Assessment of the Costs and Benefits of Climate Change Adaptation in Agriculture, Forestry and Water Management Sectors of Tajikistan

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1. Executive Summary

Out of the Central Asian region, Tajikistan is considered to be the most vulnerable to climate change. Being a predominantly rural society, substantially dependent on agricultural production and water resources, and facing high population growth Tajikistan will have to deal with both the human-related and climate-related challenges. The adverse effects of increasing temperatures, changes in precipitation schedules, and more frequent weather extremes and emergencies are inherently interwoven with the deteriorating infrastructure, land degradation, lack of irrigation water, and unfavourable agriculture-related technologies. More often than not, the exact sizes of these impacts are hard to separate. Most of the studies predict serious economic losses coming from the lack of adaptation leading to immense socio-economic problems. It is estimated that a 20 percent decline in agricultural productivity caused by climate change may increase poverty by 13 percent.

These findings present substantial dilemmas for the policymakers and donor organizations as, on the surface, it seems that country is doing well. The other dilemma the policymakers and international donor organizations will have to solve is how to separate the interventions aimed at adaptation to climate change from the interventions aimed at economic help to the country. The third dilemma of policymakers relates to the choice of the specific intervention measures as related to the costs and benefits. While the costs of adaptation measures are relatively easy to estimate, the benefits are trickier as they can manifest themselves in different time periods, affect local, regional or global communities, and may have direct or indirect impacts.

This study aims to assess the costs of specific adaptation measures, i.e., costs of implementing UNDP/other donor interventions (e.g., improved watershed management, new pasture/livestock systems, adapted crop species, improved water/land use, abandoned/unused land conversion to orchards, etc.). The next goal is to rank the cost-effectiveness of specific adaptation strategies.

The study focuses on the six selected target districts and on the country as a whole.

To identify the most effective measures, there have been conducted semi-structured interviews and focus groups for each selected district. The output of these semi-structured interviews and focus group aims to answer the questions about the impact of implemented adaptation and mitigation measures focused on climate change.

Representatives, and farmers from the six selected regions were questioned. Based on the interviews it has been identified that adaptation measures for different regions vary, there should be implemented different strategies to tackle different challenges in the different time frame.

We also identified the prominent donors who are active in the territory of Tajikistan. We proceeded extensive overview of all data available, identified projects related to the issues mentioned above and sorted them into 6 categories: improved watershed management; new pasture/livestock systems; adapted crop species; improved water/land use; abandoned/used land conservation and the orchard; others.

Individual projects have been assessed and compared according to average costs per affected hectare. The values range from 125 USD up to 4,212 USD per hectare. The lowest costs per hectare are for rather extensive projects. No specific (physical) investment activities are planned, activities are rather strategic. The costliest activities combine both strategic activities with construction projects.

The next step was assessment of the cost effectiveness of measures to adapt for climate change in Tajikistan. To understand the scale of adaptation measures adoption it is important to look at the possible benefits of these measures related to water. Specifically, the issue of water scarcity and its impact upon agricultural production must be evaluated. The results suggest that the majority of projects have positive net values.

Several measures concerning the capture and efficient usage of water will be extremely important in currently rain-fed areas and areas where scaled-up irrigation is environmentally unsustainable or economically infeasible, which is the case of some parts of Tajikistan. Drainage and watershed management will be particularly important in areas with increasing precipitation that can lead to flood risk that has been identified for parts of Tajikistan. Given the predicted water stress for Tajikistan, better managed and expanded irrigation will be a very important part of adaptation and therefore their cost is analysed in detail. More efficient use of irrigation water can be achieved with properly timed applications and drip irrigation, among other methods.

The greater the number of distinct crops, cultivars, and varieties on a farm, the greater the chance that some of the harvest will survive a severe storm, a drought, an early arrival of spring or another unexpected event.

It is also important to mention other techniques such as crop rotation that can increase amount of soil organic matter of offset erosion. Erosion can be also managed through different field techniques (land use) such as creation of strips, riparian zones, etc. This is extremely important for hilly parts of Tajikistan. Crop rotation can also help to mitigate damages related to pests that may survive possibly milder winters in some regions of Tajikistan. Using proper information and management, which means deployment of precision agriculture can also offset certain costs related to climate change in Tajikistan.

For animal husbandry, the key area is proper grassland management, rotational grass feed etc. Finally, fire management is extremely important for forestry and possible agro-forestry that is proposed as one tool to adapt to climate change in Tajikistan. Many of the proposed techniques and investments have overlap beyond the benefits related to climate change adaptation and when applied cost-effectively, can lead to positive internal as well as external benefits.

Climate change represents a big challenge for developing and least developed countries, such as Tajikistan, and therefore the adaptation strategies need to be applied in the most vulnerable sectors to contribute to the sustainable rural development. The proposed assessment shows the importance and significance of adopted measures for adaptation strategies in Tajikistan.

Tajikistan is a significantly diverse country presenting a wide range of climate conditions, agricultural profiles, land degradation patterns, and natural environments. Therefore, instead of analysing the country as a whole, the project concentrated on six target districts – Kuhistoni Mastchoh, Gissar, Shaartuz, Fayzabad, Kanibadam, and Muminabad – representing a wide variety of environmental profiles of the country. Based on these analyses, the project aimed to make general recommendations for climate adaptation for the districts and the country.

The project aimed to achieve the following:

1. To assess the existing and predict the future climate change in Tajikistan
2. To study the effects of climate change on agriculture, water resources, and forestry
3. To assess the benefits and costs of adaptation to climate change and land degradation
4. To provide recommendations for the policymakers

The results suggest that:

1. Climate change in selected districts is manifested via increase in average temperatures (approx. 0,3 ^{0}C per 10 years). All the districts will be affected by the change in seasonality of precipitation. Kanibadam will also suffer from the increase in wind. The evaporation indices are expected to increase in all the districts, thus increasing the need for water in agriculture and forestry. The interview data (in terms of qualitative analysis on the level of farmers and local experts) suggest increase in extreme weather events such as heat waves, spring frosts, sudden intensive rains, etc.
2. The analysis of the effects of climate change on agriculture presented controversial results. The interview data suggest decrease in yields for most of the crops. The results of CARD models suggested decrease in crop yields for some crops but not for others. The increasing temperatures will possible allow three harvests per year instead of two. The trend analysis of statistical data did not suggest any decrease in crop production for most of the crops. This ambivalence in results creates dilemma for the policy makers, as it casts doubts to the wisdom of further investments to climate change adaptation. The controversial results can be explained by the effect of low base in agricultural production in 1990th, increasing number of people in agriculture, the ability of the population to adapt, and the already enacted adaptation measures financed by the government and international donors. Last but not least, the effects of climate change might not be directly manifested on district- and country- level, since crop yields as we do not know the counterfactual. It might be the case, that the effects of climate change are manifested in the decrease of growth rates of agricultural production, but not in the production itself. In any case the effect of adaptation on crop yields is computed to be rather large. For example, in the case of wheat, the difference between crop yields produced under optimal adaptation scenario and status quo scenario in wheat yields 2050 amounts to 162 USD per ha (CARD model). This number

is well above the average monthly salary in the country nowadays (approximately 120-140 USD). The population can partly adapt to the negative (and positive) effects of climate change. However, the results of qualitative part of the analysis suggest, that the limits of the population to adapt seem to be almost reached and the need for adaptation interventions is more than real. This need will be growing over time due to population growth.

The biggest negative effect of climate change is observed in water resources as both the models and interview data suggest decreasing availability of water, especially in the periods of intense irrigation. The water availability showed to be the factor that limits the ability of the country to benefit from the climate change.

Forestry is affected by the climate change by increased droughts and temperature increase. Given the vast deforestation in 1990s, the sector of forestry is in need of intense investments in afforestation and forest regeneration.

3. We analysed the adaptation strategies and projects as suggested by locals, experts, in government adaptation plans and from the perspective of the actual results of existing projects. We also performed cost-benefit analyses of some selected projects. The results suggest, that, water resources seem to be the most pressing issue in almost all the districts and the projects aimed at availability and efficient water use bear considerable benefits also for the other sectors of agriculture and forestry including partial prevention of land degradation. The second priority for most of the regions is to give attention to the protection and prevention from floods, mudflows and land-slides as they also endanger all the other sectors including human lives. The third most prioritized area was highly dependent on the district. Cost/benefit analyses of selected projects suggest that two out of three projects present positive net present value.

The biggest controversy was found in the costs, benefits and long-term sustainability of drip irrigation. The cost-benefit analysis of existing drip irrigation projects computed payback period between 4-5 years in the case of wheat and cotton, to 1 – 2 years in the case of orchards. Increase in crop yields of 40% is anticipated among all crops (UNDP, 2019). However, the on-site interview data suggest this strategy unsuitable for particular localities. The reasons are twofold. First, the farmers often have to put up with the much lower crop price than the market price as the biggest price margin is collected by the wholesalers. Thus, the cost-benefit analysis faced by the farmer is much less optimistic than the one computed from the desk. Second, in the districts with high soil salinity, the tubes of drip irrigation are quickly clogged with minerals and the system stops operating. Thus, the drip irrigation can be suggested primarily for the high value agricultural crops, when the most of the final price is collected by the farmer and in the districts with little or no soil salinity.

The other controversy concerned the projects of wells as a substitute for the lacking irrigation water. While cost/benefit analysis provides good results making wells is one of the adaptation strategies of local communities, there are two main concerns. First, if this strategy is to be used in bigger scale, the hydrological research is needed to assure long term and sustainable water sources. For example, in Kanibadam, the wells go 120-140 m deep, reaching the layers of water not-renewable from the precipitation. Second, in the districts with high soil salinity, water from wells bring the salt to the upper levels of soil, thus increasing soil salinization.

4. The project concludes with the following general recommendations to policymakers.

4.1 The climate change in Tajikistan is manifested both on the level of meteorological data analysis as well as and on the level of implications for the local communities. It needs to be dealt with.

4.2 The effects of climate change on water resources are primarily related to the lack of water in the seasons when it is needed the most. Though the lack of water was characteristic for Tajikistan for long, the temperature increase, change in precipitation schedule and stronger winds present additional challenges in water availability and increase general water needs. The projects aimed at increased water availability and efficiency of water use will have positive synergies with the outcomes of agriculture, forestry and decrease in emergencies such as mudflows and landslides as most mudflows are caused by inability to catch excess rainfall, Thus, the adaptation projects related to water use were prioritized as the most urgent. Increasing water catchment capacity in the upper watersheds contributes to better water regulation.

