***Review Article***

Food-Climate Nexus in Qush Tepa National Irrigation Canal

# Abstract

Thoughts and steps on implementing one of Daud Khan’s seven-year plan projects, named the Qush Tepa canal, began during the final years of the Islamic Republic of Afghanistan. These plans then provoked concerns among the stakeholders of the Amu Darya with the Taliban takeover in August 2021 and the acceleration of canal construction. There was a pressing need to study the canal for its opportunities and challenges. This research, adopting a mixed-method approach, examined how the canal impacts the livelihoods of locals and agricultural productivity under a changing climate. The findings indicate that the canal is vital for Afghanistan, primarily to maintain food security for a growing population projected to reach 100 million by the end of the century. The canal is estimated to contribute around 400 million USD annually to Afghanistan's GDP. Additionally, if utilized correctly, the canal generates significant opportunities, enhancing food security and availability for Afghanistan and the region. Climate change has reduced cultivation areas since 2001, with reduced water flow, increased water usage, and decreased rainfall. The research concludes by acknowledging the annual reduction of around 6.5 billion m3 of water to downstream countries due to the new canal while highlighting the significant opportunity for mutual economic benefits for Afghanistan and Central Asian countries resulting from the canal's emergence.

Keywords: Qush Tepa, Qush Tepa National Irrigation Canal, Food-Climate Nexus

# 1. Introduction

Originally, Qush Tepa (as a location) is situated on the banks of the Amu Darya river, between Kunduz and Samangan provinces. It spans around one million hectares of arable land. Afghanistan undertook a study that predicted the growth of these lands with the use of advanced irrigation techniques. However, insufficient funding for the implementation of such a substantial project has not been identified. Qush Tepa is the most extensive land development project in Northern Afghanistan (Ahmad & Wasiq, 2004a). Later, under the program for the development of large irrigation projects aimed at fostering continuous economic growth, a cornerstone of the first republic government of Afghanistan's seven-year development plan from 1976 to 1983, there was an initiative to survey and construct projects to expand arable land in northern Afghanistan. At that time, surveys identified 217,800 hectares of land already being irrigated, with an additional 83,600 ha identified as potentially irrigable. However, estimates indicated that approximately 800,000 ha of land in the Balkh and Aqcha rivers area could be irrigated using water from the Amu Darya. Of this, 100,000 ha were planned to be irrigated by a water pump project known as the Qush Tepa project, which involved pumping 110 m³/s of water from the Amu Darya. Furthermore, the project included the construction of an irrigation canal, 200 km in length, with a capacity of 110 m³/s, totaling 220 m³/s when combined with the pump project, for further development purposes. The feasibility study report of the Qush Tepa Project was initially signed between Afghanistan and the Soviet Union, involving Selkhozpromexport, with a duration of two years and one month, and was undertaken by Afghan and Russian experts. It encompassed the headworks, pump station, main conveyance canal, and sedimentation canals. Between 1976 and 1982, activities such as surveying, project planning, building the pumping station, a segment of the canal, and other essential tasks were scheduled for completion. At that time, it was estimated that the construction of this project would require a total investment of 7.8 billion AFN. Of this amount, 4.9 billion AFN was expected to be funded by the Government Budget, while an additional 64 million USD was to be secured as foreign aid from the Soviet Union (Ministry of Planning, 1976).

Following years of conflict and the implementation of the seven-year Qush Tepa project plan, the Islamic Republic of Afghanistan, in 2016, aimed to revive the 1976 development initiative. This initiative, originally set to launch during the country’s first republic era, sought to irrigate extensive areas in the northern plains using water from the Amu Darya, with the goals of increasing agricultural output, bringing unused fallow lands into production, and enhancing the quality of existing agricultural lands. This was part of a proposal made in 2016 to re-examine canal studies. The original financing plan in 1976 involved securing long-term loans from the Soviet Union. However, contrasting with the situation 45 years earlier, where there was a reliance on Soviet Union assistance and the national budget, the Islamic Republic of Afghanistan aimed to fund and complete the canal through a combination of international banks, institutions, and its national budget. Before the Republic's fall to the Taliban, progress included the completion of 8 km of canal work in northern Afghanistan. It is significant to note that in December 2017, the re-financing of the Qush Tepa canal's feasibility study was confirmed through USAID at the Arg Presidential Palace in Kabul. The signing ceremony was attended by President Ghani, various cabinet ministers, the US ambassador, and the deputy head of USAID, and the study was to be carried out by SWIM (Strengthening Watershed and Irrigation Management).[[1]](#footnote-1) This feasibility study by SWIM project has been serving as a foundational document for the post-2021 to continue canal construction up to the present day.

The first phase of the Qush Tepa canal, spanning 108 km, constitutes the main excavation work through the deserts in northern Afghanistan. This phase also encompasses the development of branches, secondary canals, and tertiary canals in the project's second phase. This extension includes digging an additional 177 km of canal towards the Andkhoi district in Faryab province which started on Oct of 2023 (BBC, 2023; TOLOnews, 2023). The third phase involves distributing adjacent lands and preparing the command area for cultivation, including plans for setting up processing factories and other necessary infrastructure.

A map of the country

Description automatically generated

Figure 1: The location and Phases of Qush Tepa National Irrigation Canal in Afghanistan.

Under the plan in 2017, the Qush Tepa National Irrigation Project aims to deliver water to Andkhoi, a district located approximately 180 km northwest of Mazar-i-Sharif City and about 65 km from Sheberghan City in Afghanistan. Geographically, Andkhoi is located within the expansive terrains of Afghanistan, characterized by an arid to semi-arid climate that results in distinct weather patterns throughout the years.

One of the debatable topics related to this project is the land surrounding the canal. With the commencement of canal operations, the prices of these lands have increased. Although the distribution of these plots remains suspended until full canal utilization, during the first phase of the canal, plots are rented out for decades to lessees for agricultural purposes.[[2]](#footnote-2) Overall the locals and on-site individuals believe that the Taliban de-facto government should manage these lands properly, and a portion of them should be allocated to the private sector for improving the country’s economy and attracting more investment around the canal.[[3]](#footnote-3)

### 1.1 Hydro and Geopolitics of the Qush Tepa National Irrigation Canal

Since ancient times, water has been a sacred substance in various societies and has been used as a tool for war, defeat, and victory against each other. For example, the first recorded water war dates back to 2500 BC, and the latest incident occurred in Palestine in 2024 (Pacific Instituite, 2024). Throughout this time, contemporary Afghanistan, despite being a dry country, has managed to produce and distribute the necessary water for its downstream regions and countries such as contemporary Iran, Pakistan, Turkmenistan, and Uzbekistan through rivers that flow across and beyond its borders. Of the five major river basins in Afghanistan, only one - the Helmand River - has an official treaty with a downstream neighboring country, Iran, known as the Helmand/Hirmand Treaty, which was concluded in 1973 between the prime ministers of these two countries, both of whom were executed for various reasons. Regarding the North River Basin located in the north of Afghanistan, there were previously commitments and treaties with the Russian Federation in seven articles which was signed in 19 July 1964, which ceased to exist after its collapse and the independence of the Central Asian countries (Tajikistan, Uzbekistan, Turkmenistan, Kazakhstan, and Kyrgyzstan), to the extent that the Central Asian countries excluded Afghanistan from the Amu Darya water division in the Almaty Agreement in 1992, depriving it of these rights among themselves. Subsequently, Afghanistan was engaged in a series of imposed and internal wars that prevented the development of its agricultural and economic infrastructures and the focus and maximum use of its surface and groundwater management while the Central Asian countries, taking advantage of the opportunities that arose and with the support, language, and cooperation history of the Soviet Union, constructed several dams on the main and tributary branches of the Amu Darya (FAO, 2012), diverting a large amount of water and bringing a lot of bare land under cultivation.

