтного потенциала и стимулированию интегрированного регионального развития в Центральной Азии

Ключевые слова: водная безопасность; водно-энергетическая связь; гидроэнергетический потенциал; адаптация к изменению климата