Benefits of floods and mudflow prevention, if fully affective, are estimated to reach approximately $400,000 US per analysed project in target districts per year. Benefit of improved access to drinking water per one inhabitant was estimated as 47.41 US$/person.

4.3 The amendment of water regulation is indispensably connected to higher altitude pasture and forest management. Being the biggest and the least regulated water catchment area, pastures present substantial potential for water and water-related emergencies regulation. Overgrazed pastures limit the capacity of the water catchment areas to catch and retain water and worsen land degradation. Overpopulated livestock damage the forests and constrain the efforts on afforestation and forest regeneration. Regulation of pasture use and overall pasture and forest management is indispensable for improving water availability, limiting water-related disasters, and normalizing provision of other ecosystem services.

4.4 The evidence of the effects of climate change on agriculture presents an inconsistent picture. However, climate change adaptation is shown to significantly increase crop yields in any case. The increase in agricultural production will be vital for Tajikistan due to high population growth.

Qualitative analysis on the level of farmers and local experts emphasizes climate-related decrease in crop yields, climate-related land degradation, and overall decrease in quality of lives. Standardized CARD models of crop yields predict significant decrease in some crop yields and slight increase in the others. Climate related salinization and land degradation make part of land unsuitable for agricultural production. In contrast to the above, the trend analysis of agricultural production and crop yields both on the level of Tajikistan and the level of target districts suggest slight increase in production. No climate-related damage seems to be visible.

The rapidly growing population of Tajikistan will put more pressure on the food supplies in the near future. The climate change adaptation should be viewed as one of the measures to meet these increased needs.

4.5 While most of the effects of climate change are negative, the climate change also presents some opportunities. Namely, increasing temperatures is predicted to increase crop yields of particular crops and enable the population to collect three harvests per year instead of two. The positive effects above will most probably not be manifested due to the lack of irrigation water.

4.6 The effects of climate change on forestry manifested itself in droughts, extreme weather events and emergencies. The whole sector should be analysed in the context of deforestation and overgrazing. We suggest increased support in afforestation, forest regeneration and forest use. However, the effectivity and sustainability of these investments are hardly contingent upon improvement of pasture management and limiting the number of livestock. The overgrazing of pastures worsen land degradation and limits the underground water available for forests. In addition, the unregulated increase in livestock dependent on pastures damages the forests per se since the forests are often used as pastures.

4.7 In all analysed regions, pastures degradation has been identified as one of the key problems. Overgrazing that is related to the increased stock of animals magnifies the effects of climate change such as erosion, mudslides as well as water pollution.

4.8 Based on the results of the qualitative research, in case of further worsening of climate change, it will present significant pressures to the local communities. In case of no adaptation, the country will have to face desertification of the land, increased migration and brain drain, depopulation of affected localities, increase in morbidity and need of health care, the government will face the water-related reputational risks, and the whole local communities might be destroyed. In the worst case the effects might be irreversible. Most of these effects are caused by the direct effects of CC on health and wellbeing, and the limits of water supply related to CC.

4.9 The current report suggests a number of strategies for CC adaptation on the local level of target districts and on the level of the whole country. We divided the strategies to the following categories: infrastructural projects, provision of relevant animal and floral material (seeds, seedlings, animal species), local capacity building, and systemic measures. We conducted cost-benefit analysis of infrastructural projects and present feasibility-cost description of particular general adaptation strategies. However, neither infrastructural projects nor the provision of relevant floral and animal material will not be sustainable in the long run, without local capacity building. We suggest measures of knowledge transfer from old generation of farmers, water resource managers, engineers of locally used mechanisation and foresters, often born in the USSR, to younger generation in addition to new project related to the new measures for CC adaptation.

4.10 Last but not least, given the deteriorated infrastructure, most of the climate-related measures will intersect with other types of development assistance. We suggest increased cooperation of various donor organizations to achieve most pronounced synergetic effects.

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List of Abbreviations

AEZ	Agro-Ecological zones
BFC	Big Fergana Canal
CAA	Caucasus and Central Asia
CAPM	Capital Asset Pricing Model
CARD	Climate Adaptation in Rural Development
CBA	Cost Benefit Analysis
CC	Climate Change
CF	Cash Flow
DCF	Discounted Cash Flow
DCM	Debt Capital Markets
FAO	Food and Agricultural Organization
GDP	Gross Domestic Product
GHG	greenhouse gases
GIS	Geographic Information System
GIS	Geographic information system
GIZ	German Development Agency
GNI	Gross National Income
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IIASA	International Institute for Applied Systems Analysis
IRR	Internal Rate of Return
ISIMIP	Inter-Sectoral Impact Model Intercomparison Project
LD	Land Degradation
LGP	Length of growing period
LGPeq	Equivalent growing period
LGPt	Temperature growing period
NPK	nitrogen (N), phosphorus (P), and potassium (K) fertilizer
NPV	Net Present Value

OCHA	United nations office for the Coordination of Humanitarian Affairs
OECD	Organisation for Economic Co-operation and Development
OMC	Operating and Maintenance Costs
PIK	Potsdam Institute for Climate Impact Research
ppm	parts per million
RCP	Representative Concentration Pathway
SMB	small & medium business
SV	Seasonal Variability
TJS	Tajikistani somoni
UN	United Nations
UNDP	United Nations Development Programme
VSL	Value of Statistical Life
WASH	Water supply, Sanitation, Hygiene
WRI	World Resource Institute
WUA	Water User Association

3. Methodology

The project relies on fact-based methods of regional development, where the assessment of costs and benefits of climate change in Tajikistan were analysed in the six target districts. Specifically, the project focuses on Kuhistoni Mastchoh, Gissar, Shaartuz, Fayzabad, Kanibadam, and Muminabad districts. These districts represent the diversity of localities in Tajikistan and can be viewed as representative for the region. We also conduct a quantitative analysis for the whole Tajikistan.

Desk research

The desk research comprised content and document analysis of existing literature, and statistical analysis of selected data. Namely, we predicted the future trends of climate-related indicators (yearly and monthly) for six target districts and analysed their statistical significance. We provided graphical analysis of district-level data of agrarian production, and predictions of water stress indicators using the methodology of the World Resource Institute (2019) for three climate change scenarios to predict the likely climate change scenarios over next 10 and 20 years. This methodology provides quantitative and graphical map-based outputs, the risks associated with water - its availability and quality, the water risks for agriculture, the risks in the seasons, and insights into the future.

Field research

The collected knowledge was contrasted with the experiences of the local population and the local and national-level experts. The team conducted 6 focus groups in the target districts (one per district) and 72 interviews with local experts and representatives of jamoat communities (8 in Fayzabad, 11 in Gissar, 10 in Kuhistoni Mastchoh, 6 in Muminabad, 13 in Shaartuz 13 and 11 in Kanibadam district) and 4 interviews with national-level experts. The focus groups aimed at the wide local community including the representatives of farmers, local government, forestry, agriculture, water, and emergency experts. The regional semi-structured interviews were aimed at experts located in the districts. In addition, we conducted a number of interviews with the country-level experts on emergencies, climatic conditions, water resources, and forestry. The general structure of semi-structured interviews is presented in appendices. The structure was adapted to the specific expert and area.

This methodology enabled the authors to compare the outcomes of four levels of analyses: the predictions via extrapolation of existing trends and correlates in existing statistical data, the predictions coming from standard internationally accepted climate-related models, the opinions of the experts, and the opinions of the local community. Thus, this research was able to present more robust and balanced outcomes.

The quantitative data sources

The current project employed district specific data on hydro-meteorology, agricultural production, water resources, prices and outputs. The following data sources were used.

The methodology for selecting adaptation options in target districts

Essentially, we adopted the following step-wise procedure for the target districts:

Step 1: Identification of manifestations of climate change

Step 2: Identification of climate benefits, risks, and threats

Step 3: Prioritisation of climate risks and threats and selection of shortlisting for the districts

Step 4: Identification of adaptation strategies

Step 5: Identification of the range of the projects that enhance adaptation

Step 6: Identification of the existing projects aimed at similar risks and threats in the region

Step 7: Cost-benefit analysis of selected projects contingent upon the availability of the relevant data

Step 8: Prioritisation and selection of the projects and adaptation options.

The ranking criteria

- Socio-economic and health conditions of the households in the short and long run
- Sustainable and efficient agriculture
- Preservation of arable land and natural resources, reduction of land degradation
- Preservation and sustainable use of water resources
- Preservation, maintenance, and enhancement of existing forests
- Cost efficiency

- **Cost/benefit analysis**
- Cost-benefit analysis is used to evaluate investment projects. Its purpose is to quantify not only the financial costs of project implementation and the revenues that flow directly from the founder, but also to financially evaluate all other social benefits (e.g. improving the health of the population, reviving agriculture, environmental impact) that the project will bring - for locals, municipality, state. CBA thus makes it possible

to assess the profitability of investments even for projects that ultimately do not bring profit (public projects). By converting indirect benefits into financial amounts, it is possible to assess the appropriateness of financial investment, even if its main purpose is a social benefit and not a financial return.

This study aims: (i) to assess the costs of specific adaptation measures, i.e., costs of implementing UNDP/other donor interventions (e.g., improved watershed management, new pasture/livestock systems, adapted crop species, improved water/land use, abandoned/unused land conversion to orchards, etc.) and (ii) to rank the cost-effectiveness of specific adaptation strategies.

This report uses different methodological approaches to achieve the aims.

Chapter 5.1 of Solution relies on desk research. In particular, the desk research comprised content and document analysis of existing literature, and statistical analysis of selected data. Within the report, we identified projects in which we're supposed to cover issues related to agriculture or land use, forestry, improved land management, watershed management, new approaches towards pasturing and livestock systems, land conservation strategies and other related areas.

We identified the prominent donors who are active in the territory of Tajikistan, and we collected formation from the national resources (public sources, government documents and reports) and international resources. We proceeded extensive overview of all data available, identified projects related to the issues mentioned above and sorted them into the following categories.

- improve watershed management
- new pasture/livestock systems
- adapted crop species
- improved water/land use
- abandoned/used land conservation and the orchard
- others.

After extensive research of available data, we identified that international financial institutions, national development agencies and some nongovernmental organizations are active contributors to Tajikistan's development. The following institutions are the most active in the territory of Tajikistan (sorted alphabetically)

- Asian Development bank (ADB)
- Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)
- European Bank for Reconstruction and Development (EBRD)
- Food and Agriculture Organization (FAO)
- Global Environmental Facility (GEF)
- Green Climate Fund (GCF)
- International Fund for Agricultural Development (IFAD)

- Japan International Development Agency
- Oxfam
- United Nations Industrial Development Organization (UNIDO)
- United Nations Development Programme (UNDP)
- USAID
- Word Bank (mainly IDA)

As observed, many of those organizations compliment their activities either financially or by sharing competencies. We were able to identify the same projects either in databases of Asian Development Bank or Global Environmental Facility, in the database of Word Bank and USAID; etc.