The Islamic Republic of Afghanistan, which collapsed in August 2021 and the Taliban that regained control of Afghanistan for the second time, strenuously continued the work on this agricultural canal to the extent that in one year, 100 km of the canal route was dug without technical consultation of international experts, but mainly with the support of Afghan local engineers. This rapid canal digging raised concerns among neighboring countries downstream of the Amu Darya, even preventing them from reconsidering their water resources management and efficiency during the canal's construction phase to protect themselves from its potential and significant impacts. Additionally, with rising temperatures, the demand for water in the region is increasing, and Central Asian countries, including Afghanistan, which mainly rely on snowmelt for water, will ultimately face major problems with water division and use. Over the past 45 years, downstream countries accustomed to free and undisturbed water use and pass now face some dissatisfaction and disputes that this canal is being built. Although the canal was established with the goal of creating jobs, ensuring regional security, and reducing food insecurity, its development has potential to cause regional tension, reduces water flow to downstream countries while climate change causes temperature rises and decreases in natural glacier flows, negatively affecting agriculture and food security in the region (Faizee & Schmeier, 2023; Murzakulova, 2023). Meanwhile, the concerns of neighboring countries downstream of the Amu Darya have resonated so much that a month before the inauguration of the second phase of the Qush Tepa canal, Shavkat Mirziyoyev, the President of Uzbekistan, reminded of the impacts of constructing the Qush Tepa agricultural canal, stating that this canal "actively being built by Afghanistan fundamentally changes the water situation and balance in Central Asia" (Daryo, 2023, p.1). The Taliban's response, via the Ministry of Energy and Water, is that "currently, in the Amu Darya basin, we (Afghanistan) have no treaty with anyone" (TOLOnews, 2023b, p. 1), while Taliban’s defense minister called the completion of this major canal "the realization of a decades-long dream of the Afghan people" (Afintl.com, 2023, p. 1).

Jennifer Murtazashvili argues that examining former bilateral inter-Afghan-Central Asian projects highlights the win-win nature of those initiatives. However, the Qush Tapa project is different due to its zero-sum nature (Rickleton, 2023). Albeit Faizi & Susan (2023) argue that backing Afghanistan necessitates the continuum of the development of this canal. Notably, there is vast potential in front of the Central Asian countries to make the utmost use of the canal in Afghan soil. This can be achieved if these countries think outside the box and pursue different ways of mutual economic benefit and betterment of relations. Despite hunger and poverty trends going on in Afghanistan, it is estimated that about 18-20 billion AFN will be spent in the second phase and part of the third phase of this canal (TOLOnews, 2024).

Farmers across the regions that the canal passes through believe that once water flows into the canal, their groundwater levels will increase. They are relatively optimistic about the canal's profitability, anticipating it will double. They add that if they use more agricultural fertilizer, they can plant two seasons in one year—otherwise, they will have one harvest season. According to residents around the first phase of the canal in Balkh, the current water level is 30 m below ground, which they expect will rise to 15 m after water flows into the canal.[[4]](#footnote-4) The number of solar panels along the Qush Tapa canal is increasing, and farmers use them to pump water from the canal for irrigation. It is worth mentioning that this canal has divided the lands into two parts, separating farmers from their agricultural fields and creating a major commuting problem. Farmers use boats to pass from one side of the canal to the other. Currently, only two bridges are available: Hairatan Bridge and Dowlat Abad Bridge (Qarchighak area).[[5]](#footnote-5) Vehicles can only pass through these two bridges from one side to the other. The people's request to the current government is for one more bridge to be built in their area over the canal. For example, the village of Jungle Saziq, which is located 65 km down from the intake, with a population of about 200 people living in it. The lack of jobs and weak economy are considered their major problems, and the crossing of the canal and separating them from the surrounding lands and cutting off their access to the center of Dowlat Abad district – without a bridge – have added to their existing problems. They cross with a handmade boat without a motor, which is moved by human force through a cable installed on both sides of the canal, transferring their motorcycles and belongings from one side of the canal to the other, including women and children.[[6]](#footnote-6) The project officials say that several bridges for commuting will be built, a total of 6 bridges. The construction of the third bridge from Dowlat Abad to Shur Tapa is ongoing after Hairatan Bridge for traffic and trains, which will be built in ten months.[[7]](#footnote-7) People from nearby provinces come to visit the canal, while in the second phase of the route, ancient sites and people's homes are being tried not to be affected by the construction of the project.[[8]](#footnote-8) The second phase starts from Dowlat Abad district of Balkh province to Andkhoi district of Faryab province. The people of these areas hope to get rid of the brackish groundwater of their areas and benefit from the sweet water of the Qush Tapa canal.[[9]](#footnote-9)

According to the National Development Company's plan, from the start of the headwork to the end, 18 pump stations, 12 tertiary canals, and four branch canals will be built to deliver water to the surrounding lands. These branch canals will also have other sub tertiary canals. The canal is not confined with above mentioned structures and will have other clusters. Taliban has assigned a 200-person unit to secure this canal so that the construction of this canal proceeds in a completely secure environment, and the staff also have no worries from this area.[[10]](#footnote-10)

# 2. Materials and Methods

The necessity to study the Qush Tepa National Irrigation Canal stems from a multifaceted set of challenges and opportunities that this infrastructure presents to the region it serves and it does not. These challenges and opportunities required an overarching study. The function of the canal in diverting water from the Amu Darya River, as argued by Central Asian countries (mainly Uzbekistan & Turkmenistan) bordering the north with Afghanistan, underscores challenges related to water availability for them and their agricultural growth (Ilkhamov, 2023; Mushtaq, 2024). However, the construction of the canal is closely connected to the larger socio-economic landscape and prosperity of Afghanistan, where the canal shall operate, impacting its food security and cross-border water management strategies. In addition to relying on their own agriculture and certain imports from other nations, Central Asia is home to over 100 million people. Over the last 50 years, either under the Soviet Union or after independence Uzbekistan, Turkmenistan, Tajikistan, and Kazakhstan have particularly depended heavily on irrigated agriculture, primarily drawing water from the Amu River. None of these nations seemed prepared or even aware of how Afghanistan would rethink to construct the Qush Tepa canal and divert water supplies to the nations downstream and take this action in light of its commitment to the United Nations Convention to Combat Desertification, which it joined in 1995. This convention mandates Afghanistan to combat desertification, mitigate the effects of drought, and promote sustainable development practices.[[11]](#footnote-11) From another perspective complementary to the aforementioned, the aspect of food security, crop growth, and lushness, particularly in the context of the North River Basin of Afghanistan and the broader Central Asian region, is critically dependent on the availability and efficient and equitable water use of the shared water resources. The construction of the Qush Tepa canal, without adequate information among the northern neighboring Central Asian nations and Afghanistan per se, has highlighted the need for studies to explore the canal's impact on water distribution, agricultural productivity, and food security resulting from its construction on Afghan territory. Such understanding is crucial for clearing up misunderstandings and knowing the extent to which water is being diverted from the Amu Darya River Basin toward Afghanistan in a manner that supports the livelihoods of millions while also assessing the canal's efficiency.

