In cooperation with

IWES Innovative Water & Environmental Solutions

CERR CENTER FOR ECONOMIC RESEARCH AND REFORMS

GET German Economic Team

Impact of the Qush-Tepa canal on the agricultural sector in Uzbekistan

by Dr Abror Gafurov, Dr Ihtiyor Bobojonov, Dr Maksud Bekchanov and Carolin Busch

NO 02 | JUN 2023

POLICY STUDY UZBEKISTAN

About the German Economic Team

Financed by the Federal Ministry for Economics and Energy, the German Economic Team (GET) advises the governments of Ukraine, Belarus, Moldova, Kosovo, Armenia, Georgia and Uzbekistan on economic policy matters. Berlin Economics has been commissioned with the implementation of the consultancy.

*Advisory activities in Belarus are currently suspended.

CONTACT

Woldemar Walter, Project Manager Uzbekistan
walter@berlin-economics.com

German Economic Team
c/o BE Berlin Economics GmbH
Schillerstraße 59 | 10627 Berlin
Tel: +49 30 / 20 61 34 64 0
info@german-economic-team.com
www.german-economic-team.com

Our publications are available under
https://www.german-economic-team.com/uzbekistan

Implemented by

Berlin Economics

About the authors

Dr Abror Gafurov is a researching hydrologist at the GFZ German Research Centre for Geosciences as well as a member of Innovative Water & Environmental Solutions (IWES), a spin-off company from GFZ Potsdam. Recent activities of Abror Gafurov include climate impact assessment on water resources, hydrological forecasting, snow cover monitoring using satellite data as well as Disaster Risk Reduction (DRR) in Central Asia. He also developed a MODSNOW-Tool that has a capacity of operational water resources monitoring in Central Asia and is widely used in the region.

Dr Ihtiyor Bobojonov is an economic expert on agricultural economy. He works on several projects related to the mobilisation of agricultural market potentials in Commonwealth of Independent States countries. He mainly carries out research on the impact of supply chain transformation on the welfare of agricultural producers. Furthermore, he investigates the role of agricultural insurance in agricultural sector development and analyses possible options to improve the performance of insurance markets.

Dr Maksud Bekchanov is an environmental and resource economist with an extended expertise in integrated environment-economic modelling. His previous research addressed economic and environmental effects of water scarcity, hydro-infrastructural developments, and adoption of efficient irrigation technologies in Central Asia. He has international research experience contributing to projects on deforestation prevention in Brazil, agricultural mechanization in Africa, waste management in South Asia, WEF nexus in Central Asia, and hunger reduction and climate change mitigation in the world.

Carolin Busch is a consultant at Berlin Economics focused on agricultural policy. She has previously worked for GIZ in Tajikistan and the Food and Agriculture Organization of the United Nations in Rome, where she focused on financial inclusion and sustainability in the agricultural sector. Her research has focused on index-based climate risk insurance and on greenhouse gas reductions across agricultural value chains.

Content

Executive summary

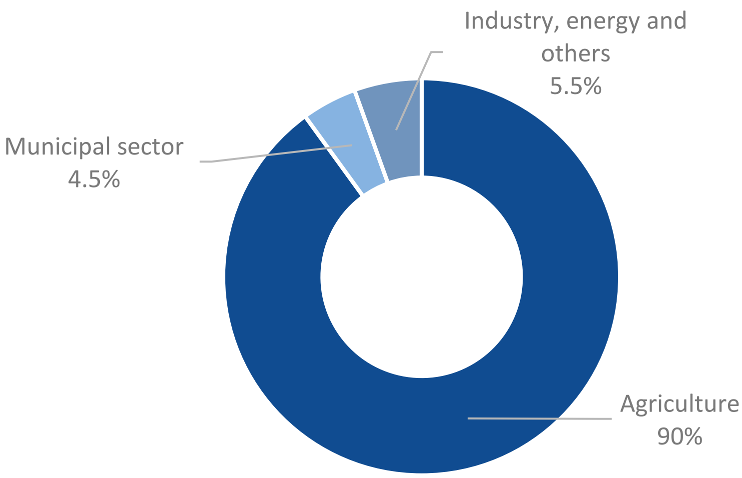
- Water resource availability plays a key role for the agricultural sector in Uzbekistan, which accounts for about 25% of GDP and thus plays an important role for the economy.
- Already today, Uzbekistan is confronted with limited water resources, which are expected to decrease by 5.9% until 2030 due to climate change.
- The water scarcity is expected to further exacerbate due to the construction of the Qush-Tepa canal in Afghanistan, which is located upstream on the Amu Darya river, one of the two main rivers supplying water to Uzbekistan.
- The reduction of available water resources will have an impact on the economy of Uzbekistan, especially on the agricultural sector, which accounts for 90% of the country’s water use.
- This study models the changes in water availability until 2030 taking into consideration the impact of climate change as well as the construction of the Qush-Tepa canal, which is expected to reduce the availability of water in the Amu Darya in three steps of 5%, 15% and 25% based on the amount of water extracted through the canal at each construction stage.
- The reduction in water availability affects five regions in the Amu Darya river basin to different degrees. The Surkhandarya region is less affected as it also takes in water from other rivers. Bukhara, Khorezm and Karakalpakstan will be worst affected as they rely on the Amu Darya for 100% of their water supply. The Kashkadarya region relies on the Amu Darya for 70% of its water supply, thus the impact is only somewhat moderated.
- Using a linear optimisation model, which is calibrated to the observed data based on a positive mathematical programming approach, the study estimates the impact of the reduced water availability on the agricultural sector, in particular on cropland under cultivation, the cropping structure, value added from crop production and employment in crop production in the regions of the Amu Darya basin.
- The impact differs across regions: Kashkadarya will be the region worst affected with a decline in cropping value added of 18.2% under the Qush-Tepa water intake scenario of 25%. This would be accompanied by a reduction in employment of about 97,000 jobs in crop production.
- The least affected region will be Surkhandarya with a 5.7% reduction of cropping value added for the 25% water intake scenario and employment reduction of roughly 37,000 jobs in crop production.
- In terms of crop structure, rice cultivation would decrease most strongly across regions due to its high water intensity. Wheat production would continue provided prices are similar to 2022 levels. Cotton production would decline if land allocation policies were further liberalised and be substituted with fruits and fodder.
- The macroeconomic impact of the water reduction would be noticeable but not very large, with a reduction in GDP of 0.7% if a 25% water intake scenario happened in 2022. For the cropping sector at national level, the reduction would be 6.2% in 2022.
- A water intake scenario of 25% is expected to lead to a reduction in employment of almost 250,000 jobs in crop production in the Amu Darya basin.
- Considering that the construction of the canal is already under way, the government of Uzbekistan should focus on adaptation measures that can reduce the negative economic impacts of reduced water availability.

- Measures should be taken to further incentivise and speed up the adoption of more efficient irrigation measures that would allow for a better use of this scarce resource and a larger cropland area to be cultivated. Such measures could reduce the negative economic implications estimated in this study.
- Liberalisation of the usage of agricultural land should be further advanced and sped up as current practices impede optimal crop allocation and the ability of the agriculture sector to adapt to the water reduction shock.
- Considering that the most significant economic effects occur at region level, the policy response should be targeted at those regions worst affected by the reduction in water resources such as Kashkadarya, Bukhara and Khorezm.

1. Introduction

Uzbekistan as a country and its economy in particular are highly dependent on the reliable availability of freshwater. However, water demand is increasing in accordance with the economic development of the country and supply is decreasing as a result of climate change. Water availability is increasingly becoming an issue for Uzbekistan, which has both economic and social dimensions. The main reasons for the water shortage are climate change-related decreasing precipitation, higher evaporation, faster melting of glaciers and snow cover in the mountains but also poor management of water resources and increased demographic pressure. 90% of water in Uzbekistan is used for irrigation purposes in the agriculture sector, which accounts for about 25% of GDP and thus represents a significant share of the economy. Increased water scarcity will have an impact on the agricultural sector in Uzbekistan and in turn the economy.

