

Case Study

Large-scale Technical Feasibility Studies for the Qosh Tepa Canal Irrigation Project

Swati Rao and Mohammad Qasim Nazari



Introduction

The Qosh Tapa Canal Irrigation Project (QTCIP), popularly known as the "Qosh Tapa Canal", is a historically important project for Afghanistan. Former Afghan leaders had envisioned the megaproject as early as the latter half of the 20th century; however, due to the country's prolonged instability and conflict over the past several decades, it remained unrealized and continued to be a distant aspiration.

QTCIP was born out of a pressing need to address Afghanistan's growing water scarcity and its impact on agricultural livelihoods. The northern provinces of Kunduz, Balkh, Jawzjan, and Faryab, once thriving agricultural hubs and termed the "breadbasket of Afghanistan", have been grappling with inconsistent water supply, leading to reduced crop yields and food insecurity. Ensuring a sustainable water source is not only critical for putting food on the table for the millions of Afghans facing acute food insecurity, but also vital for the country's economic stability and long-term development.

While the canal shows potential for enhancing domestic economic conditions, the project comes with a set of serious regional implications. The Amu Darya River, a critical water source for multiple Central Asian countries, is already under stress due to climate change and increasing demand. Once fully operational, the Qosh Tapa Canal is expected to divert up to 13 billion cubic meters of water annually (estimate based on the Adroit Associates Technical Feasibility Studies Report), which could impact downstream water availability for Uzbekistan, Turkmenistan, and Kyrgyzstan. While Afghanistan has historically underutilized its share of the river, concerns have been raised by regional stakeholders about potential disruptions to existing water-sharing dynamics.

QTCIP aims to divert water from the Amu Darya River to irrigate over 500,000 hectares of land. This would not only boost agricultural productivity but also improve the resilience of rural communities against climate change and water shortages.

Supported by USAID under the Strengthening Watershed and Irrigation Management (SWIM) initiative, the technical feasibility studies for QTCIP were divided into two phases, each designed to assess the technical, environmental, and socio-economic feasibilities of the scheme. **Phase I** focused on conducting preliminary studies to identify the most viable intake location for the irrigation canal. Phase II built on these findings by comparing potential sites in Kaldar District of Balkh



province and Qosh Tapa, an area on the border between Balkh and Kunduz, ultimately recommending Qosh Tapa for its engineering and environmental advantages.

While Qosh Tapa was found to be the technically optimal intake location due to its ability to support gravity-fed irrigation, the Afghan government ultimately selected Kaldar, citing cost-effectiveness and logistical feasibility. This decision aligns with immediate financial constraints but may affect the long-term efficiency and sustainability of the project. Additionally, regional concerns persist over how the canal's water diversion could impact agricultural and hydropower operations downstream.

From 2020 to 2021, Adroit Associates (formerly AACS Consulting) was mandated by USAID and the Afghan Government to conduct detailed feasibility studies in anticipation of the Qosh Tapa Canal construction. Despite challenges such as limited data availability, field access limitations and security threats, tight deadlines, and complex stakeholder dynamics not to mention the obvious irritation of Afghanistan's northern neighbors, these studies provided valuable insights to promote effective and efficient water resource management, agricultural feasibility, and environmental sustainability.

While Adroit's findings were grounded in rigorous technical and environmental analysis, it is important to note that the ongoing construction and implementation of the canal do not necessarily reflect all of the recommendations made in our feasibility studies. Political, geopolitical, financial, and optical considerations have understandably shaped the final decisions, occasionally diverging from the technically optimal solutions identified through our assessments.

This case study highlights the technical evaluations, decision-making process, and lessons learned from both phases of the feasibility studies, showcasing Adroit's expertise in delivering high-impact solutions for large-scale irrigation projects such as the Qosh Tapa Canal.

Feasibility Studies Project Background

USAID and the Government of Afghanistan tasked Adroit Associates with assessing the Qosh Tapa Canal's technical, environmental, and socio-economic feasibilities. The feasibility studies were divided into two phases, each providing critical insights to guide critical decision-making that would ensure Afghanistan benefited from Amu Darya River at a grand scale in the most effective and efficient manner.