To address the abovementioned intricate concerns and demand for further understanding, the current article builds on the implementation of the Qush Tepa National Irrigation Canal (QTNIC) in the North River Basin of Afghanistan. It seeks to respond to the following questions*. i) What is the impact of the Qush Tepa National Irrigation Canal on the livelihoods of local communities under a changing climate? ii) How does the Qush Tepa National Irrigation Canal impact food production and security in the North River Basin of Afghanistan?; Will there be any changes in crop yields or agricultural production? and iii) How does climate change impact the Qush Tepa National Irrigation Canal's agricultural food productivity?* By responding to these questions, it seeks to fill the gap in the i) understanding of the (QTNIC) and its potential impacts on the economy, food availability, water resources, and local communities' livelihood. ii) Canal's impact on downstream countries, and iii) explore the impacts of the Qush Tepa National Irrigation Canal on riparian stakeholders economically and politically.

The research methodology of this study is built on a mixed-method approach that encompasses three parts. Firstly, the research began with a thorough literature review to assess the existing overarching knowledge on Afghanistan’s river basins, North River Basin, and the case study area, which is Qush Tepa National Irrigation Canal and projects regionally and globally akin to Qush Tepa over the topics relevant, interconnected and helpful to the study’s objectives and the research is grounded in the most current understanding of the topic. This step was crucial for identifying knowledge gaps and setting the research foundation because literature reviews are essential for understanding the scope of existing research and avoiding duplication, thus ensuring that new research adds value to the existing body of knowledge. The literature review spanned a broad spectrum of sources to ensure a holistic overview of the topic, including a feasibility study of the Qush Tepa by Strengthening Watershed and Irrigation Management (SWIM), peer-reviewed articles, Afghan governments and NGO’s reports, documents in English, Persian and Pashto languages, and set of research conducted by Ministry of Agriculture, Livestock and Irrigation of the Islamic Republic of Afghanistan and Ministry of Public Works.

Secondly, by combining quantitative data with qualitative insights from interviews, focus groups, and surveys, the research adopted a mixed-method approach. For this study, 19 semi-structured anonymous interviews with locals, including farmers (8), shepherds (2), and local residents (9), and six anonymous interviews with site engineers and workers of over the Qush Tepa canal in Balkh, 17 semi-structured anonymous interviews with local residents of the districts the canal passes through in Jawzjan and eight semi-structured anonymous interviews with the locals of Andkhoi district in Faryab conducted in the course of July, August and September 2023. Moreover, an online focus group with a former minister of Islamic Republic of Afghanistan and two experts conducted. In each province of Balkh, Jawzjan, and Faryab, 13, 5, and 4 focus groups were also conducted, respectively. Furthermore, a livelihood survey among the locals of the districts that canal passes through also conducted. The inclusion of primary data and stakeholder perspectives (locals, farmers, shepherds, engineers, experts and workers) ensured that the findings are grounded in local realities, enhancing the relevance and applicability of the research outcomes.

Thirdly, the study’s methodology focused on projecting future climate scenarios, including a) utilization of Google Earth Engine (GEE) for projecting climate change scenarios, analyzing NDVI, TSI, and changes in cropland areas in the North River Basin and b) specifically targeting the agricultural regions impacted by the Qush Tepa National Irrigation Canal by studying the monthly data from the two stations named Hairatan and Andkhoi (2012 - 2017). These two stations on the ground are located at the beginning and at the end of the canal. These steps were pivotal in understanding the potential climatic changes that could influence agricultural productivity and food security in the region. Moreover, the statistical downscaling to translate global climate model (GCM) outputs into local-scale projections was employed in the study. Then, the bias correction based on linear regression between air temperature at the stations and the GCM dataset was applied to projections. Next, climate models from the Coupled Model Intercomparison Project Phase 6 (CMIP6) were selected, which provides the latest suite of global climate models. These models are chosen based on their performance in simulating key climatic variables (e.g., temperature, precipitation) over Afghanistan and their ability to capture the regional climate dynamics. Consequently, the study utilized Representative Concentration Pathways (RCPs) 4.5 and 8.5 to project climate scenarios. RCP 4.5 represents a moderate mitigation scenario leading to a stabilization of radiative forcing by 2099, while RCP 8.5 is a high greenhouse gas emissions scenario. These scenarios allow the research to explore a range of potential futures, from more optimistic to more severe impacts of climate change. Data is sourced from international climate modeling centers participating in CMIP6, ensuring access to the latest projections. Historical climate data (2006 - 2022) from CHIRPs v.2 daily data set for Andkhoi & Hairtan meteorological stations in Afghanistan also provided the baseline for bias correction. Climate data for the scenarios is also downloaded from the global database of CORDEX which offer comprehensive climate datasets.

# 3. Results

As previously detailed, the issue of Afghanistan’s population in the trend of development and progress is a major topic of discussion. One of the challenges Afghanistan faces is ensuring food and consumable supplies. Despite having vast lands, and natural resources Afghanistan has not fundamentally resolved this pressing issue due to various reasons. Furthermore, climate change, drought, and insecurity have significantly exacerbated the problems and obstacles to progress. Climate change has led to rising temperatures and reduced rainfall across the country, particularly in this region, prompting residents to consider migration, poverty, unemployment, and dissatisfaction with the government. Taking these challenges into account, that republic and de-facto Taliban government decided to revisit and implement the 1976 development plan with regard to irrigation projects, which includes the ambitious the Qush Tepa National Canal. With the construction of this canal, the government aims to achieve four main objectives: first, to curb citizens’ migration to neighboring and Western countries; second, to create permanent and stable employment opportunities for those engaged in agriculture and livestock. Third, to diminish the food insecurity and release itself from dependency to first need crops and the fourth, to transform the desert in the north basin to farmlands and pasture. Additionally, it aims to reduce Afghanistan’s dependence on other countries that were major exporters of wheat, rice, and other grains, thus striving for short-term independence in agricultural production. The Qush Tepa Canal is being constructed in

the arid plains that were previously uncultivated which already, it has significantly impacted land prices in these regions. Recent studies show that the area of vegetation has drastically decreased in the last 10 years. (*See cropland analysis and monitoring topic, figure 8*)

