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Analysis of Water Management in the Amu Darya and Syr Darya River Basins for the Growing Season over 2017-2024

Prepared by: I. Ergashev, G. Khamdamova

Introduction

Sound use of water resources is a key challenge for the Central Asian countries, especially in the context of climate change, population growth, and increasing demand for water from economic sectors.

This policy brief presents an analysis of water use in the Amu Darya and Syr Darya River Basins for the growing season from 2017 to 2024. The aim is to assess the current status and trends in the ratio of actual water withdrawal to planned one (allocated water withdrawal quotas or the so called limits).

Trends by river basin

Amu Darya River Basin

Actual water withdrawal during the growing season in most basin countries often falls below planned levels. This could point to unreliable runoff forecasts and water supply issues stemming from scarcity or optimized water use. Water availability, the ratio of actual to planned water withdrawal, shows a downward trend in Turkmenistan and Uzbekistan, suggesting difficulties in meeting planned needs (see Table 1).[1]

Tajikistan: In Tajikistan, actual water use during the growing season averaged 88% of planned targets from 2017 to 2021. Water availability increased to 97% between 2021 and 2024, peaking in 2023 before declining to 91% in 2024. Despite the 2024 dip, water availability generally demonstrates an upward trend.

Turkmenistan: Turkmenistan's water availability during the growing season exhibited a slight decline from 2020 to 2022 (87%, 84%, and 83%, respectively), followed by a recovery to 90% in 2023 and

[1] Table below shows the data on planned (quota) and actual water withdrawals by CA countries in the Amu Darya and Syr Darya basins from 2017 to 2024

Scientific-Information Center
of the Interstate Commission for Water Coordination (SIC ICWC)

Karasu-4, B.11A, Tashkent, 100187, Republic of Uzbekistan

sic.icwc-aral.uz cawater-info.net

2024. Notably, actual water withdrawal in Turkmenistan remains consistently high despite these fluctuations.

Uzbekistan: Uzbekistan exhibits the most significant decline in water availability. From 100% in the 2017 growing season, it dropped to 69% by 2022. While slight increases to 72% and 79% were observed in 2023 and 2024, respectively, the overall trend remains downward. This suggests not only the impact of water scarcity but also Uzbekistan's substantial efforts to optimize water use, enhance irrigation efficiency, and adopt water-saving technologies. Additionally, shifts in the economic structure and a reduction in water-intensive crops likely contribute.

Dependence of water availability on water content of rivers

Tajikistan's water availability is less dependent on water content of the Amu Darya than that of Turkmenistan and Uzbekistan, as evidenced by its insignificant correlation coefficient (r = -0.39). This negative correlation implies that water availability in Tajikistan decreases with increasing water content of the Amu Darya, and vice versa. In contrast, Turkmenistan and Uzbekistan exhibit a strong positive correlation (r = 0.82 and 0.83, respectively), indicating a high dependence on Amu Darya's water content. This shared dependence is likely due to the 1996 Agreement between Uzbekistan and Turkmenistan on Cooperation on Water.

A country-by-country analysis of the Amu Darya basin's water resources suggests that **Tajikistan** enjoys a relatively stable position. **Turkmenistan**, though exhibiting variations, appears to maintain control, but long-term trends require further monitoring. **Uzbekistan**'s pronounced commitment to water optimization underscores its dedication to achieving sustainable water development.

Syr Darya River Basin

Water availability in the Syr Darya River Basin, like that of the Amu Darya, demonstrates variability, albeit less pronounced than the fluctuations observed in Uzbekistan within the Amu Darya basin. Available water supply in the Syr Darya experiences periods of both decline and growth across different countries (Table 2), reflecting **changes in the river's reservoir-controlled hydrological regime**. Furthermore, **agricultural water requirements**, which are subject to shifts in irrigated crop areas and cropping patterns, play a significant role.

Kyrgyzstan: The ratio of actual to planned water withdrawal shows significant variability, declining from 76% in the 2017 growing season to 57% in 2020. It then experienced a gradual recovery to 70%, followed by an abrupt increase to 90% in 2024.

Kazakhstan: Water is diverted from the Dustlik Canal. Available water supply varies visibly, mainly from 66 to 101%. Peak is observed in the growing season 2017 (101%), followed by a decline and then stabilization within 77-79%.

Tajikistan: Water availability during the growing season is relatively stable in the country, varying within 75-84% until 2023. During the growing season 2024, water availability decreased significantly to 69%. Heavy raining was observed in April-May 2024, thus leading to small quantity of requests for irrigation from water users.

Uzbekistan: Water availability shows variation, still remaining quite high - within 75-99%. It experiences a decline during the growing season 2019 (75%), followed by recovery and stabilization within 85-88%.