Phase I: Comprehensive Feasibility Studies

In Phase I, Adroit Associates deployed a team of 20 international experts and over 100 national specialists to conduct several technical field investigations and tests aiming to assess the feasibility of diverting water from the Amu Darya River. The focus was on selecting a suitable intake location and evaluating the hydrological and environmental impacts.

Key activities in this phase included:



Hydrological Studies

Using advanced hydrological models such as HEC-HMS, Adroit evaluated water availability from the Amu Darya, focusing on peak flow periods and potential deficits.



Hydropower Generation and Climate Change Studies

The feasibility study explored the potential for run-of-river hydropower generation, estimating a possible 18.2 MW capacity. Climate modeling using CSIRO GCM and RCP 6.0 scenarios assessed long-term water security risks due to rising temperatures and changing precipitation patterns.



Water and Soil Testing

A comprehensive soil and water testing program was conducted, involving 100+ wells drilled across the proposed canal route to assess groundwater depth and quality, 130+ soil profiles examined to evaluate soil texture, fertility, and irrigation potential, and 500+ soil samples analyzed for salinity, permeability, and suitability for crop production.



Topographic and Geodetic Surveys

A detailed topographic survey was performed using 30m DEM models, Soviet-era topographic maps, and Google Earth elevation data. 53 geodetic control points were installed along the canal alignment, ensuring high-precision mapping (± 10 cm accuracy).



Geotechnical Assessments

Conducted slope stability and seepage analysis to determine foundation requirements for key structures.



Environmental Impact Assessment

Adroit carried out a detailed environmental impact assessment to understand the potential ecological and social effects of the project.

Phase II: Intake Location Selection and Detailed Studies

Building on Phase I, Phase II narrowed the focus to a comparative analysis of intake locations. The two shortlisted sites—Qosh Tapa and Kaldar—were evaluated on factors such as water flow reliability, engineering feasibility, and socio-economic benefits. Adroit's team conducted advanced hydrological simulations, environmental flow assessments, and sensitivity analyses to recommend Qosh Tapa as the optimal site.

This phase also included in-depth engineering studies, such as:



Environmental and Social Impact Assessments

The feasibility studies included extensive field surveys to assess the ecological impact of water diversion and 15+ community consultations to evaluate socio-economic concerns and resettlement impacts. Despite the feasibility study recommending Qosh Tapa, the Afghan government ultimately selected Kaldar as the intake location to reduce initial costs.



Gravity vs. Lift Irrigation Comparison

The study compared gravity-fed irrigation at Qosh Tapa with lift irrigation at Kaldar, concluding that Qosh Tapa's higher elevation (311 meters above sea level) allowed for cost-effective gravity irrigation, saving \$413M in capital costs and \$181M in operational costs over 10 years.



Water Allocation Models

Adroit used Water Evaluation and Planning (WEAP) models to analyze different water demand scenarios for 500,000 hectares, including climate change impacts.

Qosh Tapa Irrigation Project: Key Milestones and Adroit's Impact

Phase I (Nov 2018 – Dec 2019):

Milestone 1

Initial hydrological and environmental assessments.

Milestone 2

Collection of soil, water, and topographic data.

Milestone 3

Shortlisting of intake locations (Qosh Tapa and Kaldar).

Phase II (Jan 2020 – Dec 2020):

Milestone 4

Comparative technical studies of Kaldar vs. Qosh Tapa.

Milestone 5

Advanced hydrological and environmental impact analysis.

Milestone 6

Final recommendation of Qosh Tapa as the intake site, balancing technical feasibility, cost-effectiveness, and environmental sustainability.

Adroit's Roles

- Conducted one of the most detailed technical feasibility studies in Afghanistan.
- Successfully navigated challenges such as limited field access, data scarcity, complicated stakeholder dynamics, and political considerations.
- Demonstrated technical expertise in hydrology, soil science, engineering, and project management.



Photo credit: Adroit Associates

Technical Feasibility Studies

QTCIP involved comprehensive technical feasibility studies to evaluate the viability of diverting water from the Amu Darya River to support large-scale irrigation. Below are the key technical aspects covered.

Hydrology, Hydropower, and Climate Change Studies

The hydrological assessments were central to evaluating the water availability for QTCIP. The Amu Darya River was identified as the primary source of water, and advanced hydrological models were used to simulate water flow and assess potential deficits during critical irrigation months.

