MINISTRY OF ECOLOGY, ENVIRONMENTAL PROTECTION AND CLIMATE CHANGE OF THE REPUBLIC OF UZBEKISTAN

GGGI

KOICA

CAPITAL EXPENDITURE FOR INFRASTRUCTURAL ADAPTATION MEASURES FOR AGRICULTURE

In the Republic of Karakalpakstan

GGGI Uzbekistan. Insight Brief 6. Green Rehabilitation Investment Project for Karakalpakstan Republic to Address Impacts of the Aral Sea Crisis (Aral Sea GRIP)

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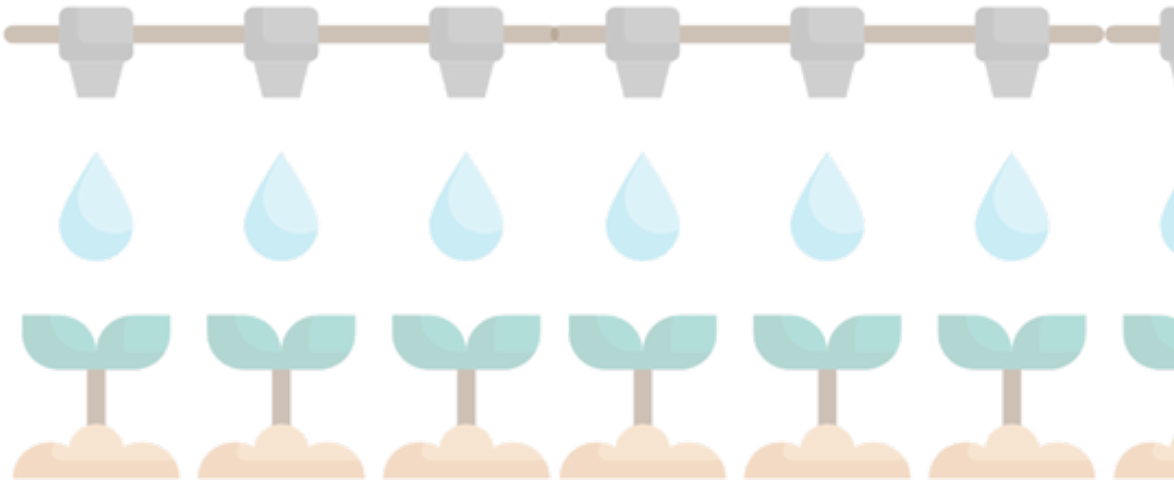
Executive Summary

Agricultural production in the Republic of Karakalpakstan is sensitive and vulnerable to climate change, water stress, and the continuous degradation of the Aral Sea. As part of future planning for the development of the region's agricultural sector, the Government of Uzbekistan has identified and set priorities for the implementation of sectoral adaptation measures in Karakalpakstan, specified in Presidential and Cabinet of Ministers' Resolutions.

In terms of infrastructural adaptation measures, and following government targets to increase agricultural production under greenhouses in 1,000 hectares from 2022 to 2026, the total investment in assets needed (expressed in present value in 2022) is estimated at USD 140 million. For implementing additional drip-irrigation systems in 25,000 hectares following government targets for 2022 and 2023, the total investment in assets needed (expressed in present value in 2022) is estimated at USD 96 million. Finally, for the plantation of trees as windbreaks, aimed at increasing the yield of agricultural land and following government targets of an additional 2,420 hectares from 2022 to 2030, the total investment in trees needed (expressed in present value in 2022) is estimated at USD 1.1 million.

Considering the need for training for the proper management of infrastructural adaptation measures in Karakalpakstan, it is estimated that the human capital expenditure needed for the proper management and maintenance of greenhouses is USD 2.5 million, approximately USD 4.98 million for the proper management and maintenance of drip-irrigation systems, and nearly USD 1,300 for the proper maintenance of trees as windbreaks.



Objective

The main objective of this Insight Brief is to **provide an estimate for the one-time investment needed for implementing three infrastructural adaptation measures for farm protection against the effects of climate change and sand/dust storms from the Aral Sea**. Following the government's official targets established for the Republic of Karakalpakstan, the capital expenditures are estimated for implementing **drip-irrigation systems**, **greenhouses**, and planting **trees for windbreaks**.