Figure 1: Water use by sectors in Uzbekistan 2019



Source: Ministry of Water Resources

Water supply in Uzbekistan relies heavily on two large rivers, Syr Darya and Amu Darya, both of which originate in the mountainous areas of Uzbekistan's neighbouring countries Kyrgyzstan, Tajikistan, and Afghanistan. The Amu Darya River is the largest river in Central Asia and the main source of surface water in the region primarily used to irrigate agricultural fields. The average annual water volume of the Amu Darya is estimated to be about 65 km^3, which varies depending on seasonal snow accumulation in the Pamir Mountains and precipitation. Afghanistan has the lowest water consumption among the countries using water from the Amu Darya. However, in March 2022, the construction of the about 285 km long irrigation Qush-Tepa canal began in the north of Afghanistan, which will redirect increased amounts of water from the Amu Darya to irrigate cropland in Afghanistan. Once the canal is fully constructed, which is expected until 2030, the amount of water withdrawal is estimated to be up to 25% of the current Amu Darya river flow. This will have a strong impact on water availability in downstream countries such as Uzbekistan. To be able to mitigate the potential impact on the Uzbek economy, it is important to understand what the effect would be, in particular on the agricultural sector.

This study estimates the impact of the construction of the Qush-Tepa canal on the water availability in the five regions of Uzbekistan located in the Amu Darya river basin. Based on the expected reduction in water, the study estimates the impact on crop production in each of the five regions, examining the implications for cropland area under cultivation, crop distribution, value added from crop production and employment in crop production. Based on the modelling results, the macroeconomic impact of the reduction in water availability is illustrated. The study does not examine the impacts of reduced water availability on other sectors such as the energy sector or the food processing industry.

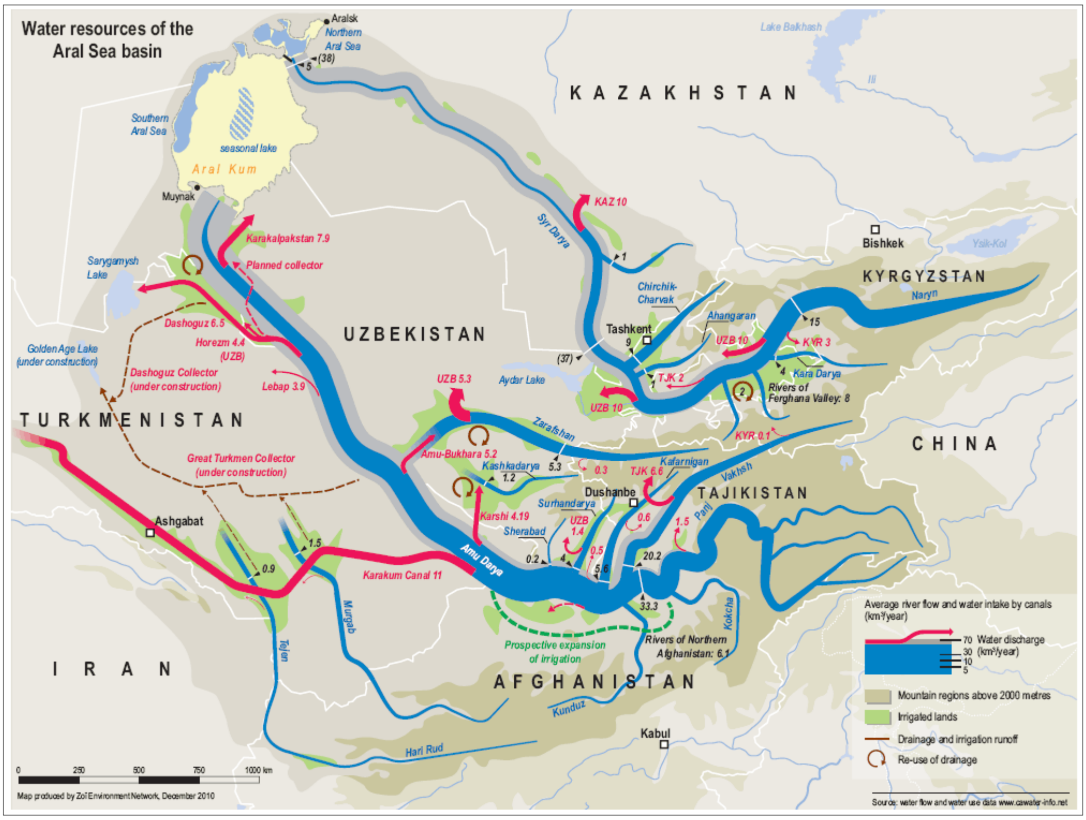
This policy paper is structured as follows. Chapter 2 provides an overview of the current situation concerning water resources and the agricultural sector of Uzbekistan. Chapter 3 describes the Qush-Tepa canal and its planned construction phases. Chapter 4 estimates the impact of the different stages of the construction of the Qush-Tepa canal on the water availability in Uzbekistan. Chapter 5 illustrates the estimated impacts of the reduction in available water resources for the agricultural sector in the downstream regions of the Amu Darya in Uzbekistan. Building upon the findings, in Chapter 6, conclusions and recommendations to mitigate the negative impact of reduced water availability on the agricultural sector in Uzbekistan, are derived.

2. Water use and agriculture in Uzbekistan

About 85% of water used in Uzbekistan is generated in the territories of its neighbouring countries, only about 15% of water resources used in the country are also formed on its territory. This makes Uzbekistan's available water resources vulnerable to actions of its upstream neighbours such as the construction of hydro power plants or irrigation canals such as Qush-Tepa, which can have significant negative impact on downstream flows.

The Amu Darya river, which has its sources in Afghanistan and Tajikistan and flows through Uzbekistan and Turkmenistan ending up in the Aral Sea, is one of the longest rivers in Central Asia. During the Soviet period, many canals were constructed to use the Amu Darya for the irrigation of the extensive cotton fields in the Central Asian plain. Water from the river had already been used for agriculture since ancient times, but not on such a massive scale. The Karakum Canal, Karshi Canal, and Amu-Bukhara Canal were among the largest of the irrigation diversions built, sharing water from Amu Darya between Tajikistan, Turkmenistan, and Uzbekistan (Figure 2). The massive use of water for irrigation purposes started to become a key factor for water scarcity in the region during the Soviet times, most prominently illustrated by the significant shrinkage of the Aral Sea.

Figure 2: Water resources of the Aral Sea basin and canals



Source: cawater.info

Today, around 90% of water resources in Uzbekistan are used for irrigation purposes in the agricultural sector. Irrigation is still widely practiced with conventional and less efficient basin and furrow irrigation technology, where the average water use efficiency is only about 55% (about 45% are lost to run-off or evaporation and not effectively used by crops). Since about 2017, the government of Uzbekistan has been reforming the irrigation practices in the country, incentivising the switch from non-efficient furrow and basin irrigation to more effective water saving technologies such as drip irrigation.

Five regions (oblasts) of Uzbekistan rely on water from Amu Darya for agricultural, industrial, and drinking water purposes. The Surkhandarya and Kashkadarya regions located mid-stream of the Amu Darya are only partially reliant on water intake from Amu Darya, as these regions have access to additional rivers as sources of water. On the other hand, the regions more downstream of Amu Darya, Bukhara, Khorezm, and Karakalpakstan are fully reliant on the Amu Darya river for their water needs.

Table 1: Water use and intake from Amu Darya river by regions

Oblast	Water use (km^3/year)	Water intake from Amu Darya (km^3/year)
Surkhandarya	2.50	0.50
Kashkadarya	3.30	2.31
Bukhara	2.60	2.60
Khorezm	2.80	2.80
Karakalpakstan	5.06	5.06

Source: own calculations based on data provided by national authorities

In 2022, the total value added of agricultural production was UZS 303,415.5 bn (about USD 26.5 bn), which is about 25% of the country's GDP. From it, about 50% relates to crop production and the remaining 50% to livestock production[1]. Cotton and wheat occupy the largest cropping area in the country, which is in part due to land usage policies, which de-facto allocate a set land area to these crops. Furthermore, the importance of agricultural production is seen in the large share of agriculture in employment of 26%. In addition, about 56.9% of the country's area is considered agricultural land, though not all of it is permanently cultivated.

While cotton as well as wheat and other cereals remain the most important crops grown in Uzbekistan, the policy shift towards slowly liberalising land usage policies has led to an increase in the cultivation of fruits and vegetables. Nevertheless, growth rates for fruits and vegetables production have started to slow down from just under 10% in 2007 – 2017 to below 5% between 2018 – 2021[2]. For the case of cotton, the area under cultivation has been slowly declining. At the same time, Uzbekistan has started focusing more on domestic cotton processing rather than exports of raw cotton, which contributes to an increase of value addition throughout the cotton value chain in the country.

3. Description of the Qush-Tepa canal

The Qush-Tepa canal is planned to be constructed in the north of Afghanistan, redirecting water resources from the Amu Darya. The project is designed to supply water for land irrigation purposes and is expected to convert 550,000 hectares of desert into farmland[3]. This will allow a massive extension of the agricultural area in Northern Afghanistan and is intended to increase agricultural output, food security and economic attractivity of the region. As a result, the construction of the canal could potentially lead to the relocation of a significant number of people from other regions of Afghanistan to this region.

