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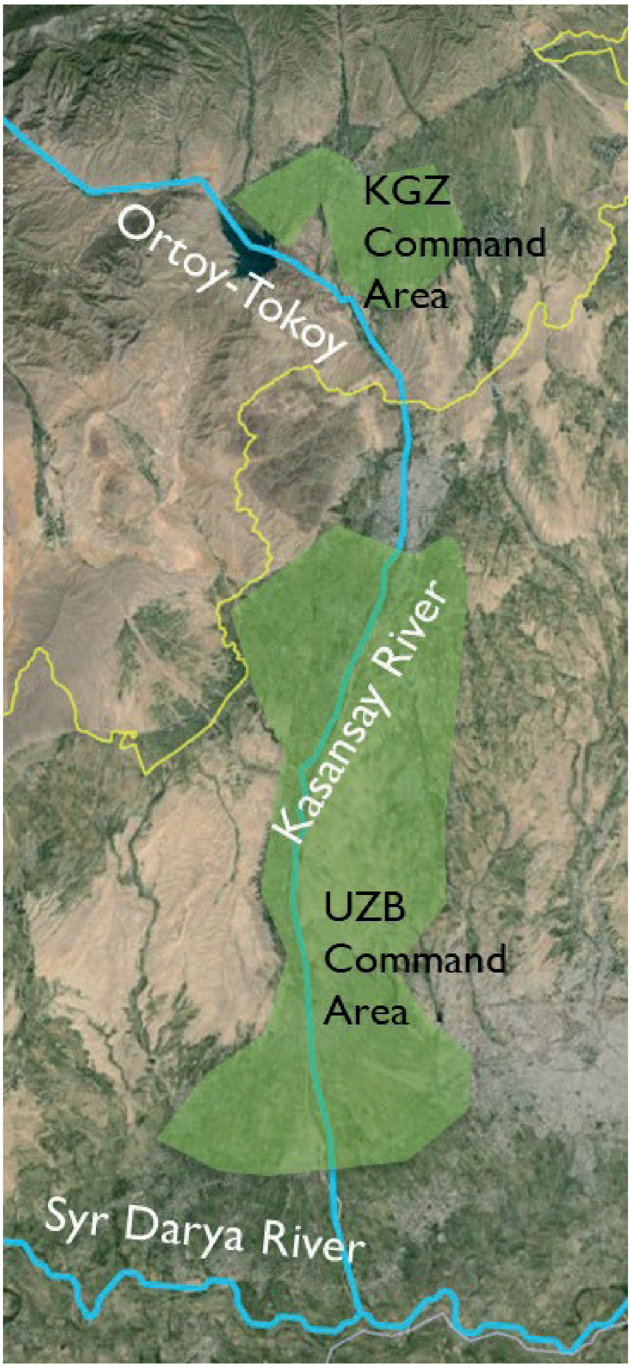
REDUCING WATER AVAILABILITY THREATS TO ORTO-TOKOY (KASANSAY) RESERVOIR OPERATIONS[1]

[1] The analysis described here was undertaken via the USAID Central Asia' Regional Water and Vulnerable Environment Activity (hereafter, the Activity) – a five-year project that aims to strengthen water cooperation among Central Asian countries to increase stability, economic prosperity, and healthy ecosystems. The Activity is implemented by a Tetra Tech ARD Inc. branch in the Republic of Kazakhstan. The technical work was conducted with a team at the Stockholm Environment Institute – US Center, and local experts from each of the countries of the Amu Darya basin.

HIGHLIGHTS

- The Orto-Tokoy (Kasansay) Dam and reservoir face several significant threats. Built in 1956, the aging infrastructure requires regular maintenance and upgrades to maintain its structural integrity. The region's seismic activity also poses a risk to the dam's stability. Changes in precipitation and temperature patterns further exacerbates these challenges, as their variability can lead to periods of drought or excessive flooding, while higher temperatures additionally increase evaporation rates, reducing water availability.
- Expanding the reservoir's capacity and implementing adaptive management are crucial for enhancing water resource resilience and sustainability in the Orto-Tokoy region.