Methodology

This Insight Brief builds on the '**Green Rehabilitation Investment Analysis**'[1], which informs decision-makers regarding the potential return on investment for implementing infrastructural adaptation measures targeting the area under the '**Green Rehabilitation Investment Project for Karakalpakstan Republic to address impacts on the Aral Sea crisis**', expanding the investment expenditure analysis to cover the entire Republic of Karakalpakstan. It should be noted that the overarching priority issue highlighted by policy makers is the need to ensure adequate supply of, and effective/efficient water resource governance within Karakalpakstan (GGGI 2022).

This Insight Brief employs a Present Value (PV) calculation for estimating the one-time capital and installation cost in 2022 for implementing infrastructural adaptation measures following government targets for 2022 to 2030.

The calculation of the PV for each measure takes into consideration the average of Uzbekistan's inflation rate from 2010 to 2020 (12%), as reported by the Asian Development Bank, as well as a regular discount rate reflected by the commercial interest rate for Uzbekistan as of 1 January 2021. According to the report 'Cost of Doing Business in Uzbekistan' (2021), interest rates of loans made in national currency (UZS) are within the refinancing rate of the Central Bank – equivalent to 14% – plus 3-10% per annum depending on the risk and the cost of recovery (USAID 2021).

Considering the uncertainty of inflation and discount rates in the future, a sensitivity analysis was conducted to test how changes in these two variables will impact the PV. A Monte Carlo simulation[2] using @Risk[3] was conducted running five simulations, each with 1,000 iterations per simulation. For both variables, a probability distribution was assigned in order to run the simulation. A normal distribution was assigned for the inflation rate, while for the discount rate, a discrete uniform distribution between 5% (social discount rate[4]) and 17% (commercial discount rate) was assigned.

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[1] J.J. Robalino, A.J.M Russell, N. Oblomuradov, & J. Kazbekov (2022) Green Recovery Investment Analysis – Climate-Resilient Agriculture in the Republic of Karakalpakstan, Global Green Growth Institute (GGGI), Seoul, South Korea. (https://www.greengrowthknowledge.org/research/green-recovery-investment-analysis-climate-resilient-agriculture-republic-karakalpakstan)

[2] Monte Carlo simulation (or Monte Carlo Method) is a computerized mathematical technique that allows accounting for risk in quantitative analysis and decision making when facing uncertainty, ambiguity, and variability.

[3] @Risk Monte Carlo Simulation Tool – Palisade – www.palisade.com

[4] Employed by the World Bank for a cost benefit analysis for adaptability options conducted in Uzbekistan in 2013.

GREENHOUSES

According to the 'Guide on Development of Hothouses and Greenhouses in Karakalpakstan' (UNDP 2017), one of the most profitable and acceptable mechanisms, both commercially and economically, for promoting resource- and water-savings at the production level is the construction of greenhouse facilities. Moving crops to greenhouses enables more frequent harvesting, protects plants from adverse weather conditions, pests, and diseases, prevents overheating of the plants, and allows establishing the optimal temperature and humidity for production.

By 2017, the existence of 22,000 greenhouses on household plots and dehkan farms with a total area of 384 hectares (with a greenhouse average size of 175 m^2) was reported in Karakalpakstan (UNDP 2017).

According to Resolution of the Cabinet of Ministers of the Republic of Uzbekistan No. 155 (04.04.2022) "*On additional measures for the complex socio-economic development of the territory of the Republic of Karakalpakstan in 2022-2026 and further improvement of living standards*", the government has set targets for the establishment of greenhouses in the Republic of Karakalpakstan for 2022-2026 (See Table 1).

Table 1. Greenhouse targets in the Republic of Karakalpakstan for 2022-2026.

Unit	Target by Year				
	2022	2023	2024	2025	2026
ha*	84	128	215	281	292

**ha - hectares*

GGGI (2021), conducted an assessment of Karakalpakstan-located technology/supply providers for establishing greenhouses. The information about the investment needed is presented in Table 2.

[5] Includes installation cost.

Table 2. Capital expenditures for establishing greenhouses in Karakalpakstan.

