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INCREASING THE RESILIENCE OF THE TUYAMUYUN HYDRO COMPLEX[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 Tuyamuyun Hydro Complex (THC) faces significant threats that jeopardize its capacity to regulate water flow, provide reliable water supply, and generate hydroelectric power. Chief among these threats are:

1. Diversions to the Qosh Tepa Canal in Afghanistan, which are projected to withdraw between ten and 16 billion cubic meters of water annually, significantly reducing the water available for the THC and impacting agricultural and energy needs downstream.
2. Sedimentation, particularly in the Channel Reservoir, has already reduced its storage capacity by nearly half, with projections indicating that continued sediment accumulation could render the reservoir non-functional by 2045.

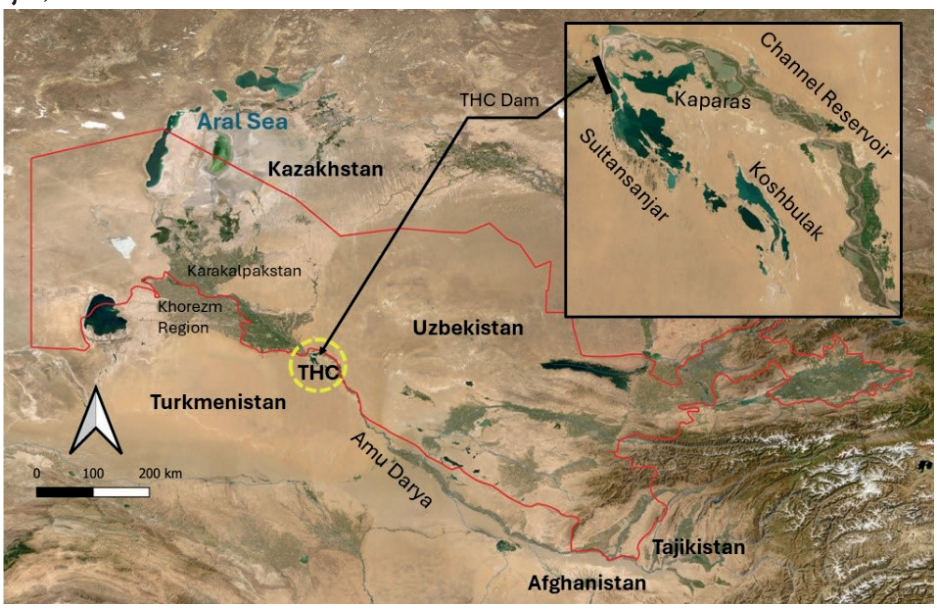
The Water Evaluation and Planning (WEAP) model simulations confirm that diversions to the Qosh Tepa Canal could significantly reduce the annual inflows to the THC by approximately 25 percent, impacting water deliveries to agriculture and reducing hydropower generation by about 22 percent. Individually, reservoir expansion and sediment dredging mitigate some of these negative impacts. Based on this, we recommend that both of these measures should be applied simultaneously, which will have a more significant mitigating effect of ensuring water requirements for both agriculture and energy.

INTRODUCTION

The THC is a significant water management facility located on the lower Amu Darya River. This extensive complex is strategically positioned. It plays a pivotal role in supporting agriculture, storing drinking water, and energy production. Importantly, the THC is physically located on the territory of Turkmenistan, though it is owned and maintained by Uzbekistan. The power generated and irrigation water is utilized by Uzbekistan

The THC consists of four main reservoirs—Channel, Kaparas, Sultansanjar, and Koshbulak—which have a combined storage capacity of 7.8 km³. These reservoirs are designed to control the flow of the Amu Darya River, ensuring a reliable water supply during dry periods for Uzbekistan.

The THC faces several challenges, including decreasing water flow, sedimentation, and growing demand for water. Its construction and operation have had significant environmental impacts, including altering the natural flow of the Amu Darya River, which has impacted ecosystems and biodiversity. Given that the Amu Darya River flows through multiple countries, effective transboundary water management is crucial to ensure fair and sustainable use of water resources. The aging infrastructure, now several decades old, requires ongoing maintenance and potential upgrades to ensure its continued functionality and safety.



