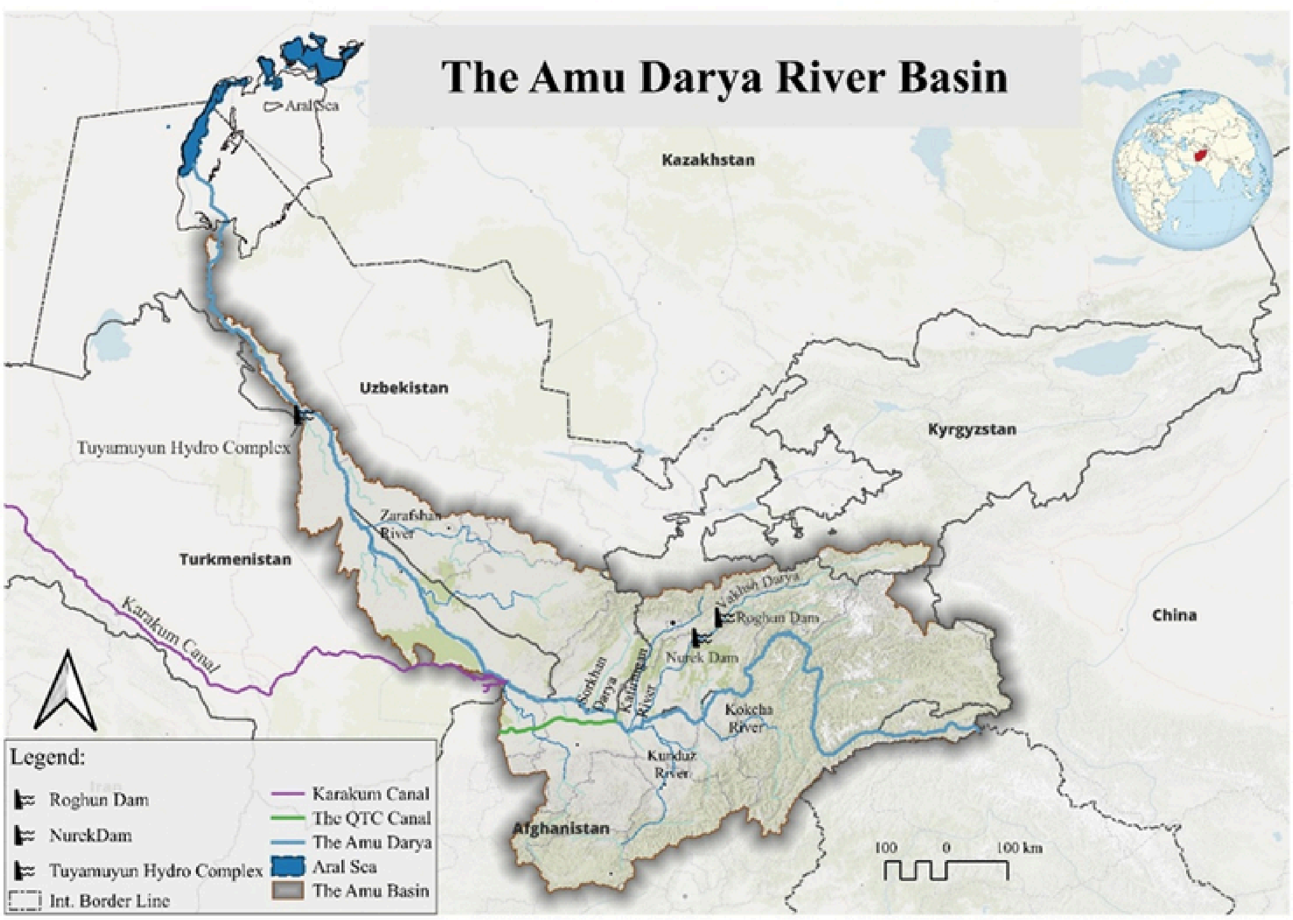
Water, Peace and Security

The Qosh Tepa Canal: Implications for Amu Darya Hydrology and Regional Hydropolitics



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The Qosh Tepa Canal: Implications for Amu Darya Hydrology and Regional Hydropolitics

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1 Executive Summary

Afghanistan's construction of the Qosh Tepa Canal (QTC) is one of the most consequential water developments in Central Asia, with far-reaching implications for the hydrology, governance, and political stability of the Amu Darya Basin. Once fully operational, the QTC command area would need an estimated 7.1 bm^3 or around 12% on average of Amu Darya annually for irrigation—decreasing water availability in downstream Uzbekistan and Turkmenistan, both of which are highly dependent on the Amu Darya for irrigated agriculture. The absence of a framework for consultation or coordination between Afghanistan and other riparians has further amplified uncertainty over the project's future trajectory and regional implications.

The QTC, the largest agricultural project in Afghanistan's history, is intended to enhance livelihoods, strengthen food security, and generate employment for communities affected by decades of conflict and poverty. However, its ultimate contribution to these goals will depend heavily on the quality of construction and operational efficiency, particularly with respect to conveyance losses, water management, and agricultural practices. If the canal is not built and managed efficiently, it may fail to deliver its anticipated socio-economic benefits and could even exacerbate existing water and governance challenges. Once the canal is operational, the water abstraction is likely to compete with the peak downstream irrigation needs, exacerbating existing water stress in an already over-allocated basin. This challenge is compounded by the accelerating impacts of climate change, rising temperatures, shifting precipitation patterns, and the retreat of Pamir and Hindu Kush glaciers that sustain Amu Darya flows. These trends are expected to heighten seasonal variability, reduce dry-season availability, increase competition among sectors and states and exacerbate environmental degradation and public health risks across the basin. The anticipated completion of the Rogun Dam in upstream Tajikistan around the same period, adds an additional layer of hydrological and political complexity.

Yet, despite these risks, the QTC also creates an opening for dialogue and cooperation. Because the project remains under construction and its full hydrological impacts will unfold gradually, there is still scope for technical collaboration and political engagement to mitigate adverse outcomes. Joint efforts and targeted investments in efficiency improvements—such as canal lining, modernized irrigation, adaptive cropping patterns, and better water accounting across the basin, could reduce losses and provide riparian countries with time to adjust. Moreover, regional engagement framed around shared challenges like climate change adaptation, food and energy security, regional trade and transit, and resilience building may provide more constructive and politically feasible entry points for dialogue than direct water-sharing negotiations.

This study highlights that existing regional water institutions offer potential platforms for advancing water cooperation. However, they require long-awaited reforms and more inclusive approaches, particularly through integration of Afghanistan into these frameworks. Even an observer-level participation of Afghanistan could serve as a confidence-building measure and lay the groundwork for cooperation. At the same time, wider regional cooperation mechanisms beyond the water sector could also be leveraged to promote mutual benefits across the region. Given the political sensitivities surrounding water and the non-recognition of Afghanistan's de facto authorities, track 1.5 and track 2 diplomacy processes—facilitated through regional research centres, universities, civil society, and donor organizations—provide practical avenues for advancing constructive dialogue. Such platforms can also complement existing and new official processes by nurturing trust, enabling evidence-based exchanges, and promoting a culture of cooperation grounded in shared risks and shared opportunities.

Importantly, the time for such engagement is now. With the rapid progression of the QTC, advancement of Rogun, accelerating climate impacts, and emerging geopolitical pressures, inaction carries rising costs for all the riparian states. Early coordination, joint analysis, and structured dialogue can help prevent deterioration of relations and steer the region toward cooperative pathways. To address the challenges in the basin, the report proposes several key recommendations:

- **Reframe water cooperation** around shared climate, water, energy, food and environment challenges with a particular focus on how to include Afghanistan in these topics/processes within existing dialogue processes.
- **Explore legal and institutional options for future cooperation:** Analyze feasible pathways for Afghanistan's gradual inclusion in IFAS, ICWC, ICSD, and River Basin Organizations, and map realistic future cooperation scenarios.
- **Leverage bilateral channels to complement slow regional processes** Resume and support existing bilateral water cooperation platforms with Afghanistan especially bilateral water committees with Tajikistan, Uzbekistan and Turkmenistan, to continue technical exchange, data and information sharing.
- **Promote efficient and sustainable water use** through climate-smart irrigation, adaptive cropping systems, experience sharing, better market access and targeted investments in climate-resilient agriculture.
- **Establish a Regional Research & Knowledge Network including Afghanistan** Create a platform for joint studies and technical analysis, knowledge and experience exchange, and capacity building involving universities, research centers, and experts from all riparian countries.
- **Enhance donor coordination** to align external support, avoid duplication, and ensure Afghanistan's inclusion in basin-wide initiatives.

2 Introduction

The construction of the Qosh Tepa Canal (QTC) on the Amu Darya in northern Afghanistan introduces new hydrological and geopolitical dynamics into an already fragile and water-stressed region. Once completed, the canal—stretching over 285 km, is intended to irrigate approximately 550,000 hectares of new and existing agricultural land inside Afghanistan (USAID, 2019). The canal would enhance livelihoods and food security in Afghanistan, offering hope to communities that have long faced chronic water scarcity, unemployment, and food insecurity, and have been plagued by decades of conflict and instability. However, the river flow diversion by the canal would also alter downstream flows and disrupt long-established water-sharing arrangements among the Central Asian riparians of Amu Darya. These arrangements, largely shaped during the Soviet era, have historically excluded Afghanistan despite its geographic position as a key upstream riparian state. As a result, the QTC marks Afghanistan's first large-scale attempt to utilize the Amu Darya's waters at a national scale, reshaping not only regional hydrology, but also the political landscape of transboundary water governance in Central Asia.

The Amu Darya, Central Asia's largest and most vital watercourse, supports more than 40 million people across Afghanistan, Tajikistan, Turkmenistan, and Uzbekistan with smaller portions of the basin extending into Kyrgyzstan and Kazakhstan (figure 1). Its waters sustain extensive irrigation networks that are central to the agricultural economies of downstream states, particularly the cotton- and rice-producing regions of Uzbekistan and Turkmenistan. However, decades of intensive irrigation, poor efficiency, and weak coordination have left the river system ecologically degraded and highly vulnerable to climate variability.

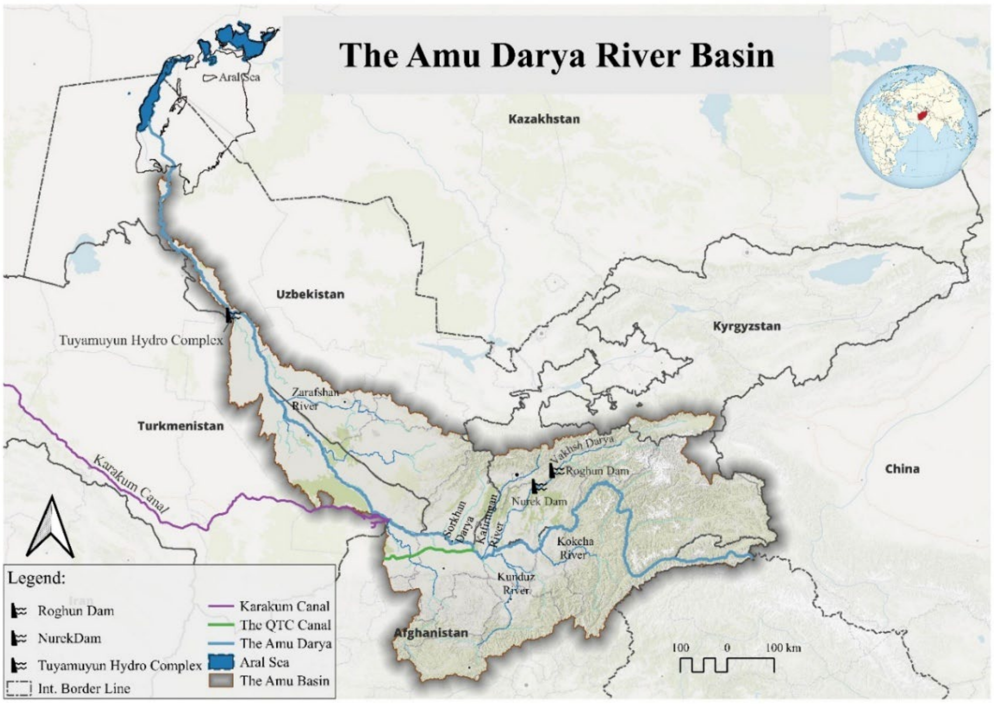

Figure 1. Amu Darya Basin: catchment areas, riparian countries, major tributaries, and key infrastructure.

Against this backdrop, two major developments—the large-scale diversion of water through Afghanistan's QTC and the significant new storage capacity created by Tajikistan's Rogun Dam—are advancing in parallel. Both are likely to become operational around the same period. Without a corresponding basin-wide dialogue and coordination, these shifts in water use and regulation could have wide-ranging environmental, socio-economic, and political consequences for all riparian states. This report provides an integrated assessment of the QTC's potential impacts on the Amu Darya Basin, combining water balance assessment with political economy and socio-economic analysis. On the technical side, the research first estimates irrigation demand for the QTC command area based on the major crops planned for cultivation according to the canal's feasibility study. The research then employs a Conceptual Water Balance Approach (CWBA) to assess the canal's potential impacts on average flows at the Kerki gauging station on the border between Turkmenistan and Uzbekistan. Using historical inflow data, this approach estimates outflows- diversions for agricultural use, to assess monthly and annual water balance variations at Kerki station. Given the unavailability of detailed basin-wide data, the CWBA provides a pragmatic framework for estimating the scale and timing of flow reductions, while identifying key uncertainties, data gaps and critical assumptions.

The results are then complemented by a broader qualitative assessment of QTC's socio-economic and geopolitical implications. This includes an assessment of potential downstream impacts on agricultural productivity, food and energy security, and livelihoods in Turkmenistan and Uzbekistan—countries where over 80% of the Amu Darya water are used and nearly 40% of the population relies directly or indirectly on agriculture (Abdullaev & Akhmedov, 2024). The report also considers how the canal could reshape regional political relations and challenge the existing institutional frameworks such as the International Fund for Saving the Aral Sea (IFAS) and the Interstate Commission for Water Coordination (ICWC).

Beyond immediate hydrological and climate change impacts, the report situates the QTC within the broader context regional hydropolitics. The Amu Darya's headwaters, originating in the Pamir and Hindu Kush ranges, are among the most climate-sensitive in the world. Glacial and snow melt contributes a significant portion of the river's annual flow, yet recent studies project that continued temperature rise could significantly reduce this contribution over the next three decades (Savoskul & Smakhtin, 2013). Increased flow variability shifts in seasonal timing, and the intensification of droughts will likely compound the challenges posed by the QTC, straining both local adaptation capacities and regional cooperation mechanisms. The effect of climate change has been assessed through implications on water balance components, mainly inflow and expected abstraction by the QTC.

It should be noted that this report does not include the potential impacts of the Rogun Dam in upstream Tajikistan, which represents an additional critical factor influencing basin hydrology and future water availability.

The report aims to move beyond a narrow focus on water competition by identifying opportunities for cooperative adaptation, shared resilience, and broader regional integration.

By integrating technical aspects of water management with political economy and socio-economic perspectives, it underscores that the QTC, while a potential source of tension, can also serve as an entry point for renewed regional dialogue not only on sustainable water use and benefit-sharing, but also on interlinked sectors such as energy, trade, transit, food security, and environmental management. Strengthening cooperation across these interconnected domains could unlock the region's enormous potential for economic growth, stability, and integration, transforming a source of contention into a platform for mutual gain and long-term peacebuilding.

The findings draw on academic and policy literature, organizational reports, and publicly available data. Building on this, the report provides a foundation for understanding the QTC's implications and for informing policies that balance national development goals with the collective management of a shared and fragile transboundary river system. The report concludes with practical recommendations to guide more cooperative, resilient, and equitable management of the Amu Darya Basin.