The construction of the Qush-Tepa canal was already planned in the 1970s but not further considered after that due to political instability in the country. Only in 2018, a feasibility study for the canal was initiated and conducted by an international development consulting firm. The cost of the Qush-Tepa canal construction is estimated to be around

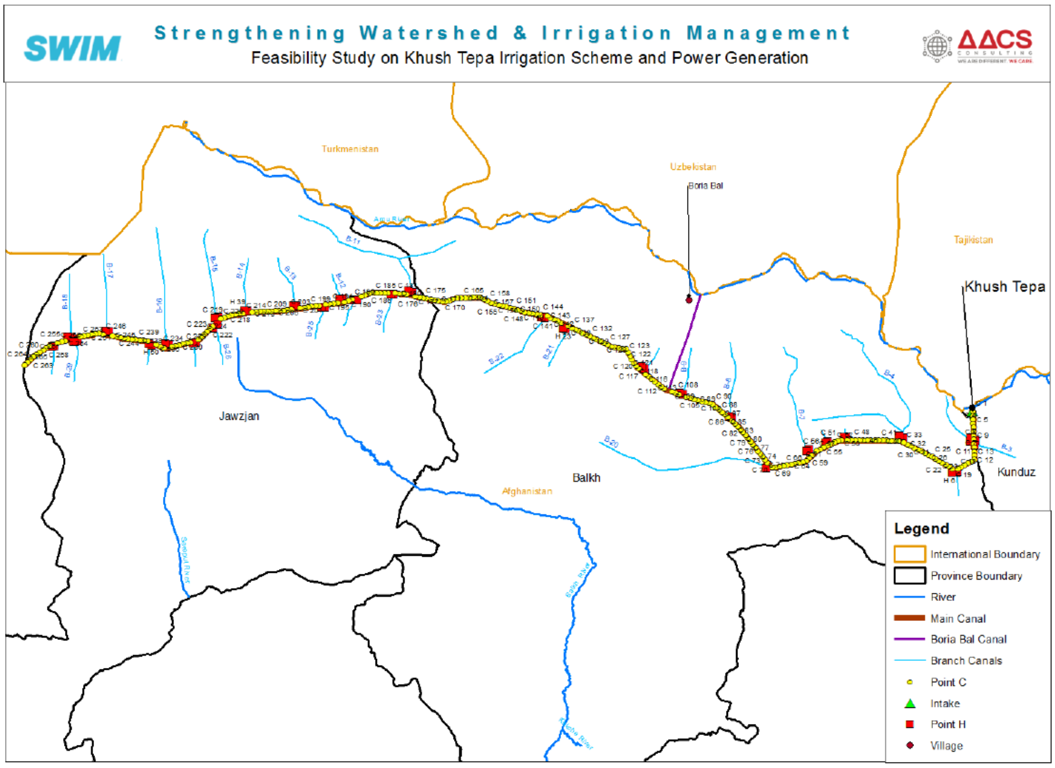
[1] National Statistics Agency

[2] National Statistics Agency

[3] The Taliban are digging an enormous canal, The Economist, Feb 16th 2023

USD 700 m. The construction of the Qush-Tepa canal (Figure 3) is currently considered the most significant infrastructure project in Afghanistan.

Figure 3: The Qush-Tepa canal in north Afghanistan: intake, sub-canals and end



Source: Qush-Tepa irrigation scheme and power generation feasibility study project, RFP for Geotechnical site investigation, 2019

The construction of the canal started on March 10, 2022. The length of the canal is expected to be about 285 km, with a width of 100 m, and depth of 6.5 m to 8.5 m with a maximum discharge capacity of 650 $m^3 s^{-1}$. In addition, three reservoirs are to be built for water storage and hydro power generation, expected to store up to 9 km^3 of water.

The canal is planned to be constructed in three stages as outlined below:

- **Stage I:** This section is 108 km long. The section will end at Dawlat Abad district of Balkh province (planned until end of 2023, but delayed, likely to be finished by 2024 or 2025)
- **Stage II:** This section will start from Dawlat Abad district with a length of 177 km and will end in Andkhoy (planned until 2028)
- **Stage III:** This includes the construction of sub-canals and distribution of agricultural land along the canal (planned after construction of Stage II is completed around 2028, finalisation is expected for 2030)

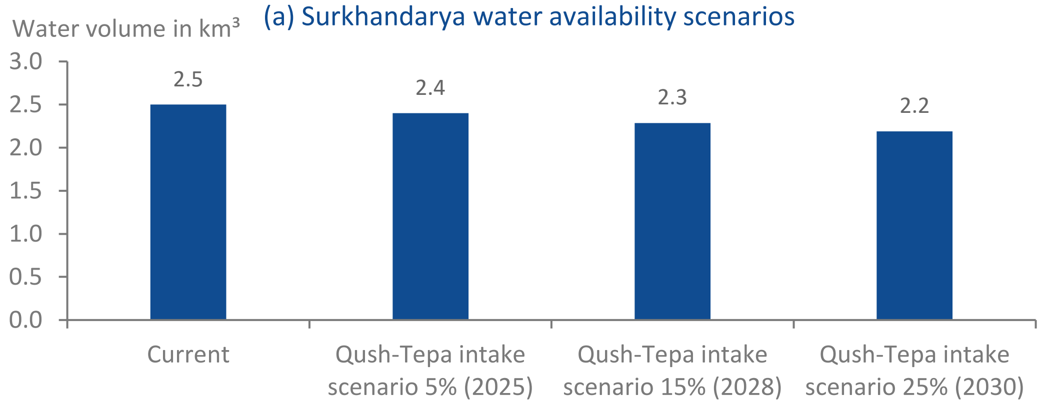
As mentioned above, this infrastructure project, is expected to significantly reduce the water flow of the Amu Darya with negative consequences for agricultural and industrial supply in adjacent areas of Tajikistan, Uzbekistan, and Turkmenistan.

4. Estimation of reduced water availability in Uzbekistan due to the construction of the Qush-Tepa canal

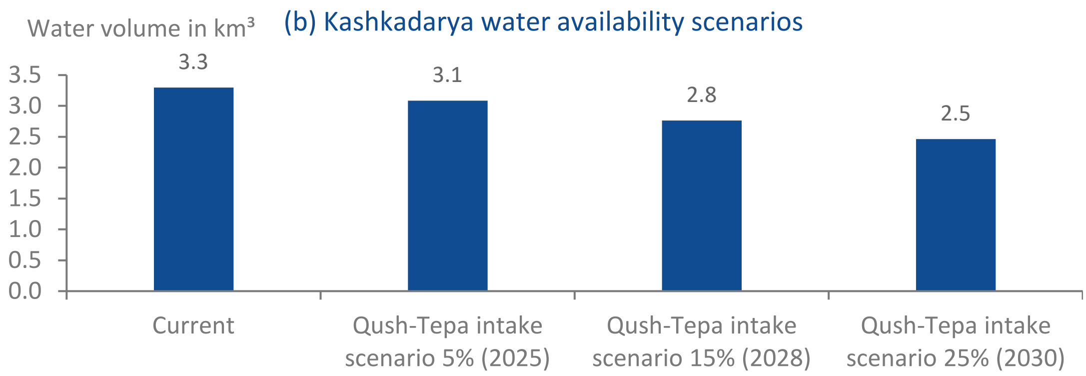
The estimation of the water reduction impact of the Qush-Tepa canal construction in the Amu Darya river basin of Uzbekistan is done considering the expected impact of climate change and water withdrawal rates of 5% after the first phase of construction, 15% after the second phase of construction and 25% after the third phase of construction relative to the water flow in 2022. The relative reduction rates are based on total water volumes expected to be extracted through the Qush-Tepa canal at different stages of construction according to its physical dimensions (planned width, depth, and length as well as number and size of planned sub-canals) and relative to the current water flow. The reduction of water resources due to climate change impacts is assumed to be 2.6% by 2025, 4.6% by 2028 and 5.9% by 2030, each relative to the 2022 water flow level[4]. The total reduction of available surface water in the Amu Darya river basin taking into account the Qush-Tepa canal as well as climate change amounts to 7.4% in 2025, 18.9% in 2028 and 29.4% in 2030. The changes are projected for the five regions (oblasts) of the country, which are fed by the Amu Darya river based on their water intake rate through canals, as outlined in Table 1. However, it should be noted that water flow varies from year to year depending on weather conditions and can thus be lower or higher in some years.