THREATS AND PROPOSED INTERVENTIONS

THC faces significant sedimentation issues, particularly in the Channel Reservoir. Sedimentation has reduced the storage capacity of the Channel Reservoir from its original 2.34 km³ to 1.28 km³. Currently, the average storage loss due to sedimentation is about 48 million cubic meters per year. If this rate continues, it is projected that storage within the Channel Reservoir will be lost to sedimentation by 2045. This poses a threat to the complex's ability to regulate water flow, provide reliable water supply, and mitigate flood risks.

The Qosh Tepa Canal in Afghanistan presents a significant potential disruption to water management in the lower Amu Darya River Basin. It is anticipated that the annual diversions to the canal could total between ten and 16 billion cubic meters per year. The potential reduction in water flow to the lower Amu Darya will adversely affect the complex's ability to provide a reliable water supply for irrigation, drinking water, and hydroelectric power generation.

To address these challenges, the WEAP software was used to evaluate two scenarios proposed by the Government of Uzbekistan aimed at enhancing THC performance.

The **Expand THC Storage** scenario involves increasing the total reservoir capacity by one billion cubic meters (one km³), which is stated in the National Strategy "Uzbekistan 2030", adopted by the Government in 2023. This scenario evaluates the potential benefits of expanded off-stream storage across three of the four main THC Reservoirs (Kaparas, Sultansanjar, Koshbulak). It aims to enhance water security, mitigate risks from reduced inflows, and support sustainable water management practices.

The **THC Dredge** scenario focuses on dredging the sediments from the Channel Reservoir to restore its original storage capacity. Sedimentation has reduced the Channel Reservoir's capacity, impacting its ability to regulate river flows and provide water for hydropower generation. This scenario examines improvements in water supply reliability, hydropower generation efficiency, and overall operational effectiveness.

These two scenarios plus a **Baseline** (or Business-as-Usual) scenario were assessed under conditions with and without annual diversions of 13 billion cubic meters[2] to the Qosh Tepa Canal in Afghanistan. These assessments explore how diversions to the Qosh Tepa Canal could affect water availability, reservoir operations, and the THC's capacity to meet demands for irrigation, domestic use, and hydropower downstream.

ASSESSING VULNERABILITY AND EFFECTIVENESS OF INTERVENTIONS

Before evaluating the effectiveness of the proposed management strategies, it is important to understand the relative impact of Qosh Tepa Canal diversions. The WEAP model was run for a Baseline scenario with and without these diversions reveals significant differences. These results indicate that **with Qosh Tepa Canal diversions incorporated, the average annual inflow to THC decreases by approximately 25 percent from 37,960 to 28,606 million cubic meters per year.** This underscores the considerable impact of external diversions on water availability and management within the basin.

[2] The range of reported possible diversions for the canal is from 10-16 BCM. 13 BCM is selected as one possibility.