For each project, either the expected budget has been considered, or the final budget was considered. The final funding was sourced from the projects where the final reports were published/were available. Approved budgets have been used in the cases where projects still have not been finalized.

Based on the above-stated procedure, we identified 34 projects which targeted into above-stated areas of agriculture, land management or forestry. A more detailed description of each project is in the Appendix 1.

Chapter 5.2 of Solution section is based on the field research. The collected knowledge was contrasted with the experiences of the local population and the local and national-level experts. The team conducted 6 focus groups in the target districts (one per district) and 72 interviews with local experts and representatives of jamoat communities (8 in Fayzabad, 11 in Gissar, 10 in Kuhistoni Mastchoh, 6 in Muminabad, 13 in Shaartuz 13 and 11 in Kanibadam district) and 4 interviews with national-level experts. The focus groups aimed at the wide local community including the representatives of farmers, local government, forestry, agriculture, water, meteorology and emergency experts. The regional semi-structured interviews were aimed at experts located in the target districts. In addition, we conducted a number of interviews with the country-level experts on emergencies, climatic conditions, water resources, and forestry.

Chapter 5.3 relies on water balance model. The water balance model analyses the allocation of water between the individual components of the hydrological system using a monthly accounting procedure based on the entered data in the form of precipitation and temperature, as well as the parameters of the model. A program in JAVA was used for modelling, namely the model of monthly water balance incl. GUI (graphical interface).

The methodology is described in detail in (McCabe and Markstrom, 2007). The methodology in the program is according to McCabe and Markstrom (2007) modified according to the originally introduced methodology of the Thornthwaite model (Thothwait, 1948; McCabe and Wolock, 2018). The inputs to the model are the average monthly temperature (T, in degrees Celsius), the monthly total precipitation (P, in millimetres) and the latitude (in decimal degrees) of the place of interest. The latitude of the site is used to calculate the length of day needed to calculate potential evapotranspiration (PET). The latitude for the model was set for Tajikistan's regions of 38.86 degrees N.

Model has been further calibrated for the conditions of Tajikistan using variables such as soil moisture storage, snow storage, surplus and runoff.

The most important output variable of the model is the water deficit $Wdef_t$ that is calculated as the difference between potential evapotranspiration PET_t minus the actual evapotranspiration AET_t.

This calculation has been done from available data for precipitation and temperature that were taken for six target districts of Shaartuz, Fayzabad, Kanibadam, Muminabad, Gissar and Kuhistoni Mastchoh that were available in monthly expressions. Consequently, all six districts were aggregated into one indicator of water deficit.

Chapter 6 uses the yield predictions based on the International Fund for Agricultural Development (IFAD) modelling tool called the Climate Adaptation in Rural Development (CARD) assessment tool. These tools enable modelling of expected yield predictions under climate change. The version v2.0rc3 from February 2021 was used. The combination of yield changes from CARD together with a-priori information from the statistical data is then used for calculations of predictions in Tajikistan agriculture, as well as in the selected districts.

CARD is based on the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP) initiated by the Potsdam Institute for Climate Impact Research (PIK) and the International Institute for Applied Systems Analysis (IIASA). Simulations results of the underlying global gridded crop models are currently included up to the year 2050. IFAD CARD model was selected as a robust tool to assess the climatic change perspective in Tajikistan, as the tool is based on ISIMIP simulations, which are widely accepted by international scientific community for modelling not only agriculture under climate change (Jägermeyr & Frieler, 2018; Leng & Hall, 2019; Liu et al., 2016; Orlov et al., 2021)

All underlying simulations use the greenhouse gas emission scenario RCP8.5, an emission scenario that leads to around 4°C global warming by 2100[1].

As presented below, mostly there are 6 possible scenarios presented:

- Rainfed – median
- Rainfed – pessimistic
- Rainfed – optimistic

[1] RCP (Representative Concentration Pathway) is the green house concentration trajectory developer by International Panel on Climate Change. The pathways work with different climate futures, all of which are considered to be possible. All of them depends on the volume of greenhouse gases (GHG). RCP 8.5 counts with GHGs emission rising over the 21st century. This is generally the worst-case scenario.

- Irrigated – median
- Irrigated – pessimistic
- Irrigated – optimistic

Rainfed and irrigated models takes in consideration whether agricultural production is fully irrigated or rainfed.

For the uncertainty, three scenarios are defined as follows:

- **Median** option reflects a "best guess" of the uncertainties reflected in the models. The models are aggregated using the median.
- **Pessimistic** option reflects a pessimistic consideration of the uncertainties reflected in the models. The models are aggregated using the 10^{th} percentile of all underlying crop yield predictions (i.e., close to the model with the largest decline, or smallest increase in crop yields).
- **Optimistic** option reflects an optimistic consideration of the uncertainties reflected in the models. The models are aggregated using the 90^{th} percentile of all underlying crop yield predictions (i.e., close to the model with least decline, or largest increase in crop yields).

The CARD predictions serve for the calculation of shadow values of the agricultural production representing the gains of implementation of adaptation and/or mitigation strategies. We assume that status quo for rainfed and irrigated land is represented by the pessimistic scenario of the wheat yield development. Scenario 1 is the difference between median (neutral) scenario and the pessimistic scenario of wheat yield development. Scenario 1 represents the situation with the minimum effect of the implementation of adaptation and/or mitigation strategy on the wheat yield. Scenario 2 is the difference between optimistic and pessimistic scenario of wheat yield development. Scenario 2 represents the situation of maximum (optimal) effect of the implementation of adaptation and/or mitigation strategy on the wheat yield. Then, since wheat belongs to the most important commodity in Tajikistan, we use it for the calculation of the shadow values of agricultural production. Shadow value of agricultural production then represent the monetary effects of the implementation of the adaptation and/mitigation strategy that allows us to carry out the comparison of the effects of different adaptation and mitigation strategies even though they differ in their natures and scope.

Limitations: like any analysis, this study is subject to a number of limitations. The largest limitation concerned the availability and reliability of relevant data. In many cases, the requested data were not available or did not exist. Another type of limitation concerns the quality of the available data.

4. Introduction

Tajikistan is considered to be the most vulnerable to climate change among Asian countries as 75 to 100% of the population in particular districts live in rural areas and are heavily dependent on agriculture. Increasing temperatures, changes in precipitation schedules, more frequent and intense winds in some districts, heatwaves, and weather-related disasters decrease the quality of life and cause substantial economic damage. The intense reliance on agriculture and the rural style of living does not enable the population to shield itself from the effects of climate change via technological means. Adaptation measures are needed.

Tajikistan is a mountainous country that provides a wide variety of natural conditions in terms of altitudes, steepness of the terrain, types of soil, climate zones, water availability conditions, types of agriculture and irrigation, etc. The climate-related effects in one district may substantially vary from the other ones emphasizing the need to tailor the adaptation measures to the particular locality.

This project focuses on six target districts belonging to three climatic zones. Namely, we studied the effects of climate change on agriculture, water resources, and forestry in Gissar, Shaartuz, Fayzabad, Kanibadam, Kuhistoni Mastchoh, and Muminabad. In all the districts, we conducted the analysis of climate change based on meteorological data collected via satellites. The effects of climate change on agriculture, water resources, and forestry were researched (1) as perceived by the local communities, (2) by local and country-level experts and stakeholders, (3) as manifested in statistical data of agricultural production, and (4) as modelled in standardized CARD (agriculture) and WRI (water resources) models. We identified shortlists of the most vulnerable areas and most efficient adaptation measures in the target districts based on these results. Further on, we conducted the cost-benefit analysis of some adaptation measures and suggested projects to provide an economic evaluation of suggested strategies.

Tajikistan is a country with a considerable history of development assistance, including climate change adaptation assistance. The dissolution of the Soviet Union and the civil war of 1990th destroyed production links and substantially damaged the infrastructure, environmental conditions, and economy in general. As a result, the agricultural production over the war was substantially shortened, and the country's population got at the edge of survival. The work opportunities were scarce. Some of the population found temporary employment abroad and sent the remittances home; others became completely reliant on agriculture for their basic needs. Working abroad produced significant damage to women, families, and growing children as fathers often spend a considerable part of the year earning money abroad, leaving the rest of the family (overrepresented by women and children) to manage rural life in Tajikistan. Despite this fact, Tajikistan presents an immense rate of population growth which will increase the pressure on agriculture and water resources even more.

The Government of Tajikistan assisted the people by allocating some agricultural land for private needs, which partly solved the problem. However, the agricultural land got highly fragmented, which disabled economies of scale and more intensive ways of agriculture, locking the country in the status quo. The improper use of land and water resources for agricultural production leads to accelerating land degradation, which may eventually make some land unsuitable for agricultural production.

To sum it up, the effects of climate change in Tajikistan should be analysed in the context of deteriorated underfinanced infrastructure, limited water resources, and highly fragmented agricultural land, often given to a population with limited knowledge of agricultural technologies. The effective lack of professionals educated in new methods of agriculture or able to maintain and renew irrigation systems (including pumps) and the frequent lack of basic mechanization in agriculture, water management, and forestry (e.g., tractors) make the climate change adaptation even more difficult and resource-demanding. Moreover, it is often difficult to separate the measures aimed at climate adaptation from measures aimed at overall development assistance.

The rest of the report is structured as follows. The next section provides executive summary of the report one through three on the existing and future climate change, the costs and the benefits of climate change for agriculture, forestry and water resources, the costs of no adaptation and the costs and benefits of adaptation strategies. Based on these analyses, the following section provides recommendation to project, local and national authorities on socio-economic justification and rationale for land degradation reversal and climate change adaptation in selected districts. Conclusions are drawn in the last section.

Out of the Central Asian region, Tajikistan is considered to be the most vulnerable to climate change (Heltberg et al. 2012). Being a predominantly rural society, substantially dependent on agricultural production and water resources, and facing high population growth Tajikistan will have to deal with both the human-related and climate-related challenges. The negative effects of increasing temperatures, changes in precipitation schedules, and more frequent weather extremes and emergencies are inherently interwoven with the deteriorating infrastructure, land degradation, lack of irrigation water, and unfavourable agriculture-related technologies. More often than not, the exact sizes of these impacts are hard to separate. Most of the studies predict serious economic losses coming from the lack of adaptation leading to immense socio-economic problems. It is estimated that a 20 percent decline in agricultural productivity caused by climate change may increase poverty by 13 percent (ibid).