The following three chapters begin by outlining the hydrology, water use, and governance arrangements of the Amu Darya Basin. Chapter 3 presents an in-depth analysis of the QTC, including its hydrological and broader socio-economic and political impacts. Chapter 4 interprets these findings, synthesizes the key risks and opportunities, and offers actionable recommendations to support cooperative and sustainable basin management.

3 Water Resources and Uses in the Amu Darya Basin

This chapter provides an overview of water resources and water use in the Amu Darya Basin, drawing primarily on existing literature due to the limited availability and reliability of hydrological and water-use data in the region. It also highlights regional water governance arrangements and key socio-economic dimensions shaping the basin.

3.1 Water Resources of the Amu Darya Basin

The Amu Darya Basin, covering approximately 534,000 km², is Central Asia's largest and most complex transboundary river system. Originating in the Pamir–Hindu Kush mountains, the river flows for nearly 2,400 km before reaching the Aral Sea delta, draining territories of Afghanistan, Tajikistan, Uzbekistan, and Turkmenistan, with minor headwaters in Kyrgyzstan. The river forms at the confluence of the Panj and Vakhsh rivers, with major tributaries including the Kafirnigan, Surkhandarya, Sherabad, Kunduz, and Kokcha rivers. Historically, the Zarafshan River also contributed to the Amu Darya, but its flow is now almost entirely diverted within Uzbekistan for irrigation.

Hydrologically, the basin is dominated by snow and glaciers melting, resulting in pronounced seasonal variation—flows peak in late spring and summer, then declining sharply in dry years. Annual discharge at the Kerki Station has fluctuated between 72 km³ and 123 km³ (Wang et al., 2016), averaging around 78 km³ (UNECE, 2011). The Vakhsh River alone contributes about

25% of this volume (Olsson et al., 2009), drawing from alpine glaciers such as the Abramov (Kyrgyzstan) and Fedchenko (Tajikistan). The Panj River, originating near the Vakhdjir Pass, delineates much of the Afghanistan–Tajikistan border, with roughly 42% of its catchment in Afghanistan and 58% in Tajikistan (Rosenthal, 2009). Among Afghanistan's tributaries, the Pamir, Wakhan, Kunduz and Kokcha rivers are particularly significant. Figure 2 illustrates major inflows and outflows of the Amu Darya Basin.

The Scientific Information Centre of the Interstate Commission on Water Coordination (SIC ICWC) estimates that approximately 74% of the Amu Darya's surface water originates in Tajikistan, 13–15% in Afghanistan, 8.5% in Uzbekistan, and 1.7% in Turkmenistan. These proportions vary among datasets from different sources. For instance, data from the Afghan government estimates that Afghanistan contributes approximately 24 (bm^3) or 30% of the total renewable water resources of the Amu Darya (Vinokurov et al., 2023).

Throughout its course, the river defines large portions of political boundaries—between Afghanistan and Tajikistan, along the full Afghanistan–Uzbekistan border, and parts of the Afghanistan–Turkmenistan and Turkmenistan–Uzbekistan borders. However, due to highly variable flows and embankment activities on the right bank, the Afghan side has experienced severe erosion, causing the river to shift its course inside Afghanistan in some areas and resulting in the loss of thousands of hectares of land each year. In the lower basin, large-scale irrigation withdrawals—particularly the Karakum Canal and the Tuyamuyun Hydro Complex—govern the flow regime and profoundly alter the river's hydrology.

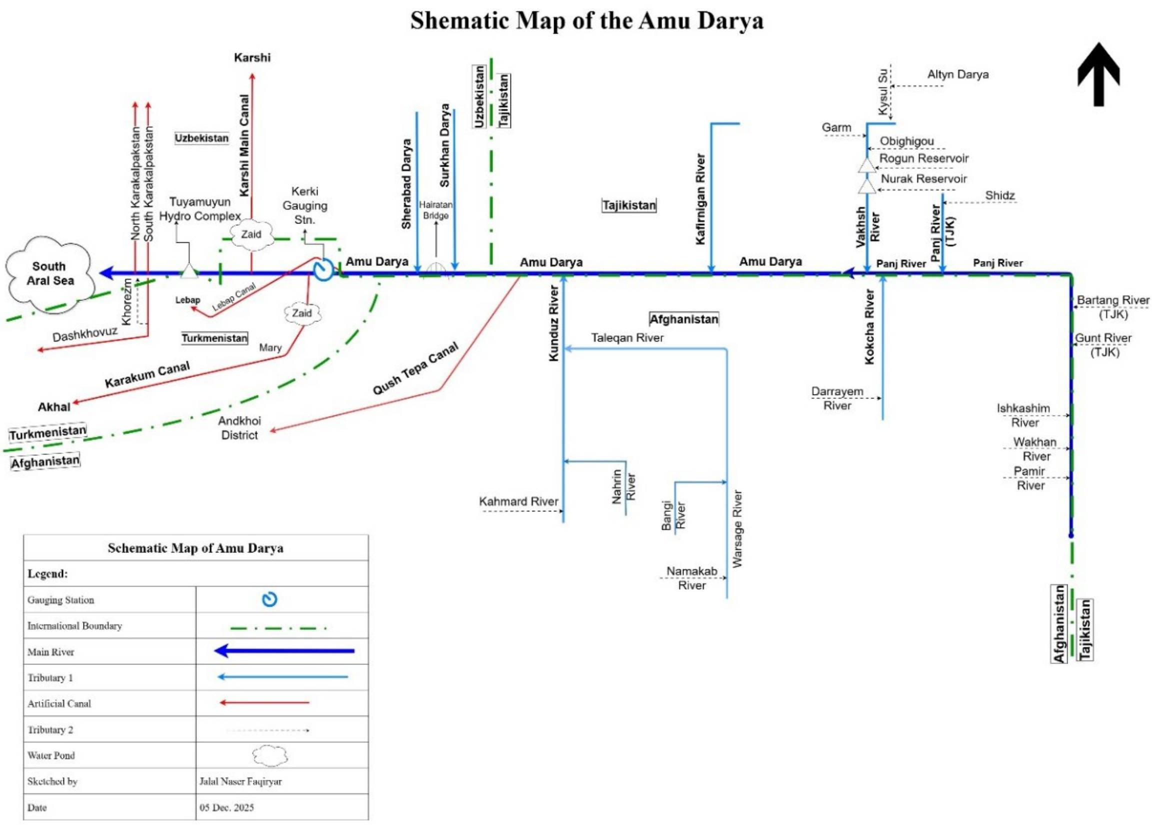

Figure 2. Schematic Representation of the River System, Illustrating Major Inflows and Outflows.

Until the 1980s, the Amu Darya still discharged into the Aral Sea, once the world's fourth-largest lake. Intensive irrigation withdrawals, inefficient water use, and rising demand have since the 1960s reduced downstream flows dramatically, transforming the Aral Sea into one of the most prominent symbols of unsustainable water management. Today, the basin faces chronic water scarcity, recurrent droughts, and heightened intersectoral competition, land degradation, high salinization and dust storms all within a predominantly arid and landlocked environment.

Groundwater resources in the Amu Darya Basin exhibit substantial spatial and temporal variability, shaped by the region's complex hydrogeology. In the delta region, groundwater levels fell sharply between 1999 and 2002, later recovering unevenly by 2017; while districts in Karakalpakstan Uzbekistan like Muynak continued to experience decline, others such as Karauzyak saw rapid rises (Pan et al., 2020). Recharge processes differ across the basin: in upper zones, infiltration from rivers and mountain runoff sustains aquifers, while in the lower reaches, recharge is minimal, and extraction often compensates for surface water shortages (Gafurov et al., 2019; Liu et al., 2020). Groundwater quality has deteriorated significantly, characterized by high salinity (up to 23 g/L in the delta) and mineralization linked to agricultural return flows—posing serious threats to both water usability and land productivity (Pan et al., 2020; Hao et al., 2023).

As glaciers play a vital role in maintaining the Amu Darya's flow regime by sustaining discharge during dry months, a detailed discussion of glacial retreat and climate-induced hydrological shifts follows in the subchapter on climate change impacts.

3.2 Water Resources Utilization and Distribution:

The Amu Darya's water resources are almost fully utilized, with approximately 98% of the river's annual flow in average years diverted by riparian states for irrigation purposes (Prniyazova et al., 2025). The majority—around 26-40 bm³ of total renewable water—supports agriculture in Uzbekistan, 23-28 bm³ in Turkmenistan, while Tajikistan's allocation use is estimated at about 7.5-8.5 bm³. Afghanistan's consumption is estimated at around 5 bm³ annually, and Kyrgyzstan consumes only between 0.1–0.5. bm³ of the river's flow annually (Zoï Environment Network, 2013). Table 1 presents water use by sectors for each of the riparian countries. Irrigated agriculture accounts for 92–98% of total water use in the Amu Darya Basin, while industrial and domestic consumption each represent only 1–7% (Duran, 2017).

The basin sustains more than 40 million people, providing livelihoods, food, and energy security. Middle and downstream regions face intense anthropogenic pressure from water use in agriculture, but upstream regions experience increasing environmental impact of activities such mining. Extensive irrigation has drastically reduced the Aral Sea's volume by over 90% since 1960, with the southern portion, fed primarily by the Amu Darya, nearly completely desiccated (Karimov et al., 2022).

Table 1: Water Use by Different Sectors in the Amu Darya Basin Source: Duran, 2017

Countries	Agriculture/Food	Urban	Industries
Afghanistan	*98%*	*1%*	*1%*
Kyrgyzstan	*93%*	*4%*	*3%*
Tajikistan	*90%*	*6%*	*4%*
Turkmenistan	*94%*	*2.7%*	*3%*
Uzbekistan	*90%*	*3%*	*7%*

At least eleven major water intakes divert Amu Darya water for irrigation across Tajikistan, Turkmenistan and Uzbekistan (Table 2). The largest, the Karakum Canal, constructed between 1952 and 1967, extends approximately 1300 km—almost reaching the Caspian Sea—and withdraws an estimated 22 bm^3 annually, serving as Turkmenistan's primary water artery.

Table 2. Major intakes from the Amu Darya *(Petersen, 2024, Rizk & Utemuratov, 2014, V.A.Dukhovniy & A.G.Sorokin, 2024, Cilek, 2017, V.A.Dukhovniy & A.G.Sorokin, 2024, Olsson et al., 2009, Wegerich, 2008, World Bank, 2014, Manschadi et al., 2010; Tischbein et al., 2013)*

No	Country	System/Canal Name	Location/Reach	Length (km)	Capacity (bm^3/y)	Irrigated Area (ha)
1	**Tajikistan**	8 Intakes from Amu Darya tributaries	Upper Reach	N/A	N/A	287,300
2	**Turkmenistan**	Karakum Canal	Middle Reach	1300	13.5 – 22	698,000 / 1,250,000
3		Tuyamuyun Hydro Complex (THC) – Dashoguz (TRK side)	Lower Reach	432	3.38	350,000 / 420,000
4		Lebap Province	Middle Reach	N/A	N/A	315,000
5	**Uzbekistan**	Amu-Bukhara Main Canal (ABMC) System	Middle Reach	385	3.85	315,000
6		Karshi Canal (Kashkadarya)	Middle Reach	79	4.5 – 5	332,000 / 720,000
7		Tuyamuyun Hydro Complex (THC) – UZB side	Lower Reach	102	7.8	500,000 / 270,000 – (Khorezm)
8		Amu-Zang Irrigation System (Surkhan darya)	Lower Reach	56.6	3.9	96,800 / 108,520
9		Sherabad Main Canal System	Lower Reach	27	4.7	103,400 (Khazarbag-Akkapchigay)
10		Pakhtaarna Canal – Karakalpakistan	Lower Reach – right bank	N/A	N/A	412,000
11		Khorezm Region Intakes	Lower Reach – main canal	N/A	N/A	270,000

In addition to these major intakes, the basin includes numerous left/right-bank intakes and large distributaries (e.g., Pakhta-Arna, Suenli, Parallel, Dustlik), plus extensive collector–drainage works managed by the Basin Water Organizations (BWO) "Amu Darya. Together they comprise hundreds of pumping stations and dozens of reservoirs that shape seasonal delivery across Uzbekistan/Turkmenistan oases (OSCE, 2017; Sanu Khanal et al., 2023). The QTC would be the first major intake in the Afghan part of the basin.

The flow of the Amu Darya is regulated primarily by the two major reservoirs: Nurek dam, located upstream on the Vakhsh River in Tajikistan, and Tuyamuyun Hydro Complex, a system of dams, canals and four interconnected reservoirs at the lower Amu Darya along the Uzbekistan and Turkmenistan border. Together, at full live capacity, these reservoirs can store approximately 20–22% of the river's annual flow. Both have, however, lost a considerable part of their designed storage capacity due to siltation - 17-20% in the Nurek reservoir (UNEP, 2011) and 38-45%, in the Tuyamuyun Hydro Complex (World Bank, 2010). Numerous smaller reservoirs are scattered across irrigated areas in Uzbekistan and Turkmenistan. The largest planned reservoir in the basin, the Rogun Dam on the Vakhsh River in Tajikistan, is expected to hold around 13.5 km^3—potentially controlling nearly 20% of the river's flow in average years once operational (CAWater-Info, n.d.). Similarly, Afghanistan's QTC represents a major planned diversion in the basin. Currently, Afghanistan has no operational large-scale dams or reservoirs on the Amu Darya system. The completion of the Rogun and QTC projects is expected to substantially reshape water utilization patterns across the basin.

3.2.1 Agriculture

The Amu Darya Basin represents one of the oldest irrigated regions in Central Asia, with approximately four million hectares currently under cultivation. Agriculture remains the dominant economic sector across the riparian states. Historically, ancient cities such as Bukhara, Samarkand, Khiva, and Balkh relied on surrounding rural agricultural systems for sustenance, fostering local food security and regional trade. Despite this rich agricultural heritage, the harsh continental climate, recurrent water deficits, and limited access to agricultural inputs continue to constrain productivity.

In Tajikistan, irrigated agriculture has gradually shifted from cotton to food crops such as potatoes, barley, and rice, though cotton remains widely cultivated. Agriculture contributes approximately 20-25% of the GDP (The Global Economy, 2025; White Peak, 2025). The sector depends heavily on 798 electric pumping stations serving 62% of all irrigated lands. Regular maintenance and the replacement of pumps and canal structures remain persistent challenges.

Uzbekistan is the largest water consumer in the Amu Darya Basin, with agriculture accounting for over 92% of total withdrawals (Schlüter et al., 2013; Satymov, 2025). Cotton remains the dominant cash crop, with an annual output of about 1 million tons (FAS Turkey Staff, 2022), although recent government policies encourage diversification into cereals and higher-value crops. Agriculture's contribution to GDP was around 18.3% in 2024, down from 20.2% in 2023, reflecting a gradual shift toward economic diversification (Trading Economics, 2025; The Global Economy, 2025).

In Turkmenistan, agriculture is constrained by its predominantly desert landscape and contributes roughly 10% to GDP. Cotton remains the principal export crop, occupying over half of cultivable land. Wheat, rice, corn, fodder, grapes, almonds, vegetables, melons, and pomegranates are grown primarily for domestic use and livestock feed. Despite agriculture's modest GDP share, the sector remains the largest employer and an important avenue for rural development (Moody's Analytics, 2025).

In Afghanistan, agriculture contributed 34.7% of GDP in 2023 (World Bank, 2023), with over 80% of the population depending on it for livelihoods. Major crops include wheat, barley, maize, alfalfa, onions, potatoes, and cotton (Ministry of Agriculture, Irrigation and Livestock, 2019). Livestock provides a vital source of food and income, though water scarcity remains a critical constraint, exacerbated by prolonged instability and poverty (Abdullaev & Shah, 2011).