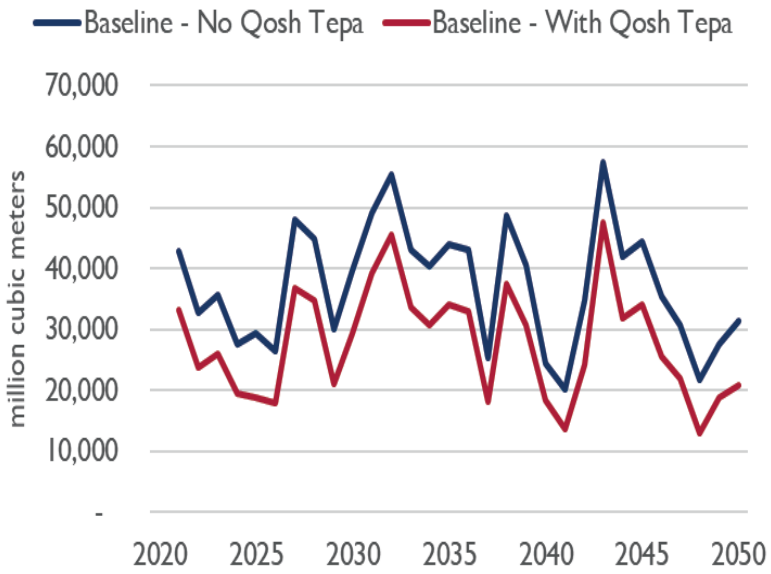


Figure 1. *Annual inflow to THC with and without Qosh Tepa canal diversions*

The WEAP model results for water deliveries to agriculture from the THC across the two scenarios provide valuable insights into the impacts of different management strategies and external diversions, such as from the Qosh Tepa Canal. *Table 1* illustrates annual water delivery data for the *Baseline, Expanded Storage*, and *THC Dredging* scenarios, both with and without Qosh Tepa diversions.

In the Baseline scenario, Qosh Tepa diversions have the most significant impact on water deliveries to agriculture, resulting in a reduction of annual deliveries by six percent compared to the Baseline without Qosh Tepa diversions. This reduction underscores the substantial challenge posed by external water withdrawals on agricultural water availability within the basin.

Conversely, neither the *Expanded Storage* nor *the THC Dredging scenarios* show significant impacts on total water deliveries to agriculture when considered individually. These scenarios are primarily focused on enhancing reservoir capacities and managing sedimentation to maintain consistent water supply levels for agricultural needs.

However, **the combined effect of implementing both the THC Dredging and Expanded Storage scenarios proves beneficial in offsetting some of the negative impacts caused by Qosh Tepa diversions**. Specifically, these scenarios mitigate the water delivery reduction from six percent in the Baseline scenario to four percent in each individual scenario. When both scenarios are implemented together, the reduction in water deliveries decreases further to only three percent compared to the Baseline, highlighting **the synergistic benefits of implementing multiple water management strategies simultaneously**.

Table 1. *Average annual water deliveries from THC for selected scenario combinations*

Scenario	Annual Delivery (million m^3)	Percent Change from Baseline
Baseline	10,079	
Baseline with Qosh Tepa	9,467	-6%
THC Dredge	10,119	0%
THC Dredge with Qosh Tepa	9,721	-4%
THC Expansion	10,118	0%
THC Expansion with Qosh Tepa	9,646	-4%
THC Expansion with THC Dredge and Qosh Tepa	9,768	-3%

The WEAP model results for hydropower generation from the THC across the modeled scenarios highlight the significant impacts of management strategies and provide insights into how different scenarios affect THC's ability to generate hydropower.

In the Baseline scenario, Qosh Tepa Canal diversions threaten to reduce THC's hydropower generation by approximately 22 percent annually. This reduction underscores the substantial challenge posed by external water withdrawals on THC's hydropower production capacity.

The interventions of Expanded Storage and THC Dredging scenarios individually show limited effectiveness in addressing hydropower generation. Expanded Storage, aimed at increasing reservoir capacities, inadvertently diverts more water into off-stream portions of the THC, reducing the availability of water for hydropower generation by two percent and compounding the negative impact caused by the Qosh Tepa diversions.

On the other hand, the THC Dredging scenario exhibits a modest effect, marginally increasing hydropower generation by one percent. Despite this improvement, it is insufficient to counterbalance the overall reduction caused by the Qosh Tepa diversions.

Interestingly, when both scenarios—Expanded Storage and THC Dredging—are combined, their impacts essentially cancel each other out. While Expanded Storage slightly reduces hydropower generation, THC Dredging slightly increases it. As a result, hydropower generation remains at approximately the same level in the Baseline scenario with the Qosh Tepa diversions, indicating that the combined scenarios do not effectively mitigate the reduction in hydropower generation caused by the Qosh Tepa diversions.