Figure 4 shows the current state of water availability and its expected reduction considering the impacts of climate change and the stages of construction of the Qush-Tepa canal at regional level.

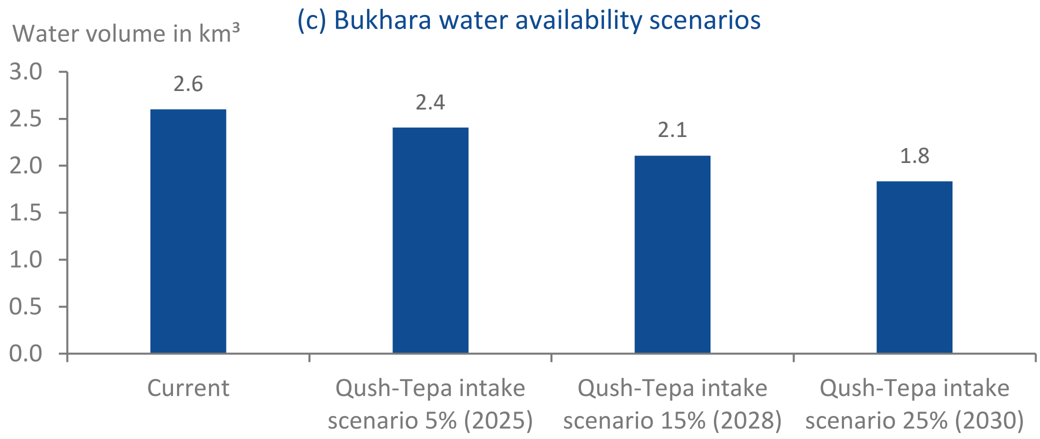
Figure 4: Availability of surface water in the Amu Darya River basin at regional level for (a) Surkhandarya region, (b) Kashkadarya region, (c) Bukhara region, (d) Khorezm region, and (e) Republic of Karakalpakstan.



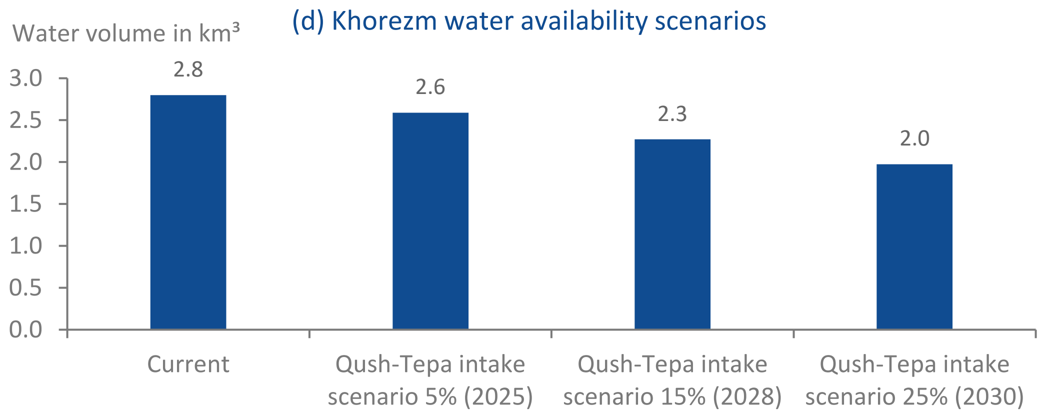
[4] Z.P. Xu, Y.P. Li, G.H. Huang, S.G. Wang, Y.R. Liu. 2021. A multi-scenario ensemble streamflow forecast method for Amu Darya River Basin under considering climate and land-use changes, *Journal of Hydrology*, Volume 598.



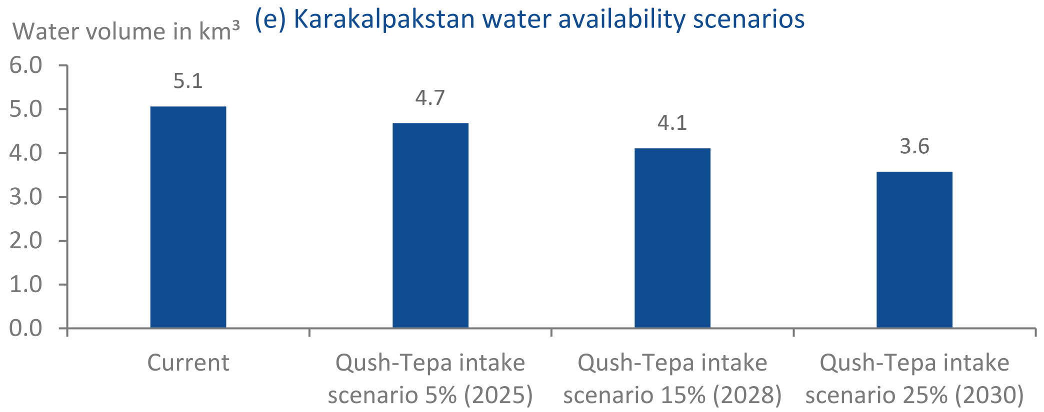
(b) Kashkadarya water availability scenarios
Water volume in km³
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
3.3
3.1
2.8
2.5
Current
Qush-Tepa intake scenario 5% (2025)
Qush-Tepa intake scenario 15% (2028)
Qush-Tepa intake scenario 25% (2030)



(c) Bukhara water availability scenarios
Water volume in km³
3.0
2.5
2.0
1.5
1.0
0.5
0.0
2.6
2.4
2.1
1.8
Current
Qush-Tepa intake scenario 5% (2025)
Qush-Tepa intake scenario 15% (2028)
Qush-Tepa intake scenario 25% (2030)



(d) Khorezm water availability scenarios
Water volume in km³
3.0
2.5
2.0
1.5
1.0
0.5
0.0
2.8
2.6
2.3
2.0
Current
Qush-Tepa intake scenario 5% (2025)
Qush-Tepa intake scenario 15% (2028)
Qush-Tepa intake scenario 25% (2030)



Source: own estimations based on data provided by national authorities; Note: modelled scenarios include impacts of climate change and Qush-Tepa canal

The level of water reduction differs between the five regions of Uzbekistan. The Surkhandarya and Kashkadarya regions feature the lowest loss of available water of 12.4% and 25.4% relative to 2022 levels respectively for a scenario of 25% water intake from Qush-Tepa, reflecting the fact that these regions also receive water from sources other than the Amu Darya itself. In comparison, the regions further downstream of the Amu Darya will be more severely affected by the construction of the Qush-Tepa canal. For the Bukhara, Khorezm and Karakalpakstan regions, the reduction in available water resources is expected to be 29.4% relative to the 2022 level for the 25% water intake scenario. Thus, the impact on economic activities in each of the regions and on the agricultural production is equally expected to diverge.

5. Assessment of the Qush-Tepa canal construction impact on the agricultural sector of Uzbekistan

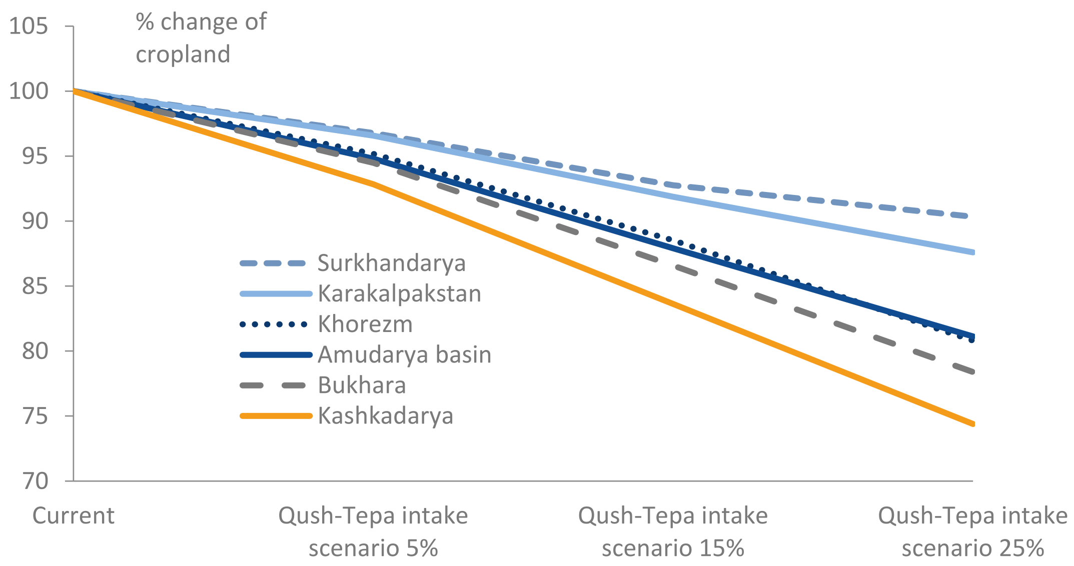
Considering the key role of water for the growth process of plants, a reduction in available water resources will directly affect the agricultural sector and crop production in particular. To predict the potential impact of reduced water availability on the agricultural production in Uzbekistan, a modelling approach based on the various inputs needed to produce crops in the different regions of Uzbekistan that rely on the Amu Darya river for their water supply is employed.