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Command Area** | | **Agriculture Area (ha)** | | **Irrigated Area (ha)** | |  |  | |  | |  |
|  | **1212572** | | **444391.2** | | **68003.28** | |  |  |  |  |  |  |
| **Major crops** | **Before project** | | | | **After project** | | | | Revenue difference | **Operation cost (8% of total project)** | **Net benefit for one year** | **Net Benefit for 10 years** |
| cultivated Area (ha) | Yield Kg/Ha | Price $/kg | Revenue USD | Area increase | Yield Kg/Ha | Price $/kg | Revenue USD |  |  |  |  |
|  |
| **Wheat** | 348,944.00 | 3000 | 0.30 | $314,049,600.00 | 399,003.00 | 2970 | 0.30 | $355,511,673 | $41,462,073 | $1,658,483 | $39,803,590 | $398,035,901 |  |
| **Vegetables** | 23,259.00 | 200 | 0.35 | $1,628,130.00 | 310,459.00 | 198 | 0.30 | $18,441,265 | $16,813,135 | $672,525 | $16,140,609 | $161,406,092 |  |
| **Orchard** | 39,928.20 | 6000 | 0.50 | $119,784,600.00 | 155,647.20 | 5940 | 0.44 | $406,799,522 | $287,014,922 | $11,480,597 | $275,534,325 | $2,755,343,250 |  |
| **Pulses** | 32,260.00 | 1140 | 0.60 | $22,065,840.00 | 90,947.00 | 1129 | 0.58 | $59,532,815 | $37,466,975 | $1,498,679 | $35,968,296 | $359,682,958 |  |
| **Total Net benefit for One year** |  |  |  |  |  |  |  |  |  |  | $367,446,820.18 | **$3,674,468,201.82** |  |

Table 1: Agricultural Products - Cost - Benefit Analysis of Qush Tepa Canal

As shown in the table 1, by cultivating previously fallow lands and additional areas totaling over one million hectares, Afghanistan generates approximately $400 million in net revenue annually from the development of the North Basin. While this amount is substantial for Afghanistan’s economy, it pales in comparison to the country’s declined GDP. However, if investments were directed toward other development projects—such as hydropower dams on other rivers (such as the Kunduz River or Kabul River) or railway lines (Hairatan- Torkham or Torghundi to Spin Boldak)—the benefits would be far greater.

Now, the main discussion revolves around determining the water requirements for irrigating for all this command area, considering the significant impact of climate changes on humidity and evaporation. This study classified all agricultural products in this region into four categories: wheat, vegetables, orchards, and cereals/legumes. This study recalculated land values both before and after development, considering the construction of this channel, and adjusted product prices to reflect current rates. Factoring in rising temperatures and assuming full operation of this channel with crops at their peak growth and water consumption, along with maximum plant evaporation and transpiration under RCP 4.5 for climate change projection—the average daily water demand for this area amounts to 36.8 Mm3. To provide perspective, this is approximately equivalent to 426 m3/s from the Amu Darya River, constituting roughly 23% of the total flow at the Karki station, based on flow data from 1932 to 1989 of Amu Darya, figure 6. This water demand reaches its peak in May for this canal.

Within the course of the hydrology studies, not only the climatic conditions of the project area but also the water potential of the Amu Darya River is assessed. This gives a general idea of the peak water demand and total water required for the full operation of the canal and crops needed over the two years.

A graph with red and green rectangles

Description automatically generated

Figure 2: Water Deman for Full Operation of Qush Tepa Canal (Data Source: MAIL, 2020).

The total water required for one year of full cultivation of crops with 60% canal transfer efficiency would be 6,352,326,535 m3/year, which makes 7.9% of the total water flowing in the Amu Darya River (80 Bm3) and 28% of total water generated in Afghanistan (22.25 Bm3) flowing into the Amu Darya River.

To fully utilize the Qush Tepa Irrigation Canal along with its command area for cultivating cereals, orchards, and vegetables, calculations indicate a potential positive shift in the trend of food availability in Afghanistan. Cultivating 350,000 hectares within the command area of the Qush Tepa Canal could lead to the production of 490,000 metric tons of wheat. This significant increase in wheat production could substantially reduce Afghanistan's dependency on importing this crucial food staple. Similarly, the cultivation of vegetables, orchards, and pulses is expected to positively impact the economy and enhance the access and availability of food in the markets of Afghanistan for its residents. The figure below illustrates the revenue generated from the total command area of the Qush Tepa Canal before and after the project's implementation. This initiative represents a strategic move towards improving food security and economic stability in the region.

A graph of growth of crops

Description automatically generated with medium confidence

Figure 3: Revenue After the Canal Implementation.

The total command area of the Qush Tepa Canal encompasses 1,212,572 hectares of land. Presently, 21% of this area is irrigable and holds the potential for crop cultivation under specified conditions. Details regarding the soil type and other existing features of the command area are illustrated below:

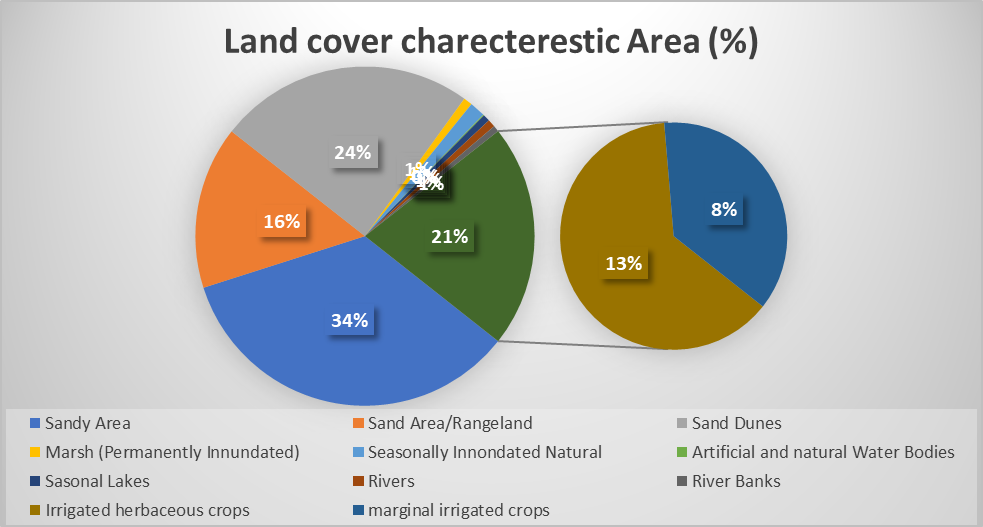


Figure 4: Land Cover Characteristics Area Percentage at the Project.

Given the current conditions and soil characteristics, it is not feasible for most crops to achieve full production, leading to reduced crop productivity. This reduction in productivity could be attributed to increased temperatures or soil infertility within the command area. Thus, the percentage of land suitability for various crops is defined below. The Qush Tepa Canal, which passes through three provinces, supports a diverse range of crop patterns. According to the report by the Ministry of Agriculture, Irrigation, and Livestock (MAIL) in 2020, the major crops produced in these provinces include several key varieties. Notably, the areas dedicated to wheat cultivation and production deserve attention, as they encompass both rainfed and irrigated wheat areas.