Item	Value
Average investment cost[5] (x1,000 UZS* per hectare)	1,525,000
Average useful life expectancy (# of years)	10
Average cost per person for training purposes (x1,000 UZS* per person per month)	2,500
Average number of months for training (# of months)	10
Average number of people to train per hectare (# of people)	1.64

**UZS - Uzbekistan Sum*

Considering government targets and the average capital expenditure above, the PV of the total investment needed in 2022 has been estimated and modelled through a Monte Carlo Simulation. Considering multiple scenarios, the estimated capital expenditure needed is USD 140.69 million, with 90% confidence that the investment needed is between USD 141-139 million (See Table 3).

Table 3. Total investment needed for establishing greenhouses in Karakalpakstan in present value in 2022 (in million USD).

Item	Value
Mean	140.69
90% CI*	± 0.92
Minimum	106.59
Maximum	185.85
Median	138.65
Std. Dev**	17.63

**CI – Confidence Interval **Std. Dev – Standard Deviation*
***Exchange rate 2022 – UZS/USD 11,258*

Box 1. Human Capital Investment for Establishing Greenhouses.

Following targets in Table 1, this analysis estimates that the investment needed (in PV in 2022) for farmers' training to properly manage and conduct farming practices in greenhouses is USD 2.5 million.

DRIP IRRIGATION SYSTEMS

According to the World Bank Study for Reducing Uzbekistan's Vulnerability of the Agriculture Sector to Climate Change (2013), a high benefit to cost ratio was observed when implementing drip-irrigation systems for tomatoes, potatoes, and apples in the Republic of Karakalpakstan (Sutton and et al. 2013).

A cost-benefit analysis conducted by the NGO Khorezm Rural Advisory Support Service (KRASS), located in the Aral Sea region, found that the implementation of drip-irrigation systems provides significant water savings estimated at 6,600 m^3 per hectare of wheat and 11,455 m^3 per hectare of other crops. The analysis also revealed significant savings in energy, labor, fertilizers, and an improvement in productivity and product quality. The forecasted increase in yield was substantial, averaging 40% for all crops (GEF 2013).

The government has set targets for the implementation of drip-irrigation systems reflected in Resolution of the President of the Republic of Uzbekistan, No. 4912 (05.12.2020) "*On urgent measures for the efficient use of water resources and improvement of the land reclamation state in the Republic of Karakalpakstan*". The resolution approved forecast indicators for the introduction of water-saving irrigation technologies, as outlined in Table 4.

Table 4. Drip-irrigation targets in the Republic of Karakalpakstan for 2022-2023.

Unit	Target by Year	
	2022	2023
ha*	10,000	15,000

**ha - hectares*

Utilizing data collected from Karakalpakstan-located technology/supply providers for drip-irrigation systems, a calculation of the average capital expenditure for installing this system is presented in Table 5.

[6] Includes installation cost.

Table 5. Capital expenditures for establishing drip-irrigation systems in Karakalpakstan.

Item	Value
Average investment cost[6] (x1,000 UZS* per hectare)	43,240
Average useful life expectancy (# of years)	5
Average cost per person for training purposes (x1,000 UZS* per person per month)	2,500
Average number of months for training (# of months)	2
Average number of people to train per hectare (# of people)	0.53

**UZS - Uzbekistan Sum*

Considering government targets and the average capital expenditure above, the PV of the total investment needed in 2022 has been estimated and modelled through a Monte Carlo Simulation. Considering multiple scenarios, the estimated capital expenditure needed is USD 96.94 million, with 90% confidence that the investment needed is between USD 97.23-96.65 million (See Table 6).

Table 6. Total investment needed for establishing drip-irrigation systems in Karakalpakstan in present value in 2022 (in million USD).

Item	Value
Mean	96.94
90% CI*	± 0.29
Minimum	84.44
Maximum	110.49
Median	96.46
Std. Dev**	5.58

**CI – Confidence Interval **Std. Dev – Standard Deviation*
***Exchange rate 2022 – UZS/USD 11,258*

Box 2. Human Capital Investment for Establishing Drip-irrigation Systems.

Following targets in Table 4, this analysis estimates that the investment needed (in PV in 2022) for farmers' training to properly manage and maintain drip-irrigation systems on-farm is USD 4.98 million.