A linear optimisation model is used to investigate rational decision making under declined water availability conditions. The model optimises crop allocation in each of the regions, for the most profitable usage of the available irrigation water and other resources (land, labour, fertilizers, and diesel). The model maximises the value added generated from crop production across each of the regions. The availability of resources is considered separately for each region (Surkhandarya, Kashkadarya, Bukhara, Khorezm, and Republic of Karakalpakstan). Current policy settings in Uzbekistan such as the land allocation policies for the planting of cotton and wheat are considered in the optimisation process as currently existing and remain unchanged in the scenario simulations due to a lack of reliable information on the area and regional distribution of land that is planned to become available for other crops as a result of the announced policy liberalisation. A positive mathematical programming (PMP) approach is used to consider the effect of omitted constraints and the hidden costs and benefits of producing certain crops within the current policy environment. The PMP is based on the current land allocation at the regional level and does not directly consider farm-level profitability and motivation for planting certain crops. On the other hand, this approach does allow for the inclusion of indirect benefits from producing each crop.

The modelling exercise is based on the predicted reduction in water availability from climate change and the different stage of construction of the Qush-Tepa canal as illustrated in Chapter 4: 1) Qush-Tepa canal intake of 5% by 2025 2) Qush-Tepa canal intake of 15% by 2028 and 3) Qush-Tepa Canal intake of 25% by 2030.

If the amount of water available for agricultural purposes is reduced, the overall level of production will decline assuming that all other input factors stay the same and that no technological changes are applied to reduce the amount of water needed to produce specific crops. In terms of cropland, this means that the area of cropland that can be irrigated decreases in line with water availability. The modelling results show the decrease in cropland area that can be cultivated in each of the regions under the different water reduction scenarios related to the construction of the Qush-Tepa canal. Figure 5 illustrates the reduction in cultivated cropland for each region.

Figure 5: Changes in cropland area due to reduced water availability

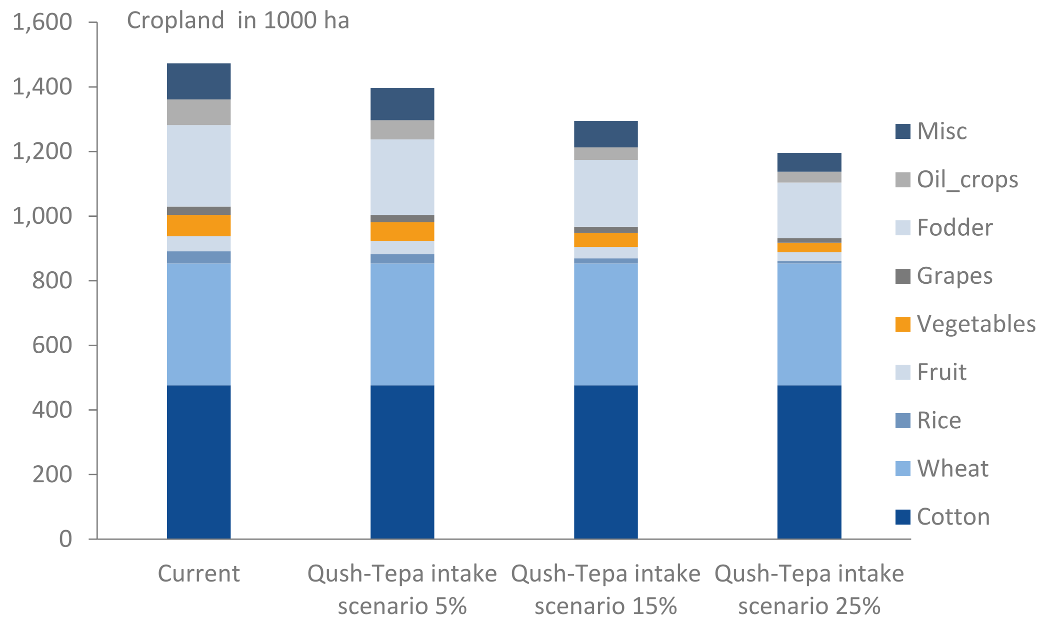


Source: own estimations based on data provided by national authorities; Note: modelled scenarios include impacts of climate change and Qush-Tepa canal

The average reduction in cropland for the entire Amu Darya basin is expected to be 5.2% for a 5% water intake from Qush-Tepa scenario, 12.1% for a 15% water intake scenario and 18.9% for the 25% water intake scenario relative to the 2022 baseline. However, some regions will be more adversely affected by cropland reduction than others. The Kashkadarya region is expected to be most severely affected with a reduction in usable cropland of 7.2% for the 5% water intake scenario, 16.4% for a 15% water intake scenario and 25.6% for the 25% water intake scenario. The Surkhandarya region is expected to be the least affected in terms of cropland change with reductions of 3.2% for 5% water intake, 7.2% for 15% water intake and 9.7% for the 25% water intake scenario.

In addition to the reduction in cropland area under cultivation in each of the regions, the structure of how cropland is allocated is expected to change as well if the amount of available water decreases. Based on the policy specifications, the model optimises the allocation of different crops considering the reduced availability of resources. Figure 6 illustrates the prospective structure of the reduced cropland area for the entire Amu Darya basin under the different water intake scenarios.

Figure 6: Change in cropland structure

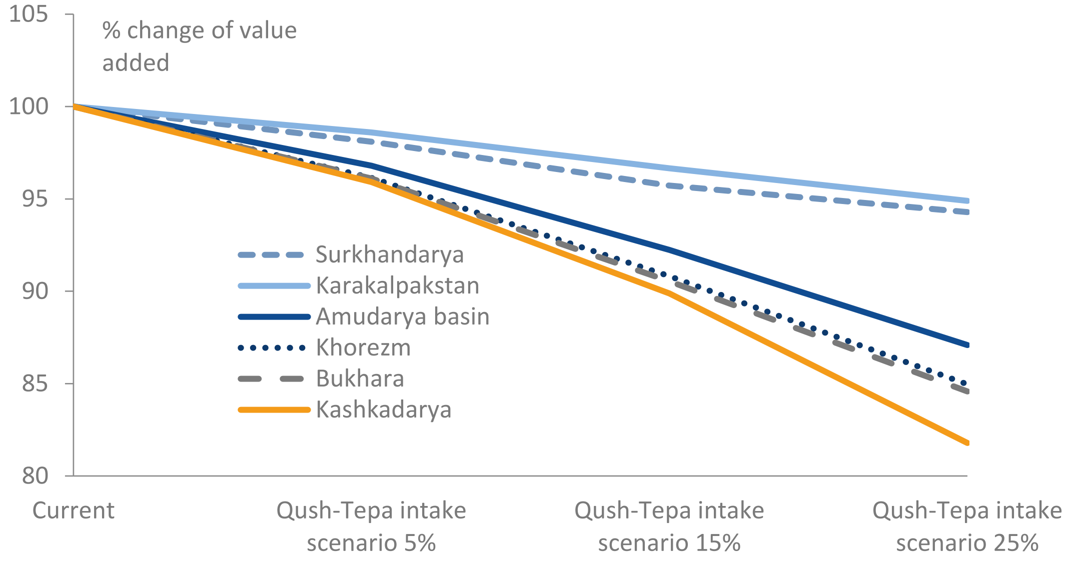


Source: own estimations based on data provided by national authorities; Note: modelled scenarios include impacts of climate change and Qush-Tepa canal

Due to the land allocation policies for cotton and wheat, the land planted with these crops remains unchanged in the modelled scenarios even though water availability is reduced. As a result of the overall reduction in cultivated cropland, this means that the area allocated to all other crops decreases. The largest relative decline takes place for the land area under cultivation with rice, which is reduced by 81% across the entire Amu Darya basin in the 25% water intake scenario, reflecting the high water-intensity of this crop. In the 25% water intake from Qush-Tepa scenario, large declines in cultivated area are also expected for oil crops (-58%), vegetables (-55%), grapes (-48%), and other crops (-48%). The crops with the relatively smallest declines include fruit (-40%) and fodder (-32%). Nevertheless, even for these crops the losses are substantial. Such changes could have considerable implications for food security and food prices at the local level.