INTRODUCTION



TheThe Orto-Tokoy (Kasansay) Reservoir, located on the Kasansay River in the countries of the Kyrgyz Republic and Uzbekistan, serves as a crucial channel reservoir with seasonal regulation. Its primary function is to control the flow of the Kasansay River to enhance the water supply for agricultural lands in both countries. The main beneficiaries of this water resource are the irrigation systems of farms, which collectively irrigate 28,000 hectares of land—2,000 hectares in the Kyrgyz Republic (7.2 percent) and 26,000 hectares in Uzbekistan (92.8 percent).

From 2018 to 2022, the average volume of water available for irrigation was 275 million cubic meters, though the system was originally designed to distribute up to 393 million cubic meters. Of the available water, eight percent is allocated to irrigation areas in the Kyrgyz Republic, while the remaining 92 percent serves irrigation areas in Uzbekistan. This distribution underscores that the reservoir, located in Kyrgyz Republic, plays a vital role in supporting regional agriculture and ensuring sustainable water management across national borders.

The Kasansay River flow rate is impacted seasonally. The average annual flow rate is 8.6 cubic meters per second. Discharges typically start increasing in April, peaks during May and June, and then decline steadily from July through September. During the period from September to March, water flows remain relatively stable, fluctuating between three to five cubic meters per second.

About 80 percent of the annual flow occurs from April to August, with the majority of it (60 percent) occurring in May and June. This indicates a pronounced seasonal variability in the river's discharge, with significant contributions to overall flow during the spring and early summer months.

THREATS AND PROPOSED INTERVENTIONS

The performance of the Orto-Tokoy (Kasansay) Dam and reservoir is threatened by several issues that can impact its effectiveness in water management, flood control, and irrigation. Built in 1956, the dam is several decades old and requires regular maintenance and upgrades to ensure its structural integrity. The region may also be prone to seismic activity, which can threaten the stability of the dam.

Variability and seasonal changes in precipitation and temperature pose further challenges. Changes in precipitation patterns can affect the inflow of water into the reservoir, leading to periods of drought or excessive flooding. Higher temperatures can increase evaporation rates from the reservoir, reducing the available water supply.

Since the reservoir is located on the territory of Kyrgyz Republic, but serves mostly for Uzbekistan, effective management of the reservoir requires coordination between the two countries, and any lack of cooperation can hinder the dam's performance.

To address these challenges, the Water Evaluation and Planning (WEAP) software was used to assess two proposed scenarios of expanding the storage capacity to enhance the overall performance of Orto-Tokoy:

The first scenario, **Dredging**, looks into maintaining usable storage within Orto-Tokoy reservoir by regularly removing sediments with the dead storage still remaining fixed at ten million cubic meters. Otherwise, this scenario assumes the same operational regime as the Baseline.

The second scenario, **Reservoir Expansion**, assumes the expanded storage capacity of the Orto-Tokoy reservoir from 165 million cubic meters to 525 million cubic meters. This figure was suggested by the Central Asian Scientific-Research Institute of Irrigation in 1988[2], when the government considered the possibility of extending the irrigation in the area. Based on the expert assessment, the number, as well as the suggestion on expanding the irrigation area is still actual and possible. By expanding the reservoir's capacity, this scenario aims to assess how enhanced storage capabilities could influence water management objectives, such as increased water availability, flood control, and overall water resource sustainability.

Both scenarios are evaluated relative to a **Baseline** scenario that represents the current operational regime of the Orto-Tokoy dam and reservoir. It serves as a reference point against which other scenarios are compared. The baseline scenario reflects the existing conditions and management practices without any significant changes to infrastructure or operational procedures.