Figure 5: Wheat Production in the Three Provinces.

Figure 6: Total Rainfed and Irrigated Area for Wheat Production in the NRB (Data Source: MAIL, 2020)

Based on the provided data, the productivity in metric tons per hectare for the provinces of Balkh, Faryab, and Jawzjan are 1.42, 1.22, and 1.62, respectively, with Jawzjan province achieving the highest yield. The total area of irrigated wheat in these regions amounted to 348,944 hectares, encompassing both rainfed and irrigated wheat.

Wheat stands as one of Afghanistan's principal crops, occupying a total area of 2.53 million hectares and yielding an estimated production of 4.89 million metric tons. Given the country's population, the demand for wheat in 2020 was projected at 6.32 million metric tons. With the optimistic domestic yield of wheat accounted for, Afghanistan faces a deficit of 1.43 million metric tons, necessitating imports to meet this shortfall.

This analysis assumes that major crops, which are significant consumers of water, would be cultivated within the command area of the project. Initially, the suitability for cultivation in this command area is limited due to the soil's insufficient fertility for high-level crop growth. By adjusting the suitability criteria for crops to beyond 60%, only certain crops such as some varieties of wheat, orchards, vegetables, and pulses become viable options, with a total cultivable area of 130,000 hectares being feasible.

Figure 7: Suitability of Crop Cultivation at Project Area beyond 60%.

Within the specified range, wheat, pomegranate, and barley emerge as the most productive crops, with potential for widespread production across the area. Adopting an optimistic outlook and assuming efforts towards land improvement, soil classification, and enhanced fertility are successful, and by considering land with suitability beyond 40%, there will be opportunities to cultivate a broader array of crops. This expansion of crop cultivation could extend the cultivable command area to 512,000 hectares of land, significantly increasing agricultural productivity and diversity in the region.

Figure 8: Suitability of Crops Beneath 60% Revenue.

However, beneath 40% suitability, there will be further crops that are not feasible to use. Certainly, climate and temperature will have a significant impact on them. In this scenario, the amount of land will be almost 50% of the total command area of the Qush Tepa Canal project.

Now, we categorize all the possible crops in the command area of the project into four categories, such as wheat, vegetables, Orchard, and pulses. Based on these categorizations, we will develop our economic analysis and calculations.

Since the area is sandy with sand dunes including rangeland, the cultivation of a variety of crops at the beginning of the project is challenging and needs efforts, technology, and research to find out the suitability of crops and production. The below graph shows that.

A graph of growth of crops

Description automatically generated with medium confidence

Figure 9: Comparison of Revenue - Before and After the Implementation of the Project for Four Groups of Crops.

Wheat and orchards are identified as the most revenue-generating crops in the North Basin. Although the project is in its initial phase of implementation and may not yield substantial revenue at the onset of harvesting, it is anticipated to have a significant financial impact and generate considerable profit over time.

A graph of a number of different colored columns

Description automatically generated with medium confidence

Figure 10: Net Profit in One Year with Current Market Price.

At the elementary stages, this project requires significant investment and meticulous attention, particularly in the operation and maintenance of the canal and its dependencies. Such investments are crucial for enhancing yield and productivity. For this reason, it has been considered appropriate to allocate four percent of the net profit from each major crop towards operation and maintenance costs. Despite the expectation that yield per hectare will remain unchanged before and after the project, it is projected that the net revenue, after achieving full cultivation of the area with efficiency below 85%, will amount to 367 million USD annually. When distributed across the total population of Afghanistan, which stands at 42 million according to the World Bank in 2023, this equates to an almost 10 USD yearly impact on the individual GDP of Afghanistan’s residents, which may seem minimal. However, reinvesting this amount into other infrastructure projects, such as diversion dams for irrigation or hydropower production along the Kunar or Kabul River, or into initiatives aimed at increasing crop productivity and yield, could significantly enhance the living standards of the population.

Afghanistan's annual import of 1.2 million metric tons of wheat, accounting for 20% of its consumption (World Bank, 2014), underscores the critical need for increased wheat yield. The World Bank's 2014 report recommends that irrigated wheat offers the best potential for yield improvement, proposing two strategies: expanding the area under irrigation through rebuilding and new investments. Following this recommendation, the Government of Afghanistan has embarked on the Qush Tepa Canal project as part of a self-sufficient strategy for wheat production, aiming to significantly reduce the nation's dependency on wheat imports and other agricultural products.

It is obvious that climate will affect the environment and water resources of the North River Basin and significantly impacts agriculture in the area. Livelihood, and dependency of the residents on agriculture and its productivity is vital. Production of food for households with low income through agriculture will be endangered and moves through famine as result endangers dietary recommendations. The trend of temperature increase and reduction in rainfall up the end of century, Afghanistan will experience higher temperature in the North River Basin with reduction of rainfall. This impact rainfall, cropping pattern and crop harvesting along with productivity. Population growth, and excessive increasing food demand in current state and future requires innovative solutions be seeking which the Qush Tepa is one of them. However, this canal was established more than 50 years ago, but it is necessary for the region to produce enough food for the residence. Climate change impacts the production of primary food need of the residence by reduction in harvesting, however the soil of the command area is not still fertilized to produce the maximum yield. The food production of the canal will have one percent impact on GDP of Afghanistan. However, although it may not be sufficient for per capita use, it is highly beneficial to utilize the revenue generated by the canal to invest in other infrastructure projects. These projects could include hydropower generation dams on the Kunar River, establishing and extending train tracks, and other appropriate domestic infrastructural developments.

# 5. Discussion

Construction of the Qush Tepa canal has been in the plan of former governments of Afghanistan when there was no discussion of climate change and water reduction. However, droughts were sensible in some parts of the country, but not obvious. The former governments had projections that for self-sufficiency and being independent, there is need for fostering agriculture and livestock. Based on various reports, 75% of Afghanistan population deals with agriculture and it is counted as agricultural productive country. Non-existing of machinery and advanced tools have made agriculture and irrigation in Afghanistan to grow in the form of local and indigenous type which reduced production and harvesting. It also needs many efforts to gain a reasonable harvesting limit. Considering the last 24 years, since 2001, establishment of republic government in Afghanistan, significant steps picked up for managing natural resources especially water, but majority of them did not end up in a way to have continued sustainability and economic productivity. Reinitiation of Qush tepa canal was taken on hand to reduce migration and create jobs for the people of Afghanistan and release the country from dependency to other countries. This is during that antigovernment groups had been spread mostly in rural areas of the country and the neighboring countries, mainly the central Asian as neighbors of Afghanistan had expressed their concerns over the mass migration of the people and insurgents/insurgency from Afghanistan. However, the government of Afghanistan had several proposals for boosting the economy of the country and the region, but due to instability of the political state of the country these plans were not welcomed by the neighbors. Restarting the feasibility study of the Qush Tepa commenced in 2017 from Ministry of Agriculture, Irrigation, and Livestock (MAIL). It was concepts that irrigating the norther deserts of Afghanistan from Amu Darya will significantly reduce the cereals imports, but in return increases the exports. Technical teams from the Ministry of Agriculture, Irrigation and Livestock (MAIL) dispatched to the site to collect basic information, while from previous studies there was no information on hand.