■ HEC-HMS Mode

The Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS) was deployed to simulate precipitation-runoff processes across the Amu Darya River basin. This model was essential in generating naturalized flow estimates, compensating for missing historical streamflow data between 1988 and 2009.

■ Hydropower and Climate Change Study

The feasibility study included an assessment of the potential for hydropower generation at the intake locations. The study found that while a run-of-river hydropower plant could generate 18.2 MW at the Qosh Tapa site, the economic feasibility of hydropower in this context was limited due to fluctuating seasonal water flows. Furthermore, a climate change assessment was conducted using CSIRO GCM and RCP 6.0 scenarios, predicting that while water availability could sustain irrigation for 500,000 hectares, projected increases in temperature and variability in precipitation could impact long-term water security. As a result, adaptive water management strategies were recommended to ensure sustainability.

■ Water Availability

The studies identified that, while the Amu Darya River generally provides sufficient water, both intake locations (Kaldar and Qosh Tapa) faced water deficits during May and June, the peak irrigation months. Using the 80% exceedance probability flow analysis, it was determined that approximately 270,000 hectares could be irrigated under normal conditions. However, under optimized scenarios, reducing cropping intensity and adjusting environmental flow requirements, up to 500,000 hectares could be irrigated.



Infrastructure Engineering Feasibility Studies

The engineering studies focused on comparing two potential intake sites—Kaldar and Qosh Tapa—based on the viability of canal construction, irrigation methods, and overall project sustainability.

■ Gravity vs. Lift Irrigation

One of the key engineering decisions was between gravity-fed irrigation (Qosh Tapa) and lift irrigation (Kaldar). The study concluded that Qosh Tapa's location at 311 meters above sea level allowed for gravity-fed irrigation, significantly reducing long-term operational costs. In contrast, Kaldar required costly lift systems to irrigate the same areas.

■ Cost-Benefit Analysis

The gravity-fed system at Qosh Tapa offered substantial savings. It was projected that gravity irrigation could save up to USD 413 million in capital costs and reduce operations and maintenance costs by USD 181 million over ten years. These savings made the Qosh Tapa intake the more financially viable option.

As the canal construction progresses, careful water management is necessary to prevent excessive depletion of the Amu Darya, which remains a shared resource among multiple Central Asian nations.

Infrastructure Engineering Feasibility Studies: Gravity Irrigation vs. Lift Irrigation

Gravity Irrigation (Qosh Tepa)

Benefits

- Long-term cost savings (USD 413 million in capital costs).
- Sustainable with lower maintenance costs (USD 181 million savings over 10 years).
- Higher irrigation potential (up to 500,000 hectares).

Challenges

- Higher initial construction costs for canal systems.

Lift Irrigation (Kaldar)

Benefits

- Lower initial construction costs (USD 271 million savings upfront).

Challenges

- Expensive operational costs for lift systems and pumping stations.
- Limited irrigable land (around 270,000 hectares).
- Higher environmental impact due to infrastructure needs.

Conclusion: Gravity irrigation at Qosh Tepa is more cost-effective and sustainable over the long term.

Environmental and Social Impact Assessments

- **Field surveys to map** ecological and biodiversity impacts.
- **Public consultations with 15+** communities to assess social concerns.
- **Analysis of potential** resettlement and compensation needs.
- **Environmental Flow Requirements**

The studies also evaluated environmental flow needs to ensure the river's ecological balance was maintained. Qosh Tepa was found to support sustainable irrigation without drastically impacting downstream users or ecological zones.

Water Allocation and Planning

The feasibility study employed Water Evaluation and Planning (WEAP) models to simulate water allocation under different scenarios, including potential impacts of climate change.

■ **WEAP Model**

This model was developed to simulate water demand and supply scenarios under different conditions to assess water demand for domestic, agricultural, and environmental uses across the command area. The model provided insights into how water resources could be managed to support irrigation while maintaining environmental flow classes. The model accounted for:

- Irrigation demand (500,000 hectares)
- Environmental flow requirements (10–37% of river flow)
- Downstream water use for Uzbekistan and Turkmenistan



Photo credit: Adroit Associates

■ **Climate Change Scenarios**

A climate change analysis (based on the CSIRO GCM and RCP 6.0) showed that Qosh Tepa Canal could reliably irrigate over 500,000 hectares under projected conditions, while minimizing risks to downstream users.