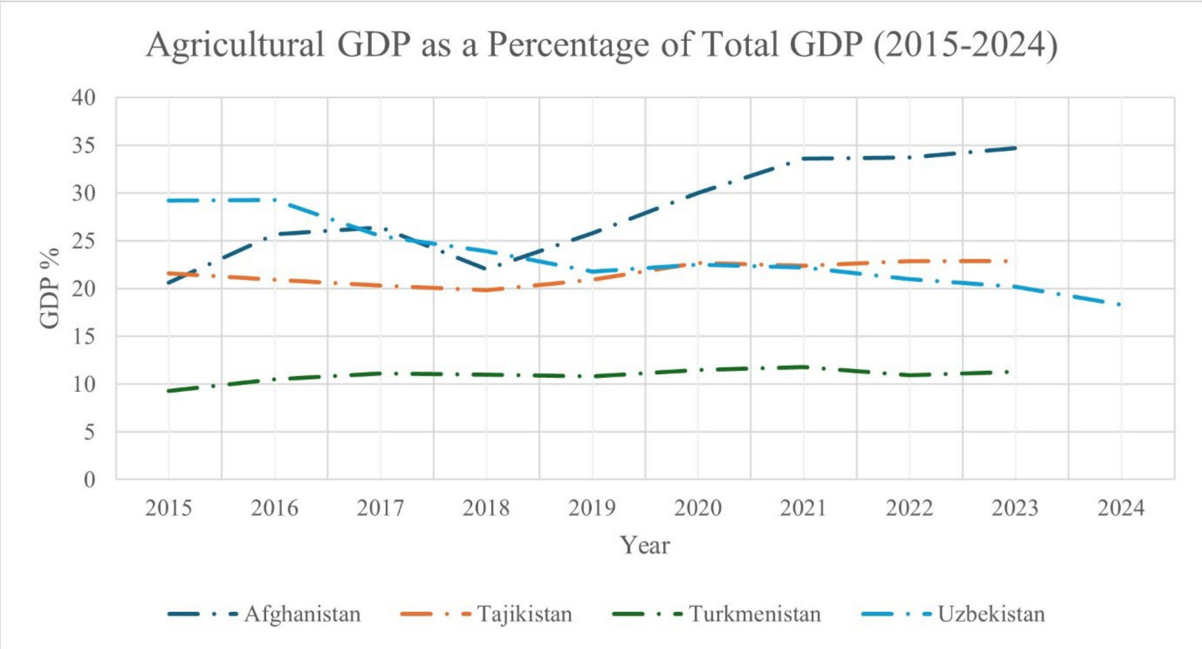

Figure 3: Agricultural GDP as a Percentage of Total GDP (2015-2024) (Source: World Bank, 2023).

The analysis of agricultural GDP underscores contrasting economic trajectories in the region. Afghanistan is increasingly reliant on agriculture, reflected in the sector's growing share of national GDP. In contrast, Uzbekistan's declining agricultural GDP contribution indicates a deliberate shift toward economic diversification. Tajikistan and Turkmenistan, meanwhile, exhibit relative stability, with agriculture remaining a consistent and central pillar of their economies (World Bank, 2023).

3.2.2 Energy

Hydropower represents another vital use of the Amu Darya's waters, particularly for Tajikistan—a mountainous country with limited arable land. Hydropower accounts for more than 90% of Tajikistan's total electricity generation (Union, 2021; World Energy Outlook, 2025). Tajikistan aims to continue the construction of new hydropower stations to keep pace with economic growth.

Country	Name	River	Installed Capacity (MW)	Average annual output (GWh)
Tajikistan	Rogun (under construction)	Vakhsh	3780 (planned)	-
	Nurek	Vakhsh	3,000	13,465
	Baypaza	Vakhsh	600	2,732
	Vaksh Cascade	Vakhsh	285	1,298
	Sangtuda-1	Vakhsh	670	2,184
	Sangtuda-2	Vakhsh	220	1,000
Uzbekistan	Tuyamuyun	Amu Darya	150	571

Table 3: Major hydropower infrastructures in the Amu Darya Basin. (Source:Asian Infrastructure Investment Bank, 2024; Union, 2021; Nexus, 2021; Power Technology, 2024)

The cornerstone of hydropower production on the Vakhsh–Amu Darya system is the Nurek hydropower plant, which generates around 70% of Tajikistan's electricity and is operated primarily to cover a chronic winter energy deficit of roughly 2,700 GWh—about one quarter of winter demand (Fields et al., 2013). Sedimentation has reduced Nurek's live storage capacity by roughly one third, to less than 4 km^3, forcing Tajik operators to run the Vakhsh cascade in an "energy-first" regime: capturing summer glacier-fed inflows and releasing them in winter to keep lights and heating on (World Bank, 2012). This operating logic is structurally misaligned with the irrigation regime of downstream Uzbekistan and Turkmenistan, where large canal systems and cotton- and wheat-based agriculture depend on high flows in late spring and summer and account for the vast majority of basin withdrawals (Mamatova et al., 2016). Winter releases are of little use for irrigation and can even be damaging, while reduced or delayed summer discharges translate into lower yields, higher pumping costs, soil salinization, and further stress on the Aral Sea delta (Bekchanov et al., 2015). Hydrologically, the existing cascade has already altered the timing and reliability of Amu Darya flows: mid-winter discharges are higher than under natural conditions, and the capacity to guarantee peak summer releases is weakened by both lost storage and the imperative to meet winter power demand (Fields et al., 2013). Ecologically, these seasonal shifts compound decades of over-abstraction and infrastructure-driven change in the lower basin. To meet energy demands and balance the loss of energy imports from neighboring countries, Tajikistan has been constructing new HPPs in the past decades. The biggest – and most controversial – is the Rogun HPP, which began its operation in 2018. The question if and how the operation regime of these dams is coordinated between the energy and agricultural sectors is crucial for the resilience to impacts of the QTC – and can either exacerbate water shortages or mitigate negative consequences.

3.2.3 Domestic Use

Domestic water demand remains minor compared to agriculture, accounting for approximately 6% of total flow. Yet usage has increased significantly since the 1970s—by approximately 2.12 bm^3, or 0.4 bm^3 per year (Z. Wang et al., 2022). Population growth is expected to further heighten demand.

Table 4: Monthly and annual average domestic water needs of populations living adjacent to the Amu Darya in each riparian country.

Country	**Population in Amu Darya Basin (million)**	**Domestic Water Demand/capita/year (m^3)**	**Total annual Domestic Water Demand /year (Mm^3/*year*)**
Afghanistan	12	62.76	753
Tajikistan	7	69	483
Kyrgyzstan	0.5	63	32
Uzbekistan	17	109	1,853
Turkmenistan	3	74	222
Total	**39.5**	**84.63**	**3,343**

3.2.4 Environmental Use

Before the 1960s, the Amu Darya contributed around 70% of total inflow to the Aral Sea (Murodov et al., 2023). However, massive water abstraction primarily for the large-scale expansion of irrigated cotton cultivation between 1960 and 1985 disrupted the natural hydrological regime, drastically reducing flows to the Aral Sea and creating one of the world's most severe ecological disasters (ibid).

The Aral Sea has since lost roughly 70% of its volume, devastating regional ecosystems and economies. Rising salinity has eliminated indigenous fish populations and 60,000 fishery jobs, while windborne salt and chemical dust now travel up to 500 km (Micklin, 2007), degrading land and air quality across vast areas including northern and central part of Afghanistan.

Although regional agreements exist to address the Aral Sea crisis and should guarantee an annual minimum inflow from Syr Darya and Amu Darya, competition over irrigation water continues to prevent sufficient environmental flows. Studies using flow duration curve (FDC) methods indicate that only around 35% of naturalized mean annual flow would be required to sustain downstream ecosystems, yet these thresholds are consistently unmet below the Kerki gauging station (Schlüter et al., 2013).

3.3 Climate Change Impacts on the Amu Darya Basin

The Amu Darya Basin spans contrasting climatic zones—from the cold, glaciated highlands of the Pamir and Hindu Kush ranges down to the hot, arid deserts of Uzbekistan and Turkmenistan. Precipitation falls mainly between October and May, with heavy snow in the mountains and light rainfall in the plains. This pattern produces a melt-dominated hydrological regime, where river flows peak between May and August (Jalilov et al., 2013).

Mean annual temperature across the basin is about 13°C, though regional variation is pronounced: downstream temperatures often exceed 30°C in July, while upstream areas remain below freezing in winter. Over the past century, the basin has warmed by approximately 2°C, with high-elevation zones heating at twice the global average (Khodjiev, 2023; Su et al., 2025). Maximum temperatures are rising, intensifying evapotranspiration, while warmer minimum temperatures shorten frozen periods and trigger earlier snowmelt (Murodov et al., 2023).

Among riparians, Turkmenistan has recorded the steepest warming, while Tajikistan shows the least. Annual precipitation remains highly variable—ranging historically from 113 mm (1917) to 353 mm (1969)—but most downstream regions now receive less than 100 mm annually (Britannica, 2023). Afghanistan has warmed by about 1.8 °C from 1950 to 2010—more than double the global average—contributing to recurrent droughts and floods (Akhtar & Shah, 2020; Shokory & Lane, 2023).

The sparsely populated headwater zones exert relatively limited anthropogenic pressure compared to lower reaches, yet climate impacts are clearly visible. Many glaciers have already disappeared, and the total glacier area has declined by around 30% in the past three decades (ADB, 2022). Glaciers are a critical driver of the Amu Darya's hydrology, providing steady meltwater during peak irrigation periods and buffering the system in dry years (Petrov & Akhmedov, 2018).

However, this buffering capacity has reached its peak feeding point (Glantz, 2005), after which overall runoff is expected to decline (Shokory & Lane, 2023). Between 1957 and 1980, an estimated 126 km^3 of ice was lost (Olsson et al., 2009). The Pamir glaciers alone lost 16% of their area in that period, while the basin as a whole has shrunk by about 30% since the 1990s (Khodjiev, 2023).

Accelerated melting initially increases river discharge but leads to a sharp decline once glacial reserves are exhausted. Under the various climate scenarios, the basin could lose a significant part of its glacier area by 2100 (Hou et al., 2024).

Overall, climate models predict a 2.8°C temperature rise across the basin by 2060, accompanied by reduced precipitation (Murodov et al., 2023). By the 2050s, annual runoff may decrease by 10–15%, and normal summer flows could drop 26–35% (Petrov & Akhmedov, 2018). In the Panj sub-basin alone, streamflow is projected to decline by 25% by 2030 (Shokory et al., 2023).

Less snow and more rain instead would also yield to more sediment dynamics in Amu Darya which trigger more erosion of riverbanks and river. Glacial lake outburst floods as result of glacier melt have also increased in Amu Darya head catchment and has contributed to sediment mobilization. More sediment mobilization can pose a threat to flow regulation and hydraulic infrastructure (Azizi & Lane, 2025).

Earlier snowmelt will likely shift peak flows to spring, reducing summer water availability precisely when agricultural demand is highest. According to ADB (2013a), agricultural water requirements are projected to increase by around 9% by 2050 which doesn't account for additional demand from the QTC command area. While accelerated glacial melt may temporarily boost discharge, the high discharge would be unsustainable and will be followed by persistent water deficits (Salehie et al, 2022a).

In the Amu Darya Basin, downstream countries already face water stress, and future reductions in supply will intensify scarcity. Between 2008 and 2020, water availability declined by an estimated 25–30% in dry years. Reduced flows will heighten tensions between upstream hydropower generation and downstream irrigation, threatening both food and energy security.

Additionally, Central Asia's vulnerability also stems from low water productivity, dependence on water-intensive crops, and heavy reliance on transboundary inflows. By mid-century, the combined effects of rising temperatures, declining glacial reserves, and shifting runoff patterns will fundamentally reshape water distribution in the Amu Darya Basin. Without adaptive measures, these trends are likely to exacerbate hunger, food insecurity, public health challenges, and even political instability across the region (F. Su et al., 2022; White et al., 2014; Zhan et al., 2022)

3.4 Regional Water Governance

In the late 1980s, as water shortages worsened in the Soviet Union, two Basin Water Organizations (BWOs) were created to manage the Amu Darya and Syr Darya. Withdrawal limits were established according to annual water availability, coordinated and enforced by the BWOs. In 1987, Protocol 566 formalized annual water quotas for Uzbekistan, Turkmenistan, Tajikistan, and Kyrgyzstan. The four republics were authorized to withdraw 61.5 bm^3 annually, while Afghanistan's estimated withdrawal of 2.1 bm^3 was noted separately.

The water allocation of Amu Darya between four Central Asian Republics based on the Almaty Agreement 1992 are presented in the table 6.

Table 5: Protocol 566 (1987) Water Allocations for the Amu Darya Basin.

#	Countries	Shares from the Amu Darya [%]
1	Kyrgyzstan	0.6-0.7
2	Tajikistan	15,4

3	Turkmenistan	35,8
4	Uzbekistan	48.1 – 48.2
Total		100

Following the dissolution of the Soviet Union, the newly independent Central Asian states transitioned to separate national water management systems, disrupting the previous basin-wide, integrated plans. To counter this fragmentation and coordinate transboundary water resources, the Central Asian countries on February 18, 1992, signed the "Agreement on Cooperation in the Field of Joint Management of the Use and Conservation of Water Resources in Interstate Sources," known as the Almaty Agreement. It provided the basis to establish the Interstate Commission for Water Coordination (ICWC). This body inherited the foundational water allocation principles of the Soviet era and continued to be responsible for setting annual water withdrawal quotas for the Amu Darya and Syr Darya for both growing and non-growing seasons. However, the negotiation within ICWC is sometimes challenged by diverging national priorities, particularly during dry years which leads to inconsistent adherence to the agreed-upon water release and withdrawal (OECD, 2021).

At the broader regional level, the Interstate Fund for Saving the Aral Sea (IFAS) was established in 1993 to coordinate efforts in mitigating the environmental and socio-economic consequences of the Aral Sea crisis among countries and with donors, and to foster cooperative transboundary water management. However, a significant gap in this framework is the absence of Afghanistan. Historically, cooperation with Afghanistan on water issues has been limited, a situation stemming from decades of internal conflict and its historically limited water usage from the Amu Darya. To date, Afghanistan remains outside the key regional water governance institutions.

However, while several bilateral agreements and Memoranda of Understanding (MoUs) with Afghanistan—including some dating back to the Soviet era and touching upon water cooperation—have been signed (see Table 7), a comprehensive and effective framework to facilitate water cooperation between Central Asia and Afghanistan, whether bilateral or regional, remains absent.

3.5 Socio-economic aspects in the Amu Darya Basin

The Amu Darya is not only a critical water source but the economic backbone of Central Asia. Its water sustains agriculture, energy production, industry, and livelihoods for over 40 million people, most of whom live in rural areas and depend directly on water for jobs, food, and livelihoods. Limited regional water cooperation comes at a high cost: Pohl et al. (2017) estimated potential economic losses of around USD 4 billion due to inefficient and fragmented water management across Central Asia, excluding Afghanistan. This underscores the direct link between transboundary water governance and regional economic stability.

Most riparian countries, except Afghanistan, have been transitioning from centralized to more market-oriented economies and remain below the global middle-income threshold. According to the World Bank (2023), their GDPs are projected to grow by 1–10% annually in the near-term Afghanistan, by contrast, remains the poorest riparian, with nearly half of the population living in poverty and heavily reliant on subsistence agriculture.