Despite the particularly negative predictions of climate-related models and qualitative analytical tools, the analysis of available agrarian data presented in the previous outputs of this study suggested that the agricultural production did not present downward sloping trends, expected given climate change. Moreover, some of the trends were slightly positive, and the correlation of agrarian production with yearly average temperature suggested positive effects. These findings present substantial dilemmas for the policymakers and donor organizations as, on the surface, it seems that country is doing well. The previous outputs of this study suggested that the trends in the macro data on agricultural production are substantially affected by the effects of a low base caused by very limited agricultural production in 1990th due to the civil war. The second effect was the partial ability of the population to adapt, though the qualitative part of the study suggests that the limits of this adaptability seem to be reached or will be reached in the near future. The possible positive effects of climate change – such as more harvests per year – present a potential that will probably not be realized in full due to the lack of water and other effects.

The other dilemma the policymakers and international donor organizations will have to solve is how to separate the interventions aimed at adaptation to climate change from the interventions aimed at economic help to the country. Most often than not, the climate-related measures are interwoven with the measures aimed at overall development assistance. It is highly likely that the measures proposed will have both outcomes. Implementation of adaptation measures is also closely tied to capacity building, as it is an important factor in future resistance to climate change impacts. All the analyzed target districts have issues related to the lack of education concerning modern agrarian technologies and the effects of climate change. Findings show lack of awareness on the side of the farmers of what modern agrarian and water use technologies could be used. Education does not provide qualified engineers that would be able to effectively operate and repair the mechanization necessary for irrigation and agrarian production. There are missing systems of coordination and effective use of available mechanization. On the level of the affected communities, there is lack of information related to the measures of adaptation to climate change. It is also worthwhile to mention brain drain and lack know-how transfer between generations.

The third dilemma of policymakers relates to the choice of the specific intervention measures as related to the costs and benefits. While the costs of adaptation measures are relatively easy to estimate, the benefits are trickier as they can manifest themselves in different time periods, affect local, regional, or global communities, and may have direct or indirect impacts. It seems reasonable to assume that all indirect impacts will never be possible to estimate. Thus, the estimates of the benefits will inevitably be biased down.

This study aims to assess the costs of specific adaptation measures, i.e., costs of implementing UNDP/other donor interventions (e.g., improved watershed management, new pasture/livestock systems, adapted crop species, improved water/land use, abandoned/unused land conversion to orchards, etc.). The next goal is to rank the cost-effectiveness of specific adaptation strategies.

Similar to the first two outputs, the study focuses on the six target districts and on the country as a whole. The selected target districts include Kuhistoni Mastchoh, Gissar, Shaartuz, Fayzabad, Kanibadam, and Muminabad. These districts represent the diversity of localities in Tajikistan as to the altitude, type of soil, sources of water, the extent of deforestation, and the types of climate-related problems the population had to adapt to.

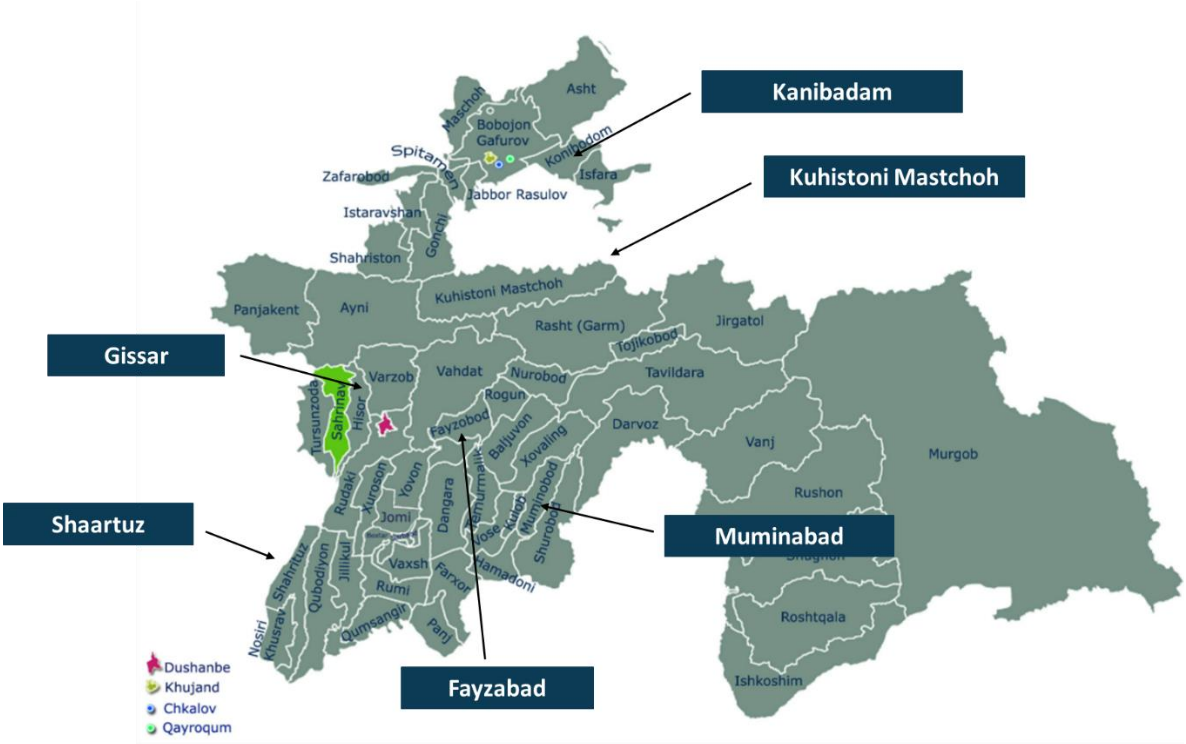
Six main climate-related threats to the socio-economic well-being of households were identified in previous parts of this study – lack of irrigation water, insufficient quality of drinking water, climate-related land degradation and decrease in crop yields, climate-related increase in emergencies, climate-related increase in pests, climate-related impact on human and animal health. The current study aims to suggest measures to adapt.

The rest of the report is structured as follows. The next Section 5 provides the report on costs of implemented UNDP and other projects, presents the suggested adaptation strategies based on the qualitative research and cost effectiveness of measures to adapt for climate change in Tajikistan using water balance model. Assessment of the implemented projects is carried out in Section 6. Conclusions are drawn in the last section.

5. The districts

The project focused on the following six target districts: Kuhistoni Mastchoh, Gissar, Shaartuz, Fayzabad, Kanibadam, Muminabad.

Figure 5-1 The target districts: Kuhistoni Mastchoh, Gissar, Shaartuz, Fayzabad, Kanibadam, Muminabad



6. The methodology for selecting adaptation options for target districts

The methodology for selecting adaptation options relies on the results of preliminary analyses and on the cost-benefit analysis of existing projects. We also took into account the possible benefits of climate change and the ability of the population to adapt. If possible, when choosing an option, we relied on three types of analyses: focus groups and structured interviews with inhabitants, analysis of available meteorological data, and structured interviews with experts and stakeholders. Thus, our analysis does not rely on the opinions of stakeholders only, but provides a more comprehensive basis for adaptation options. In order to make adaptation more feasible, we prioritized the climate risks and threats to reduce the number of categories and tailored them to the target districts. Essentially, we adopted the following step-wise procedure for the target districts:

- Step 1: Identification of manifestations of climate change
- Step 2: Identification of climate benefits, risks, and threats
- Step 3: Prioritisation of climate risks and threats and selection of shortlisting for the districts
- Step 4: Identification of adaptation strategies
- Step 5: Identification of the range of the projects that enhance adaptation
- Step 6: Identification of the existing projects aimed at similar risks and threats in the region
- Step 7: Cost-benefit analysis of selected projects contingent upon the availability of the relevant data
- Step 8: Prioritisation and selection of the projects and adaptation options.

When suggesting the measures we consulted the existing literature, projects, opinions of stakeholders, results of interviews and focus groups and the previous results. The following general strategies were considered:

Table 6-1 Adaptation options Water Resources

Adaptation options, Water Resources
Increase water resource reliability and drought resilience
Increase water storage capacity to capture the benefits of winter and springtime water flow
Construct retention basins to regulate water flow
Increase availability of water through small scale water catchments or other sector projects
Construct water reservoirs for hydropower, irrigation, water supply, flood control
Reduce the water loss in water transport systems via (1) lining irrigation ditches and water transmission canals, (2) cleaning existing canals, (3) provision of new water transport infrastructure
Develop new water transportation systems to water new land used for agricultural production
Provide the WUA with the necessary mechanization to improve and maintain the existing water distribution system on a sustainable basis
Improve underground water resources protection and management
Promotion of water resources saving techniques, creation of relevant incentives
Promotion of fair distribution and management of water resources, creation of relevant incentives. Allocation of water supply through market-based systems
Increase the capacity and efficiency of existing WUAs in efficient, fair, transparent, and sustainable water use. Creation of new WUAs if needed
Investigate and disseminate more efficient water transfer and use practices
Provide relevant education/specialists to maintain, regulate and improve existing water resources technologies
Improved pasture management especially in the upper water catchment areas

Note: WUA stands for Water Use association

Pasture management proved to be important not only because it prevents land degradation and makes livestock production sustainable, but, most importantly, higher altitude pastures serve as water catchment areas. The proper pasture management improves the water catchment capacity and reduces water shed. The following adaptation options were considered (table 6-2).

Table 6-2 Adaptation options Pastures

Introduce an institutionally viable pasture management system to limit the number of animals authorized to graze in fall-spring, winter and all-year pastures
Make pasture management the responsibility of users through a pasture users association
Clearly define the rules of pasture use that will establish access to pastures on a sustainable basis
Increase the availability of livestock feed through sustainable and economically acceptable agricultural practices (reinforce cotton-Lucerne crop rotation, raise forage crop yields, increase the domestic supply of wheat)
Raise forage and mixed feed availability by making land and business permits easily available for mixed feed storage and production plants and for forage and mixed feed sales point operated by farmer cooperatives in rural areas
eliminate trade barriers for imported wheat flour from Russia and Kazakhstan, thus making more domestically grown soft wheat available for feed use

Source: Sedik (2009).