The expectation from this irrigation canal is very high and hopes are that it will create jobs for the people and boost food availability in the markets of the country. Elementary estimations show that cultivating cereals in the newly developed area will significantly decrease the import of cereals from abroad specially the wheat which is the main substance of users. Additionally, Afghanistan will be able to control and use wisely the water resources it has in the possession. While at the time of the republic government only 8 km of the canal was constructed, several letters of the downstream countries specially Uzbekistan had reached to address of Ministry of Foreign Affairs of Afghanistan (MoFA) and requested information regarding the new excavation across the Amu Darya. Later, as the republic government collapsed, and the new regime came to power, the construction of this canal expedited which reached to 108 km in almost two years as the first phase of the project. Similarly, the central Asian countries, mainly the downstream ones, (Uzbekistan and Turkmenistan) continued sending similar letters to the new de facto regime. However, these letters did not reduce the speed of excavation of the canal on the ground. As result, the president of Uzbekistan announced that this canal will change the water rights of the downstream canals and changes the water regime. Water is mainly used in the downstream countries for cultivation of cotton for export. Various challenges exist on the ground for fertilizing the soil and enabling it to produce maximum yield in a short period of time.

Economically this construction of this canal will have a significant increase in production and job opportunities for Afghanistan. Form the other side, it prevents people from migrating out of the country to work outside as farmers, especially in the neighboring countries’ farms and greenhouses. It increases the average income of the basins’ residences at first step and secures food production and availability for the entire country.

Politically, it is a weighting stone that pressures the downstream countries to consider Afghanistan as a major water contributor and user of the Amu Darya. This position provides Afghanistan power to play significant role in ensuring its valid requests and bilateral interactions. However, using water from Amu Darya to Qush Tepa canal might not significantly harm the down streamers, as in comparison to water waste and inefficient water consumption in Central Asia, but it impacts them in long time when the glaciers melts in upstream. (Murzakulova, 2023) believes there will be 10-15% reduction in water flow to downstream riparian. Additionally, it encourages them to collaborate and cooperate with the new player and consider them as a major stakeholder. In the past, the water of Amu Darya was distributed among the five the Central Asian countries and Afghanistan was not considered as shareholder. Moreover, Afghanistan still do not have any treaty or signed MoU with the Central Asian countries over the shared water.

Afghanistan is geographically close to a large desert area, and the problems of desertification and sandstorms are very prominent. After the completion of the Qush Tepa canal, there is a plan to set large numbers of trees along the canal in the desert area. Through a forestation they can increase soil moisture and improve soil texture thus promoting land restoration and desertification prevention at the same time trees can block sandstorms slow downwind speed and sand erosion turn deserts into fertile farmland to developed agriculture and solve employment problems for more people the goal of grain exports can also be achieved. However, some countries are not optimistic about this plan which involves a vas territory huge investment and is time consuming. Israelis experts analyze that turning desert to fertile farmland is a miraculous project that cannot be realized in the short term. If it wants to complete it as soon as possible, Afghanistan can learn from China’s experience or seek help. China has been very successful in controlling desertification through decades of efforts it has save 700,000 acres of fertile farmland and pasture for the local area. Of course, in addition to China, Australia and Israel are also world leading in desert control technology. They also have rich and successful experience in desert control and can also provide Afghanistan with good suggestion.

# 6. Conclusion

Within the diverse river systems of Afghanistan, the North River Basin stands out as a pivotal watershed, notably housing the significant city of Balkh, which is a major hub of population. Additionally, this basin shares a border with Uzbekistan, adding to its strategic importance. Over the years, numerous feasibility studies such as the first Afghan republic government in 1976, and later 2017- have been conducted to explore the potential of irrigating the vast, yet untapped, desert plains within this region. The Qush Tepa project, conceived in 1976, remained on the drawing board until 2017 when the Islamic Republic of Afghanistan undertook a fresh feasibility study and initiated its physical construction. This move aimed to reduce food insecurity and domestic water competition, generate employment for returning migrants and citizens, address the mismatch between water demand and availability in the basin, and decrease the nation's reliance on imported wheat and other cereals to sustain food security.

However, the project's progression has heightened concerns among downstream countries, particularly Uzbekistan, due to potential impacts on water distribution. The Afghan governments have consistently argued that it is merely exercising the country's legal water rights and that neighboring countries should comprehend, especially since Afghanistan has no formal water-sharing agreements with Central Asian states. It is projected that Afghanistan will allocate between 7-10 Bm3 of its 22 Bm3 contribution to the Amu Darya River to the Qush Tepa canal.

Downstream countries, especially those reliant on the Amu Darya, have expressed worries that the canal's construction will disrupt the established water distribution framework in Central Asia, as outlined in the 1992 Almaty Agreement. Despite these concerns, the canal is deemed essential for Afghanistan to assert its legal water rights, aiming to alleviate hunger and boost agricultural production. This need has become increasingly urgent as the northern regions of Afghanistan have been suffering from severe droughts and climate change impacts over the past decade, significantly reducing cropland cultivation and agricultural output.

This report addresses downstream countries' concerns, highlighting that the areas traversed by the canal (Kaldar – Andkhoi districts) feature diverse soil conditions, which currently yield suboptimal agricultural productivity. Nevertheless, the completion of the canal's first phase, extending 108 km, is a significant milestone. Despite challenges posed by climate change, there is potential for cultivating a variety of crops with productivity increases of 60%, including cotton, wheat, barley, eggplant, melon, watermelon, cucumber, and pomegranate. This could generate an annual net profit of $367.5 million, significantly benefiting Afghanistan's GDP.

Afghanistan is facing the impacts of climate change sooner and more severely than climate models CMIP6, and RCPs 4.5 and 8.5 projections anticipated. Current trends indicate a warming trajectory exceeding global averages, with temperature increases between 1.4 and 5.4°C expected by 2099. This warming is likely to severely affect water resources and agricultural yields, further challenging food availability in the country. Also, there is reduction in precipitation by 25% after two decades from now. The canal, designed to meet the irrigation needs of its command area, requires 6.35 Bm3 annually, with peak water demand reaching 36.83 Mm3 under the 4.5 RCP climate change scenario during periods of maximum crop growth. This demand is within the seasonal flow capacities of the Amu Darya and the canal's design, suggesting a thoughtful approach to balancing water use and agricultural needs.

The study has concluded that the Qush Tepa canal is a strategic and innovative endeavor that seeks to tap into the potential of the Amu Darya River, aiming to strike a balance between environmental conservation and the well-being of society. It suggests that the project is poised to significantly influence the livelihoods and resilience of the local population. However, the quantity of water flowing downstream is decreasing, leading to the failure of efforts to maintain the downstream environment. Agrarian lands along the path of the tailwater will not receive the same amount of water as before, potentially increasing transboundary water conflicts.