Rural livelihoods encompass 50–70% of the population, with approximately 4 million hectares of irrigated agriculture providing their primary source of income and food security. Despite this dependence, the economic weight of agriculture varies across riparian states:

Table 6: Economic Indicators of Amu Darya Riparian States (Source: World Bank, 2024)

Indicators	Afghanistan	Kyrgyzstan	Tajikistan	Turkmenistan	Uzbekistan
Population, million people	42.6	7.2	10.6	7.5	37.2
GPD, billion USD	17.15	17.5	14.2	64.24	115
GDP per capita, USD/people	413.8	2423.9	1340.6	8571.6	3094
GDP growth in %	2.3%	9%	8.4%	2.3%	6.5%
Significant sectors of the economy	Agriculture, services, trade	Mining, agriculture, and remittances	hydropower, agriculture, food processing and remittances,	Oil and gas, infrastructure	Industry, agriculture, and services
Role of agriculture in GDP, %	36%	8.6%	23%	11.7%	24%
Rural, % of the population	70%	63%	72%	47%	50%
Poverty, % of population	49.4%	33.3%	12.4%	0.6%	11%

Agriculture's contribution to GDP is highest in Afghanistan and lowest in Turkmenistan, though the sector remains politically sensitive everywhere due to its employment and food security roles. In Uzbekistan and Turkmenistan, the cotton sector still shapes the political economy of water. Both rank among the world's top ten cotton producers (Nurbekov et al., 2015). Cotton occupies more than half of Turkmenistan's arable land and remains a major export earner, while in Uzbekistan it continues to employ a large share of rural labor despite ongoing liberalization and reform.

These water-intensive cropping systems—dominated by cotton, rice, and wheat—are historically linked to the Aral Sea's desiccation and continue to constrain sustainable water allocation. Agricultural productivity remains low due to outdated irrigation systems, poor drainage, deteriorating infrastructure, and high soil salinity. In Uzbekistan, nearly 50% of irrigated land is saline, causing yield losses of up to 30%, while an estimated 15% of all water withdrawals are used solely for leaching salts rather than for productive use (Hamidov et al., 2022). Climate extremes and recurrent water deficits further undermine productivity, leaving many farming communities highly vulnerable.

Recent reforms in Uzbekistan and Turkmenistan have focused on digitalizing water management, modernizing canals, and introducing water-saving technologies such as drip and sprinkler irrigation. These remain in early stages but signal important steps toward sustainable water use and soil restoration.

Afghanistan stands apart from other riparians in both socioeconomic and institutional capacity. It remains the poorest country in the basin, with widespread poverty and a fragile governance environment. A large number of provinces face severe water insecurity, driven by recurrent droughts and inadequate infrastructure (ACAPS, 2024). Afghanistan's hydropower and irrigated agriculture remain largely underdeveloped, constrained by political instability, lack of investment, and limited engagement in regional water-sharing frameworks.

While across the basin, consumptive water use is overwhelmingly dominated by agriculture (92–98%), industrial demand, however, is expected to increase steadily as riparian economies diversify and urbanize, creating additional pressure on irrigation allocations (Asian Development Bank, 2020).

The heavy reliance on irrigation and economic dependence on water-intensive exports of the downstream states create deep structural vulnerabilities across the basin. Food security, employment, and energy generation are all tightly linked to water availability. Recurrent droughts reduced glacial runoff, inefficient water use and ineffective regional cooperation could heighten these risks, especially in downstream states.

4 The QTC and Its Implications for the Amu Darya Basin

4.1 Overview of the QTC Project

The Qosh Tepa - also spelled Qush Tepa or Khosh Tepa - Irrigation Canal (QTC) is an ongoing large-scale irrigation project in northern Afghanistan. As of February 2026, the canal remains under construction with the Taliban De Facto Authorities (DFA) recent announcement that the second phase is 95% completed.

Once completed, the canal will span approximately 285 km in length, 100 m in width, and 8 m in depth and would have the capacity to divert up to 650 m^3/s, or 10–13 bm^3 of water annually from the Amu Darya. Its intake point is located on the Afghan–Tajik border near Kaldar district, Balkh province (see figure 3) from where it runs westward through Jowzjan and into Faryab province, connecting to the existing Andkhoi irrigation system. Traversing 11 districts, the project's total command area extends to approximately 550,000 hectares, of which about 78% consists of newly irrigated land, while the remaining 22% comprises existing agricultural land that currently lacks sufficient water and suffers from water scarcity and recurrent droughts.

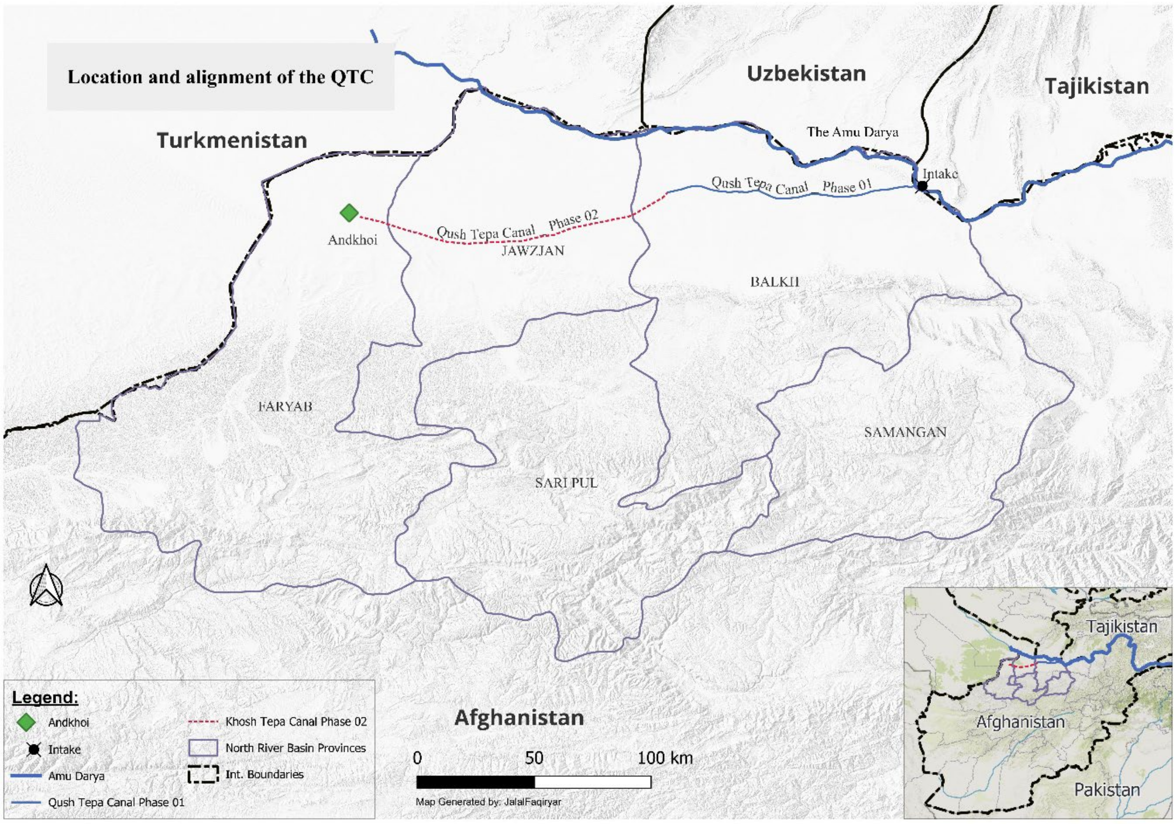

Figure 3: QTC on the Amu Darya

Originally conceived in 1970, the project's feasibility study (FS) was completed in 2018, followed by initial construction in 2021 under the previous Afghan government. Work was suspended during the 2021 takeover of Afghanistan by the Taliban and resumed in February 2022 under DFA.

The feasibility study of the canal project estimates that the total cost of constructing the QTC irrigation network over a projected nine- to sixteen-year period could exceed USD 2 billion. Although the DFA estimated basic excavation costs at roughly USD 684 million. The project is divided into three phases, with a total planned length of 285 km. Phase I included the construction of the intake structure and the first 108 km of the main canal. Phases II and III are designed to extend the canal by an additional 177 km, ultimately linking it to the Andkhoi district in Faryab province. Importantly, the project's long-term completion plan includes the development of secondary, tertiary, and quaternary canals, irrigation networks as well as head regulators and a comprehensive drainage network.

However, construction under the de DFA has not followed this implementation plan, and progress appears to be driven by ad hoc planning. The focus has largely been on excavating the main canal, with recent DFA announcements claiming that Phase II is nearly complete and that the main canal will soon reach 236 km and connect to Andkhoi irrigation canal. This is despite the intake structure—an essential component of Phase I—remaining unfinished, and no substantive work having begun on the secondary or tertiary canals.

Despite limited technical capacity and financial constraints, the project remains a high priority for the DFA. While the initial stages of the construction advanced rapidly, albeit without adherence to the original phased design, progress has slowed down since 2024. Some excavation machinery has reportedly been transferred to mining sites in nearby provinces. Work on the canal headworks is ongoing, several bridges along the canal have already been completed.

The main purpose of the QTC is to support agriculture development in the northern provinces of Afghanistan. Once completed, QTC would be the largest agricultural project implemented in Afghanistan's history. While the total command area of the canal is estimated to be around 585,000 hectares, based on the feasibility study report, 51% of this area is alkaline, and only 49% is ready for agriculture. This means even if the canal construction is completed soon, realizing full agriculture potential of the project will take longer. Moreover, the absence of concrete lining in the canal, particularly in the initial sections, could lead to high seepage losses and reduced water efficiency (Kuchins et al., 2024). Additionally, poor drainage and inefficient irrigation practices are likely to exacerbate soil and water salinization which could reduce agricultural productivity across the project area.

4.2 Assessment of the QTC impacts on the Amu Darya flow

Evaluating the impact of the QTC on the Amu Darya Basin requires quantifying the volume and timing of water withdrawals for irrigation within the QTC command area along with associated losses from evaporation, seepage, and agricultural and water management practices and how these would influence downstream water availability. To achieve this, first the irrigation demand for the total command area of 550,000 ha command areas of the QTC was estimated based on the planned crops mentioned in the feasibility study report, with an estimated 60% irrigation efficiency. Then a Conceptual Water Balance Approach (CWBA) was developed to estimate the QTC's monthly and annual water abstraction and calculate the remaining available water downstream at the Kerki gauging station. It should also be noted that the assumed irrigation efficiency of 60% applies only to on-farm irrigation demand and does not account for conveyance losses, including seepage and evaporation, within the canal system. These losses are not included in this calculation, as they depend largely on whether the canal will be lined and the final design and construction specifications.

Originally, the study intended to use the RIBASIM (River Basin Simulation Model), a sophisticated tool commonly employed for integrated river basin analysis and planning. However, the successful operation of RIBASIM requires comprehensive hydrological, hydraulic, and infrastructural data — such as operational rules of reservoirs, irrigation return flows, and seasonal flow distributions at sub-basin levels. Many of these datasets were either unavailable or highly inconsistent across different national sources.

Given these limitations, a Conceptual Water Balance Approach (CWBA) was developed. While simpler, this method still provides a robust estimate of how much water enters, is used, and exits the river system. It focuses on quantifying the annual and seasonal water balance of the basin. This approach's goal is not to provide precise engineering forecasts but to generate realistic, evidence-based insights into how the QTC could alter the basin's river flow.

4.2.1 Estimating Water Abstraction by the Qosh Tepa Canal

The irrigation water demand for the QTC was estimated using available design parameters and projected cropping patterns. According to project documentation and supplementary reporting, the canal is designed to irrigate approximately 550,000 hectares in northern Afghanistan, of which roughly 78% (about 214,500 ha) constitutes newly cultivated land. However, according to the canal's feasibility study, 51% of the designated lands are characterized by high alkalinity and are therefore not suitable for irrigation in the near term unless significant soil treatment or reclamation measures are undertaken. This means that only 49%—approximately 275,000 hectares—is currently ready for agricultural use. Nevertheless, the study estimates water requirements based on the full 550,000 hectares, rather than limiting calculations to the portion that is immediately cultivable.

The feasibility study identifies the primary crops expected to be grown in the command area. Crop water requirements were estimated using standard values form FAO (FAO, 2012a) and an estimated overall irrigation efficiency of 60% on farm, consistent with unlined earthen canals such as those planned for the QTC. Because detailed, sector-specific data were not consistently available, regional averages and FAO reference values for irrigation needs were applied. Water needs were then calculated according to the irrigation demand of the dominant crops. Effective rainfall was considered to compute irrigation requirements (Table 7).

Based on these assumptions, the cropping pattern across command area requires an average irrigation depth of about 1,015 mm/year. Per-hectare demand varies significantly by crop: orchards exceed 1905 mm/year, whereas wheat requires less than 341 mm/year. As a result, orchards (fruit tress) and maize together account for over half of total irrigation demand, despite covering only about one-third of the area. Wheat, while occupying the largest share of land (36%), contributes only around 11% of total demand—an important consideration when prioritizing crops under water-scarcity conditions.

Peak water demand occurs in July, reaching approximately 44.6 million m³/day. This peak is driven primarily by summer crops (maize, cotton, melon) and orchards. All calculations assume flood irrigation delivered through earthen canals with 60% efficiency.

Table 7: Irrigation water demand per crop in the QTC command area, assuming flood irrigation through earth canal

Crop	**Area**	**Crop Water Requirements (ETc)**	**Effective Rainfall**	**Net Irrigation Water Requirements (IWR)**	**Net IWR**	**Irrigation Efficiency**	**Gross IWR**	**% of Gross IWR**
	Ha	**mm**	**mm**	**mm**	**Bm³**	**(%)**	**Bm³**	**%**
Wheat	200,000	341	111	230	0.46	60	0.8	11
Maize	121,000	992	36	956	1.16	60	1.9	27-
Cotton	81,000	972	26	947	0.77	60	1.3	18

Melon	81,000	863	33	830	0.67	60	1.1	16
Orchards	67,000	1905	145	1760	1.18	60	2.0	28
Total	**550000**				**4.2**		**7.1**	**100**

As shown in Table 7, approximately 7.1 bm³ of water—equivalent to about 12% of the Amu Darya's annual flow at the Kerki gauging station (based on the six-year available mean flow data 2010-2015)—would be required to irrigate the QTC command area. These estimates exclude ecological, climatic, and environmental flow requirements and may vary depending on the efficiency of the main canal and conveyance losses, as they account only for on-farm irrigation efficiency. They are also based on the assumption that the crop mix identified in the feasibility study will indeed be cultivated; any significant changes in cropping patterns, temperature and precipitation of the area would shift total water demand.

It is important to note that abstraction will increase gradually as irrigation development expands over time. Bringing the full QTC command area of approximately 550,000-58500 hectares under cultivation is likely to take several years and require considerable technical expertise and financial resources, especially to address the estimated 51% of land affected by high soil alkalinity. Figure 4 illustrates the monthly irrigation demand once the canal is fully operational and the targeted irrigation area is achieved. The figure indicates that water demand peaks in July.