As the cropland area under cultivation decreases, the value added realised from crop production also decreases as long as all other conditions remain unchanged. Again, the results differ by region, which is a result of the differing use of input resources across regions as well as differences in the structure of cropland allocation. Figure 7 illustrates the total value added from crop production for each of the regions under the different water reduction scenarios.

Figure 7: Estimated change of crop value added



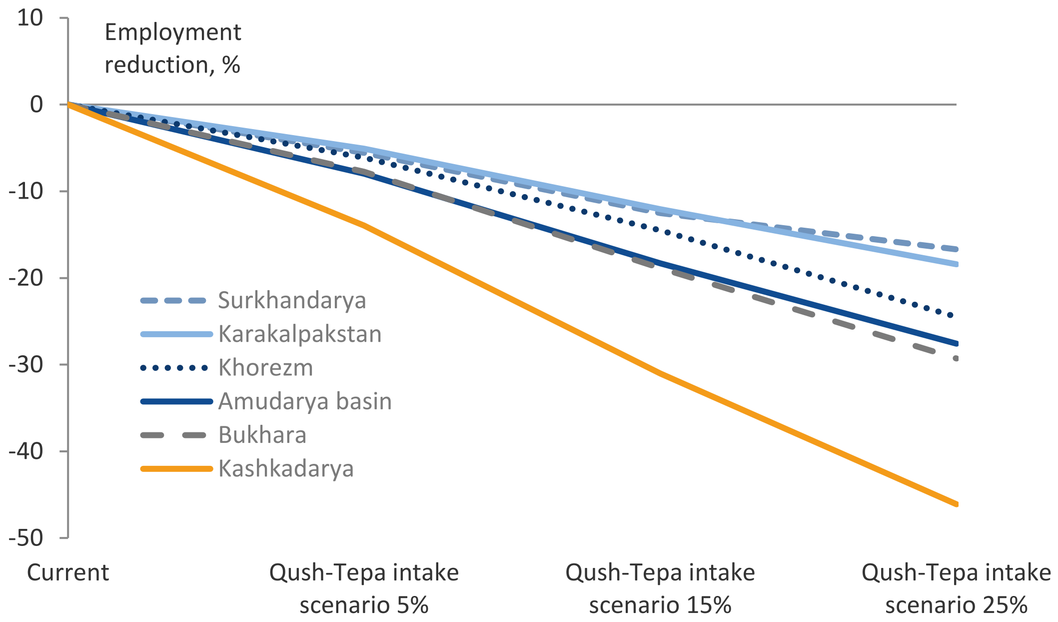
Source: own estimations based on data provided by national authorities; Note: economic growth is not accounted for, it is a static comparison to 2022 values; modelled scenarios include impacts of climate change and Qush-Tepa canal

On average, the value added from crop production in the Amu Darya basin is expected to decline by 3.2% in the 5% water intake scenario, by 7.8% for the 15% water intake scenario and by 12.9% for a 25% intake from Qush-Tepa scenario. The impacts on each of the regions differ from this average. The most affected region will be Kashkadarya with a reduction in value added from crop production of 4.1% for the 5% water intake scenario, 10.1% for the 15% water intake scenario and 18.2% for a scenario with a water intake of 25% expected to occur in 2030. This result can be explained by the crop structure in Kashkadarya, which differs from that of the other regions mainly in the fact that the region does not grow any rice. Since rice is extremely water-intensive, small reductions in the rice-growing area frees up more water resources for other crops. Thus, in regions growing rice, the reduction in overall cropping area can be somewhat moderated at the cost of reductions in the rice growing area. In the Kashkadarya region this is not possible, thus leading to a stronger decrease in overall cropland use and value added. After Kashkadarya, Bukhara and Khorezm are the second and third most affected regions with reductions in cropping related value added of 15.4% and 15% respectively under a Qush-Tepa water intake scenario of 25%. The least affected region will be Surkhandarya with reductions in crop production-related value added of 1.9%, 4.3% and 5.7% for the respective water intake scenarios, which is reflective of the fact that this region will experience the smallest reduction in available water resources.

When these reduction in value added are considered in relation to the national-level cropping value added of Uzbekistan, the reduction would be about 6.2% for the 25% water intake scenario. This implies a drop of GDP by 0.7%. However, since such a scenario is expected to occur only in 2030, the relative impact would not be as large, since GDP will be much higher in 2030 considering expected average annual GDP growth rates of about 5.5% for Uzbekistan over the coming years. On the other hand, these figures do not include impacts on related economic activities like the livestock sector and the processing of crops, the inclusion of which would increase the economic impact.

As the land used for cropping in the Amudarya basin and value added from crop production decline due to reduced water availability, secondary impacts on factors such as employment are to be expected. Figure 8 shows the reduction of employment in the crop production in each of the regions associated with the different water reduction scenarios. The estimates are calculated under the assumption that all other factors affecting labour supply and demand in these regions remain unchanged.

Figure 8: Reduction of employment in crop production



Source: own estimations based on data provided by national authorities; Note: static comparison to the year 2022; modelled scenarios include impacts of climate change and Qush-Tepa canal

On average, for the entire Amu Darya basin, a reduction of employment in crop production of up to 27.6% is expected under a Qush-Tepa intake scenario of 25% in 2030, which would signify a loss of almost 250,000 jobs. The largest impact on employment is expected for the Kashkadarya region with a loss of roughly 97,000 jobs or 46.1% of current employment in crop production under a 25% water intake scenario, which is indicative of the fact that the region will overall face the largest negative economic impact. These impacts are strongly related to the presence of the land allocation policies for the on average less labour-intensive crops cotton and wheat. As a result, the area grown with other more labour-intensive crops such as vegetables and grapes decreases very strongly leading to a large loss of employment.

The lowest impact is expected for the Surkhandarya region with a loss of up to 37,000 jobs in a 25% water intake scenario accounting for 16.7% of current employment in crop production reflecting the fact that this region experiences the lowest water loss from the Qush-Tepa construction. The difference between the impacts on these two regions illustrates the large importance of water resources for the economy of Uzbekistan.

5.1 Discussion of results

The results of the modelling exercise are strongly affected by the land allocation policies for cotton and wheat production, which set certain de-facto requirements for the land area under cultivation with cotton and wheat. However, the Uzbek government has publicly declared in recent years that these policies will be liberalised over the coming years. A reduction of about 8% in cotton and wheat planting area is planned from 2022 to 2025. Beyond 2025, no announcements have yet been made regarding the pace or extent of the phase out as well as the regional distribution of land liberalisation. Due to this lack of data, this new policy scenario was not included into the quantitative modelling. Nevertheless, a reduction in cropland for cotton and wheat will have impacts on the allocation of cropland as well as the value added from crop production in the different regions. The allocation of newly liberalised cropland to other crops will depend on several factors, including productivity of each crop, water use efficiency - especially as water becomes an even scarcer resource – and the development of prices for each of the crops.

To understand how crop allocation would develop if the cropping area for cotton and wheat is reduced, we compare the Amu Darya region average value added per water input used for each crop. Based on the available data for the Amu Darya region for 2022 provided by the national authorities, the highest value added per m^3 of water is realised for wheat. This means that even if the de-facto allocated cropland area for wheat is reduced, the area planted with wheat could stay the same or even increase, if areas previously allocated for cotton production are alternatively planted with wheat. However, the long-term development of market prices for outputs as well as inputs will also be relevant as it influences the value added from the production of each crop. The year 2022 featured unusually high wheat prices due to the global market developments in the wake of the war against Ukraine. Thus, the economic rationale could change in the long run if wheat prices revert to a lower level.

Conclusion: Provided market prices for wheat remain similar to 2022 levels, wheat will continue to be planted in the Amu Darya basin regions of Uzbekistan if water availability is reduced and even with liberalised land allocation policies.

The crops with the third and second highest value added per water input are fodder and fruit. Fruit being a traditional high value-added agricultural crop is likely to benefit from a liberalisation of the land allocation policies under scarce water conditions. Under such a scenario, it can be assumed that areas currently planted with cotton would be planted with fruits. For the case of fodder, high value added can be achieved relative to the water requirements. Nevertheless, it is unclear whether the production of fodder would increase considerably, as fodder requirements are driven by demand from the livestock sector. The average growth rate of the livestock sector has been about 4% between 2017 and 2021[5], thus a small increase in fodder production could be expected as well.

