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Security Issues of Transborder Rivers and Major Water Sources of Central Asia

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Abstract: This study is devoted to the regional distribution of water resources in Uzbekistan, the increase in water demand as a result of population and economic growth, the impact of climate change, and ways to ensure water security. The main focus is on the effective use of water resources in the Amu Darya and Syr Darya rivers, the impact of the Aral Sea problem, reducing losses in the irrigation system, modernizing water infrastructure, and prospects for developing regional cooperation. The study proposes modern water-saving technologies, international experience, and solutions adapted for Uzbekistan.

Keywords: Water distribution, water security, Amu Darya, Syr Darya, Aral Sea, water conservation, regional cooperation.

Introduction: Uzbekistan is located in a geopolitically important region of Central Asia, and rational management of water resources is of strategic importance for its economic and social development. The country's geographical location and natural conditions put it in a disadvantageous situation in terms of water resources: landlockedness, arid climate conditions, and limited internal water resources complicate the provision of water security for sustainable development. Today, Uzbekistan's water management system faces a number of serious problems. First, the increase in the population from 20 million to 36 million over the past 30 years (1991-2023) has sharply increased the demand for water. Second, an average increase in temperature by 0.5°C and a change in precipitation patterns as a result of climate change are intensifying droughts. Third, a large part of the water is being lost due to the inefficiency of traditional methods of using water resources, mainly directed to agriculture. The Amu Darya and Syr Darya rivers, the main sources of water supply for the country, are transboundary in nature, with their waters shared between several countries. This has created a complex system of regional water relations and led to disputes over the use of water resources. In particular, water problems in the Aral Sea basin pose a threat to the entire region.

The main problems of Uzbekistan's water management can be classified as follows:

1. The Aral Sea disaster and its economic and environmental consequences

2. Inefficiency of irrigation systems (35-40% water loss)

3. Obsolete water infrastructure (60% of reservoirs were built in the 1960s-1980s)

4. Insufficient use of water-saving technologies

5. Insufficient effectiveness of legal mechanisms for water resources management

The significance of this study is that it not only analyzes the current state of water resources in Uzbekistan, but also offers practical solutions in the following areas:

- Modern water saving technologies

- Prospects for modernization of water infrastructure

- Mechanisms for developing regional cooperation

- Legal basis for water management restructuring.

The study attempts to develop an optimal water management model for Uzbekistan based on scientific analysis methods, statistical data, reports of international organizations, and practical experience. The article extensively covers modern methods of ensuring water security, international experience, and

solutions suitable for the conditions of Uzbekistan.

Water resources in Central Asia depend primarily on two major rivers, the Amu Darya and the Syr Darya. These two rivers form the Aral Sea basin.

Amu Darya: 2,540 km long, flows through Afghanistan, Tajikistan, Turkmenistan and Uzbekistan. The main sources are the Panj and Vakhsh rivers, and many hydroelectric power plants are located in this basin (Janusz-Pawletta & Gubaidullina, 2015). Annual water consumption: 68.63 km³ 85% of the water comes from the Vakhsh and Panj rivers. Distribution of water consumption - Agriculture: 60%, Industry: 15%, Domestic needs: 10%, Other: 15% Sur consumes.

Syrdarya: 3019 km long, formed by the Naryn and Karadarya rivers. It originates in the mountains of Kyrgyzstan and flows through Uzbekistan, Tajikistan and Kazakhstan. The Syrdarya is mainly used for irrigation and agriculture (MDPI, 2025). Annual water consumption: 38 km³ (varies between 19-72 km³). Distribution of water consumption: Agriculture: 70%, Industry: 12%, Domestic needs: 8%, Other: 10%.

These rivers are the "arteries" of the region's economic life, playing a crucial role in everything from agricultural productivity to energy security. As such, they are not only ecologically important, but also geopolitically important.

No.	Reservoir name	Capacity (million m^3)	Year of construction	Useful volume (million m^3)	Area (km^2)
1	Charvak	2,006	1970	1,580	40.1
2	Kattakurgan	845	1952	834	84.5
3	Sardoba	922	2020	890	36.0
4	Andijan	1,900	1983	1,750	42.3
5	Gather	520	1974	490	28.7