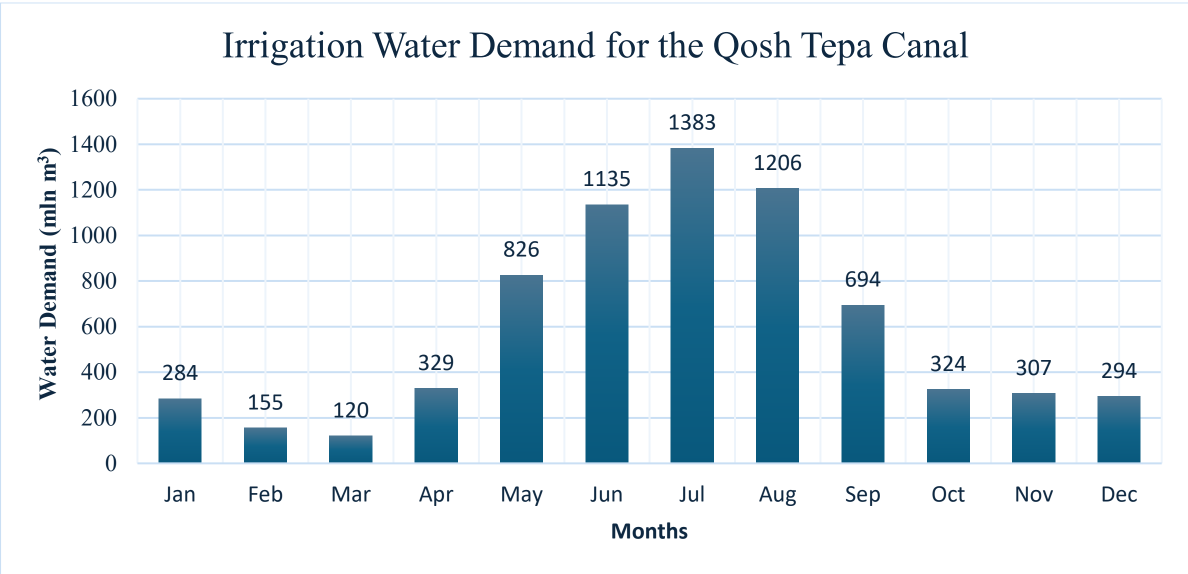

Figure 4: Monthly Irrigation Water Demand in QTC Command Area.

Temperature and precipitation patterns play a key role in shaping irrigation requirements in the QTC command area. The region experiences cool, relatively wet conditions from January to March, with mean temperatures below 15 °C and monthly rainfall of roughly 20–30 mm. From May through September, however, temperatures rise to 23–32 °C while rainfall falls to nearly zero, creating a hot, dry summer with almost no effective contribution from precipitation. A second, weaker rainy period occurs between October and December, but even then, the monthly totals remain modest relative to evaporative demand. This climatic pattern reinforces that peak irrigation demand coincides with the driest and hottest months, when rainfall provides virtually no offset to crop water needs. Figure 5 illustrates the temperature and precipitation regime across the QTC command area.

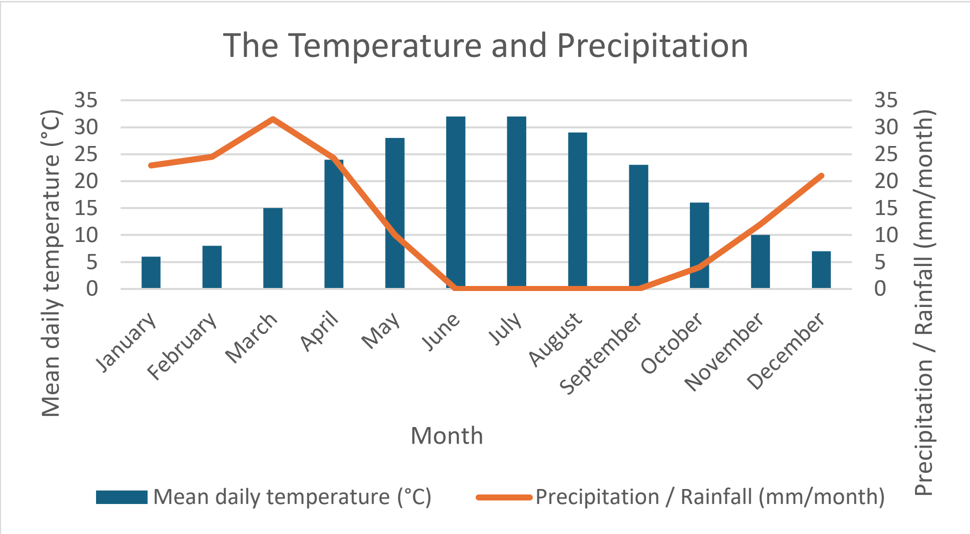

Figure 5: Temperature and Precipitation at Andkhoi station. (Data Source: Ministry of Energy and Water - AFG)

Taken together, the table and figure highlight a structurally irrigation-dependent system in which both crop choices and planting calendars must align with a sharply seasonal climate. Winter precipitation slightly reduces early-season requirements for wheat and orchards, but summer crops—such as maize, cotton, and melon—depend almost entirely on canal water during a prolonged dry period. For planning the QTC command area, these results underscore the need to size conveyance and potential storage capacity to accommodate very high peak flows in July and August, while also considering measures—such as improved application efficiency or modest adjustments to cropping patterns—to reduce pressure during the peak-demand period.

4.2.2 Implementation of the CWBA

The CWBA is designed to estimate the residual downstream flow at the Kerki gauging station after accounting for potential QTC water abstraction. The Kerki station, located near the city of Kerki in Turkmenistan on the left bank of the Amu Darya, was selected as the reference point because it captures the combined flow of all upstream tributaries after both natural and regulated inflows, and before major irrigation withdrawals occur in the lower basin. Moreover, discharge data from Kerki form the official basis for water allocation between Turkmenistan and Uzbekistan under Protocol No. 566. Available data from 2010 to 2015 shows flow records at Kerki station:

- The minimum annual discharge was 43,541 billion m^3,

- The maximum reached 71,958 billion m³ (in 2010),
- The six-year average was 58,496 billion m³ (Cawater-info, n.d.)

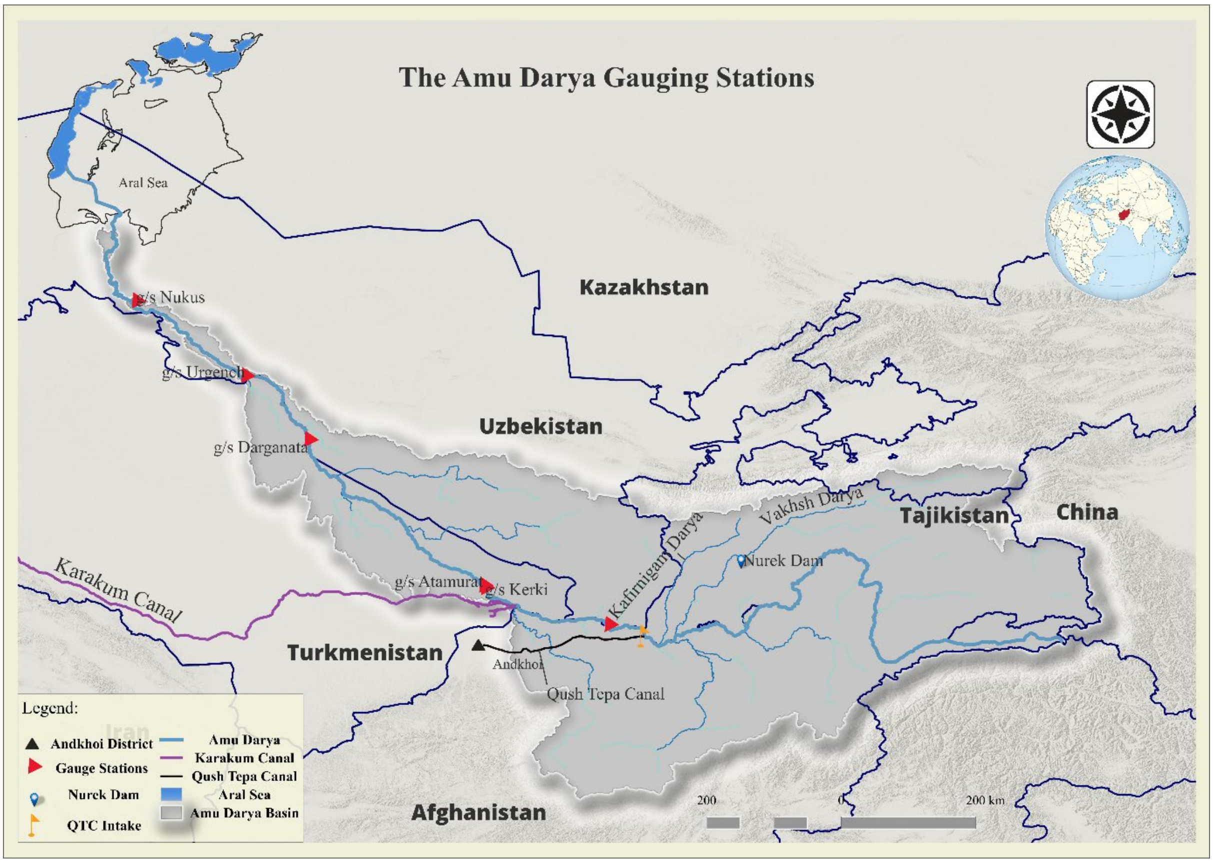

Figure 6: Location of Kerki station and other main gauging stations downstream of the QTC.

Steps for Calculating Monthly and Annual Reductions in Amu Darya Flow at the Kerki Gauging Station.

Step 1: Estimation of average monthly and annual reference flow at Kerki gauging station

In our analysis, we use the measured discharge at Kerki, which therefore accounts for the contributions of all the watersheds and sub-basins mentioned above. The average flow of the Amu Darya at Kerki (Avg. 2010–2015 – mln.m³) is obtained from measured discharge at the Kerki gauging station. The observed monthly flows over the years 2010–2015 are averaged to produce a single "typical" monthly flow value in billion m³. Summing, these twelve-monthly averages give the annual reference flow at Kerki for an average year.

Step 2: Estimating QTC Water Abstraction from total river flow
As calculated in the previous section, the QTC is projected to withdraw approximately 7.1 billion m³ per year for irrigation, with monthly withdrawals varying according to irrigation

water requirements. These estimates reflect net irrigation demand, assuming 60% irrigation efficiency on farm, excluding environmental requirements both seepage and evaporation in the main conveyance canal. This means actual diversion by the QTC could be still slightly higher than these estimates. Diversions peak during late spring and summer, aligning with the highest irrigation requirements. Because peak abstraction coincides with naturally high river flows, the withdrawal behaves proportionally rather than as a fixed constant—but nonetheless imposes sizeable reductions even during low-flow months.

Step 3: Calculating Remaining Flow at Kerki
For each month, the remaining flow is obtained by subtracting the projected QTC abstraction from the baseline Kerki discharge, producing a "reduced" hydrograph. The annual remaining flow is estimated at 52.1 billion m^3. While the seasonal pattern of high summer and low winter flows remains intact, the entire hydrograph is depressed, meaning downstream users, ecosystems, and allocation systems would need to adapt to a relatively smaller flow particularly during high irrigation season from May to August.

Table 8 summarizes the projected impact of QTCwithdrawals on the monthly flow of the Amu Darya at the Kerki station. The first column shows the 2010–2015 average monthly discharge, the second column lists the projected monthly QTC abstractions, the third column gives the remaining flow after abstraction, and the final column expresses the reduction as a percentage of the original flow.

On average, the canal is expected to remove roughly 12% of the six years average annual flow at Kerki. The largest absolute withdrawals, around 60% of the total withdrawals occur between May and August, coinciding with peak irrigation demand. In months with lower irrigation requirements, such as March and April, reductions are smaller.

Table 8: Remaining flow at the Kerki gauging station after the Qosh Tepa's water abstraction.

Month	Amu Darya at Kerki (Avg. 2010 – 2015 - mln.m^3)	Abstraction by Qosh Tepa (Projected - mln.m^3)	Remining flow (mln.m^3)	Reduction % per month
Jan	2582	284	2298	11
Feb	2526	155	2371	6
Mar	3373	120	3253	4
Apr	4257	329	3928	8
May	6478	826	5652	13
Jun	8226	1135	7091	14
Jul	9751	1383	8368	14
Aug	8174	1206	6968	15
Sep	4699	694	4005	15

Oct	3162	324	2838	10
Nov	2644	307	2337	12
Dec	2624	294	2330	11
Total	**58496**	**7058**	51438	12

4.2.3 Summary of findings

The approach used for this study indicates that the QTC could reduce the Amu Darya's annual discharge by approximately 12% or 7.1 bm^3 at the Kerki gauging station. This figure doesn't account for seepage and evaporation in the main canal. The actual volume of the diversion by QTC may vary in different years depending on:

- Crops, cropping patterns and agricultural practices,
- Seasonal rainfall and glacier melt contributions in upstream basins,
- Climate change-induced variability in inflows.

Other studies have produced varying estimates of QTC-related diversion. For instance, the feasibility study conducted in 2019 under the USAID-funded Strengthening Watershed and Irrigation Management (SWIM) project estimated annual diversions of approximately 13 billion m^3 under full development of the command area (550,000–585,000 hectares), and around 6.5 billion m^3 if only 275,000 hectares—representing about 49% of the command area classified as arable—are irrigated. However, current construction does not appear to be progressing in accordance with this feasibility study, and no updated or alternative technical plans from the DFA are publicly available.

Busch (2023) provides an early assessment based on satellite imagery, construction observations, and analogies with comparable regional canals. His analysis suggests an initial diversion of 2–3 bm^3/year, reflecting the expectation that only a limited area will be irrigated during the early years of canal operation, with withdrawals gradually increasing as infrastructure develops Busch (2023).

Gafurov et al. (2023) conduct a more detailed modelling exercise using irrigation demand projections, crop-water requirements, and assumptions tied to the full 550,000 ha command area. Rather than presenting a single diversion volume, they estimate reductions in downstream water availability of 5% by 2025 (after Stage I), 15% by 2028 (after Stage II), and up to 25% by 2030 after full completion. Based on historical flows of ~55–60 bm^3/year, a 25% reduction implies a diversion of 13–15 bm^3/year—far higher than Busch's estimate (Gafurov et al., 2023).

However, these higher estimates depend on highly optimistic assumptions. The modelling assumes that the entire command area will become irrigable by 2030, that ~250,000 ha of highly alkaline soils will be reclaimed, that the canal system will reach relatively high conveyance efficiencies, and that the de facto authorities (DFA) will rapidly develop the capacity to operate a large-scale irrigation scheme. These assumptions are inconsistent with current realities: As of February 2026, no water diversion has yet occurred; sub-canals and distribution networks remain incomplete; substantial parts of the command area remain unsuitable without major investment; the canal is unlined; seepage losses will be significant; and operational capacity remains limited. As a result, the 25% reduction scenario (13–15 bm³/year) likely overestimates what can be achieved in the near to medium term.

By contrast, our estimations arrive at a more conservative—and more plausible—estimate of 7.1 bm³/year, or roughly 12% of the Amu Darya's six years average annual flow. While it is difficult to out a timeline for the volume of abstraction, this estimate also reflects assumptions that total command area will likely to be brought under irrigation over a longer period of time, typical irrigation efficiencies in Afghanistan, and a gradual scaling of water withdrawals. The timeline of the abstraction will depend on the DFA plans and ability to push through the construction process. Importantly, our approach recognizes that agricultural water demand based on assumed crop patterns is inherently uncertain**,** since it is not guaranteed that the crops listed in feasibility studies will ultimately be cultivated, nor how many cropping seasons per year will be feasible under local climatic and agronomic constraints.

4.3 Implications of QTC

This section aims to contextualize the observed hydrological changes in the Amu Darya within the broader regional, socio-economic, and geopolitical landscape. Building on the findings of the CWBA, it examines how the projected reduction in river flow resulting from the QTC may influence livelihoods, agricultural productivity, and regional relations. The analysis employs a qualitative document review approach, drawing on policy documents, academic and policy literature, as well as relevant grey materials such as news reports, governmental and non-governmental publications, and expert commentaries. This approach allows for a comprehensive understanding of how technical shifts in water availability intersect with political economy, governance, and transboundary cooperation dynamics in Central Asia.