As water resources were identified as one of the most limiting factors related to climate change, we paid special attention to district level expert suggestion (see table 6-3)

Table 6-3 District-level adaptation options for water resources as suggested by country level experts

	Adaptation options, water resources
Kanibadam district	1. Water basin management, downstream basin management office, equitable water distribution, international water management in Isfara and Syrdarya. 2. If it will not exceed the norm for Tajikistan, we can take water from Syrdarya to increase the irrigation capabilities. Currently, the amount of water Tajikistan can withdraw from Syrdarya is limited by the international agreement with neighbouring countries. However, from the maximal 100% the country can take, it uses around 50% of its allowance. The reason is overuse of this source of water in neighbouring countries. There is still a space for increase of water use 3. To purchase excavators and other mechanization 4. Improvement of the payment system of water users (billing system) 5. To conduct drainage works 6. To clean irrigation and drainage systems
T Kuhistoni Mastchoh district (Gornaja Matcha)	1. Create alternative paths for mudflows, 2. Improve forest planting on terraces 3. Reduce the speed of water movement in other ways 4. Purchase excavators and other mechanization
Gissar district	1. Terracing agricultural land to reduce the speed of irrigation water and lower the slope of the land, 2. To reduce the speed of the irrigation water by zigzag irrigation – tractors make furrows in a zigzag manner 3. To create small reservoirs (10-15 tons on slopes + collect rainwater) to hold water, pump, and irrigate 4. They should have built a large water reservoir in the district under the communistic regime, but it did not happen 5. Purchase excavators and other mechanization
Fayzabad district	1. Build alternative paths for mudflows. 2. Clean canals, put pumps, including pumps directly from Kafernigan river, and rebuild infrastructure. 3. It is not enough to concentrate on water-saving technologies as there is little water. It is necessary to bring water to the region. 4. In the mountainous area, there is a large loss of water during transportation. One needs to send ten cubic meters of water so that 1 meter reaches the destination. Improve the efficiency of water transportation and irrigation. 5. Procure excavators and other techniques. 6. Bank Shore protection works are necessary for the rivers in mountains
Muminabad district	1. Build alternative paths for mudflows. 2. Clean canals, put pumps, including pumps directly from Kafernigan river, and rebuild infrastructure. 3. It is not enough to concentrate on water-saving technologies as there is little water. It is necessary to bring water to the region. 4. In the mountainous area, there is a large loss of water during transportation. One needs to send ten cubic meters of water so that 1 meter reaches the destination. Improve the efficiency of water transportation and irrigation. 5. Procure excavators and other techniques. 6. Shore Bank protection works are necessary for the rivers in mountains 7. There is a lot of soil erosion. Reduce the speed of the water 8. In order to prevent landslides and mudflows, the local drainage systems are important. For example, on slopes, one could barrel and connect with a pipe. Otherwise, soil absorbs and one time can come off. Drainage prevents the accumulation of water in the soil.
Shaartuz district	1. World Bank worked on PUMP 2 project. It created a sub-basin department of land reclamation and irrigation. Here, three rayvodkhoz organizations were merged into one.

	Adaptation options, water resources
	2. The payment collection system should be changed—billing system. 3. Bank shore protection work for the rivers 4. Village drainage
Tajikistan	1. Management in WUA (payment for water), irrigation method, large losses, farmers do not follow irrigation rules 2. Education of farmers is necessary 3. Management of natural risks – afforestation, terracing, reduction of mudflow formation rate, riverbed regulation works, river sedimentation, adjustments where there is erosion, nobody deals with erosion, no measures are taken. 4. Landslides – underground drainage systems don't work, need to be cleaned up, 5. Water-salt balance of soil should be improved 6. In areas where agricultural land is on steep slopes, it is advisable to create terraces and irrigate with reservoirs. 7. It is necessary to keep the water on the top of the hills, but not in the soil either with the system of drainage or reservoirs. 8. Mud- and water- and floods from the mountains wash away sediment, clogged canals need to be cleaned, and excavators procured at the Agency to procure an excavator for the Agency, transport to the districts. 9. To stimulate farmers to invest in technologies via payments of interest on loans (such as is done in Uzbekistan)

Source: district- and country- level experts interviews

Table 6-4 Adaptation options Agriculture sector

Adaptation options, Agriculture sector
Investigate, disseminate and adopt more efficient water use and conservation practices.
Improve irrigation efficiency by improving irrigation infrastructure, more climate- and specie- adapted and efficient irrigation technologies
Construction, rehabilitation, and management of mountainous terraces
Research and put to use cost-efficient water-saving irrigation technologies
Research and disseminate drought-tolerant seeds and practices
Promote better soil erosion protection fort the relevant type of soil erosion
Improve on-farm vertical drainage to reduce soil salinity
Provide farmers with information for appropriate planting choices, crop rotation, fertilizers use and plant-breeding technologies
Crop-freeze protection
Regulate livestock to prevent overgrazing, promotion of stall feeding
Introduce agro-forestry systems
Increase farmer access to information, practice and technologies
Provide new educated specialists incentives to work in districts
Increase pest control, veterinary care and plant disease control

Table 6-5 Adaptation options. Forestry

Adaptation options, Forestry
Create new potential for afforestation and forest regeneration including the provision of seedlings
Create new watering and melioration options
Provide the sector of forestry with relevant mechanization on a sustainable basis
Conduct new seed management system
Enhance the availability of seedlings
Create incentives for the local communities to make forest use sustainable, prevent overgrazing and forest devastation by people and animals
Locate the most significant areas for reforestation from the point of view of mud- water-flow protection, to reduce the slides.
Incentivize young, educated foresters to enter the sector
Improve the university education on forestry as related to its practical use
Research and disseminate drought-tolerant seeds and practices
Participatory forest management

Table 6-6 Adaptation options. Emergencies

Adaptation options, Emergencies
Construct relevant infrastructure for flood, slides, and mudflow protection and regulation (new paths for mudflows, regulation infrastructure for river flows, afforestation to reduce slides etc.)
Enhance flood and mudflow protection via modification of human settlement patterns and land-use decisions
Construct maintain and enhance warning systems and response systems
Watershed management
Strengthening community disaster preparedness and response potential

Table 6-7 Adaptation options. Cross-cutting areas

Adaptation options, Cross-cutting areas
Improved early warning systems
Proper utilization of meteorological information
Integrated watershed management and practices
Improve inter-institutional linkages, education, research and transmission of information
Family planning
Forestry, agroforestry, participatory management
Education on climate change, creation of climate change awareness on a community level
Strengthening community disaster preparedness and response potential

Ranking criteria

Tajikistan is a primarily agrarian country with 75-100% of the population in target districts working in agriculture. Though the country possesses an extensive potential for industrialization, the limited time scope of this project does not allow the researchers to count on the option of quick and intense industrialization and urbanization. The aims of the project directed the ranking criteria of climate adaptation strategies to sustainable agriculture, water resources, forestry, and socio-economic well-being of the households. The ranking of adaptation strategies was based on the following criteria

Table 6-8 Ranking criteria

1.	Socio-economic and health conditions of the households in the short and long run
2.	Sustainable and efficient agriculture
3.	Preservation of arable land and natural resources, reduction of land degradation
4.	Preservation and sustainable use of water resources
5.	Preservation, maintenance, and enhancement of existing forests
6.	Cost efficiency

Before we present the chosen options, we describe cost/benefit analyses of selected projects.

7. General recommendation to project, local and national authorities

7.1. Recommendations on Socio-Economic Justification and Rationale for Land Degradation (LD) reversal and Climate Change (CC) adaptation.

The following recommendations are based on the results of reports one through three. The first part of the project studied climate change in target districts from the perspective of local stakeholders (mainly farmers and local experts) and as manifested in hydrometeorological data. The time span was set to 1990-2040 (2022-2040, predictions). Given the lack of hydrometeorological stations in two of the regions, we employed data collected via satellites (provided by Big Terra). The results suggest that observed and expected the temperature increase per ten years amounted to 0,26-0,37 ^{0}C in the target regions. Thus, we expect the average temperature in 2040 to be approximately 0,52-0,74 ^{0}C higher than in 2020. The analysis of climate change scenarios suggested that the scenarios start to differ after 2040. Thus, we do not have to consider the difference in scenarios in this study. Contrary to the overall perception of diminishing water availability in the districts, the yearly precipitation is expected to increase in Kanibadam and Shaartuz. The trends of annual precipitation in other districts were not statistically significant. All the regions will be affected by the change in seasonality of precipitation. Kanibadam district will also suffer from the increase in wind. Given the changes above, it is not surprising that the evaporation indices are expected to increase in all the districts, thus increasing the need for water in agriculture and forestry. According to locals' observations and analysis of existing literature, extreme weather events such as sudden rains, spring frosts, and heat waves are also expected to increase.

The effects of climate change on agriculture, water resources, and forestry are difficult to separate from the impacts of deteriorating quality of infrastructure, the existing inefficiencies in water and land use, historical path dependencies, the effects of government, and inter-governmental policies, the overall functioning of the economy and social life. The partial ability of the population to adapt to climate change and the effects of existing governmental and intergovernmental efforts in this domain makes it more difficult to separate the impacts of climate change from other factors. Thus, the analysis of the effects of climate change on agricultural production presented unexpected results.

We employed three methods to assess the impact of climate change on agricultural production and water resources: standardized climate-related models for water stress and agricultural yields (CARD and WRI models), trend analyses of existing agricultural data, and qualitative analyses (expert interviews and focus groups with stakeholders). Namely, we computed climate-related scenarios employing CARD and World Resource Institute (2019) methodologies for all the target districts. The results suggest that we are to expect a very high risk of complex water stress in all the districts except Muminabad, where the risk is just high. The risk of water quantity was high or very high in all the districts.

The CARD model analysed the effects of climate change on crop yields of wheat, cotton, and potato. The results suggest uneven effects of climate change on selected crops depending on the scenario of climate change and the scenario of production (rainfed or irrigated). Rainfed systems seemed to be more resistant to climate change predicting a slight increase in yields for wheat and potato. The irrigated scenarios are more likely to decrease in yields. The cotton yield forecasts indicate that we can expect a decrease in cotton yields in all scenarios and districts. These results suggest that due to climate change, cotton production can be further reduced in Tajikistan.

Despite the worrisome results of both of the models above, the trend analyses of existing data on agriculture present zero or positive trends. In all of the districts and in the case of most of the studied commodities, the hectare yields proved to be relatively constant or even increased over the ten years of the last available data. For Tajikistan as a whole and the period of 1984-2019, agricultural production experienced a significant drop in 1990th caused by the civil war and presented upward trends afterward. Similarly, agricultural yields for particular crops dropped in 1990th and stabilized or even grew afterward. The significant drops in agricultural production at the district or country level due to climate change did not seem to manifest themselves. The lack of significant decline was even more surprising, given the deterioration of infrastructure, land fragmentation, problems with irrigation, etc.