ASSESSING VULNERABILITY AND EFFECTIVENESS OF INTERVENTIONS

Significant variations in reservoir inflow were observed across different climate projections. Under *historical* climatic conditions, the average annual inflow into the Orto-Tokoy reservoir was estimated to be 444 million cubic meters. In contrast, *the dry* climate projection resulted in a 20 percent reduction in inflows, bringing the average annual inflow down to 356 million cubic meters. Conversely, *the wet* climate projection saw a 20 percent increase in inflows, with an average annual inflow rising to 534 million cubic meters. These results highlight the substantial influence of climate projections on reservoir inflows, underscoring the importance of adaptive water management strategies to mitigate risks associated with these projections.

[2] The archive document #6846 dated November 30, 1988

The WEAP model results for reservoir storage volumes under the Baseline, Dredging and Reservoir Expansion scenarios reveal distinct patterns influenced by various climate projections. In the Baseline scenario, reservoir storage is regularly drawn down as part of its normal operations. Under *historical* climate conditions, inflows are sufficient to maintain standard operational levels. However, despite significantly higher inflows under the wet climate projection, there is no additional storage benefit, and the reservoir does not refill more frequently than it does under historical conditions. Conversely, under the dry climate projection, the reservoir struggles to refill, highlighting the challenges of maintaining adequate storage levels during periods of reduced water availability.

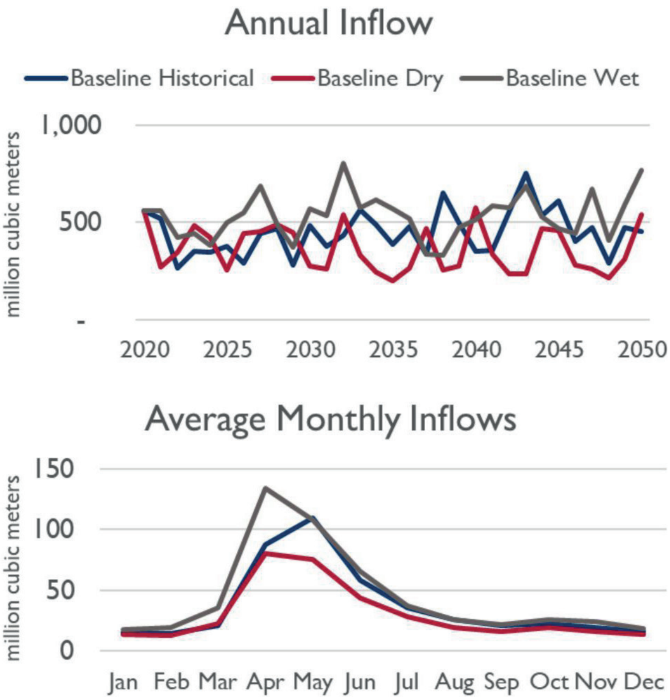


***Figure 1.** Annual and Average Monthly Inflow in to Oro-Tokoy reservoir (2019-2023)*

The Baseline and Dredging scenarios exhibit very similar storage patterns, with getting drawn down slightly more than the Baseline – i.e. to ten million cubic meters versus an average of 15.8 million cubic meters under the Baseline. This implies that the Dredging scenario has access to an additional 5.8 million cubic meters of water each year. In both the Baseline and Dredging scenarios, reservoir storage is regularly drawn down as part of normal operations. Under historical climate conditions, inflows are sufficient to maintain standard operational levels.

In the Reservoir Expansion scenario, storage volumes are generally much higher across all potential climate projections compared to the Baseline scenario. The increased storage capacity allows for better water retention and management. Under the wet climate projection, the expanded storage capacity results in higher storage levels than the historical climate, effectively capturing and utilizing the increased inflows. Although storage volumes under the dry climate projection continue to trend lower than both the historical and wet climate projections, the expanded capacity still provides some improvement in storage levels compared to the Baseline scenario.