4.3.1 Regional Context and Evolving Dynamics

Decades of conflict and instability in Afghanistan have isolated the country from its northern neighbors, fostering a regional environment shaped primarily by security concerns rather than cooperation. Under the former Afghan Republic (2001-2021), Afghanistan's engagement with its neighbors expanded through a variety of bilateral and regional mechanisms with the support of international actors and organizations. Several cooperative platforms were initiated during this period, including the Heart of Asia–Istanbul Process and the Regional Economic Cooperation Conference on Afghanistan (RECCA), while collaboration also expanded through broader regional mechanisms such as the Shanghai Cooperation Organization (SCO), the UN Regional Centre for Preventive Diplomacy for Central Asia (UNRCCA), and various OSCE programs.

Economic, trade, and transit cooperation also deepened through major regional projects and initiatives such as the Turkmenistan–Afghanistan–Pakistan–India (TAPI) gas pipeline, the Central Asia–South Asia Electricity Transmission Project (CASA-1000), the Lapis Lazuli Corridor Agreement, Uzbekistan–Afghanistan-Pakistan railway and transport cooperation, the Chabahar–Central Asia transit route via Afghanistan, and expanded trade agreements with Kazakhstan and Turkmenistan. Additionally, Afghanistan engaged in several connectivity and infrastructure initiatives under China's Belt and Road Initiative (BRI), further linking it with Central Asian countries.

In contrast, cooperation over shared waters remained limited. Afghanistan has never been part of the International Fund for Saving the Aral Sea (IFAS) or the Interstate Commission for Water Coordination (ICWC). Bilateral arrangements were similarly narrow. Memoranda of Understanding (MoUs) on hydrological and environmental data sharing were signed with Tajikistan, while bilateral water cooperation committees, under the Bilateral Cooperation Commissions were established with Uzbekistan and Turkmenistan separately, though they achieved limited progress. A draft MoU on hydrological data exchange had been negotiated between Afghanistan and Turkmenistan but didn't finalize by the fall of the Afghan government in August 2021.

Engagement on water issues mostly occurred only indirectly and to a limited extent through broader initiatives such as the World Bank supported Central Asia Water and Energy Program (CAWEP), the United Nations Regional Centre for Preventive Diplomacy (UNRCCA), the UNECE Water Convention Secretariat, Central Asian Regional Environmental Centre (CAREC), USAID-funded Smart Water Project, and the German funded Green Central Asia Initiative. While these processes were important platforms for dialogue, exchange of information and establishment of professional networks, they did not provide or lead to formalized water cooperation between Afghanistan and Amu Darya riparian states.

Since the Taliban's return to power in 2021, most cooperative mechanisms, both regional and bilateral, have weakened or become dormant, largely due to international isolation of Afghanistan and the non-recognition of the Taliban De facto authorities. Yet, some pragmatic bilateral cooperation has not come to a complete halt, as Central Asian countries have all engaged with the DFA, albeit to varying degrees. Uzbekistan is oriented towards economic pragmatism and regional connectivity. This approach might have in part been due to the constraints that landlocked Central Asia has been facing due to Russia- Ukraine War. Similar with the Turkmenistan which has been pushing on the stalled TAPI project. These interactions in such a politically difficult environment are partly inspired by the concerns that these two downstream countries have about the potential impacts of QTC.

When it became public that the DFA resumed the construction of QTC, it led to immediate reactions by the most affected downstream countries, in particular Uzbekistan. During the Fifth Consultative Meeting of Central Asian Heads of State in Dushanbe (September 2023), President Mirziyoyev of Uzbekistan voiced strong concern that the QTC could "fundamentally alter the water balance in Central Asia" and called for Afghanistan's inclusion in regional water dialogue (ToloNews, 2023). Similar apprehensions were echoed during the Trilateral Summit of Turkmenistan, Uzbekistan, and Tajikistan in Ashgabat (August 2023), where leaders stressed the need for mechanisms to address emerging water challenges (Akhel-Teke, 2023).

Uzbekistan included water issues in its ongoing talks with the DFA, that until then mostly focused on economic cooperation. Notably, it has not fundamentally rejected the project (as it earlier had done in case of upstream developments). Rather, it chose a pragmatic approach and combined raising its concerns and pointing to international water law principles with proposing technical assistance to reduce negative consequences of the canal.

Overall, while Central Asian countries recognize the significant impacts of the QTC and importance of cooperation with Afghanistan, there remains no shared framework for engagement with Afghanistan, nor any established joint regional stance on managing its transboundary implications. So far, bilateral approaches dominate and information on negotiations is hardly available. Uzbekistan has been most proactive, abut also the water cooperation committee that has been recently established between Uzbekistan and DFA in 2023, has not yet yielded tangible outcomes.

4.3.2 Domestic Significance of The Qosh Tepa Canal

The QTC is Afghanistan's largest irrigation infrastructure initiative, currently prioritized by the DFA as a flagship project. For Afghanistan, the canal represents a cornerstone of national self-reliance and food security policy. It is expected to create up to 3,000 direct jobs and involve roughly 250,000 local people (Mushtaq, 2024). The QTC could also mitigate chronic vulnerabilities—recurring droughts, loss of arable land, and rural unemployment—and serve as pathway toward agricultural self-sufficiency and eventual export of grain and wheat (Intezar & Sarwari, 2025) (Faqiryar, 2024).

This ambition stems from Afghanistan's underutilization of the Amu Darya and severe water scarcity. Due to decades of conflict and lack of infrastructure, the country has been unable to utilize sufficient water. Large areas of farmland have been abandoned due to inadequate irrigation, while floods and riverbank erosion have caused severe land loss along the Amu Darya. The QTC is thus seen by the Afghans as both a symbol of sovereignty and an economic necessity, intended to ensure food security for a population projected to reach 100 million by 2100 (Faqiryar, 2024).

However, the feasibility study report highlighted significant challenges. For instance, half of the command area is affected by high soil alkalinity, making it unsuitable for cultivation without extensive reclamation. The estimated reclamation cost of USD 140 million is not included in the project budget and is unlikely to be carried out. Moreover, the absence of concrete lining raises concerns about low conveyance efficiency and substantial seepage losses, which could worsen soil salinity and further reduce agricultural productivity.

Overall, Afghan experts remain concerned about the DFA's limited technical and financial capacity to implement such a flagship initiative.

Construction of the QTC under the current circumstances—characterized by DFA's insufficient technical expertise, limited legitimacy and international recognition, and constrained financial resources—could pose multiple domestic risks. These include challenges related to land management, soil salinization and alkalinization, canal siltation, and potential increased frequency of dust storms. Furthermore, in the absence of robust governance frameworks and DFA's lack public support among other minorities in northern Afghanistan, the project may exacerbate issues such as land grabbing, unregulated land use and forced displacement. Collectively, these constraints could significantly undermine Afghanistan's ability to utilize its shared water resources and derive sustainable benefits from the canal, while also complicating its relations with neighboring countries.

4.3.3 Implications for Downstream Central Asian States

The Amu Darya's downstream countries—Uzbekistan and Turkmenistan—are acutely dependent on its waters for irrigation, food security, and livelihoods. Even if the estimated reduction in flow due to the QTC in our study is lower than in many other projections, it would have far-reaching consequences for their economies and societies.

A decline in Amu Darya flows would undermine rural livelihoods, particularly in already water-stressed regions such as Karakalpakstan, Khorezm, and Bukhara in Uzbekistan, and Dashoguz and Lebap in Turkmenistan. Communities located at the tail end of irrigation networks—where water delivery is already irregular—would face the most acute impacts.

Crop vulnerability is another concern. Cotton plantations across both countries, and especially rice cultivation in Uzbekistan, are highly water-intensive and are expected to be the first to suffer from reduced irrigation availability (Fazl-e-Haider, 2024) (Busch et al., 2023). With agriculture forming the economic backbone of many rural regions, such disruptions would have cascading effects on employment, food prices, and household incomes. For instance, Economic modeling by the German Economic Team projects that a 25% reduction in Amu Darya flows could result in up to 250,000 job losses in Uzbekistan alone (Gafurov et al., 2023).

Salinization and water quality degradation compound these risks. Over 50% of irrigated land in Uzbekistan is already affected by high salinity, with similar or higher figures likely in Turkmenistan. Reduced flow would further exacerbate soil and water soil salinization particularly in lower Delta region. While the QTC command area currently exhibits low salinity levels (though high alkalinity, according to feasibility assessments), the eventual return of irrigation water from new fields could worsen downstream water quality, intensifying the ecological stress on already fragile ecosystems.

Human security implications are equally concerning. Around 7.8 million people in Uzbekistan live in districts directly dependent on Amu Darya irrigation systems. The World Bank estimates that nearly one-third of Central Asia's population (about 22 million people) already lacks access to safe drinking water (Sara & Proskuryakova, 2022). Reduced river flows could aggravate shortages, affecting both rural and urban supplies. Increased water scarcity is also expected to accelerate rural out-migration, adding to the more than one million people who have already migrated from rural areas across the region. This could heighten pressure on urban infrastructure and local governments and generate social tensions with host communities.

Within the agricultural labor force, women and vulnerable groups face particular risks. In Uzbekistan, 62% of cotton pickers are women, while in Turkmenistan, a large share of agricultural labor remains involuntary (Labour Rights Monitoring Mission, 2018). Declining agricultural activity would disproportionately affect these groups, eroding one of the few available sources of cash income and further marginalizing poor rural households.

The environmental implications are no less severe. The Aral Sea delta region would likely experience further desiccation as inflows decline. Lower water levels would accelerate ecological degradation across the Karakalpakstan and Khorezm deltas, an area already plagued by dust storms, air and water pollution, and severe public health impacts particularly respiratory and waterborne diseases.

By contrast, hydropower impacts are expected to remain limited. Reduced Amu Darya flows may affect the 150 MW Tuyamuyun Hydroelectric Complex in Uzbekistan, but these account for less than 1% of the country's installed capacity. No major hydropower facilities exist along the downstream stretch in Turkmenistan. Thus, while energy generation impacts are likely to be modest, the broader agricultural, environmental, and human security effects of flow reduction could be profound, potentially destabilizing rural economies and increasing social vulnerabilities across the basin.

4.3.4 Regional Governance and Geopolitical Implications

The QTC presents a fundamental challenge to the existing legal and institutional water-governance frameworks in Central Asia. Water allocation in the Amu Darya is currently managed under the 1992 Almaty Agreement, with the riparians negotiating annual withdrawal quotas through ICWC. The Amu Darya Basin Water Organization (BWO) is responsible for regulating and monitoring water distribution. As the broader umbrella framework, IFAS provides a platform for regional dialogue and coordination on water, environment, and sustainable development. However, Afghanistan is not a party to these arrangements, thus is not part of these water withdrawal and allocation mechanism.

Under the current system, water allocation among Kyrgyzstan, Tajikistan, Uzbekistan, and Turkmenistan are renegotiated annually based on the agreed quotas and current forecasts, a process that is already fraught with tension due to competing agricultural demands, fluctuating river flows, and increasing climate-induced variability. Tajikistan as an upstream country—whose water use from the Amu Darya is limited and whose primary interest lies in hydropower generation— will not be directly affected by the QTC. Uzbekistan and

Turkmenistan share flows equally below the Kerki gauging station. While, Turkmenistan relies almost entirely on the mainstream flows of the Amu Darya, Uzbekistan could partially offset shortages through tributaries and inter-basin transfers, including limited inflows from the Syr Darya, shared with Kyrgyzstan and Kazakhstan. A reduction in Amu Darya inflows could destabilize this delicate equilibrium. Internally, Uzbekistan would also face challenges in balancing limited water supplies between regions and sectors, especially in the semi-autonomous region of Karakalpakstan, where water scarcity is already a politically sensitive issue (Faizee and Schmeier 2023).

With potential increase of water withdrawal by Afghanistan, these existing arrangements are likely to face growing contention. The absence of Afghanistan in current water sharing mechanisms creates an institutional gap that complicates collective basin management and raises complex questions about future cooperation frameworks with Afghanistan. Since not all Aral Sea riparians will be equally affected by the project, the issue of how to integrate Afghanistan into the basin's governance structure—or whether to establish a separate arrangement—remains unresolved.

More broadly, the QTC places existing regional institutions under significant strain. IFAS and ICWC are already under pressure from fragmented participation—notably Kyrgyzstan's suspended engagement—and from their limited ability to address cross-sectoral issues such as energy, food security, and environmental management. The increasing impacts of climate change—including glacier retreat, growing water demand, and more erratic flow patterns—further expose the limitations of these mechanisms.

In this context, the QTC is not only a technical or hydrological challenge but also a test of the region's institutional resilience and political will to adapt governance frameworks to new realities. Even if direct impacts are mainly concerning the downstream countries, they have repercussions for the whole basin and therefore also need a region-wide approach. Strengthening or reforming regional mechanisms to include Afghanistan, integrate cross-sectoral linkages, and better manage climate-related risks will be essential to prevent escalation and promote cooperative water management across the Amu Darya Basin.

However, Afghanistan's international isolation, the non-recognition of the DFA, and its limited technical and institutional capacity, absence of an existing platform for cooperation, combined with the low appetite of donors and international actors to engage—have so far resulted in minimal cooperation between Afghanistan and the Central Asian states. Nevertheless, downstream countries need to continue their pragmatic, topic-focused engagement with the DFA out of necessity, as the canal directly affects their water security. To make such engagement constructive, it needs to be backed-up by a regional approach, ideally also with external support. International partners, particularly those who have long been supporting water and climate in Central Asia, can play a crucial role by providing technical expertise, facilitating dialogue, sharing global best practices, and mobilizing financial resources to strengthen cooperative frameworks. Such support, at the request of regional country(s), can help reduce regional uncertainty, enhance institutional resilience, and create pathways for more inclusive and stable basin governance involving Afghanistan.

5 Discussion and Recommendation

5.1 Discussion

While construction of the QTC progresses in Afghanistan, interactions between Afghanistan and the Central Asian states remain limited. The project's feasibility study did not cover nor account for the current uses of downstream riparians along the Amu Darya. Since construction began, no bilateral or regional agreement has been reached between Afghanistan and Central Asian countries, neither on the canal specifically nor on Amu Darya water sharing more broadly.

The region has yet to articulate a unified position on how or whether to integrate Afghanistan into a water sharing framework, whether the current or any new one. Uzbekistan and Turkmenistan have pursued bilateral pragmatic engagement with the DFA, yet tangible outcomes remain limited. Given Afghanistan's historical exclusion from regional water arrangements, coupled with extensive riverbank erosion over the years that has resulted in the loss of thousands of hectares of land, water-sharing issues and discussions focused solely on the QTC may not be a top priority for the DFA unless broader, related concerns are also included in the dialogue.

Given the project's scale, the estimated 12% reduction in flow based on our analysis, and uncertainty about the exact volume and timing of diversions, the absence of coordination and data exchange severely constrains downstream countries' ability to prepare and adapt. The abstraction would likely coincide with the peak irrigation demand in downstream regions, given similar climatic conditions, thus the impacts could be pronounced. Climate variability may further exacerbate these effects through increased flow fluctuations, prolonged dry period, and rising water demand due to higher temperatures.

Downstream dependence on agriculture intensifies these vulnerabilities. Given widespread water use inefficiency, salinization, and limited crop diversification, downstream regions such as Bukhara, Khorezm, and Karakalpakstan—wholly dependent on the Amu Darya—would likely face acute shortages with limited alternatives. These would have impacts on the livelihoods of populations depending on these water resources, increase unemployment, outmigration, food insecurity and exacerbate environmental degradation. The impacts will be severe on the marginalized groups such as women and youth. Managing such dynamics at the local and national level would be difficult in the short term, and they could easily transcend across political boundaries in both water sector and beyond. The existing regional water sharing institutions are fragile and not inclusive.