Furthermore, the Qush Tepa National Irrigation Canal embodies both opportunity and challenge. It has the capacity to revolutionize the North River Basin, yet its successful implementation and management demand meticulous consideration of technical, social, institutional, and geopolitical complexities. Looking forward, it will be essential to monitor its effects on local communities and regional dynamics closely.

In addition to the key insights of this study, another notable aspect is the interplay between food security and climate change within the region, which could variably affect transboundary water conflicts and cooperation, contingent on the specific circumstances and political climate among neighboring countries. The canal not only has the potential to impact the environment, food security, and foster closer ties between neighboring states but also to drive them apart, while unlocking new economic and bilateral opportunities for the region and its sole stakeholder.

# 6. References

Ahmad, M., & Wasiq, M. (2004a). Water resource development in Northern Afghanistan and its implications for Amu Darya basin. In *World Bank Working Paper* (Issue 36).

Ahmad, M., & Wasiq, M. (2004b). Water Resource Development in Northern Afghanistan and Its Implications for Amu Darya Basin. In *World Bank Working Paper* (Issue 36). The World Bank. https://doi.org/10.1596/0-8213-5890-1

Aich, V., Akhundzadah, N., Knuerr, A., Khoshbeen, A., Hattermann, F., Paeth, H., Scanlon, A., & Paton, E. (2017). Climate Change in Afghanistan Deduced from Reanalysis and Coordinated Regional Climate Downscaling Experiment (CORDEX)—South Asia Simulations. *Climate*, *5*(2), 38. https://doi.org/10.3390/cli5020038

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

Akhtar, F., & Shah, U. (2020b). 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

Akhundzadah, N. A., Soltani, S., & Aich, V. (2020). Impacts of Climate Change on the Water Resources of the Kunduz River Basin, Afghanistan. *Climate*, *8*(10), 102. https://doi.org/10.3390/cli8100102

Ansar, M. (2018). *Two Million Afghans Face Food Shortage*. TOLOnews. https://tolonews.com/afghanistan/two-million-afghans-face-food-shortage

Archer, D. R., Forsythe, N., Fowler, H. J., & Shah, S. M. (2010). Sustainability of water resources management in the Indus Basin under changing climatic and socio economic conditions. *Hydrology and Earth System Sciences*, *14*(8), 1669–1680. https://doi.org/10.5194/hess-14-1669-2010

Badescu, V., & Schuiling, R. D. (2010). Aral Sea; Irretrievable Loss or Irtysh Imports? *Water Resources Management*, *24*(3), 597–616. https://doi.org/10.1007/s11269-009-9461-y

BBC. (2023). *طالبان با تکمیل فاز اول، فاز دوم کانال انتقال آب قوش‌تپه را آغاز کرد*. https://www.bbc.com/persian/articles/cw9v5v1levgo

Bekchanov, M., & Lamers, J. P. A. (2016). The effect of energy constraints on water allocation decisions: The elaboration and application of a system-wide economic-water-energy model (SEWEM). *Water (Switzerland)*, *8*(6), 253. https://doi.org/10.3390/W8060253

Berking, J., Beckers, B., Reimann, T., Pollock, S., & Bernbeck, R. (2017). Modern impacts on an ancient landscape, the piedmont plain in southwest Turkmenistan. *Wiley Interdisciplinary Reviews: Water*, *4*(2), 1–20. https://doi.org/10.1002/wat2.1202

Central Intelegence Agency. (2021). *The CIA world factbook 2021-2022*.

Daryo. (2023). *Its establishment may fundamentally change the order and balance of water use in Central Asia’ - President of Uzbekistan on construction of Koshtepa Canal*. https://daryo.uz/en/2023/09/15/its-launch-may-fundamentally-change-the-order-and-balance-of-water-use-in-central-asia-shavkat-mirziyoyev-on-construction-of-koshtepa-canal

Dost, R., Soundharajan, B. S., Kasiviswanathan, K. S., & Patidar, S. (2023). Quantifying Drought Characteristics in Complex Climate and Scarce Data Regions of Afghanistan. *Geosciences (Switzerland)*, *13*(12). https://doi.org/10.3390/geosciences13120355

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

Frotan, M. S., Nakaza, E., Schaab, C., & Motoyashiki, R. (2020). Surface water resources of Afghanistan’s northern river basin and effects of climate change. *Journal of Japan Society of Civil Engineers*, *8*(1), 118–126. https://doi.org/10.2208/JOURNALOFJSCE.8.1\_118

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

Hakimi, B. A. (2024). *50% of Afghans Live in Poverty: Advocacy Advisor of NRC*. TOLOnews. https://tolonews.com/business-187936

Hu, Z., Zhang, C., Hu, Q., & Tian, H. (2014). Temperature changes in central Asia from 1979 to 2011 based on multiple datasets. *Journal of Climate*, *27*(3), 1143–1167. https://doi.org/10.1175/JCLI-D-13-00064.1

Ibrahimzada, M. W., & Sharma, D. (2012). *Vulnerability assessment of water resources in Amu Darya river basin ,*. *3*(2), 802–812. https://doi.org/10.6088/ijes.2012030132007

Ilkhamov, A. (2023). *Implications for Uzbekistan ’ s Water Supply of Qosh Tepa Canal Construction in Afghanistan*. 1–13.

Jawid, A. (2020). A Ricardian analysis of the economic impact of climate change on agriculture: Evidence from the farms in the central highlands of Afghanistan. *Journal of Asian Economics*, *67*, 101177. https://doi.org/10.1016/j.asieco.2020.101177

Jawid, A., & Khadjavi, M. (2019). Adaptation to climate change in Afghanistan: Evidence on the impact of external interventions. *Economic Analysis and Policy*, *64*, 64–82. https://doi.org/10.1016/j.eap.2019.07.010

Kamil, I. (2021). Afghanistan, the Amu Darya Basin and Regional Treaties. *Chinese Journal of Environmental Law*, *5*(1), 37–62. https://doi.org/10.1163/24686042-12340063

Lipponen, A. (2007). Applying GIS to assess the vulnerability of the Päijänne water-conveyance tunnel in Finland. *Environmental Geology*, *53*(3), 493–499. https://doi.org/10.1007/s00254-007-0671-4

Lipponen, A., Manninen, S., Niini, H., & Rönkä, E. (2005). Effect of water and geological factors on the long-term stability of fracture zones in the Päijänne Tunnel, Finland: a case study. *International Journal of Rock Mechanics and Mining Sciences*, *42*(1), 3–12. https://doi.org/10.1016/j.ijrmms.2004.05.006

Liu, Y., Jiang, Y., Zhang, S., Wang, D., & Chen, H. (2024). Framework for comprehensive assessment of ecological water conveyance based on long-term evolution forecast of riparian forests in arid floodplains: synergistic consideration of flood inundation and groundwater. *Process Safety and Environmental Protection*, *184*(February), 1357–1368. https://doi.org/10.1016/j.psep.2024.02.056

Ministry of Economy. (2019a). *Balkh Provincial Profile*.