Overall, the Reservoir Storage scenario demonstrates enhanced resilience and capacity to manage varying climate projections, particularly under wet climate projection, whereas the Baseline scenario shows limitations in adapting to both dry and wet climate projections.

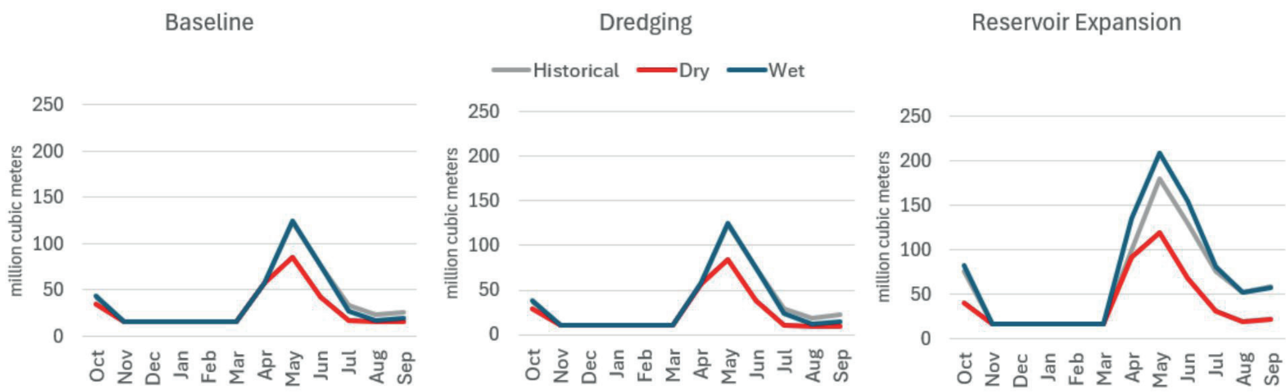


***Figure 2.** Reservoir storage volumes for Baseline, Dredging and Reservoir Expansion scenarios under historical, dry, and wet climate conditions*

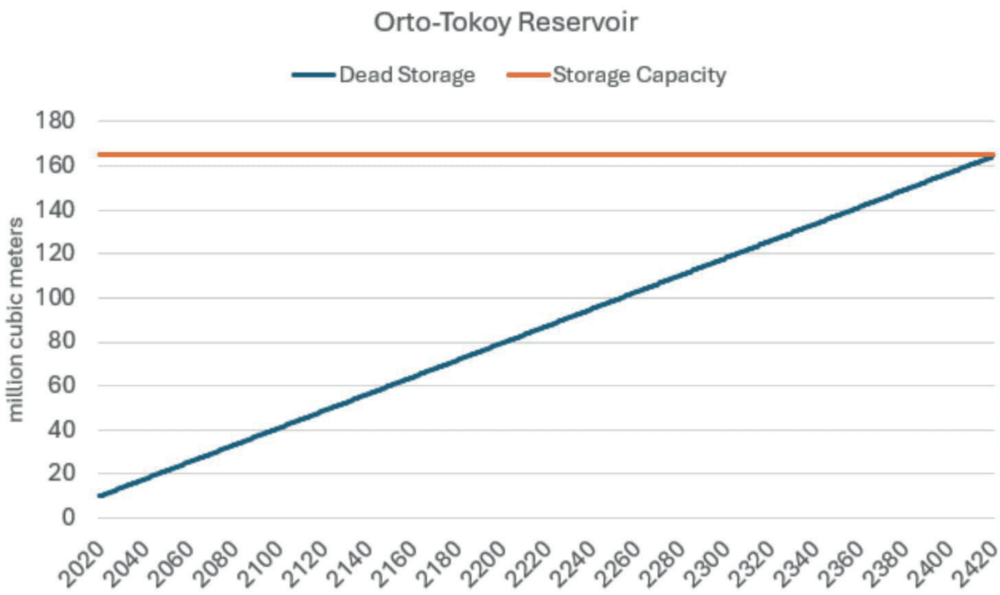


Figure 3. *The time to fill Orto-Tokoy Reservoir at current rates of sediment loading*