Geotechnical and Soil Assessments

Geotechnical studies were essential to ensure the viability of large-scale irrigation across the Qosh Tapa command area. These studies assessed the soil's ability to support sustained irrigation without degradation.

■ Detailed Topographic Survey

The survey identified key elevation constraints and slope variations, ensuring that the canal alignment optimized water flow efficiency while minimizing excavation costs. It was carried out using:

- 30m resolution Digital Elevation Models (DEM)
- Historical Soviet-era topographic maps
- Google Earth elevation data

■ Soil and Water Testing Program

This included:

- 30 soil profiles dug across Balkh and Jawzjan provinces.
- 436 soil samples collected and analyzed in the laboratory.
- Water quality testing for pH levels, salinity, and suitability for irrigation.
- Hydraulic conductivity and permeability testing to assess soil drainage capacity.

The tests revealed that while 90% of the soil was suitable for irrigation, 10% had high salinity levels, requiring soil reclamation efforts to ensure long-term agricultural viability.

■ Soil Suitability

Initial soil investigations confirmed that the land around Qosh Tapa was suitable for intensive agriculture, but further studies were recommended to assess the long-term viability and potential reclamation needs of the land.

■ Geodetic Investigations

53 geodetic control points were installed along the canal alignment, ensuring high-accuracy horizontal and vertical elevation mapping (accuracy: ± 10 cm). The geotechnical studies assessed seismic risk, foundation stability, and soil-bearing capacity.

A preliminary slope stability and seepage analysis was performed, ensuring that the canal alignment would minimize the risk of erosion or structural failure.

■ Well Drilling (100+ Wells)

To further validate groundwater availability and soil conditions, the feasibility study team drilled 100+ wells along the proposed canal route. These wells provided critical subsurface data on depth to groundwater table, soil moisture retention properties, and the potential for secondary water sources for irrigation. The findings from these wells helped refine water allocation models and ensure that the canal could sustainably support 500,000 hectares of farmland.



Key Findings in Brief

Hydrological and Climate

- Water Availability**
Both Kaldar and Qosh Tapa showed sufficient water for most months, but Qosh Tapa had slightly better water availability during critical irrigation periods.
- Irrigation Potential**
With optimized cropping intensity and environmental flow adjustments, Qosh Tapa could irrigate up to 500,000 hectares, meeting the project's goals.
- Climate Resilience**
Qosh Tapa demonstrated 97% reliability under projected climate change scenarios, ensuring long-term sustainability.