TREES FOR WINDBREAKS

Trees perform various functions, including producing fruit and acting as a source of fodder, firewood, and construction materials. However, trees also support soil stabilization and erosion control, stimulate productivity and, if planted systematically, they can provide wind protection. The territory of Karakalpakstan suffers from strong winds, dust storms and garmsels (hot dry winds). These affect agriculture by decreasing soil and air humidity, by blowing off the most fertile soil layer, and by destroying crops. Tree windbreaks play a positive role in microclimatic change and protection of neighboring fields. Wind velocity can be reduced by 50-80% when intercepted by optimally designed strips of trees. As a result, relative air humidity can rise by 1-13%, while air and soil temperatures can decrease by 1.5-2.0°C and 3-4°C, respectively. The average increase in crop yield of the adjacent agricultural land has been reported at 10-20% under an optimal structure and after the trees in the windbreaks have reached their final height (Worbes, et al. 2006).

Besides the implementation of the nationwide 'Green Land/Yashil Makon' project that aims to increase tree plantations, as mentioned in Presidential Decree No. 46 (30.12.2021) "*On measures to accelerate planting work and further effective organization of tree protection in the Republic of Uzbekistan*" the government has set specific targets for the creation of protective forest plantations to protect against wind and water erosion, aiming to increase the yield of agricultural land until 2030 in the Republic of Karakalpakstan. Table 7 presents the specific targets set under Presidential Resolution No. 4850 (06.11.2020) "*On the approval of the concept for the development of the Forestry System of the Republic of Uzbekistan until 2030*".

Table 7. Targeted trees for windbreaks in the Republic of Karakalpakstan for 2022-2030.

Unit	Target by Year			
	2022	2023	2024	2025
ha*	250	250	250	260
2026	2027	2028	2029	2030
260	270	280	300	300

ha - hectares

Utilizing data collected in Karakalpakstan, as well as referential data provided by forestry experts in the region, a calculation of the average capital expenditure for planting trees for windbreaks is presented in Table 8.

Table 8. Capital expenditures for planting tree windbreaks in Karakalpakstan.

Item	Value
Average plantation cost[7] (UZS* per hectare)	4,770,729
Average cost per person for training purposes (UZS* per person per month)	2,500
Average number of months for training (# of months)	5
Average number of people to train per hectare (# of people)	0.79

UZS - Uzbekistan Sum

Considering government targets and the average capital expenditure above, the PV of the total investment needed in 2022 has been estimated and modelled through a Monte Carlo Simulation. Considering multiple scenarios and with 90% confidence, the estimated investment needed is between USD 1.11-1.09 million (See Table 9).

Table 9. Total investment needed for planting tree windbreaks in Karakalpakstan in present value in 2022 (in million USD).

Item	Value
Mean	1.1
90% CI*	± 0.01
Minimum	0.73
Maximum	1.65
Median	1.07
Std. Dev**	0.19

*CI – Confidence Interval **Std. Dev – Standard Deviation
***Exchange rate 2022 – UZS/USD 11,258*

Box 3. Human Capital Investment for Trees for Windbreaks.

Following targets in Table 7, the estimated investment needed (in PV in 2022) for farmers' training for proper tree management on farm is USD 1,270.

[7] Investment in Natural Capital.

KEY TAKEAWAYS

- Currently in the Republic of Karakalpakstan, the agriculture sector is the most sensitive and vulnerable among all economic sectors to climate change risks, water stress, and the continuous degradation of the Aral Sea.
- The Government of Uzbekistan has identified and set priorities for the implementation of adaptation measures for the agricultural sector in Karakalpakstan. In particular, the government has targeted the establishment of greenhouses across a total area of 1,000 hectares from 2022 until 2026, the implementation of drip-irrigation systems across a total area of 25,000 hectares in 2022 and 2023, and the plantation of trees for windbreaks aimed at increasing agricultural production across a total area of 2,420 hectares by 2030.
- This analysis has estimated that the total investment needed for infrastructure in Present Value terms for 2022 is USD 140 million for greenhouses, USD 96 million for drip-irrigation systems, and USD 1.1 million for trees as windbreaks. The estimated total investment needed for these infrastructural adaptation measures is USD 237.1 million.
- In addition to investing in infrastructure, it is essential to invest in human capital with the objective of reducing the implementation risk and promoting a successful and efficient adoption of these measures with an estimated value of USD 7.48 million.

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