The WEAP model results for water deliveries from the Orto-Tokoy reservoir under the Baseline and Reservoir Expansion scenarios show distinct differences based on historical, dry, and wet climate projections. In the Baseline scenario under historical projections, the average annual water delivery is estimated at 321 million cubic meters. When the dry climate projection is applied, water deliveries are reduced by 16 percent to 268 million cubic meters. Conversely, under the wet climate projection, water deliveries increase by ten percent to 352 million cubic meters per year.

The Dredging scenario suggests a marginal increase in average annual water deliveries for each climate projection compared to the Baseline. Under each projection, average water deliveries increase by about one percent as compared to the same projection under the Baseline. Another way to illustrate is shown in Figure 3, at the current rate of sedimentation, it would take almost 400 years to completely fill the reservoir.

The Reservoir Expansion scenario enhances water delivery across all climate projections compared to the Baseline. Under the historical climate projection, total water deliveries increase by seven percent relative to the Baseline. In the dry climate projection, water deliveries increase by ten percent, demonstrating an improved ability to manage reduced inflows. Under the wet climate projection, the expansion leads to a 12 percent increase in water deliveries, maximizing the utilization of higher inflows. Overall, the Reservoir Expansion scenario significantly improves water delivery resilience and capacity across varying climate projections.

Table 1. *Average annual water deliveries from Orto-Tokoy for Baseline, Dredging and Reservoir Expansion scenarios under historical, dry, and wet climate conditions*

Scenario	Average Annual Deliveries	Percent Change from Baseline with Same Climate (1985-2014)
Baseline - Historical	318	
Baseline – Dry	263	-17%
Baseline - Wet	347	+9%
Dredging – Historical	322	+1%
Dredging – Dry	268	-16%
Dredging - Wet	352	+11%