Environmental and Socio-economic

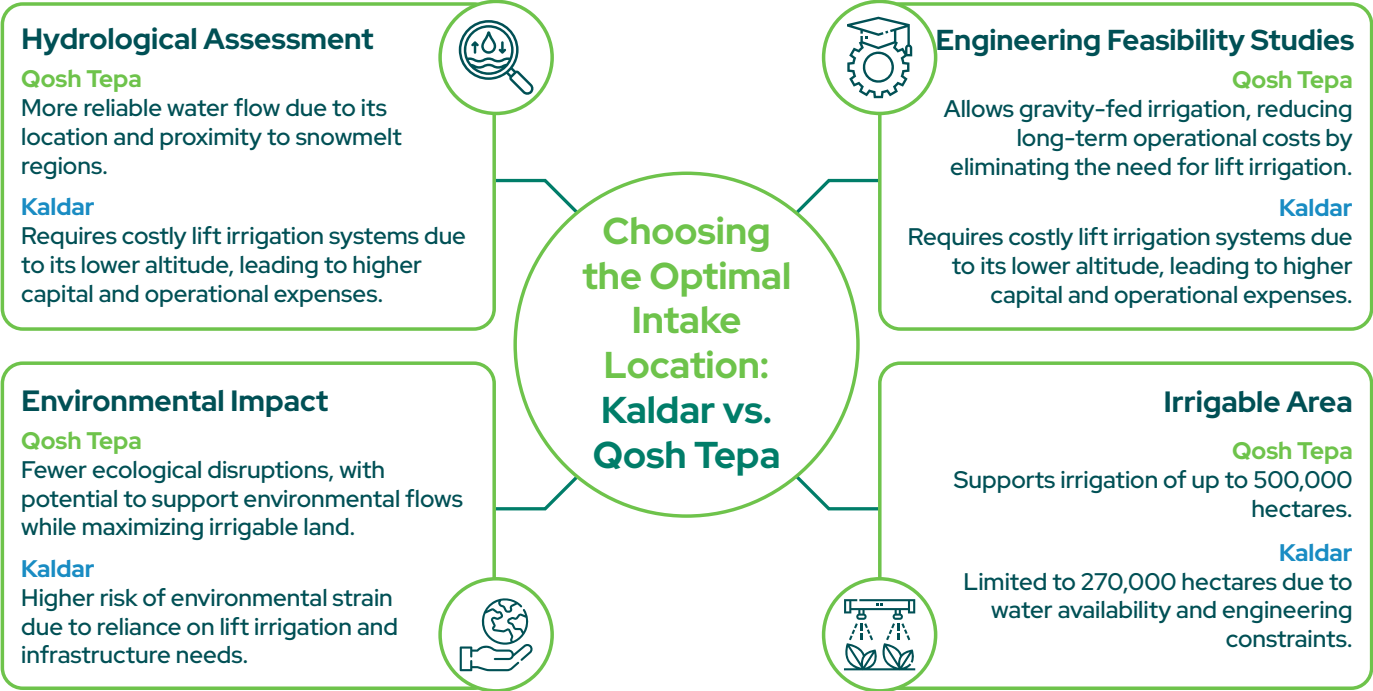
- Environmental Impact**
Though Qosh Tapa incurs slightly higher resettlement costs, its larger irrigable area and cost benefits outweigh those of Kaldar.
- Socio-economic Benefits**
Qosh Tapa supports a larger irrigated area, enhancing food security and creating jobs.

Infrastructure Engineering

- Gravity Irrigation**
Qosh Tapa's elevation allows for cost-effective gravity-fed irrigation, avoiding the high operational costs associated with lift irrigation at Kaldar.
- Cost Savings**
Qosh Tapa offers USD 413 million in capital savings and USD 181 million in reduced maintenance costs over 10 years.
- Infrastructure Feasibility**
The canal system at Qosh Tapa is more efficient and expandable than Kaldar.

Water Management and Allocation

- WEAP Model**
Water allocation models showed that Qosh Tapa can support over 500,000 hectares while maintaining environmental flows.
- Climate Adaptation**
Qosh Tapa can maintain high water reliability under future climate conditions by optimizing irrigation intensity.



Conclusion: Qosh Tapa was recommended for its cost-effective gravity irrigation, and larger irrigable area (though the Afghan Government has chosen Kaldar for reasons mentioned earlier).

Lessons Learned

The Qosh Tepa Canal feasibility studies included field investigations, hydrological modeling, engineering assessments, and environmental reviews. Key challenges and takeaways emerged throughout the process.



Data Collection and Management

Limited availability of accurate and timely data, especially related to hydrology and environmental factors, and the lack of access to data from government agencies, delayed the progress of studies.



Lesson Learned: For future feasibility studies in data-scarce environments, early investment in field surveys and use of global climate databases can significantly improve data reliability and project accuracy. Clearly define data requirements at the outset and establish data-sharing agreements. Establishing and maintaining a strong relationship with key stakeholders is key for timely access to data. Last, but not least, establish a cutoff date after which no additional data will be considered in design to avoid costly delays.



Stakeholder Coordination

Coordination among key stakeholders, such as the Ministry of Agriculture, Irrigation, and Livestock (MAIL), Ministry of Energy and Water (MEW), National Environmental Protection Agency (NEPA), and USAID, proved complex. Given the transboundary nature of the Amu Darya River, regional political considerations also influenced discussions around water allocation. While the feasibility studies focused on Afghanistan's irrigation needs, concerns from Uzbekistan and Turkmenistan over reduced downstream water availability required diplomatic engagement and transparency in water-sharing assessments.



