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ASSESSMENT OF CHANGES IN THE SYRDARYA RIVER FLOW UNDER THE INFLUENCE OF RESERVOIRS

Abstract: *This article is devoted to assessing changes in the flow of the Syrdarya river, which has transboundary significance in Central Asia, under the influence of the Toktogul and Andijan reservoirs. The conducted hydrological analyses focus on the section of the river within the Fergana valley, using water discharge data observed at the Syrdarya-Kal hydrological station for the period 1935–2025. In addition, the study develops relevant recommendations for the efficient management of water resources in the Syrdarya basin under conditions of climate change.*

Keywords: *Syrdarya, river flow, Toktogul reservoir, Andijan reservoir, hydrological changes, assessment.*

Introduction. Today, the Syrdarya basin is considered one of the most complex and anthropogenically transformed hydrological systems in Central Asia, where the flow regime is artificially managed and regulated through large reservoirs alongside natural factors. In particular, major hydraulic structures within the basin, such as the Toktogul, Andijan, and Kayrakkum reservoirs, have a significant impact on the annual and seasonal distribution of river flow. Therefore, assessing changes in the Syrdarya flow under the influence of reservoirs is of great importance not only from a hydrological perspective, but also in terms of water management, ecology, and regional security.

The relevance of this topic is primarily explained by the uneven distribution of water resources under climate change conditions. In recent years, the reduction of snow cover and glacier areas, as well as changes in the atmospheric precipitation regime, have led to the destabilization of the natural flow within the Syrdarya basin. Under such conditions, the necessity of regulating river flow through reservoirs increases; however, this process often results in the disruption of the natural hydrological regime of rivers, causing water shortages in downstream areas or, conversely, increasing the risk of floods.

The main purpose of this article is to assess changes in the flow of the Syrdarya under the influence of reservoirs. Based on the objectives of the research, the following tasks were identified and accomplished in the study: 1) to determine the main hydrological indicators of the major hydraulic structures in the Syrdarya basin, namely the Toktogul and Andijan reservoirs; 2) to evaluate the impact of

these reservoirs on the flow of the Syrdarya; 3) to develop recommendations for the efficient use of water resources in the Syrdarya basin under climate change conditions.

Main Results and Their Discussion. The Syrdarya is considered one of the largest rivers in Central Asia. The Syrdarya is formed by the confluence of the Naryn and Karadarya rivers, and its total length is 2,200 km. Flowing through the territories of Kyrgyzstan, Uzbekistan, Tajikistan, and Kazakhstan, the Syr Darya historically discharged into the Aral Sea; however, at present, it is characterized by the fact that its waters no longer fully reach the sea. From a hydrological perspective, the Syrdarya is mainly fed by snow and glacier waters, and under natural conditions its flow regime reached a maximum during the spring–summer period and a minimum during autumn and winter. However, beginning from the second half of the twentieth century, the construction of large hydraulic structures fundamentally altered the natural flow regime of the river. Currently, the river flow is anthropogenically regulated, with water being released during the winter period for energy needs and redistributed in summer for irrigation purposes. Below, the main hydrological indicators of the major hydraulic structures causing such changes — the Toktogul and Andijan reservoirs — are discussed (Table 1).

Main hydrological characteristics of the Toktogul and Andijan reservoirs

No.	**Hydrological indicators**	Reservoirs	
		Toktogul	Andijan
1	Year of commissioning (or Year put into operation)	1974	1983
2	Total capacity	19500	1900
3	Active (useful) capacity [3]	14000	1750
4	Active (useful) capacity	5500	150
5	Dead (inactive) storage capacity	215	121
6	Normal water level	900	910
7	Water surface area	284,3	56

The Toktogul Reservoir is a large hydraulic engineering structure located in the lower reaches of the Naryn River, the main tributary of the Syr Darya. It was constructed in a canyon situated between the Chatkal and Fergana mountain ranges within the territory of the Kyrgyz Republic. Construction of the facility began in 1962 and it was commissioned in 1974. The total storage capacity of the reservoir is 19.5 km³, while its active (useful) storage capacity amounts to 14.0 km³ [5].

The Andijan Reservoir was designed by the "Sredazgiprovodkhlopok" Institute in 1961–1962 at the request of the Ministry of Land Reclamation and Water Management of Uzbekistan. The project was developed on the Karadarya River in the Fergana Valley with the aim of further expanding cotton production in the region. The reservoir was fully commissioned in 1983. Its design total storage capacity is 1.9 km³, while its active (useful) storage capacity is 1.75 km³.