Crop yields are just one of three main indicators of agricultural production. The arable land is the second one. According to available data on almost all the crops, little or no decline in land devoted to this crop was reported. The third resulting indicator of agricultural production, the total production in districts and in the country or particular crops, also did not show any significant decline. The growing tendencies were more evident. Part of these growing tendencies was due to the effect of a low base as the production significantly declined over the period of civil war. The current production partly catches up with this decline and partly corresponds to the increasing population in agriculture.

The qualitative analysis of the effects of climate change on agriculture via expert interviews and focus groups, water resources, and forestry drew a rather worrisome picture of evident land degradation, increasing lack of water, unfair and inefficient distribution of water, increase in temperature and extreme weather events, decreasing crop yields (not supported by quantitative data) and deteriorating infrastructure. On this level, it was often impossible to separate the impacts of climate change from the effects of lack of water due to increasing population, deteriorating infrastructure, lack of education, declining material base, inefficient agrarian technologies, land fragmentation, and insufficient investment in emergency regulation, etc. However, the existing donor-supported projects, such as Water Use Association, seem to help the communities to adapt. Moreover, the communities provided evidence of individual adaptation to climate change. The limits of this adaptation seem to be almost reached.

The contradiction between the prediction of the mathematical models and the trend analyses of the district- and country-level data and qualitative analyses presents a substantial dilemma for policymakers. On the one hand, the predictions are worrisome, especially in the case of water stress. On the other hand, the predictions of some crops seem to present no evident danger, while in the case of other crops (cotton) the yield decline seems to be evident. On the third hand, the existing trend analysis does not substantiate the worrisome results of the other two methods. The adaptation measures are costly. The question arises of the wisdom of extensive investments in climate change adaptation.

The other dilemma the policymakers need to solve concerns the differentiation of measures aimed at climate change adaptation from the measures aimed at overall development assistance. It is more often than not that both types of measures will intersect. The infrastructural measures aimed, for example, at building small (or large) scale water catchments or improving irrigation efficiency will help decrease the vulnerability of the agricultural sector to climate change and increase the productivity of agriculture and water availability in general. The infrastructural measures aimed at disaster protection will deal with climate change and will party compensate for the lack of investment in infrastructure over the last thirty years.

The dilemmas above presented to the policymakers can be resolved in three ways. The first is related to the adaptation potential of the population in target districts without additional assistance. The qualitative analysis suggests that, especially in the area of water resources, the adaptive potential of the population seems to be very close to its limits. The problems are threefold. First, the population seems not to be able to increase the water availability on its own sustainably. The popular strategy of building wells is not suitable for all the areas and deploys the underground water. The building of small- or large- catchments of water seems to be out of the financial reach of the local communities. Second, the population without outer help will not be able to coordinate the use of existing water resources efficiently. If not coordinated from above, there will always be a free-rider problem, given that the excessive use of water resources is much more profitable than the incorporation of water-saving technologies. Moreover, the land fragmentation and distribution make it unprofitable for each particular water user to invest in machinery to increase water use and agriculture efficiency. Third, the lack of information about adequate watering technologies makes farmers use more water than needed. Obviously, outer assistance is needed.

The second argument in support of the need for outer assistance in climate adaptation relates to water availability. Though some crops present a reasonable potential for yield growth under the condition of climate change and there are prospects to collect three harvests per year instead of two, both of these positive tendencies may not realize themselves due to the lack of water. As stated above, the population has reached its limits in increasing water use effectiveness and availability on its own.

The third argument in support of assistance is related to the demographic potential of the country and its perspectives on industrialization. These issues were discussed in report two. The population of Tajikistan currently amounts to 9.54 million and is expected to reach 13.85 million by 2040 and 25.33 million by the end of the century (UN, 2022). 75-100% of the population in target districts is rural and dependent on agricultural production and water resources. If the country does not undergo industrialization in the near future, the expected population growth will put substantial pressure on agriculture and water resources.

The lack of adaptation to climate change will lead to the following consequences:

- The lack or inefficient use of water resources will not allow the country to capitalize on positive aspects of climate change
- The lack or inefficient use of water resources accompanied by sub-optimal agrarian technologies will lead to fast land degradation, which may become irreversible
- The increase in temperature and negative weather events will lead to inter- and intra-regional migration in the most exposed districts making them desert lands
- The stagnant or slightly increasing crop yields accompanied by the limited availability of the new land will not be able to feed the increasing population in the middle and long runs
- If the country does not industrialize fast enough, there will be more pressure for temporary or permanent migration of the most productive population of the country abroad. One of the negative consequences is brain drain, loss of existing practical knowledge, and difficulty in adapting to new, modernized technologies.

The last point needs to be discussed separately. Currently, almost 30% of the country's GDP is composed of remittances from the population working in neighbouring countries, predominantly in Russia. According to qualitative data, this migration is predominantly temporal. The most frequent pattern is when a considerable part of the mostly male population goes abroad for a significant period of time, leaving women and children in Tajikistan. The resulting gender composition in villages puts more pressure and responsibilities on women. The detachment of the fathers from the families for a significant part of a year disturbs the relationships and changes the behavioural patterns of children.

The tendency to bring the whole family abroad is not pronounced yet (interview data; representative quantitative data are not available yet), though it might become more frequent in the future. According to existing literature, the connection to the place where people were born and lived long is very strong in predominantly rural societies, and the long-term migration is not popular. Similarly strong is the connection to local communities and extended families. However, if the worse comes to worst, people will have to move.

Besides the attachment to the land and to the extended families, language and education are the two main factors preventing long-term migration abroad. Though the Russian language was propagated and taught under the communistic regime in the whole country, the rural communities do not use it often nowadays, and the most frequently spoken language differs according to the district. For example, in Kanibadam, besides Tajik and Russian, the Uzbek language was frequently used. Overall, the use and ability to speak the Russian language in rural districts is limited and is a domain of more educated and/or politically exposed inhabitants (teachers, officials in Jamoats, etc.).

Thus, if increased, we expect that the migration will be a domain of a more productive and educated workforce, leaving the country with a more dependent part of the population. Though the short-term benefits of this migration in the form of remittances are evident, the country will lose its most productive and economically active potential in the long term.

The same holds for intra-regional migration from predominantly agrarian communities. Presented with deteriorating infrastructure and low incomes, the most active and educated part of the population of productive age tends to leave the region. The destination may vary from Tajik cities (education or work), to abroad. In both cases, the population structure of rural communities is then shifted to overrepresentation of older people, females, and children and underrepresentation of active and educated males of productive age.

One can emphasize brain drain and lack of agrarian experience of the male population of productive age among the negative consequences. This especially means that the old and experienced farmers have few options to transfer the agrarian know-how to the younger generation, which may eventually lead to the loss of know-how when the old and experienced generation passes away. In countries like Tajikistan, where much of the agricultural sector depends on mechanized and canal irrigation, this may mean the loss of knowledge on how to operate the irrigation systems and a lack of new know-how of more intensive and water-saving technologies. Even now the studied districts lack qualified engineers to operate, maintain and modernize the existing irrigation systems (interview data). The same holds for the sector of forestry, veterinary care, and agricultural technologies.

Although the educational system of Tajikistan produces the relevant professionals, few of them, if any, return to their home districts to apply their knowledge due to the low wage in agriculture. The perspective of earning more money in cities or abroad is more lucrative. Moreover, the knowledge they get in universities, often theoretical, needs to be adapted to the local conditions, which requires the cooperation of a new specialist with the more experienced ones (interview data).

Special attention needs to be paid to the sector of forestry. Though forestry is not a major sector of production in terms of GDP, it provides significant ecosystem services, including the pastures for livestock, source of firewood, fruits, and nuts, regulation of local climate conditions, prevents soil degradation, reduces the negative weather-related emergencies, accumulates and stores CO_2, stores water in the soil preventing the landslides, provides cultural and spiritual ecosystem services, etc.

The forest sector in Tajikistan went through substantial degradation during the civil war when forest wood effectively replaced part of the other energy sources. Much of accessible forests were cut, leading to immense negative impacts on the local ecosystems. Besides anthropogenic damage, the forestry sector suffers from droughts and general lack of water, overgrazing and damage caused by domestic animals, and a general lack of finances for afforestation and forest regeneration efforts. In addition, the foresters, educated in Soviet times, grew older. Younger people have a low incentive to look for a job in this sector as the salaries are low, although the local university produces a sufficient number of future foresters. The increasing temperatures make lower altitudes unsuitable for the endemic species. The afforestation scheme is then shifted to the higher altitudes. New, more temperature and drought-resistant species are needed.

Last but now least, all the sectors above – agriculture, forestry, and water resources - suffer from increased frequency and severity of weather-related emergencies. The qualitative analysis supported the conclusion that the frequency of these events seems to increase. The quantitative assessment was not possible due to the lack of data. In any case, the emergencies cause substantial damage.

Four possible reasons for increased damage from weather-related emergencies were identified in the study: (1) the climate change leading to change in temperature, precipitation, and wind profiles of the target regions, (2) the degradation of existing infrastructure aimed at control of emergencies including warning systems, (3) deforestation and land degradation, and (4) more intensive exposal of the population to extreme weather events due to population growth and lack of urban planning. Similarly to agriculture, it is almost impossible to separate the effects of the particular reasons. The climate-related adaptation strategies will inevitably have to intersect with the strategies aimed at development assistance. In order to make the system more effective, the district-level strategies, such as new dams, water reservoirs, new pathways for mudflows, or emergency-proof urban planning, will have to be accompanied by the national level measures such as all country warning systems, afforestation, and overall prevention.

Climate related adaptation is necessary but costly. The following sections compute cost-benefit analysis of adaptation strategies and provide recommendations to the project local and national authorities.

7.2. Recommendations for CC adaptation in Tajikistan from the perspective of costs and feasibility

One of the aims of this project was to suggest cost-effective CC measures in target districts. However, the effective measures are largely contingent upon the current governmental policies, cultural prerequisites, and overall formal and informal institutions effective in the country. Some of these factors cause that the effective measures might not be feasible. Second, some factors that are effective in the short run may prove ineffective in the long run. The time scope of the measures should also be considered. Third, the long-term sustainability of the majority of CC measures is predicated on local capacity building. Though as itself capacity building does not deal with the CC directly, is may be considered as one of the most important powers that will ensure the continuation of the CC measures after the external donor help is extinguished and may substantially reduce the costs of CC measures when enacted as some of the work can be done by locals. Apart CC measures, local capacity building will ensure the transmission of know-how from the old generation to the new one. Some conclusions on the local capacity building are presented in the section Education, Coordination and Counselling. The particular suggestions are also scattered across the various suggested CC approaches. The following table summarises the main aims of the local capacity building independent from the particular area.