Conclusion: With liberalised land allocation policies, the land area used for cotton production would decrease. Cotton would be replaced with crops that provide higher value added per water input such as fruits and livestock fodder.

According to official statistical data, the value added per water usage is on average higher for cotton than for vegetables, grapes, and oil crops. Based on this data, it is expected that the area planted with vegetables, grapes and oil crops would not increase if land allocation policies were liberalised. Instead, the areas planted with these crops will decrease as the availability of water is reduced. In addition, cotton is increasingly used for

[5] National Statistics Agency

domestic production of fibres and textiles within the so-called cotton clusters, which increases the total value added created in the cotton value chain. Such downstream benefits of cotton production, which are not directly reflected in the cropping value added, may contribute to the continued attractiveness of planting this crop.

Conclusion: Vegetables, grapes, and oil crops create less value added per water input than wheat, fruits, and cotton. Thus, the production of these crops is expected to decline as a response to reduced water availability.

The cultivation of rice offers the lowest value added per water input, reflecting the fact that rice has by far the highest water intensity of all the crops planted in the region. This was also shown in the modelling results, where rice showed the highest rates of decline among all crops. Thus, rice production becomes more and more unattractive as water availability declines. Even in a scenario with liberalised land allocation policies, it is unlikely that more rice would be grown in Uzbekistan. Considering the climatic conditions and increased water stress in the country, substitution with imports from other countries would be more efficient.

Conclusion: The production of rice in the Amu Darya basin will decrease significantly as a response to reduced water availability.

5.2 Methodological limitations and further research

The modelling scenarios are based on data for the year 2022 and take the policy considerations such as the existing land allocation policies for cotton and wheat as given. The positive mathematical programming approach used to calibrate the model infers hidden benefits and costs of producing various crops from current land allocation. The scenario modelling assumes that these hidden costs and benefits will stay constant over time, which may not be fully realistic.

In addition, the scenarios assume that only the availability of water changes, all other inputs and their usage are assumed to stay constant. The model does thus not consider technological advances, which would increase the input use efficiency. This holds true also for the efficiency of water use. This decision was made due to a lack of sufficient farm-level data. Nevertheless, technological advances could contribute to higher yields, thus ceteris paribus increasing the value added per hectare of land. Water saving technologies and more efficient irrigation practices could reduce the amount of water needed per hectare. Currently, the water use efficiency in the agricultural sector in Uzbekistan ranges between 55% and 74%[6], which indicates large potential for improvement. The government of Uzbekistan has already started taking measures to improve water efficiency and thus reduce water usage, for example by supporting the usage of drip irrigation technology and more than 27% of the cropland was already equipped with drip irrigation in the years 2017 to 2022. As water scarcity increases, investing in such technologies becomes more attractive. If water usage per hectare could be reduced, a larger cropping area could be irrigated with the same, limited amount of water. If efficiency enhancing measures are applied at large scale, this could lead to a less severe impact than the one outlined by the modelled scenarios. Similarly, technological progress could reduce the amount of labour needed to produce crops in Uzbekistan, which has

[6] Data provided by national authorities

already been the case in the cotton industry, where many processes are mechanised. Under such circumstances, the rate of employment reduction in the agricultural sector may accelerate.

Furthermore, this study does not consider the effect on livestock and fishery production (except fodder production). The economic losses related to the construction of the Qush-Tepa canal could be higher than the losses estimated in this study when losses in the livestock and fishery sectors are included as well. The same is true for the food processing industry, which could not be considered due to the limited scope of the study. Additional economic implications for the processing sector are likely if the production of certain crops decreases, especially for the production of fruits, vegetables and grapes. Similarly, the impacts of reduced water availability on industry are not considered in this study. Reduced water availability will have an impact on various industrial sectors including projects still in the planning phase like the nuclear power plant, which would require large amounts of water for cooling. Additional studies should be conducted to assess the impacts of the construction of the Qush-Tepa canal would have on these sectors.

Beyond the economic implications assessed in this study, the ecological impacts of water intake through Qush-Tepa canal will likely be negative, especially in the delta region of the Amu Darya (e.g. Khorezm, Republic of Karakalpakstan). These impacts should be studied, and adaptation measures should be considered.

Finally, access to statistical data in Uzbekistan still leaves room for improvement in particular at regional level. Some of the data used for this study was taken from normative acts, for example recommended use of inputs per crop instead of actual input use, due to gaps in the available data. Furthermore, in some cases, large variations in statistical data across regions suggest inconsistencies that could affect the outcomes of the modelled scenarios. We would like to stress that data transparency and quality control would increase the accuracy of scientific research and allow for improved policy guidance.

6. Conclusions and policy recommendations

The water availabe from the Amu Darya river is expected to decrease due to the construction of the Qush-Tepa canal and the impact of climate change in the region. This will have significant negative consequences for the agricultural sector of Uzbekistan. The reduction in water availability in the regions dependent on the Amu Darya River will differ based on the amount of water each region takes in from the river. The most severely affected regions in the Amu Darya basin in terms of water reduction will be Bukhara, Khorezm, and Karakalpakstan, whereas the least affected will be Surkhandarya.

The economic analysis of the impact on the agricultural sector within the scope of this study shows heterogeneous impacts as well. Among the regions which take in water from the Amu Darya river basin, the Kashkadarya, Bukhara and Khorezm regions would be the worst affected due to their high dependence on irrigation water from the Amu Darya river basin as well as the structure of crops, which they grow. Overall, a reduction of 12.9% in value added from crop production compared to 2022 can be expected for the entire Amu Darya river basin. This loss in value added is related to an overall decline in the land area suitable for crop production and changes in the crop structure. Under current policy conditions, where large areas of land are allocated to cotton and wheat production, this means that the area planted with all other crops declines. This would include staple foods such as rice, vegetables, and fruit, as well as fodder required for the livestock sector. As such, the construction of the Qush-Tepa canal could have considerable negative consequences for food security in the Amu Darya basin, if current land allocation policies are maintained. Furthermore, unemployment could become a serious issue in Kashkadarya, Bukhara and Khorezm regions as result of the Qush-Tepa canal construction.

The macroeconomic implications of the water reduction due to the construction of the Qush-Tepa canal would not be very large with a reduction in GDP of 0.7% if a scenario of 25% water intake from Qush-Tepa would happen in 2022. Since this water reduction is expected for 2030, the macroeconomic impact will be smaller as GDP increases. For national cropping value added, the reduction would be up to 6.2% in 2022. Again, if the 25% water intake takes place in 2030 as expected, the impact will likely be smaller. For employment the overall reduction is expected to be close to 250,000 jobs in crop production.

Considering that the construction of the Qush-Tepa canal has already begun, Uzbekistan should focus policy efforts on measures that will help the regions located in the Amu Darya river basin adapt to the new resource restrictions.

Crop land usage

The area of cropland that can be cultivated in the respective areas of Uzbekistan depends directly on the amount of water available for crop production. A reduction in cropland of 18.9% is expected for the Amu Darya basin in Uzbekistan. Thus, it is recommended to maximise the cropland area that can be cultivated by decreasing the amount of water needed per hectare. One important measure is the increased use of more efficient irrigation technologies, including drip irrigation. The government of Uzbekistan has already started to implement policies that incentivise the adoption of such technologies. These efforts should be intensified to speed up the adoption considering the narrow timeframe before the first impacts from the Qush-Tepa canal will be felt.

International experience shows that the adoption of water saving technologies can face several barriers, especially within the context of developing markets. Investment subsidies are one effective way to address low adoption rates. However, subsidies should be carefully targeted to ensure effectiveness. Several studies show for example that larger farms are more likely to adopt efficient irrigation technologies even without subsidies as the large initial investment tends to pay off faster for larger land holdings[7]. Thus, subsidies should be targeted mainly at smaller farmers.

Recommendation: Investment subsidies can increase the rate of adoption of efficient irrigation technologies and should be targeted mainly at smaller farmers.

Another important factor influencing the adoption of efficient irrigation technologies is risk perception. Studies show that farmers who are more risk averse or those growing crops with higher risk profile such as the perceptibility to droughts or pests are less likely

[7] Schuck, W, Frasier M, Webb, R, Ellingson, L, Umberger J. 2007. Adoption of More Technically Efficient Irrigation Systems as a Drought Response, *International Journal of Water Resources Development*: 651-662; Martínez-Arteaga, D.; Arias, Arias, N.A.; Darghan, A.E.; Barrios, D. Identification of Influential Factors in the Adoption of Irrigation Technologies through Neural Network Analysis: A Case Study with Oil Palm Growers. *Agriculture* 2023, 13, 827

to invest in technological innovations including water saving technologies[8]. Thus, support programmes like subsidies should consider the risk profile of different crops. Another option would be to pair subsidies for efficiency enhancing technologies with agricultural insurance that helps farmers manage risks, for example by including mandatory drought insurance in subsidy packages.