Based on the tasks defined in the research and the analysis of long-term data, the general observations at the Kal hydrological station on the Syrdarya for the period 1935–2025 were divided into the following calculation periods, depending on the operational conditions of reservoirs:

The calculation periods were defined as follows:

I calculation period (1935–1973) – the period when the Syrdarya had a natural hydrological regime.

II calculation period (1974–1991) – a transitional period covering the construction of the Toktogul and Andijan reservoirs and their shift toward an energy-oriented operational regime.

III calculation period (1992–2025) – the period when the energy regime in reservoir operation became fully dominant (Figure 1).

Since approximately 78% of the Syrdarya's water resources originate from the Naryn River, and the Toktogul Reservoir—the largest hydraulic structure in Central Asia—was constructed on the Naryn, the study primarily focuses on assessing the impact of the Toktogul Reservoir on the Syrdarya flow regime.

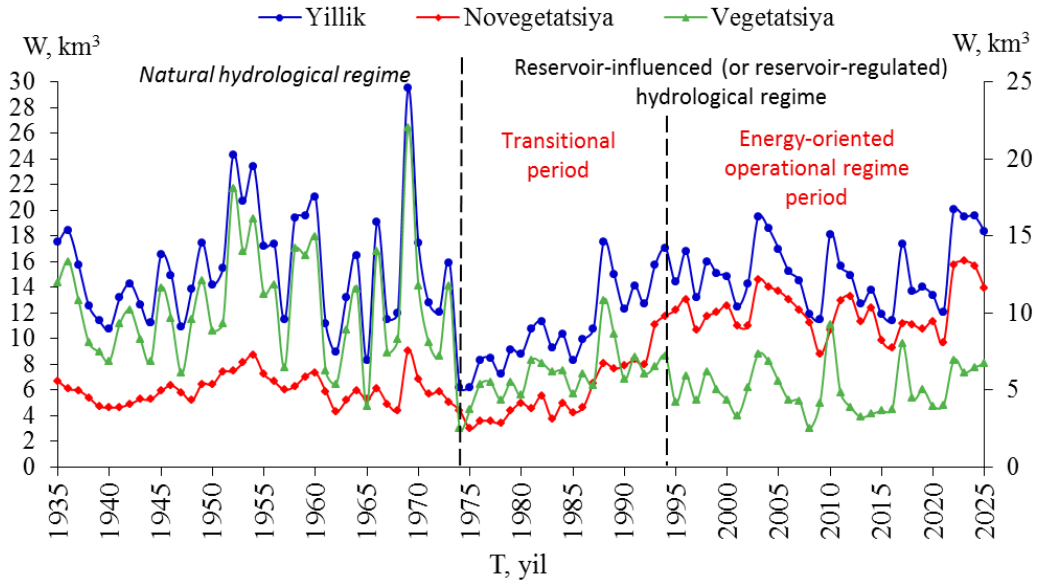

Figure 1. Interannual fluctuations of the Syrdarya annual, vegetation, and non-vegetation flow discharges (Kal hydrological station)

The first calculation period (1935–1973) represents a phase in which the Syrdarya basin maintained a natural hydrological regime. During this period, the

major portion of the river's annual flow occurred during the vegetation season. According to the calculated data, in the natural hydrological regime, approximately 65–70% of the Syrdarya's annual discharge passed during the vegetation period, while 30–35% occurred during the non-vegetation season [12, 13].

In the second calculation period (1974–1991), after the commissioning and operation of hydraulic structures, namely the Toktogul and Andijan reservoirs, the hydrological regime in the upper reaches of the Syrdarya began to change significantly. These changes were reflected in the interannual variability of average annual discharge, as well as in the seasonal and monthly distribution of river flow throughout the year. In particular, the annual discharge of the Syrdarya measured at the Kal hydrological station began to show a decreasing trend. This process continued until 1987. The main reason for this was that a portion of the river flow was used to fill the dead storage capacity of the reservoirs. As a result, low-water years were observed in the upper reaches of the Syrdarya. During this period, the reservoirs were primarily operated for irrigation purposes [9].