Since 2017, annual protocols have been signed on water and energy cooperation between the heads of water and energy agencies of the Kyrgyz Republic, the Republic of Kazakhstan, and the Republic of Uzbekistan. These agreements define the schedule for water releases from the Uchkurgan HPP during the growing season. Additionally, a trilateral protocol is signed by Uzbekistan, Kazakhstan, and Tajikistan to regulate additional water releases from the Bakhri Tojik reservoir between June and August, contributing to the stabilization of water availability for the countries.

Dependence of water availability on water content of rivers

The correlation between a country's water availability and rivers' water content is high for all riparian states.

In Kyrgyzstan, this correlation is 0.47. Over the long-term period from 2017 to 2024, actual water withdrawal ranged from 141 to 244 Mm^3. These variations are primarily due to climatic conditions, particularly high precipitation levels, which have reduced the demand for water from the Syr Darya.

Kazakhstan's water withdrawal from the Dustlik Canal is entirely dependent on water content of the river, with a correlation factor of 0.81. Compared to Kyrgyzstan, variations in actual water withdrawal are relatively low.

A similar situation is observed in Uzbekistan, where the correlation factor is 0.68.

Analysis of the accuracy of inflow forecasts: Case studies of the Toktogul, Andizhan, and Charvak Reservoirs)

Effective water resource management is crucial for the sustainable development of regions, particularly in the face of climate change and growing water consumption. Accurate forecasting of reservoir inflows is a key tool for optimizing water use, supporting agricultural and energy planning, and mitigating risks associated with potential water shortages or surpluses.

This study examines the accuracy of inflow forecasts for three key reservoirs – Toktogul, Andizhan, and Charvak – over the period from 2017 to 2024. Comparing forecast and actual data helps identify deviation patterns and refine forecasting methods.

The data analysis revealed that the actual inflow to the Toktogul reservoir exceeded forecasts in most years, particularly in 2017 (+14%), 2018 (+13%), 2022 (+11%), and 2024 (+15%). However, exceptions were observed in 2019 and 2023, when actual values fell short of forecasts by 6% (Table 3).

The inflow to the Andizhan reservoir showed an inconsistent trend. Actual inflows surpassed forecasts by 28% in 2017 and 41% in 2022. However, in 2019, 2020, and 2023, actual inflows were significantly lower than forecast, with the most pronounced deviation occurring in 2020, when the shortfall reached 42%.

In the Charvak reservoir, actual inflows exceeded forecasts by 41% in 2017 and 14% in 2019. In other years, underestimation was more common, with the most significant shortfalls observed in 2020 (-15%) and 2023 (-16%).

Considering the total inflow from the three main rivers – Naryn, Karadarya, and Chirchik – actual volumes generally exceeded forecast values, particularly in 2017, 2022, and 2024. The largest positive deviation was recorded in 2017 (+24%). In 2021, forecast and actual inflows were nearly identical (0% difference), whereas in 2020 and 2023, actual inflows fell short of forecasts by 10% and 13%, respectively.

Conclusion

Most countries exhibit a decline in the **ratio of actual to planned water withdrawals**, highlighting issues with water availability, distribution, and the low reliability of flow forecasts.

Water supply is particularly challenging in Turkmenistan, Kazakhstan, and Uzbekistan, where the decline in water availability has been most pronounced in recent years.

This reduction in water availability across the region is linked to fluctuations in rivers' water content and its reduction due to climate change.

The **analysis of water management challenges** suggests the need for the following measures: optimize water use (invest in modernizing irrigation systems to minimize water losses); strengthen international cooperation (develop joint regional programs for the sustainable use of water resources); enhance monitoring and forecasting (establish water monitoring systems to enable a timely response to changes in water availability); adapt to climate change (develop strategies and measures that account for climate risks to improve the resilience of water management systems).

Inflow forecasts for the Toktogul reservoir are generally underestimated, except in 2019 and 2023, highlighting the need for improvements in forecasting methodology.

The Andizhan reservoir exhibits significant variability in the deviation between actual and forecast inflows.

For the Charvak reservoir, inflow forecasts tend to be overestimated, particularly in 2020 and 2023. However, in 2017 and 2019, actual inflows significantly exceeded predictions.