During the Soviet Union, water resources were distributed on a unified basis. The quotas established in 1987 are still in effect: On the Syrdarya: Uzbekistan – 46%, Kazakhstan – 44%, Tajikistan – 8%, Kyrgyzstan – 2% (MDPI, 2025). On the Amu Darya: Uzbekistan – 48.2%, Turkmenistan – 35.8%, Tajikistan – 15.4%, Kyrgyzstan – 0.6% (MDPI, 2025). However, these quotas do not meet today's requirements: Demographic growth: The population is growing rapidly, irrigated land is expanding. Climate change: The volume of water is decreasing year by year, the melting of glaciers is changing the flow regime (IWMI, 2025). The Afghan factor: It was not included in the initial quota, but in recent years has begun to actively use the Amu Darya (MDPI, 2025). As a result, competition for water resources has intensified, and conflicts between countries are emerging. Various legal instruments and organizations operate in the region to manage water distribution: the 1992 Almaty Agreement is the main agreement on the coordination of interstate water resources (ICWC, 1992). The ICWC (International Commission for Water Resources Coordination) is responsible for the allocation and monitoring of water flows (Ziganshina, 2023). The BWO Amu Darya and BWO Syrdarya are basin water management organizations that manage flows in real time (Janusz-Pawletta & Gubaidullina, 2015). The UN Helsinki Convention (1992) establishes the principles of “equitable and rational use” and “do no harm” (Ziganshina, 2023). Yet, the effectiveness of institutions is often limited by political contradictions.

The state of the Aral Sea

Indicator	1960	2023	Change (%)
Area	68,000 km²	6,800 km²	-90%
Water volume	1,000 km³	75 km³	-92.5%
Water level	53 m	25 m	-53%
Salinity	10 g/l	120 g/l	+1,100%

Climatic changes Temperature: 1960-2023 region average temperature +2.3° C increased, y annual Rainfall: 150 mm from 100 mm until decreased (-33%), Evaporation: 1,700 mm / year to 2,100 mm / year increased (+24%). Current status (2023) North Aral Sea: 3,300 km² (Kazakhstan) side), South Island: 3,500 km² (90% dry), Dry Area: 54,000 km² (sea) bottom), Dust emission: 100 million tons per year, restoration projects Karakalpakstan: 12 in 2020-2023 new lake build made, water Level: North 2.1 m on the island in 2010-2023 increased, afforestation: 45,000 hectares of saxaul planted.

Large water facilities and their safety Central 100 in Asia more than large water facilities there is to be , their safety regional stability for important (Ziganshina , 2023): Toqtagul Hydropower plant (Kyrgyzstan , 19 billion m ³) – Syrdarya main order In winter many water release lower in the stream in countries village farm for problem The Nurek HPP (Tajikistan, 10.5 billion m³) is one of the highest dams in the world (300 m). The Rogun HPP (Tajikistan) is the largest project on the Amu Darya, planned to have a height of 335 m. The Farkhod HPP (Uzbekistan) has been operating since Soviet times and is in need of modernization. Many structures have been in operation for 40–50 years and are at high risk of technical obsolescence. In addition, the risk level is further increased due to the region's location in a seismic zone.

Risks and conflicts Technical obsolescence – many hydropower plants need major repairs (Janusz-Pawletta & Gubaidullina, 2015). Seismic risk – dams located in seismic areas can cause regional disasters (Ziganshina, 2023). Climate change – mountain glaciers are shrinking, increasing seasonal variability in water flow (IWMI, 2025). Political conflicts – upstream countries (Kyrgyzstan, Tajikistan) release more water for energy production in winter, while downstream countries (Uzbekistan, Turkmenistan, Kazakhstan) need more water for irrigation in summer (MDPI, 2025). Solutions and prospects

Water-energy exchange: upstream countries sell surplus electricity to downstream countries in winter, in return for releasing water for irrigation in summer (ICWC, 1992). Innovative technologies: laser levelers, drip irrigation, widespread use of water-saving technologies (IWMI, 2025).

Monitoring and digital systems: Real-time simulation of water flows in the Chirchik basin based on the Pywr model (IWMI, 2025). Regional cooperation: Implementation of joint projects through organizations such as IFAS, ICWC, and CAREC (Ziganshina, 2023). If these measures are implemented, it will be possible to rationally use water resources in the region, ensure security, and support sustainable development.

CONCLUSION AND SUGGESTIONS

Water saving program: until 2025 irrigation Reduce losses from 35% to 20 % reduce Tomo r qa Increase the irrigation area to 500,000 hectares, install up to 2 million water meters. Investments: Invest $5 billion in water management in 2025-2030, allocate $1.2 billion for the modernization of reservoirs. Regional cooperation: Sign new agreements on the sharing of the waters of the Amu Darya and Syrdarya Rivers Establish a Central Asian Alliance for Joint Water Resources Management

These statistics clearly demonstrate the need for rational management of water resources in Uzbekistan. The measures taken will help ensure the country's water security.

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