The second type of CC adaptation measures is related to the infrastructure projects aimed directly at a particular CC problem and location. These measures are often the cross-border between the general development assistance and the CC adaptation assistance as most of the direct and indirect results will serve both the purpose of improving infrastructure and CC adaptation. These projects were intensively discussed in report four. A cost-benefit analysis was provided for the projects where the data were available.

The third type of CC measures assumes the provision of CC-adapted floral and animal species, which will be more high temperature- and drought- resistant and will provide higher yields for both agriculture, forestry, and, possibly fishery when applicable. This genetic material is especially necessary not only due to the CC adaptation but also in order to increase yields in agriculture, which will be most necessary given the intense population growth.

The fourth types of recommendation include some of the systemic measures, which, at first sight, are not aimed at CC adaptation but will make the other measures more effective and in some cases, even feasible. Three types of measures were identified. First, land fragmentation does not allow to use in full the economies of scale, efficient water use, the adaptation of new agrarian technologies, and CC-proof practices. Moreover, the land fragmentation makes local capacity building more time and resource-consuming. In addition, much of the fragmented agricultural land was given to the people with little education in agriculture, which decreased the efficiency of land use.

Second, the regulation of pasture use, though not directly aimed at CC adaptation, will help to reduce land degradation and improve the water catchment capacity of the higher altitude territories, which will be manifested in the larger availability of drinking and irrigation water.

Third, suggested intensification and professionalization of agriculture will help to both increases the yields and decrease the pressure on education and capacity building. The downside of this approach is a lower number of people employed in agriculture, who will need to find jobs elsewhere. Thus, it can be enacted only jointly with the development of food processing or other industries, which will be able to employ the newly unemployed people.

Industrialization is the fourth suggested systemic measure. Industrialization will help to improve CC adaptation as, if combined with the intensification of agrarian production and regulation of pasture use, it will put less pressure on the agricultural land and enable the population to benefit from modern technologies which will mitigate the effect of increasing temperatures and other climate-related effects.

Table 7-1 Recommendations for CC adaptation in Tajikistan. The general scheme

Type of recommendation	Aim	Geographical scope	Time span till effective	How long the effects last	Feasibility	Factors supporting or obstructing	Costs
Local capacity building[a]	1) ensure the transfer of existing practical knowledge from the older generation to the younger one,	The whole country	Long term	Long term	Problematic as requires making the rural style of life attractive for the capable young generation as compared to earning money abroad	Low attractivity of the rural style of life for your generation compared to earning money abroad, low incomes, brain drain	Relatively high, require revision of schooling system, cooperation with internationally recognized best practices and strong financial motivation of personnel and absolvents.
	(2) provide the farming community with knowledge and incentives to employ more efficient and CC adapted practices	The whole country and local	Short term and long term	Short and long term	Problematic in country-wise projects, but possible locally. Dependent on informal regulation of farming practices	The natural inertia of the farming community, low prices of crops, problems with storage and marketing	Relatively low, assuming sufficient motivation of the community of local farmers.
	(3) enhance CC knowledge, planning, and practices in local communities.	Local	Short term and long term	Short and long term	Feasible, assuming sufficient engagement of local communities, people dependent, language seems to be the main obstacle	The language barrier, the necessity to work with each local community separately, and cultural prerequisites.	Relatively low investment costs, but high costs of foreign personnel. Possible transfer to local personnel if successful.
Infrastructure building (including relevant technologies)[b]	(1) improve water-related infrastructure	Mostly local	Short term	Long term effects usually require additional investments	Feasible, but may be subject to international agreements	Very welcomed by local communities, however problems with maintenance, the system of maintenance needs to be arranged (see	Costs depend on the scope of the project

						examples of good practices)	
	(2) improve water and energy-related infrastructure (energy production)	Mostly local, but the energy effect may reach the larger geographical scope	Middle to long term	Long term effects usually require additional investments	Feasible, but may be subject to international agreements	Very welcomed by local communities, however problems with maintenance, the system of maintenance needs to be arranged (see examples of good practices)	Relatively high
	(3) improve CC related emergency infrastructure	The local and whole country	Short to middle term	Long term if maintained	Feasible if realized in the whole country. The experience of the FSU may be utilized	Very welcomed by local communities, however, problems with maintenance, the system of maintenance needs to be arranged (see examples of good practices)	Low to high depending on the project
	(4) improve agriculture-related infrastructure to increase the intensity of agriculture	Mostly local	Short term	Long term if maintained and upgraded	Feasible	Very welcomed by local communities, however, problems with maintenance, the system of maintenance needs to be arranged (see examples of good practices)	Low to average depending on the project
	(5) improve forestry-related infrastructure	Mostly local	Short term	Long term if maintained and upgraded	Feasible	Very welcomed by local communities, however, problems	Relatively low, but depends on a project

						with maintenance, the system of maintenance needs to be arranged (see examples of good practices)	
Supply of CC-relevant floral and animal species such as seeds, seedlings, animal species, etc. To improve the resistance of agriculture to CC and the efficiency	Provide the country with more CC resistant and productive plants and animal species to improve CC adaptation	Local or whole country depending on the program	Short to middle term	Short or long term, depending on conditions and genetic specificities	Feasible	Generally welcomed by the communities but may be subject to regulations (for example, genetically modified crops or non-endemic species)	Relatively low, but it depends on a project
System based	Decrease fragmentation of agricultural land	Whole country	Long term	Long term	Not feasible Difficult to realize, given the current state of the economy	The need to feed the increasing population requires at least the access to agricultural soil for poor	Low
	Regulation of pasture use	Whole country	Long term	Long term	Difficult to realize but feasible	Needs political will and enforcing mechanisms. Needs to be incorporated together with other measures such as the provision of fodder to the livestock.	Low
	Intensification and professionalisation of agriculture	The local and whole country	Middle to long term	Long term	Difficult to realize, given the current state of the economy	This will lead to social stratification in local communities which may disrupt	Low to high, depending on the investment

						the traditional way of life unless is accompanied by industrialization. The informal regulation of the agrarian sector aimed at self-sufficiency in food products obstructs the market-based professionalization of agriculture	
	Industrialization	Whole country	Long term	Long term	Difficult to realize, given the current state of the economy	Needs substantial investments (mostly government level or FDI)	High, but some local projects are possible with low costs

FSU – Former Soviet Union, FDI – Foreign direct investment, CC – climate change, [a]Recommendations for local capacity building will not bring immediate results but will make the other interventions sustainable in the long run. The general recommendations are applicable to all the sectors. [b]Building infrastructure will help to deal with climate change in a more efficient manner. Source: own analysis.

From the above follows that

1. Ideally, the measures in particular localities should be adopted in well-thought groups. The effective implementation of particular CC adaptation measures, including long-term effects, is contingent upon the other measures, which need not be primarily related to CC. Thus, the cost-benefit analysis of a particular project might differ according to which particular other project is enacted at the same time.
2. Some measures present favorable cost-benefit results; however, given the circumstances, they might not be feasible
3. Local capacity building is one of the most advisable ways to go if one wants to make the effects of particular projects (for example, infrastructural projects) more sustainable in the long term. However, its full benefits of it are hard to estimate in monetary terms. Ideally, the local capacity building should be either a part of other projects or be enacted together with other projects.

7.3. The indirect effects of the adaptation strategies

This study aimed to compare the effects of the projects as summarized by the indicators above. However, one needs to be aware of numerous indirect effects of adaptation measures or the direct effects that are hard to measure. This section will summarize the likely indirect and difficult to measure direct effects from the point of view of three target areas: agriculture, water resources, and forestry. All these areas provide parts of general ecosystem services (see Table 7-2). If these ecosystems function well, they can provide food, clean air, erosion prevention, extreme weather mitigation, and human mental and physical well-being. Together, efficiently functional ecosystems increase the resilience and productivity of food ecosystems.

Table 7-2 List of ecosystem services (adapted from Reid et al., 2005)

Provisioning Services[a]	**Regulating Services**[b]	**Cultural Services**[c]	**Supporting Services**[d]
food	local climate and air quality regulation	tourism	Habitats for species
raw materials (including lumber, skins, fuelwood, organic matter, fodder, and fertilizer)	CO_2 sequestration and storage	spiritual experience and sense of place	nutrient cycle, photosynthesis
Medicine (including pharmaceuticals, chemical models, and test and assay organisms)	waste decomposition and detoxification	therapeutic (including Ecotherapy, social forestry, and animal-assisted therapy)	Conservation of genetic diversity
water	erosion prevention, maintenance of soil fertility	recreation, mental and physical health	Soil formation
energy (hydropower, biomass fuels)	pollination	aesthetic appreciation, the inspiration of art, culture, and design	
	biological control pest and disease control	science and education	
	flood protection		

Note: [a]ecosystem services that describe the material or energy outputs from ecosystems (e.g., food, water). [b] e.g., regulating the quality of air and soil, flood and disease control. [c] non-material benefits such as aesthetic experience, spiritual enrichment, and psychological benefits. [d] services necessary for the production of all other ecosystem services such as inhabited space and other support for plants and animals - these services make it possible for the ecosystems to continue providing services such as food supply, flood regulation, and water purification

As stated in the previous parts of this study, the climate change, combined with the anthropogenic impacts, substantially damaged the ability of the agroecosystems, forest ecosystems, grassland ecosystems, and aquatic ecosystems to function properly in Tajikistan. The benefits of the adaptation measures ideally will have to consider all the aspects of the ecosystem services. Moreover, if functioning properly, the ecosystems are able to partly regulate the local climate effects.

Arguably, the effects of the ecosystem services of forest ecosystems are the most difficult to estimate as many of the effects are indirect and will be manifested in the other ecosystems. The agroecosystem needs to be tuned to provide the best ecosystem services and produce food in the most effective way with the efficient use of resources, including water. The aqua ecosystem needs to provide sustainable water resources for all the other ecosystems. Thus, the effects of climate-related interventions on the regulating, cultural, and supporting ecosystem services, though important, need not be overestimated compared to provisioning services.

8. Sector related comments and recommendations

Emergencies, general suggestions

All the target district of this study is affected by weather- or water-related emergencies. Floods and mudflows are considered the most frequent and damaging. Protective measures can be advised for all districts. Most importantly, the committee of Emergencies can be assisted with the mechanization of indispensable for removal of the damages inferred from the natural disasters. On the central level, a well-functioning system of warning is strongly advised to conduct and maintain.