Despite these risks, opportunities for cooperation remain. The full potential of the QTC will take years to materialize, allowing time to improve efficiency, adjust cropping patterns, and improve regional coordination.

Improving water use efficiency, modernizing irrigation infrastructure, diversifying crops, and supporting alternative livelihoods are essential for downstream resilience. Within

Afghanistan, sustainable management of the QTC's 550,000-hectare command area, or even the 275,000ha currently suitable, could yield basin-wide benefits if supported by policies, capacity building, and awareness programs. Steps such as canal lining, experience exchange including learning from the Karakum Canal's legacy, improving agricultural practices to improve water efficiency and to mitigate salinity could reduce impacts on other riparian countries.

Dialogue on the QTC is imperative but focusing it exclusively on the canal risks might reinforce zero-sum narratives. Broader benefit-sharing approaches, centered on basin-wide cooperation and climate adaptation, can foster trade-offs and mutual gains. Climate change provides a constructive, less politicized entry point. The DFA has consistently called for external support on climate adaptation, lacking resources to address rising risks. While this requires a careful approach to avoid legitimizing the DFA, it could serve as a starting point for necessary regional engagement on issues relevant for the dignified life of Afghan people. Similarly, integrating energy and agriculture into basin management could enable cost–benefit sharing and enhance regional security. Afghanistan's dependence on energy imports, coupled with its significant hydropower potential, makes water–energy nexus discussions particularly relevant.

The QTC will inevitably affect existing water quotas in the Amu Darya, requiring new arrangements that balance water, energy, food, and environmental needs. While political uncertainty and a fragmented regional stance towards Afghanistan persist, existing institutions for regional water governance provide a starting point for renewed dialogue. However, they must adapt to the new hydropolitical reality. Expanding cooperation across the wider Aral Sea basin holds promise but must be approached carefully to avoid importing geopolitical rivalries. Afghanistan has never been part of existing water-sharing frameworks and may not recognize current quotas as binding. Nevertheless, institutions such as IFAS and ICWC—if reformed to include all riparians and issues such as energy, food and environment—could offer a platform for dialogue and trust-building. Thus, could facilitate Afghanistan's integration into regional water sharing mechanisms even as an observer as a starting point.

Beyond water, broader trade-offs in energy, food security, trade and transit offer pathways for regional cooperation. Deeper regional integration could help unlock these shared benefits while reducing the risks and costs of non-cooperation—especially as climate change increasingly exposes the region's interdependence.

Afghanistan's participation in regional platforms such as Green Central Asia or CAWEP through technical experts and representatives could help institutionalize dialogue including through Track 1.5 or Track 2 channels. Engaging technical DFA staff, researchers, academia, journalists, and civil society could promote innovative, multidisciplinary solutions while addressing capacity asymmetries. Strengthening higher education and regional exchanges is particularly crucial given Afghanistan's post-2021 brain drain.

Finally, greater coordination among external actors such as the World Bank, EU, and other donors is critical to align initiatives and avoid duplication. Innovative approaches to integrate Afghanistan into regional cooperation frameworks could help promote dialogue, build technical capacity, and encourage collective and sustainable management of shared waters across the Amu Darya and Aral Sea Basin.

5.2 Recommendations:

All riparian countries must cooperate to manage the Amu Darya's shared waters sustainably, and peacefully as climate change amplifies stress and competition. The potential impacts of the QTC increase the urgency for regional coordination to prevent instability and ensure equitable use. While the current political impasse in Afghanistan casts a blot on the outlook for such regional collaboration to take root, the recommendations presented below aim to provide initial and necessary steps in that direction particularly around the issue of engagement with DFA.

1- **Reframing Regional Water Cooperation:** Promoting basin-wide, cross-sectoral coordination is crucial. Framing cooperation within broader frameworks—climate adaptation, regional economic integration, or the water–energy–food–environment nexus—could help reduce sensitivities around water allocation. Redressing cooperation over water could also provide riparian states with more incentives for cooperation and trade-offs. These could be done through reintegration of technical people from Afghanistan in regional programmes such as CAWEP, Green Central Asia, etc.

2- **Inclusion of Afghanistan in Regional Water Sharing Mechanisms:** Strengthen and reform existing regional platforms (e.g., IFAS, ICWC,) to accommodate Afghanistan's gradual inclusion. Even an observer role can open channels for dialogue and trust-building. A nuanced, stepwise approach that combines organizational reforms with targeted joint activities and projects would help integrate Afghanistan into regional processes and ultimately pave the way for its formal observer status in these institutions.

3- **Promoting Efficient and Sustainable Water Use:** Enhance basin-wide water efficiency through climate-smart irrigation, canal modernization, adaptive cropping, and wastewater reuse. These technical measures must be backed by coherent policies and strong regulatory frameworks and could include the QTC and other irrigation systems such as Karakum canal.

4- **Supporting Research and Capacity Building:** Addressing the region's significant data and capacity gaps—especially in Afghanistan—requires joint research, information exchange, and applied science. Regional hubs such as SIC ICWC, IWMI, and CAREC, supported by international centers, can lead these efforts and already have experience bringing Central Asian and Afghan water professionals together. Strengthening networks of water scholars across Central Asia and Afghanistan—including the diaspora—would bridge the science–policy divide, enhance mutual understanding, and foster joint learning. Multidisciplinary research, knowledge generation, and systematic dissemination of lessons learned are essential for building shared understanding and innovative solutions. Providing technical expertise and long-term, capacity building for Afghanistan's water sector would help reduce regional capacity asymmetries, level playing field in regional water dialogue and create entry points for cooperation

5- **Investing in Education, Public Awareness, and People-to-People Ties:** Strengthening education is essential for preparing the next generation of water experts and policymakers in the Amu Darya Basin. Curriculum reform, scholarships, and academic exchanges between Central Asian and Afghan universities can equip students and faculty with the interdisciplinary skills needed to address emerging water challenges. Education and research Institutions can play central roles in this effort. Equally important is raising public and institutional awareness of climate and water risks. Limited civic space, restricted media, and linguistic barriers across the region fuel misinformation and exclusionary narratives that undermine trust. Supporting civil society organizations and journalists to report on climate and transboundary water issues can counter these dynamics, build resilience, and strengthen the constituency for cooperation. Finally, expanding community-level and people-to-people exchanges is critical. Cross-border interactions among farmers, water user associations, and local communities can facilitate practical problem-solving, build grassroots trust, and complement formal diplomatic processes. Linking local knowledge with regional initiatives can deepen mutual understanding, reduce misperceptions, and reinforce the societal foundations for cross-border cooperation.

6- **Improving Donor Coordination:** Many international actors support regional cooperation over water and climate in Central Asia, but Afghanistan has so far been only marginally included. Looking ahead, it is crucial to ensure Afghanistan's involvement while fostering synergies and complementarities among donor initiatives. Inclusion of Afghanistan into existing initiatives requires close consultation with Central Asian countries and a commitment to build on existing and past efforts rather than duplicating them. New projects should leverage previous outputs and focus on innovative ways to engage Afghanistan in ongoing regional cooperation.

6 References

Abdullaev, I., & Shah, U. (2011). Community water management in northern Afghanistan: Social fabric and management performance. *International Journal of Environmental Studies*, *68*(3), 333–341. https://doi.org/10.1080/00207233.2011.576817

Abuduwaili, J., Issanova, G., & Saparov, G. (2019). Water Resources and Impact of Climate Change on Water Resources in Central Asia. In *Water Resources Development and Management* (Issue 6, pp. 1–9). https://doi.org/10.1007/978-981-13-0929-8_1

ACAPS. (2024, July 4). *Afghanistan: Understanding drought* (Thematic Report). https://www.acaps.org/fileadmin/Data_Product/Main_media/20240704_ACAPS_Thematic_report_Afghanistan_Understanding_drought.pdf

ADB. (2013a). *Technical Assistance Consultant ' s Report Republic of Tajikistan : Developing Water Resources Sector Strategies in Central and West Asia Financed by the Water Financing Partnership Facility and ADB Developing Water Resources Sector Strategies in Central*. *001*(June).

ADB. (2013b). *Water Resources Management in Pyanj River Basin (RRP TAJ 47181)*. *November*. https://www.adb.org/sites/default/files/linked-documents/47181-002-ssa.pdf

ADB. (2022). *By the Numbers_ Climate Change in Central Asia*. https://www.adb.org/news/features/numbers-climate-change-central-asia

Agreement. (1959). Protocol between the Union of Soviet Socialist Republics and Afghanistan on the Joint Execution of Works for the Integrated Utilization of the Water Resources in the Frontier Section of the Amudarya. *Cawater-Infor.Net*, *3*(1), 5–10. http://www.cawater-info.net/library/eng/afghanistan_ussr_en.pdf

Agreement, F. (1946). *AFGHANISTAN et UNION DES REPUBLIQUES SOCIALISTES SOVIETIQUES No . 476 . FRONTIER AGREEMENT1 BETWEEN AFGHANIS TAN AND THE UNION OF SOVIET SOCIALIST REPUB LICS . SIGNED AT MOSCOW , ON 13 JUNE 1946*. *476*. http://www.cawater-info.net/bk/water_law/pdf/afghanistan_ussr_1946_en.pdf

Akhel-Teke. (2023). *Turkmenistan: Party of three | Eurasianet*. https://eurasianet.org/turkmenistan-party-of-three

Akhtar, F., & Shah, U. (2020). Emerging Water Scarcity Issues and Challenges in Afghanistan. In A. Ranjan (Ed.), *Water Issues in Himalayan South Asia* (Issue December, pp. 1–28). Springer Singapore. https://doi.org/10.1007/978-981-32-9614-5_1

Asian Development Bank. (2020). *Asian Water Development Outlook 2020*. https://www.adb.org/publications/asian-water-development-outlook-2020

Asian Infrastructure Investment Bank. (2024). *Sovereign-Backed Financing Program Document P000687 Tajikistan: Rogun Hydropower Development Program*. https://www.aiib.org/en/projects/details/2024/_download/Tajikistan/AIIB-PD_P000687_Rogun-Hydropower-Development-Project_clean.pdf

Azizi, F., & Lane, S. N. (2025). Classification and evaluation of dangerous glacial lakes in the Hindukush region of Afghanistan (HKA) using a multi-criteria approach. *Geomatics, Natural Hazards and Risk, 16*(1). https://doi.org/10.1080/19475705.2025.2571983

Bekchanov, M., Ringler, C., Bhaduri, A., & Jeuland, M. (2015). How would the Rogun Dam affect water and energy scarcity in Central Asia? *Water International*, *40*(5–6), 856–876. https://doi.org/10.1080/02508060.2015.1051788

Benjamin Pohl, A., Annika Kramer, A., William Hull, A., Sabine Blumstein, A., Iskandar Abdullaev, C., Jusipbek Kazbekov, C., Tais Reznikova, C., Ekaterina Strikeleva, C., Interwies, E., & Görlitz, S. (2017). *Rethinking Water Rethinking Water*. 131. https://climate-diplomacy.org/sites/default/files/2020-10/Rethinking Water in Central Asia - adelphi carec ENG.pdf

Britannica. (2023). *Amu Darya | River, Map, Delta, & Location | Britannica*. Britannica. https://www.britannica.com/place/Amu-Darya

Busch, C. (2023). *Qosh-Tepa canal to significantly impact Uzbekistan's agriculture*. https://www.german-economic-team.com/en/newsletter/Qosh-tepa-canal-to-significantly-impact-uzbekistans-agriculture/

Busch, C., Gafurov, A., & Bobojonov, I. (2023). *POLICY BRIEFING Impact of the Qosh-Tepa canal on the agricultural sector in Uzbekistan - Summary of results -. 05*. https://www.hidropolitikakademi.org/uploads/editor/files/Impact of Qosh Tepe Canal.pdf

Cawater-info. (n.d.). *Transboundary network*. Retrieved August 23, 2025, from http://www.cawater-info.net/peer/index.php/site/index?language=en#

CAWater-Info. (n.d.). Large reservoirs (with live storage of more than 10 millions m3) and HPSs in the Amudarya River Basin Republic of Tajikistan Turkmenistan. In *cawater-infor.net*. Retrieved July 9, 2025, from https://www.cawater-info.net/projects/peer-amudarya/pdf/amu_reser_hps_e.pdf

Cilek, M. (2017). Bi-annual Environmental Monitoring Report Loan 3025 / 3026-UZB : Amu Bukhara Irrigation System Rehabilitation Project Bi-annual Environmental Monitoring Report Uzbekistan : Amu Bukhara Rehabilitation Project Irrigation System. *JV Temelsu International Engineering Services Inc. Sheladia Associates Inc*, *February*. https://www.adb.org/sites/default/files/project-documents/44458/44458-013-emr-03.pdf

FAO. (2012a). Chapter 3 : Crop Water Needs. In *FAO* (pp. 1–29). https://www.fao.org/4/s2022e/s2022e07.htm

FAO. (2012b). Transboundary River Basin Overview – Aral Sea. In *FAO Aquastat Reports*.

Faqiryar, J. N. (2024). Food-Climate Nexus in the North River Basin of Afghanistan: A Case Study of the Qosh Tepa National Irrigation Canal. In *Rumi.academy* (Vol. 1, Issue 1). https://rumi.academy/10101010102.pdf

FAS Turkey Staff. (2022). *Report Name : Cotton and Products Update*. 0–9. https://apps.fas.usda.gov/newgainapi/api/Report/DownloadReportByFileName?fileName=Cotton and Products Update_Tashkent_Uzbekistan - Republic of_UZ2022-0001.pdf

Fazl-e-Haider, S. (2024). *Afghanistan's Canal Project Looks to Deepen Uzbekistan and Turkmenistan's Water Woes - Jamestown*. The Jamestown Foundation. https://jamestown.org/program/afghanistans-canal-project-looks-to-deepen-uzbekistan-and-turkmenistans-water-woes/

Fields, D., Kochnakyan, A., Stuggins, G., & Besant-Jones, J. (2013). *Tajikistan's Winter Energy Crisis*. The World Bank. https://doi.org/10.1596/978-0-8213-9967-5

Gafurov, A., Bobojonov, I., Bekchanov, M., & Busch, C. (2023). Impact of Qosh-Tepa canal on the agricultural sector in Uzbekistan. *German Economic Team*, *74*(02), 1–15. https://www.german-economic-team.com/wp-content/uploads/2023/10/GET_UZB_PS_02_2023_en-2.pdf

Gafurov, A., Yapiyev, V., Ahmed, M., Sagin, J., Haghighi, A. T., Akylbekova, A., & Kløve, B. (2019). Groundwater resources. In *The Aral Sea Basin* (Issue January 2021, pp. 39–51). Routledge. https://doi.org/10.4324/9780429436475-4

Glantz, M. H. (2005). Water, Climate, and Development Issues in the Amu Darya Basin. *Mitigation and Adaptation Strategies for Global Change*, *10*(1), 23–50. https://doi.org/10.1007/s11027-005-7829-8

Hamidov, A., Daedlow, K., Webber, H., Hussein, H., Abdurahmanov, I., Dolidudko, A., Seerat, A. Y., Solieva, U., Woldeyohanes, T., & Helming, K. (2022). Operationalizing water-energy-food nexus research for sustainable development in social-ecological systems: an interdisciplinary learning case in Central Asia. *Ecology and Society*, *27*(1), art12. https://doi.org/10.5751/ES-12891-270112

Hao, L., Wang, P., Gojenko, B., Yu, J., Lv, A., Li, F., Kenjabaev, S., Kulmatov, R., & Khikmatov, F. (2023). Five decades of freshwater salinization in the Amu Darya River basin. *Journal of Hydrology: Regional Studies*, *47*, 101375. https://doi.org/10.1016/j.ejrh.2023.101375