Table 1. Planned (quota) and actual water withdrawals of riparian countries in the Amu Darya River Basin

Country	Indicator	Unit	Year								Correlation
			2017	2018	2019	2020	2021	2022	2023	2024	
Tajikistan	Planned water withdrawal	Mm^3	6,943	6,753	6,951	6,952	6,953	6,963	6,958	6,982	
	Actual water withdrawal	Mm^3	5,980	6,186	5,999	6,137	6,236	6,640	6,782	6,326	-0.28
	Ratio of actual to planned water withdrawals	**%**	**86**	**92**	**86**	**88**	**90**	**95**	**97**	**91**	**-0.39**
Turkmenistan	Planned water withdrawal	Mm^3	15,500	15,003	15,500	15,500	15,500	15,500	15,500	15,500	
	Actual water withdrawal	Mm^3	14,838	13,005	14,696	13,512	12,986	12,911	13,969	13,960	0.87
	Ratio of actual to planned water withdrawals	**%**	**96**	**87**	**95**	**87**	**84**	**83**	**90**	**90**	**0.82**
Uzbekistan	Planned water withdrawal	Mm^3	17,220	16,775	17,220	17,220	17,220	17,220	17,220	17,220	
	Actual water withdrawal	Mm^3	17,179	12,674	15,427	12,856	12,162	11,826	12,439	13,543	0.85
	Ratio of actual to planned water withdrawals	**%**	**100**	**76**	**90**	**75**	**71**	**69**	**72**	**79**	**0.83**
River water content (at the nominal Kerki gauging station)		Mm^3	20,256	37,108	46,622	37,321	40,555	40,695	42,879	43,284	

Table 2. Planned (quota) and actual water withdrawals of riparian countries in the Syr Darya River Basin

Country	Indicator	Unit	Year								Correlation
			2017	2018	2019	2020	2021	2022	2023	2024	
Kyrgyzstan	Planned water withdrawal	млн $м^3$	246	246	246	246	246	246	270	270	
	Actual water withdrawal	млн $м^3$	188	196	165	141	144	188	188	244	0.36
	Ratio of actual to planned water withdrawals	**%**	**76**	**80**	**67**	**57**	**59**	**64**	**70**	**90**	**0.47**
Kazakhstan	Planned water withdrawal	млн $м^3$	732	705	918	878	903	903	920	921	
	Actual water withdrawal	млн $м^3$	739	613	602	610	698	701	704	728	0.50
	Ratio of actual to planned water withdrawals	**%**	**101**	**87**	**66**	**69**	**77**	**78**	**77**	**79**	**0.81**
Tajikistan	Planned water withdrawal	млн $м^3$	1,905	1,905	1,905	1,905	1,905	1,905	1,905	1,905	
	Actual water withdrawal	млн $м^3$	1,592	1,606	1,557	1,455	1,495	1,560	1,436	1,312	0.34
	Ratio of actual to planned water withdrawals	**%**	**84**	**84**	**82**	**76**	**78**	**82**	**75**	**69**	**0.34**
Uzbekistan	Planned water withdrawal	млн $м^3$	8,880	8,880	8,799	8,880	8,880	8,880	8,880	8,880	
	Actual water withdrawal	млн $м^3$	8,673	8,295	6,639	6,699	7,611	7,756	7,479	7,566	0.68
	Ratio of actual to planned water withdrawals	**%**	**99**	**84**	**75**	**76**	**86**	**88**	**85**	**86**	**0.68**
River water content (sum of three rivers: Naryn, Karadarya and Chirchik)		млн $м^3$	26,209	17,018	16,992	14,278	14,344	18,015	15,459	18,229	

Table 3. Forecast and actual inflows to upper reservoirs in the Syr Darya River Basin

Reservoir	Indicator	Unit	Year							
			2017	2018	2019	2020	2021	2022	2023	2024
Toktogul	Forecast	km^3	11.7	8.8	9.8	8.7	8.2	9.4	9.8	9.3
	Actual	km^3	13.4	9.9	8.8	8.7	8.8	10.4	9.2	10.7
	Deviation from forecast	%	14	13	-6	0	7	11	-6	15
Andizhan	Forecast	km^3	3.2	2.6	2.7	2.1	1.8	2.1	3.0	2.4
	Actual	km^3	4.1	2.5	1.9	1.2	1.7	3.0	2.1	2.5
	Deviation from forecast	%	28	-4	-27	-42	-3	41	-31	2
Charvak	Forecast	km^3	6.2	5.3	5.5	5.2	4.4	4.6	5.0	4.9
	Actual	km^3	8.7	4.7	6.2	4.4	3.9	4.6	4.2	5.1
	Deviation from forecast	%	41	-12	14	-15	-13	0	-16	4
Sum of 3 rivers	Forecast	km^3	21.1	16.7	17.5	15.9	14.4	16.1	17.8	16.6
	Actual	km^3	26.2	17.0	17.0	14.3	14.3	18.0	15.5	18.2
	Deviation from forecast	%	24	2	-3	-10	0	12	-13	10