Ministry of Economy. (2019b). *Faryab Provincial Profile*.

Ministry of Economy. (2019c). *Jawzjan Provincial Profile*.

Ministry of Planning. (1976). *First Seven Year Economic and Social Development Plan 1355 - 1361 Vol. II*. *Vol. II*, 182. http://afghandata.org:8080/xmlui/handle/azu/791

Mohd Faizee & Susanne Schmeier. (2023). *Charting Complex Currents: The Qush Tepa Canal and Central Asia’s Water*. Newsecuritybeat.Org. https://www.newsecuritybeat.org/2023/08/charting-complex-currents-qush-tepa-canal-central-asias-water/?utm\_campaign=ecsp&utm\_medium=email&utm\_source=newsletter&emci=3a231e3f-cb3d-ee11-a3f1-00224832eb73&emdi=add00779-cc3d-ee11-a3f1-00224832eb73&ceid=21014

Muradi, S., Phien-Wej, N., & Giao, P. H. (2013). Depletion of Water Resources, Issues and Challenges of Water Supply Management in Mazar-i-Sharif City, Afghanistan. *Research Journal of Environmental and Earth Sciences*, *5*(5), 242–251. https://doi.org/10.19026/rjees.5.5656

Murzakulova, A. (2023). The Impact of cClimate Change on Central Asian Hydro-Politics. In *University of Central Asia*. Wilfrid Laurier Press.

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

Nori, S. M. (2020). Challenges of transboundary water governance in Afghanistan. *Central Asian Journal of Water Research*, *6*(1), 18–38. https://doi.org/10.29258/CAJWR/2020-R1.v6-1/18-38.eng

Pacific Instituite. (2024). *Water Conflict Chronology*. https://www.worldwater.org/conflict/list/

Ranjan, A. (2020). Water Issues in Himalayan South Asia. In A. Ranjan (Ed.), *Water Issues in Himalayan South Asia: Internal Challenges, Disputes and Transboundary Tensions*. Springer Singapore. https://doi.org/10.1007/978-981-32-9614-5

Rickleton, C. (2023). *Not A Problem But A Disaster’: Afghan Canal A Test For Taliban Ties In Water-Stressed Central Asia*. Rferl.Org. https://www.rferl.org/a/afghanistan-taliban-canal-water-central-asia/32350996.html

Sanu Khanal, Corjan Nolet, Mehriddin Tursunov, Johannes Hunink, D. de C. (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

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*, *00*(00), 1–19. https://doi.org/10.1080/02626667.2022.2159411

Shroder, J. F. (2014). Natural Resources in Afghanistan. In *Natural Resources in Afghanistan: Geographic and Geologic Perspectives on Centuries of Conflict*. Elsevier. https://doi.org/10.1016/C2013-0-14018-4

Stulina, G., & Eshchanov, O. (2013). Climate change impacts on hydrology and environment in the Pre-Aral region. *Quaternary International*, *311*, 87–96. https://doi.org/10.1016/j.quaint.2013.07.015

Suryavanshi, S., Joshi, N., Maurya, H. K., Gupta, D., & Sharma, K. K. (2022). Understanding precipitation characteristics of Afghanistan at provincial scale. *Theoretical and Applied Climatology*, *150*(3–4), 1775–1791. https://doi.org/10.1007/s00704-022-04257-4

TOLOnews. (2023, October 11). *Work on Second Phase of Qosh Tepa Canal Starts | TOLOnews*. https://tolonews.com/afghanistan-185493

TOLOnews. (2024). *مستند قوش تیپه 2*. TOLOnews. https://www.youtube.com/watch?v=imhNl0ZUdzI

Torell, G. L., & Ward, F. A. (2010). Improved Water Institutions for Food Security and Rural Livelihoods in Afghanistan’s Balkh River Basin. *International Journal of Water Resources Development*, *26*(4), 613–637. https://doi.org/10.1080/07900627.2010.519492

USAID Sustainable Water Partnership. (2021). *Afghanistan Water Resources Profile*. 1–8. https://winrock.org/wp-content/uploads/2021/08/Afghanistan\_Country\_Profile-Final.pdf

Veijalainen, N., Ahopelto, L., Marttunen, M., Jääskeläinen, J., Britschgi, R., Orvomaa, M., Belinskij, A., & Keskinen, M. (2019). Severe drought in Finland: Modeling effects on water resources and assessing climate change impacts. *Sustainability (Switzerland)*, *11*(8). https://doi.org/10.3390/su11082450

Wang, D., Zhang, S., Wang, G., Liu, Y., Wang, H., & Gu, J. (2022). Reservoir Regulation for Ecological Protection and Remediation: A Case Study of the Irtysh River Basin, China. *International Journal of Environmental Research and Public Health*, *19*(18). https://doi.org/10.3390/ijerph191811582

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

World Bank. (2014). *Islamic Republic of Afghanistan Agriculture Sector review*. *June*, 107.

World Food Programme. (2024). *Wfp afghanistan*. *10163*(March), 29–30. https://reliefweb.int/attachments/78a83311-16a0-4787-a660-f5a8610627a8/AFG EXT SITREP 2024 02.pdf

Zheng, Y., Niu, J., Zhou, Q., Xie, C., Ke, Z., Li, D., & Gao, Y. (2018). Effects of resource availability and hydrological regime on autochthonous and allochthonous carbon in the food web of a large cross-border river (China). *Science of the Total Environment*, *612*, 501–512. https://doi.org/10.1016/j.scitotenv.2017.08.266

1. Participant observation of this research’s Principal Investigator. [↑](#footnote-ref-1)
2. Interviews with the farmers and local residents of Balkh, Afghanistan, August and September 2023. [↑](#footnote-ref-2)
3. Interviews with the local residents and workers on the canal in Balkh, Afghanistan, July 2023. [↑](#footnote-ref-3)
4. Interviews with the farmers, shepherds, and local residents of Balkh, Afghanistan, August and September 2023. [↑](#footnote-ref-4)
5. Interviews with the farmers, workers, and local residents of Balkh, Afghanistan, August and September 2023. [↑](#footnote-ref-5)
6. Interviews with the farmers and local residents of Jungle Saziq in Balkh, Afghanistan, July 2023. [↑](#footnote-ref-6)
7. Interviews with the engineers and workers of the canal in Balkh, Afghanistan, August and September 2023. [↑](#footnote-ref-7)
8. Interviews with the local residents of Jawzjan, Afghanistan, September 2023. [↑](#footnote-ref-8)
9. Interviews with the local residents of Aqcha and Andkhoi in Jawzjan and Faryab, respectively, Afghanistan, September 2023. [↑](#footnote-ref-9)
10. Interviews with the engineers and workers in Balkh, Afghanistan, September 2023. [↑](#footnote-ref-10)
11. Focus group with a former minister of Afghanistan and two experts on water affairs of Afghanistan, online, December 2023. [↑](#footnote-ref-11)