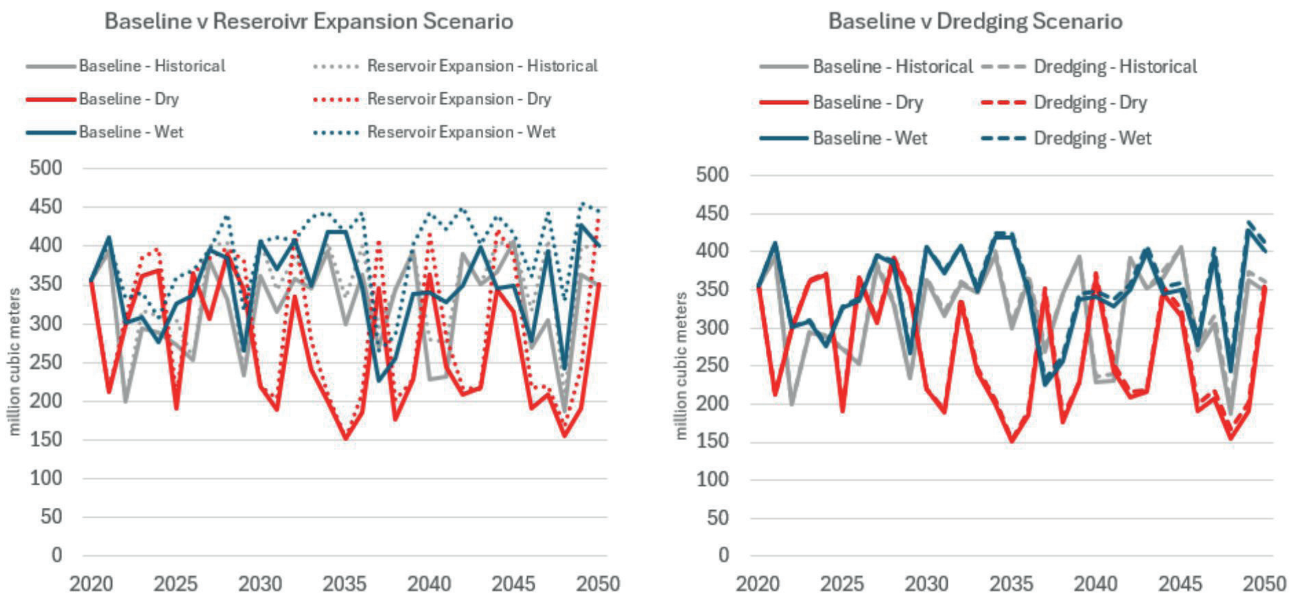


Figure 4. *Water deliveries from Orto-Tokoy for Baseline, Dredging and Reservoir Expansion scenarios under historical, dry, and wet climate conditions*

CONCLUSIONS AND RECOMMENDATIONS

The WEAP model analysis for the Orto-Tokoy reservoir under various climate projections and management scenarios provides valuable insights into the impacts of climate projections and the benefits of reservoir capacity expansion on water security. The results highlight significant differences in reservoir inflows, storage volumes, and water deliveries under historical, dry, and wet climate projections.

CONCLUSIONS:

1. **Climate Projections Impact on Inflows:** The reservoir inflows are highly sensitive to climatic projections, with inflows decreasing by 20 percent under dry climate projection and increasing by 20 percent under wet climate projection compared to historical levels.
2. **Baseline Storage Limitations:** The Baseline scenario shows limited capacity to adapt to both dry and wet climate projections. In the dry climate projection, the reservoir struggles to refill, while in the wet climate projection, the increased inflows do not translate into additional storage benefits, indicating operational constraints.
3. **Marginal Benefit of Dredging:** The Dredging scenario suggests that removing sediments from the reservoir to create additional usable storage will have very little impact on managing water storage and deliveries.
4. **Enhanced Storage Benefits:** The Reservoir Expansion scenario demonstrates significant improvements in storage volumes and water delivery capabilities. The expanded storage capacity allows for better retention and utilization of inflows, particularly under wet climate projection, and provides a buffer against reduced inflows during dry periods.
5. **Improved Water Deliveries:** Under the Reservoir Expansion scenario, water deliveries increase across all climate projections, with a seven percent increase under historical projection, a ten percent increase under dry climate projection, and a 12 percent increase under wet climate projection. This highlights the enhanced resilience and operational flexibility provided by the expanded reservoir capacity.

RECOMMENDATIONS:

1. **Implement Reservoir Expansion:** Given the substantial benefits observed in the Reservoir Expansion scenario, it is recommended to increase the storage capacity of the Orto-Tokoy reservoir from 165 million cubic meters to 525 million cubic meters. This expansion would improve water availability, enhance flood control, and support sustainable water management under varying climate projections.

2. **Adaptive Management Strategies:** Develop and implement adaptive management strategies that account for water levels variability. This includes optimizing reservoir operations to maximize storage and water delivery benefits during wet periods and maintaining adequate reserves during dry periods.

3. **Monitor and Adjust Operations:** Continuously monitor water level trends and reservoir performance to adjust operational strategies in real-time. This proactive approach will help mitigate the impacts of extreme weather events and ensure the reliability of water supplies.

4. **Stakeholder Engagement:** Engage with local stakeholders, including communities, agricultural users, and industry, to ensure that water management strategies align with their needs and priorities. Collaborative planning and decision-making will enhance the effectiveness and acceptance of proposed interventions.

5. **Further Research:** Conduct further research to refine climate projections and improve the accuracy of hydrological models. This will support more precise planning and management of water resources in the face of different variabilities.

Implementing these recommendations will enhance the resilience and sustainability of water resources in the Orto-Tokoy region, ensuring reliable water supplies for various uses.

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Key Documents

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