Table 2. Average annual hydropower generation from THC for selected scenario combinations

Scenario	Annual Generation (GWH)	Percent Change from Baseline
Baseline	754	
Baseline with Qosh Tepa	587	-22%
THC Dredge with Qosh Tepa	598	-21%
THC Expansion with Qosh Tepa	576	-24%
THC Expansion with THC Dredge and Qosh Tepa		-22%

IN SUMMARY

The findings from the WEAP model simulations of the THC in the Amu Darya River Basin reveal critical insights into water management strategies and their implications for sustainable resource utilization. Key highlights from the results are outlined below:

- **Impact of the Qosh Tepa Canal Diversions:** The simulations demonstrate that diversions to the Qosh Tepa Canal significantly impact both water deliveries for agriculture and hydropower generation from the THC. First, annual inflows into THC may be reduced by as much as 25 percent with diversions to the Qosh Tepa Canal. Annual water deliveries for agriculture are subsequently reduced by approximately six percent, highlighting the substantial challenge posed by external diversions. Similarly, hydropower generation faces a reduction of about 22 percent annually, underscoring more vulnerability of energy production to external water withdrawals.
- **Effectiveness of Management Scenarios:** The Expanded Storage and THC Dredging scenarios, aimed at increasing reservoir capacity and mitigating sedimentation, show varying degrees of effectiveness. Expanded Storage, while increasing overall water storage, exacerbates water diversion impacts, reducing

hydropower generation potential. THC Dredging scenario marginally increases hydropower generation by one percent but does not fully mitigate the broader impacts of Qosh Tepa diversions.

- **Synergistic Approach:** Combining both Expanded Storage and THC Dredging scenarios show mixed results, with benefits for agricultural water delivery but limited effectiveness in maintaining hydropower generation levels under the Qosh Tepa Canal diversions. The scenarios offset each other, resulting in marginal improvements rather than substantial gains in resource sustainability.
- **Policy and Governance Enhancements:** Effective water management in the THC requires robust governance frameworks and policy interventions. Addressing legal and institutional gaps is crucial for coordinating water allocations, managing diversions, and implementing adaptive management strategies effectively.

Overall, the assessment showed that there are several factors influencing water availability in the Amu Darya River Basin in the future, including variability of water flow under different climate projections sedimentation[3], increasing demands for water, and external factors – like construction of additional irrigation infrastructure (Qush Tepa Canal in Afghanistan). However, the influence of the Qosh Tepa Canal is observed in the lower Amu Darya River Basin – because the diversion point to the Qosh Tepa Canal is located below the basin's main water reservoirs. The model shows that the reduction in water availability will be only two percent overall in the Amu Darya Basin. However, it will affect more the downstream countries, Turkmenistan and Uzbekistan. Based on the example of THC, the assessment shows that it will significantly impact water availability and the generation of hydropower. This effect can be projected on the whole downstream area of the Amu Darya Basin.

There are ways to mitigate the external impacts. For the THC, exploring hybrid solutions to implement both – dredging and increasing the capacity of water reservoirs – leads to more impactful results rather implementing either individually. Further development of bilateral cooperation among Turkmenistan and Uzbekistan will help develop shared policies that promote equitable and sustainable water use practices.

In conclusion, sustainable water resource management in the Amu Darya River Basin necessitates proactive measures to balance competing demands to mitigate external pressures. By implementing integrated strategies based on the water-energy-food-ecosystems (WEFE) Nexus approach, enhancing water governance structures, and prioritizing adaptive management approaches, stakeholders can enhance resilience, optimize resource use efficiency, and ensure long-term sustainability of water resources in the region.

[3] More information on the sedimentation of the THC is presented in the Report - https://carececo.org/en/main/ckh/publications/prognoz-rosta-zaileniya-i-poter-vsledstvie-zaileniya-v-monetarnom-znachenii-na-ruslovom-vodokhranili/.

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Key Documents

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This report is made possible by the support of the American people through the U. S. Agency for International Development (USAID). The contents of this report are the sole responsibility of Tetra Tech and do not necessarily reflect the views of USAID or the United States Government.