Hou, M., Cuo, L., & Xu, H. (2025). Hydrological response to twenty-first century climate change in the Amu Darya Basin, Central Asia. *Journal of Hydrology: Regional Studies*, *61*, Article 102606. https://doi.org/10.1016/j.ejrh.2025.102606

Intezar, A., & Sarwari, S. (2025). Investigating the role of Ghosh Tepe Canal in improving the economic situation of Afghanistan. *Samangan Academic & Research Journal*, *2*(01), 64–73. https://doi.org/10.64226/sarj.v2i01.44

Izvorski, I., Kasyanenko, S., Singer, D., & Doytchinova, H. (2023). Europe and Central Asia Economic Update, Fall 2023: Sluggish Growth, Rising Risks. In *Europe and Central Asia Economic Update, Fall 2023: Sluggish Growth, Rising Risks*. The World Bank. https://doi.org/10.1596/978-1-4648-2045-8

Jalilov, S.-M., Amer, S. A., & Ward, F. A. (2013). Reducing conflict in development and allocation of transboundary rivers. *Eurasian Geography and Economics*, *54*(1), 78–109. https://doi.org/10.1080/15387216.2013.788873

Karimov, A. K., Amirova, I., Karimov, A. A., Tohirov, A., & Abdurakhmanov, B. (2022). Water, Energy and Carbon Tradeoffs of Groundwater Irrigation-Based Food Production: Case Studies from Fergana Valley, Central Asia. *Sustainability*, *14*(3), 1451. https://doi.org/10.3390/su14031451

Khodjiev, A. (2023). Impact Assessment of climate change on water resources of the Amu Darya River basin. *E3S Web of Conferences*, *376*, 02010. https://doi.org/10.1051/e3sconf/202337602010

Labour Rights Monitoring Mission. (2018). *Forced labor remains the norm in Turkmenistan's cotton fields*. https://labourmission.org/en/news/forced-labor-remains-the-norm-in-turkmenistan-s-cotton-fields/?f=9QpLXdfW

Liu, Z., Huang, Y., Liu, T., Li, J., Xing, W., Akmalov, S., Peng, J., Pan, X., Guo, C., & Duan, Y. (2020). Water Balance Analysis Based on a Quantitative Evapotranspiration Inversion in the Nukus Irrigation Area, Lower Amu River Basin. *Remote Sensing*, *12*(14), 2317. https://doi.org/10.3390/rs12142317

Lutz, A. A. F., Droogers, P., Immerzeel, W. W. W., Lutz, A. A. F., & Droogers, P. (2012). Climate change impact and adaptation on the water resources in the Amu Darya and Syr Darya River basins. *Report FutureWater*, *31*(May). http://www.futurewater.nl/wp-content/uploads/2013/01/CC_Downstream_Report_V51.pdf

Mamatova, Z., Ibrokhimov, D., & Dewulf, A. (2016). *The Wicked Problem of Dam Governance in Central Asia : Current Trade-Offs , Future Challenges , Prospects for Cooperation*. 1–10. https://doi.org/10.7564/15-IJWG110

Manschadi, A., Oberkircher, L., Tischbein, B., Conrad, C., Hornidge, A., Bhaduri, A., Schorcht, G., Lamers, J., & Vlek, P. (2010). "White Gold" and Aral Sea disaster - Towards more efficient use of water resources in the Khorezm region, Uzbekistan. *Lohmann-Information*, *45*(1), 34–47. https://lohmann-breeders.com/lohmanninfo/white-gold-and-aral-sea-disaster-towards-more-efficient-use-of-water-resources-in-the-khorezm-region-uzbekistan/

Micklin, P. (2007). The Aral Sea Disaster. *Annual Review of Earth and Planetary Sciences*, *35*(1), 47–72. https://doi.org/10.1146/annurev.earth.35.031306.140120

Moody's Analytics. (2025). *Turkmenistan | Economic Indicators | Moody's Analytics*. MOODY'S ANALYTICS. https://www.economy.com/turkmenistan/indicators

Murodov, A., Cuo, L., Li, N., Murodov, D., Hou, M., & Hussain, G. (2023). Extreme Hydrometeorological Conditions and Changes in the Amu Darya River Basin in Central Asia. *Journal of Hydrometeorology*, *24*(2), 315–334. https://doi.org/10.1175/JHM-D-22-0025.1

Mushtaq, B. K. (2024). The Economic Importance and Self-Sufficiency of QOSH TEPA Irrigation Canal. *Integrated Journal for Research in Arts and Humanities*, *4*(1), 131–134. https://doi.org/10.55544/ijrah.4.1.18

Nexus. (2021). *Transboundary demonstration project between Uzbekistan and ...* https://www.water-energy-food.org/stories/transboundary-demonstration-project-between-uzbekistan-and-turkmenistan

Nurbekov, A., Musaev, A., Sydyk, D., & Ziyadullaev, Z. (2015). *Conservation agriculture in irrigated areas*. https://doi.org/10.13140/RG.2.1.1342.9521

OECD. (2021). *The use and management of water resources in Central Asia: A consultation on future directions*.

Olsson, O., Bauer, M., Ikramova, M., & Froebrich, J. (2009). *The Role Of The Amu Darya Dams And Reservoirs In Future Water Supply In The Amu Darya Basin*. *January*, 277–292. https://doi.org/10.1007/978-1-4020-8960-2_20

OSCE. (2017). *Basin Water Organization "Amu Darya."* https://www.cawater-info.net/library/eng/bwo_amudarya_2017_eng.pdf?utm_source=chatgpt.com

Pan, X., Wang, W., Liu, T., Huang, Y., Maeyer, P. De, Guo, C., Ling, Y., & Akmalov, S. (2020). Quantitative Detection and Attribution of Groundwater Level Variations in the Amu Darya Delta. *Water*, *12*(10), 2869. https://doi.org/10.3390/w12102869

Petersen, G. (2024). *Water sector financial governance gap analysis in Central Asia*. https://www.riverbp.net/upload/iblock/426/mgs1ot2p570jvs2kwkjllkt0syoow9m3.pdf

Petrov, G. N. P., & Akhmedov, K. M. P. (2018). the Conflict Between Hydropower and Irrigation in the Joint Use of Water Resources of Transboundary Rivers in the Aral Sea Basin *. *Current Politics and Economics of Northern and Western Asia*, *28*(3/4), 339–448. https://sbiproxy.uqac.ca/login?url=https://www.proquest.com/scholarly-journals/conflict-between-hydropower-irrigation-joint-use/docview/2213860678/se-2?accountid=14722%0Ahttps://uqac.on.worldcat.org/atoztitles/link?sid=ProQ:&issn=21585865&volume=28&issue=

Power Technology. (2024). *Power plant profile: Tuyamuyun, Uzbekistan*. https://www.power-technology.com/data-insights/power-plant-profile-tuyamuyun-uzbekistan/

Prniyazova, A., Turaeva, S., Turgunov, D., & Jarihani, B. (2025). Sustainable Transboundary Water Governance in Central Asia: Challenges, Conflicts, and Regional Cooperation. *Sustainability*, *17*(11), 4968. https://doi.org/10.3390/su17114968

Republics, S. S. (1958). *Treaty between the Government of the Union of Soviet Socialist Republics and the Royal Government of Afghanistan concerning the Regime of the Soviet-Afghan State Frontier*. *4655*. http://www.cawater-info.net/bk/water_law/pdf/afghanistan_ussr_1958_en.pdf

Rizk, C., & Utemuratov, B. (2014). *Amu Darya Basin Network Policy Brief: Balancing Water and Energy in the Amu Darya Basin*. https://www.cawater-info.net/afghanistan/pdf/rizk-utemuratov.pdf

Rosenthal, G. (2009). Economic and Social Council. In *The Oxford Handbook on the United Nations* (Issue October, pp. 136–148). Oxford University Press. https://doi.org/10.1093/oxfordhb/9780199560103.003.0007

Salehie, O., Ismail, T. Bin, Shahid, S., Hamed, M. M., Chinnasamy, P., & Wang, X. (2022). Assessment of Water Resources Availability in Amu Darya River Basin Using GRACE Data. *Water*, *14*(4), 533. https://doi.org/10.3390/w14040533

Sanu Khanal, Corjan Nolet, Mehriddin Tursunov, Johannes Hunink, & Devaraj de Condappa. (2023). Climate Change Risk Mapping of the Amu Darya river basin , Uzbekistan Climate Change Risk Mapping of the Amu Darya river. *ADB*, *May*, 1–80. www.futurewater.eu

Sara, J. J., & Proskuryakova, T. (2022). *Central Asia: at the confluence of global water action and climate resilience Dushanbe conference to emphasize role of water in sustainable development*. World Bank. https://blogs.worldbank.org/en/water/central-asia-confluence-global-water-action-and-climate-resilience-dushanbe-conference

Satymov, R. (2025). *Turkmenistan's deepening water crisis could have far-reaching regional consequences - Atlantic Council*. Atlantic Councile Organization. https://www.atlanticcouncil.org/blogs/new-atlanticist/turkmenistans-deepening-water-crisis-could-have-far-reaching-regional-consequences/

Savoskul, O. S., & Smakhtin, V. (2013). *Glacier systems and seasonal snow cover in six major Asian river basins: Hydrological role under changing climate* (IWMI Research Report 150). International Water Management Institute (IWMI). https://doi.org/10.5337/2013.204

Schlüter, M., Khasankhanova, G., Talskikh, V., Taryannikova, R., Agaltseva, N., Joldasova, I., Ibragimov, R., & Abdullaev, U. (2013). Enhancing resilience to water flow uncertainty by integrating environmental flows into water management in the Amudarya River, Central Asia. *Global and Planetary Change*, *110*, 114–129. https://doi.org/10.1016/j.gloplacha.2013.05.007

Shokory, J. A. N., & Lane, S. N. (2023). Patterns and drivers of glacier debris-cover development in the Afghanistan Hindu Kush Himalaya. *Journal of Glaciology*, *(In review*, 1–15. https://doi.org/10.1017/jog.2023.14

Shokory, J. A. N., Schaefli, B., & Lane, S. N. (2023). Water resources of Afghanistan and related hazards under rapid climate warming: a review. *Hydrological Sciences Journal*, *68*(3), 507–525. https://doi.org/10.1080/02626667.2022.2159411

Su, F., Pritchard, H. D., Yao, T., Huang, J., Ou, T., Meng, F., Sun, H., Li, Y., Xu, B., Zhu, M., & Chen, D. (2022). Contrasting Fate of Western Third Pole's Water Resources Under 21st Century Climate Change. *Earth's Future*, *10*(9), 1–19. https://doi.org/10.1029/2022EF002776

Su, Y., Chen, S., Sui, Y., Li, X., Xu, J., Che, X., Xie, T., Chen, J., Sheng, Y., Feng, M., & Chen, F. (2025). Gaining water bodies by climate change benefits water crisis mitigation in central Asia. *Science Bulletin*, *70*(14), 2322–2329. https://doi.org/10.1016/j.scib.2025.03.053

The Global Economy. (2025). *Tajikistan Employment in agriculture - data, chart | TheGlobalEconomy.com*. https://www.theglobaleconomy.com/Tajikistan/Employment_in_agriculture/

Tischbein, B., Manschadi, A. M., Conrad, C., Hornidge, A. K., Bhaduri, A., Hassan, M. U., Lamers, J. P. A., Awan, U. K., & Vlek, P. L. G. (2013). Adapting to water scarcity: Constraints and opportunities for improving irrigation management in Khorezm, Uzbekistan. *Water Science and Technology: Water Supply*, *13*(2), 337–348. https://doi.org/10.2166/ws.2013.028

ToloNews. (2023). *Uzbek President Concerned by Construction of QTC| TOLOnews*. https://tolonews.com/afghanistan-185120

Trading Economics. (2025). *Iceland Agriculture, Value Added (% Of GDP) - 2025 Data 2026 Forecast 1995-2023 Historical*. https://tradingeconomics.com/uzbekistan/agriculture-value-added-percent-of-gdp-wb-data.html

UNECE. (2011). *Strengthening Water Management and transboundary Water Cooperation in Central Asia*. 152. http://www.unece.org/?id=28204

UNEP. (2011). Environment and Security in the Amu Darya River Basin. *Disasters*, *September*, 100. https://www.grida.no/publications/202

Union, E. (2021). *Cross-Border Electricity Trading for Tajikistan: A Roadmap*. https://iea.blob.core.windows.net/assets/b066e0be-9a3f-49ca-b932-38a1e81bda2a/Cross-BorderTradingforTajikistan_ARoadmap.pdf

V.A.Dukhovniy, & A.G.Sorokin. (2024). *Research Report*. *91*(11), 1592–1603. https://www.jri.co.jp

Wang, X., Luo, Y., Sun, L., He, C., Zhang, Y., & Liu, S. (2016). Attribution of Runoff Decline in the Amu Darya River in Central Asia during 1951–2007. *Journal of Hydrometeorology*, *17*(5), 1543–1560. https://doi.org/10.1175/JHM-D-15-0114.1

Wang, Z., Huang, Y., Liu, T., Zan, C., Ling, Y., & Guo, C. (2022). Analysis of the Water Demand-Supply Gap and Scarcity Index in Lower Amu Darya River Basin, Central Asia. *International Journal of Environmental Research and Public Health*, *19*(2), 743. https://doi.org/10.3390/ijerph19020743

Wegerich, K. (2008). Hydro-hegemony in the Amu Darya Basin. *Water Policy*, *10*(S2), 71–88. https://doi.org/10.2166/wp.2008.208

White, C. J., Tanton, T. W., & Rycroft, D. W. (2014). The Impact of Climate Change on the Water Resources of the Amu Darya Basin in Central Asia. *Water Resources Management*, *28*(15), 5267–5281. https://doi.org/10.1007/S11269-014-0716-X

White Peak. (2025). *A Snapshot of the Agriculture Sector in Tajikistan*. 750. https://whitepeakconsulting.org/blogs/f/a-snapshot-of-the-agriculture-sector-in-tajikistan

World Bank. (2010). *Methodology for Ranking Irrigation Infrastructure Investment Projects*. https://openknowledge.worldbank.org/server/api/core/bitstreams/75d6eac0-37d4-5719-bbef-9a03532acd7c/content

World Bank. (2012). *Assessment Studies for Proposed Rogun Hydropower Project in Tajikistan*. The World

Bank. https://www.worldbank.org/en/region/eca/brief/rogun-assessment-studies?utm_source=chatgpt.com

World Bank. (2014). *Uzbekistan - South Karakalpakstan Water Resources Management Improvement Project: environmental assessment (Vol. 2): Environmental assessment and management plan*. *2013*, 116. http://documents.worldbank.org/curated/en/317111468173048196/Environmental-assessment-and-management-plan

World Bank. (2023). *Agriculture, forestry, and fishing, value added (% of GDP) - Afghanistan | Data*. https://data.worldbank.org/indicator/NV.AGR.TOTL.ZS?locations=AF

World Bank. (2024). *Poverty & Equity Brief Poverty at Different Lines*. https://documents1.worldbank.org/curated/en/099615401032512686/pdf/IDU-5fb5edbd-99db-4afa-9ee6-36002a116500.pdf

World Energy Outlook. (2025). *Tajikistan - Countries & Regions - IEA*. https://www.iea.org/countries/tajikistan/energy-mix

Zhan, S., Wu, J., Jin, M., & Zhang, H. (2022). Baseline determination, pollution source and ecological risk of heavy metals in surface sediments of the Amu Darya Basin, Central Asia. *Journal of Geographical Sciences*, *32*(11), 2349–2364. https://doi.org/10.1007/s11442-022-2051-0

Zoï Environment Network. (2013, September 17). *Amu Darya freshwater withdrawals per country* [Infographic]. Flickr. https://www.flickr.com/photos/zoienvironment/9782799672