The third calculation period (1992–2025) is characterized by the transition of the Toktogul Reservoir on the main tributary of the Syr Darya to an energy-oriented operational regime. Toktogul Reservoir During this period, a decrease in flow during the vegetation season was observed, while, conversely, the volume of discharge during the non-vegetation season showed an increasing trend.

The fundamental cause of the above-mentioned processes is directly linked to the geopolitical transformations that occurred at the end of the 20th century, particularly the dissolution of the former Soviet Union. After the collapse of this system, the water–energy and fuel supply network, which had previously functioned as a unified economic complex in Central Asia, became disrupted. As a result, five independent sovereign states emerged in the region, and economic relations between them gradually shifted toward market principles.

Consequently, serious energy problems began to arise in the Kyrgyz Republic. Due to the reduced capacity to import fuel and energy resources from neighboring countries, Kyrgyzstan was compelled to rely on its internal hydropower potential to improve its energy supply. In particular, electricity demand increased sharply during the winter season. This situation necessitated a fundamental change in the operational regime of the Toktogul Reservoir. Previously, the reservoir was managed primarily under an irrigation-oriented regime, in which maximum water release occurred during the summer months, while minimal discharge was maintained in winter. However, after the transition to an energy-oriented regime, the opposite pattern emerged: greater volumes of water were released in winter for electricity generation, while water storage increased during summer.

This shift had a significant impact on the entire hydrological system of the Naryn–Syrdarya basin. In particular, the water supply regime for downstream countries located in the lower reaches of the Syrdarya was disrupted. This situation has brought the need for integrated water–energy resource management in Central Asia to the forefront of the regional agenda.

In addition, these changes are occurring in conjunction with ongoing climate

warming, which further intensifies the severity of the issue. Based on the objectives of the research, the following recommendations are proposed for the efficient utilization of water resources in the Syrdarya basin under conditions of climate change:

1. modernization of irrigation systems in response to increasing water scarcity under climate change conditions;
2. development of climate-resilient agriculture adapted to changing hydrological and environmental conditions;
3. improvement of digital monitoring and forecasting systems for more effective water resource management;
4. efficient use of water resources from small rivers and streams within the Syrdarya basin through the safe expansion of existing reservoir capacities and the construction of new reservoirs.

Conclusion. Based on the results of the conducted research, it can be concluded that the efficient utilization of water resources in the Syrdarya basin should not be limited solely to technical measures. This process requires a comprehensive strategy that integrates additional water-related interventions, regional cooperation, digitalization, and ecological approaches. Future research will be devoted to these issues.

References:

1. Авакян А.Б., Шарапов В.А. и др. Водохранилища мира. – М.: Изд-во «Наука», 1979. – 289 с.
2. Духовный В.А., Соколов В.И. Стратегия управления водными ресурсами Средней Азии. В кн. Водные ресурсы, проблемы Арала и окружающая среда. – Ташкент: Университет, 2000. – С. 121151.
3. Ильин И.А. Водные ресурсы Ферганской долины. – Л.: Гидрометеоиздат, 1959. – 247 с.
4. Матарзин Ю.М. Гидрология водохранилищ. – Перм: Изд-во ПГУ, 2003. – 296 с.
5. Никитин А.М. Водохранилища Средней Азии. – Л.: Гидрометеоиздат, 1991. – 163 с.
6. Ресурсы поверхностных вод СССР. Том 14. Средняя Азия. Вып. 1. Бассейн реки Сырдарьи. – Л.: Гидрометеоиздат, 1969. – 439 с.
7. Рубинова Ф.Э. Изменение стока р. Сырдарьи под влиянием водохозяйственного строительства в ее бассейне. – М: Гидрометеоиздат, 1979. – 136 с.
8. Сирлибаева З.С. Сток взвешенных наносов в бассейне Андижанского водохранилища: Автореф. Дисс. … канд. геогр. наук. – Ташкент, 1984. – 18 с.
9. Хикматов Ф.Х., Рапиков Б.Р. Влияние Токтагульского водохранилища на внутригодовое распределение стока реки Нарын / Международная научно-практическая конференция «Инновация-2016». – Ташкент, 2016. – С. 299-301.
10. Чонтоев Д.Т., Маматканов Д.М. и др. Водные гидроэнергетические ресурсы Кыргизстана в условиях изменения климата. – Бишкек. 2022. – 400 с.
11. Эдельштейн К.К. Гидрология озер и водохранилищ. Учебник для вузов. – М.: Изд-во Перо, 2014. – 399 с.