Recommendation: Economic risks associated with the planting of different crops should be considered within support measures, scaling subsidies and other programmes according to cropping risk. This could include the pairing of support measures with agricultural insurance.

Furthermore, a lack of knowledge and understanding of the benefits of efficient irrigation but also of the extent and severity of water scarcity can impede the adoption of water saving technologies[9]. One solution to address a lack of awareness and knowledge is the provision of extension services for farmers. Extension services have proven effective in increasing adoption of more efficient technologies and can help advance peer pressure if information about the adoption behaviour of other farmers in the region is communicated to peers[10].

Recommendation: Introduce or expand extension services focused on water saving technologies and more efficient irrigation systems in all regions of Uzbekistan to increase awareness and understanding of such technologies' benefits among farmers.

Besides awareness of the benefits of more efficient irrigation practices, farmers need to also understand the extent and severity of water scarcity within their region. Thus, it is important that water tariffs adequately reflect scarcity. If water tariffs are too low or independent of consumed volumes, farmers have little incentive to reduce consumption or invest in water saving technologies[11]. To account for the varying availability of water across regions and from year to year, tariffs should be designed flexibly. The government of Uzbekistan should publish guidelines that allow local governments to flexibly adjust tariffs based on local water availability according to a standardised methodology.

Recommendation: Use flexible water tariffs to account for varying levels of water scarcity at the local level and between years and seasons. Guidelines and methodologies for the implementation of water tariffs should be provided by the national government.

Crop allocation

The resource use per hectare can also be improved by optimised crop allocation. The reduction of water resources due to the Qush-Tepa construction presents a shock to the

---

[8] Jahangirpour D and Zibaei M. 2022. Farmers' Decision to Adoption of Modern Irrigation Systems Under Risk Condition: Application of Stochastic Efficiency With Respect to a Function Approach. *Frontiers in Water* 4:931694; Salazar, C, Rand, J. 2016. Production risk and adoption of irrigation technology: evidence from small-scale farmers in Chile. *Latin American Economic Review*, 25(1), 2.

[9] Tang, Jianjun; Folmer, Henk; Xue, Jianhong (2016). Adoption of farm-based irrigation water-saving techniques in the Guanzhong Plain, China. *Agricultural Economics*, 47(4), 445–455; Martínez-Arteaga et al. 2023

[10] Martínez-Arteaga et al. 2023.

[11] Cremades, R, Wang, J, Morris, J. 2015. Policies, economic incentives and the adoption of modern irrigation technology in China. *Earth System Dynamics*: 6, 399–410.

agricultural sector in the Amu Darya basin. With current policies, land allocation is de-facto restricted, thus preventing the sector from fully adapting to the shock via different crop allocations. A liberalisation of the land allocation process in combination with a liberalised trade regime could ensure that the land available in Uzbekistan will be planted with the most suitable crops given the resources available and developments in market prices. For some crops such as highly water-intensive rice, imports from less water-scarce countries may be more economical in the long run than local production. Similarly, cotton creates lower value added per water input than fruits and fodder. Thus, a reduction in the land area planted with cotton would lead to increased value added from fruit and fodder production.

Recommendation: A speeding up of the liberalisation of the land allocation process for cotton and wheat is recommended to ensure a resource-efficient allocation of cropland.

Furthermore, to ensure that resource allocation in a liberalised scenario can work properly, resources need to be priced appropriately to reflect the respective scarcity. This is particularly true for water tariffs, which would need to be adjusted to reflect the decreased water availability resulting from the construction of the Qush-Tepa canal. Tariff pricing is more effective in this respect than the currently applied quotas for water extraction[12], as the price effect allows farmers, who have more information about local conditions for crop production and prices, to make decisions about which crop to grow taking into account not only water use, but also relative profitability.

Recommendation: Quotas for water extraction should be replaced by appropriately priced, flexible water tariffs to allow farmers to optimise crop allocation.

Regional development

The results of the modelling showed that the macroeconomic impact of the water reduction due to the construction of the Qush-Tepa canal are noticeable but not very large. However, the economic impacts differ widely between the regions of the Amu Darya basin in Uzbekistan. Some regions, such as Kashkadarya, Bukhara and Khorezm, will face significant reductions in value added from crop production and reduction in employment in crop production reaching up to about 97,000, 50,000 and 37,000 jobs lost respectively. On the other hand, regions such as Surkhandarya that have more diversified sources of irrigation water, will face much smaller economic impacts. To account for the varying economic and social implications, the policy response should therefore focus on regional development. Such policies could include, among others, the establishment of regional development plans, which identify specific sectors with high potential for economic growth and employment opportunities within the regions. Such systematic analyses would identify also deficiencies in infrastructure or capacities and show ways how negative impact on value added and employment could be mitigated. Examples of such plans have already been prepared and could be expanded and implemented with the support of development partners.

Recommendation: Focus on regional development policies including regional development plans that can identify economic sectors with high potential for growth and employment generation.

[12] Cremades et al. 2015.

Annex

Modelled reduction in cropland area due to Qush-Tepa canal and climate change, % relative to 2022

Region	Land area planted in 2022, 1000 ha	Water intake from Qush-Tepa scenario		
		5% (2025)	15% (2028)	25% (2030)
Amu Darya river basin	1,473.3	-5.2%	-12.1%	-18.9%
Surkhandarya	232.8	-3.2%	-7.2%	-9.7%
Kashkadarya	497.1	-7.2%	-16.4%	-25.6%
Bukhara	241.9	-5.5%	-13.4%	-21.6%
Khorezm	202.9	-4.8%	-11.5%	-19.2%
Karakalpakstan	298.6	-3.4%	-8.1%	-12.4%

Source: own estimates based on data provided by national authorities; modelled scenarios include impacts of climate change and Qush-Tepa canal

Modelled reduction in cropland area per crop in the Amu Darya river basin, % relative to 2022

Crop	Land area planted in 2022, 1000 ha	Water intake from Qush-Tepa scenario		
		5% (2025)	5% (2025)	5% (2025)
Cotton	476.5	0%	0%	0%
Wheat	376.6	0%	0%	0%
Rice	37.8	-24.4%	-56.8%	-81.2%
Fruit	46.3	-9.3%	-23.0%	-40.5%
Vegetables	66.9	-14.4%	-34.9%	-55.0%
Grapes	25.6	-11.2%	-27.6%	-48.4%
Fodder	252.2	-7.4%	-18.2%	-31.6%
Oil crops	78.6	-25.3%	-50.9%	-57.9%
Other	112.5	-10.5%	-26.5%	-48.1%

Source: own estimates based on data provided by national authorities; modelled scenarios include impacts of climate change and Qush-Tepa canal

Modelled <u>reduction in crop production value added</u> due to Qush-Tepa canal and climate change, % relative to 2022

Region	Value added in crop production in 2022, USD m	Water intake from Qush-Tepa scenario		
		5% (2025)	15% (2028)	25% (2030)
Amu Darya river basin	4,620.2	-3.2%	-7.8%	-12.9%
Surkhandarya	688.5	-1.9%	-4.3%	-5.7%
Kashkadarya	1,341.5	-4.1%	-10.1%	-18.2%
Bukhara	1,082.9	-3.9%	-9.5%	-15.4%
Khorezm	694.1	-3.9%	-9.2%	-15.0%
Karakalpakstan	813.2	-1.4%	-3.3%	-5.1%

Source: own estimates based on data provided by national authorities; modelled scenarios include impacts of climate change and Qush-Tepa canal

Modelled <u>reduction in employment</u> in crop production due to Qush-Tepa canal and climate change, % relative to 2022

Region	Employment in crop production, 1000 employees	Water intake from Qush-Tepa scenario		
		5% (2025)	15% (2028)	25% (2030)
Amu Darya river basin	901	-8.0%	-18.3%	-27.6%
Surkhandarya	221	-5.6%	-12.5%	-16.7%
Kashkadarya	211	-13.9%	-31.0%	-46.1%
Bukhara	171	-7.7%	-18.9%	-29.3%
Khorezm	153	-6.1%	-14.5%	-24.5%
Karakalpakstan	145	-5.1%	-12.1%	-18.4%

Source: own estimates based on data provided by national authorities; modelled scenarios include impacts of climate change and Qush-Tepa canal