Lesson Learned: Future feasibility studies should incorporate transboundary water impact assessments early on to mitigate regional tensions and ensure sustainable water management agreements. Establish clear communication channels and stakeholder roles early in the project. Regular meetings and well-documented minutes help mitigate conflicts and track progress.



Methodological Adaptations

The complexity of comparing gravity-fed and lift irrigation systems posed challenges. Qosh Tepa's location allowed for a more sustainable gravity irrigation system, but this required extensive feasibility modeling.



Lesson Learned: Early-stage feasibility studies should fully explore engineering alternatives and their long-term sustainability. Methodologies should be flexible enough to adapt to field data, but with realistic assumptions from the outset.



Project Objectives and Flexibility

At times, political goals conflicted with technical recommendations. The project's focus on delivering a large irrigation scheme for political reasons sometimes clashed with the engineering reality.



Lesson Learned: Feasibility studies should provide multiple decision-making scenarios, balancing technical, economic, and political considerations to allow stakeholders to make informed trade-offs. A balance between technical rigor and flexibility to meet donor expectations is crucial.



Project Planning and Scheduling

The project timeline was too tight for the scope and complexity of the studies required. Limited time for field investigations led to incomplete data, requiring redesigning based on field results.



Lesson Learned: For large-scale projects, ensure that the timeline accounts for comprehensive fieldwork and data collection. Include contingency time for unforeseen delays, especially in unstable or remote regions.

Conclusion and Recommendations



Photo credit: RTA World

The feasibility studies for the Qosh Tepa Canal provided critical technical, environmental, and socio-economic insights to guide evidence-based decision-making. Through extensive field investigations, hydrological simulations, soil and water testing, geotechnical assessments, and environmental impact analyses, the studies successfully identified optimal intake locations, irrigation strategies, and water management plans.

These studies were instrumental in shaping the project's decisions and ensuring its long-term viability. These studies recommended Qosh Tepa as the optimal intake location, leveraging gravity-fed irrigation to reduce operational costs and expand irrigable land to 500,000 hectares. Detailed hydrological modeling, engineering analyses, and environmental impact assessments ensured the project balanced agricultural needs with sustainability. Additionally, the socio-economic benefits highlighted how the project would improve food security and livelihoods in northern Afghanistan. While the feasibility study identified Qosh Tepa as the best option for long-term sustainability, the Afghan government ultimately opted for Kaldar due to lower upfront construction costs. Overall, these feasibility studies laid a solid foundation for the project's future implementation and success.

The Qosh Tepa Canal has now entered its second phase of construction under the current Afghan government, with ongoing efforts to expand irrigation infrastructure. However, as the project advances, it is essential to balance national agricultural benefits with regional water security concerns.

Establishing transparent water-sharing agreements and engaging in regional dialogue will be crucial to ensuring long-term sustainability and minimizing geopolitical tensions.

Future technical feasibility studies should emphasize thorough initial planning, realistic timelines, and well-defined data-sharing protocols. Resource allocation must account for comprehensive fieldwork, with contingency time for delays. Establishing clear stakeholder roles and maintaining open communication will help avoid conflicts and delays. Managing political pressures, while ensuring technical integrity, is crucial. Carefully vetting subcontractors and ensuring team expertise from the start will also improve efficiency and project outcomes.

Adroit played a central role in the successful execution of the QTCIP feasibility studies, overcoming significant challenges including limited baseline data, tight timelines, and a politically sensitive environment. Prior to Adroit's involvement, there was virtually no reliable data or analysis available on the canal's design, hydrological impact, or socio-environmental implications. Adroit led the first comprehensive effort to collect and synthesize technical, environmental, and social data—laying the foundation for informed decision-making. Drawing on technical expertise in hydrology, environmental science, and engineering, the team delivered rigorous, evidence-based insights that guided key strategic and policy choices for the project.



Get in Touch

HQ Office in the United States

+1 614 966 6925
info@adroitassociates.org
www.adroitassociates.org
655 Metro Place South, Suite 600,
Dublin, OH 43017, United States

Afghanistan Country Office

+93 784 27 27 73
afg@adroitassociates.org
www.adroitassociates.org
House 59, Street 06, Qala-e-Fathullah,
Kabul, Afghanistan