Education, coordination, and counselling (local capacity building)

One of the biggest problems of Tajikistan related to know-how is lack of the knowledge transfer from the old generation of farmers, engineers of mechanisation and water systems and foresters, born and educated in USSR, and young generation. The older generation is dying away, while the younger generation often perceives agrarian production as sub-optimal life route as it does not provide as high income as is possible to earn abroad, in cities or in other places. Moreover, the educational system, though in place, is underfinanced, suffer from lack of practical experience and even in the case the youth graduate, the income in agriculture does not incentivise them to return to their home village to employ the received knowledge. Thus, the knowledge transfer is broken.

In addition, all the target districts suffer from a lack of education related to modern agrarian technologies and the effects of climate change. The farmers are often unaware of modern agrarian and water use technologies. The qualified engineers able to effectively operate and repair the mechanization necessary for irrigation and agrarian production are missing. The systems of coordination and effective use of available mechanization are often missing or non-functional. The communities lack information on the measures of adaptation to climate change they can use on the local level. All these measures are applicable to all the target districts.

Suggestions for afforestation

The government of Tajikistan has committed to planting 66,000 hectares of forests by 2030 (interview data). Currently, it is able to plant 2,900 – 3, 000 hectares annually which amounts to approximately 30,000 hectares by 2030. The rest – 36,000 hectares - needs to be financed and coordinated by international donors (interview data). The effective rate of survival of newly created forests is about 50 to 60%, slowing down the efforts for reforestation even more.

On average, a hectare of forest planting costs 2,200 USD (incl. watering and fencing). The cost is different for each area. The overall investment of international donors till 2030 is expected to be 79,200,000 USD (36,000 * 2,200). Taking into account the rate of survival of newly created forests of 50-60%, the overall investment needs to be twice larger, amounting to 158,400,000 USD by 2030.

According to Table 12-3 (Ranking of the projects according to the costs per hectare) the costs of 2,200 USD per hectare brings the afforestation project to the upper part of the cost table. However, the benefits of the afforestation are also large (table 8-1). We suggest locating in each particular district the place, where the afforestation brings the best effects in terms of reducing mudflows and landslides.

Table 8-1 List of ecosystem services, forestry (adapted from Reid et al. (2005))

Provisioning Services[a]	**Regulating Services**[b]	**Cultural Services**[c]	**Supporting Services**[d]
food	local climate and air quality regulation	tourism	Habitats for species, nutrient cycle, photosynthesis
raw materials	CO^2 sequestration and storage	spiritual experience and sense of place	Conservation of genetic diversity
medicine	erosion prevention, maintenance of soil fertility	recreation, mental and physical health	
water	pollination	aesthetic appreciation, inspiration of art, culture and design	

Note: [a] ecosystem services that describe the material or energy outputs from ecosystems (e.g., food, water). [b] e.g., regulating the quality of air and soil, flood and disease control. [c] non-material benefits such as aesthetic experience, spiritual enrichment, psychological benefits. [d] services necessary to produce all other ecosystem services such as inhabited space and other support for plants and animals.

General comments on effective water use and irrigation technologies

There are two general comments on irrigation technologies. First, the lack of irrigation water was persistent in the region of Central Asia for a long time. Climate change just made the problem worse. It is indispensable to look for ways to increase the efficiency of water use. However, the incentives to increase the efficiency of water use by individual farmers are predicated on the individual cost-benefit analysis. If the costs of additional water are lower than the costs of water-saving, the rational water-user will vote for more water, though this strategy is sub-optimal for the whole region in the short and long term.

The unclear and not fully enforced water distribution system presents the other source of inefficiency in water use. Facing the perspective of lack of water farmers are incentivized to use as much water as possible when available. The system needs to be changed.

Land degradation patterns in target districts and the ways of adaptation

One of the most valid indicators of land degradation is the decreased ability of the land to fulfil its ecosystem services. Like other drylands, the three main ecosystem services in Tajikistan include grazing land, agricultural land, and services provided by forests. Pastures and forests in Tajikistan partially intersect as forests are often used for grazing. The pattern of land degradation of the grazing land is primarily related to overgrazing predicated upon the number of animals, kind of animal species, and grazing system (Hochstrasser et al., 2014). The agricultural land degradation patterns are primarily affected by mismanagement practices (e.g., crop residue removal without fertilization, poor cultivation practices, ibid.), salinization, and type of soil erosion. The land degradation of forestry in Tajikistan is primarily related to human activity (deforestation) and animals (overgrazing and damaging). All these three types of ecosystems are represented in six target districts to various extent. All these ecosystems react to climate change differently and require specific adaptation measures. The following table summarizes the specificities of the districts.

Table 8-2 Types of soil degradation in target districts

District	Soil salinity[a]	Wind erosion increased[b]	Water erosion increased (steep terrain)[c]	Droughts	Overgrazing of pastures	Deforestation and forest degradation[d]
Kanibadam	x				x	
Gissar			x		x	x
Kuhistoni Mastchoh					x	x
Shaartuz				x	x	x
Fayzabad	x	x	x	x	x	x
Muminabad		x	x	x	x	x

Note: [a] soil salinity means increased soil salinity visible for farmers and affecting soil degradation; [b] wind erosion is characteristic for all the districts; however air erosion increases in case of strong winds; [c] water erosion is characteristic to all the districts; however, it is more prevalent in the case of improper irrigation technologies applied on the land in steep terrain; [d] Kanibadam is the only region not affected much by deforestation and forest degradation as historically the forest area was relatively small.

Climate-related adaptation measures in districts with increased soil salinity

Three causes of soil salinity were distinguished in the districts. First, soil salinity increases with salty irrigation water (Kanibadam, interview data). The salinity of the water in Karakum reservoir is reported to increase as part of the water sources bring some salt from the mountains. In addition, pollution and salinization of Karakum reservoir are caused by discharge of polluted drainage and flushing water (Kuvaldin, 2020). The adaptation measures aimed at better sewage systems can be useful.

Second, rising groundwater increase soil salinity. The Third, insufficient watering with clean water makes the salt concentrate at the upper parts of the soil.

Most of the target districts suffer from the lack of water in the period of intensive irrigation while the water is often available during the winter months. Farmers often solve the lack of water with building new wells for irrigation. However, these wells extract additional salt from the ground to the surface, thus increasing the salinity of the productive parts of the soil. This strategy cannot be recommended for these districts in the long run. Similarly, one would not recommend the drip-irrigation systems for the regions with high salinity as the salt in the water clogs the system very quickly. Moreover, on a large scale, these systems prove to be very expensive as compared to the revenue one can get from the agricultural output.

On the other hand, the use of, if possible, clean water for soil flushing in winter may support the productivity of soil during the growing period and will, in part, help to adapt to climate change.

Next, the measures aimed at reduction of the water loss during transportation should be taken. The water, soaked to the ground in irrigation canals, increases the levels of groundwater and may bring new salt to the surface in the productive agricultural land.

Climate-related adaptation measures in districts with increased water erosion

The districts identified in this study with increased water erosion are the districts with agricultural land located on the steep slopes. In this case, the irrigation water flows quickly down the hill flashing the fertile soil with it. The flashed away soil leads to land degradation and clogs the canals down the hill. In some cases (Gissar district) the removal of the fertile soil may be as high as 0,5 cm per year (interview data).

Two groups of adaptation measures can be suggested. First, one needs to reduce the speed and/or the quantity of irrigation water. The creation of terraces or the zig/zag irrigation method when irrigation water flows into prepared zig-zag ditches can be advised to reduce the speed of the water. The water-saving irrigation technologies such as foil irrigation, or, drip irrigation can be suggested. However, the latter is not suitable for the large-scale production of cheap crops as it is rather expensive and will probably not pay off. Neither the drip irrigation is suitable for the districts with high water mineralization as it will clog the tubes of the irrigation system. The drip irrigation is especially suitable for greenhouse production of high-value agricultural crops in districts with low water mineralization.

The second adaptation measure is related to the possibility of transfer of the flashed soil from the bottom up the hill. There are some successful attempts to do this. However, the flashed soil that is gathered in the canals and ditches down the hill tends to be contaminated with the mixture of everything that the hill produces starting from fertilizers and ending with the content of the sewage if the sewage system is non-existent or does not work properly (interview data). In addition, the bacteria that tend to flourish in the irrigation canals and ditches contaminate the soil even further.

Climate-related adaptation measures in districts with increased wind erosion

This type of soil erosion is characteristic of all the districts. However, it is more pronounced in the districts with strong winds. The main adaptation measure relates to the methods of agroforestry, where the fields are intermitted with the forest belts. The more intense irrigation and use of fertilizers may also help as it makes the soil heavier.

Droughts

In this study, three districts were subject to intense droughts to a larger extent, though some tendencies of lack of water were visible in all the districts. Besides the damage to agricultural production, droughts constitute one of the causes of land degradation. The soil lacking water is more subject to wind erosion and less able to accumulate nutrients. The proposed measures include irrigation in times other than the irrigation season (primarily in winter), increased content of fertilizers and all the methods related to drought prevention (e.g., agro-forestry).

Overgrazing of pastures, deforestation, and forest degradation

The increase in the livestock caused by population growth and more reliance on agriculture led to a significant imbalance between the availability of pastures and the quantity of animals grazing. As part of the forest in Tajikistan is also used as pastures, overgrazing causes forest degradation. Generally, overgrazing leads to fewer nutrients in the soil, more wind and water erosion, and overall soil degradation. Deforestation and forest degradation lead to lower ability of the soil to keep the water, increased speed of the water in terrain, and a higher probability of slides, mudflows, and floods. The general adaptation measures include a decrease to livestock dependent on pastures and moving some of the livestock to be fed with fodder in at home.

The comments on drip irrigation

In the case of drip irrigation, the results of qualitative analysis and the analysis of existing projects led to contradictory results. From the existing paper-and-pencil projects it seems that, introduction of drip irrigation in pump-fed areas could be an option to increase irrigation efficiency and reduce costs. On average, about 4.4 thousand USD/ha would be required to introduce drip irrigation, where feasible. For example, ALRI estimates that introduction of drip irrigation on the fourth and upper levels in areas fed by pumping cascades would save about 128 million m3 of water and over 0.9 million USD in electricity costs annually. Recent ALRI studies also suggest that drip irrigation and a shift to higher value crops could significantly improve water productivity, particularly in the case of sweet cherries, melons and potatoes (OECD, 2020). Increase in crop yields of 40% is anticipated among all crops. Payback period ranges between 4-5 years in the case of wheat and cotton, to 1 – 2 years in the case of orchards (UNDP, 2019).

On the other hand, the district level qualitative interview data present a different picture. The low prices of agricultural commodities faced by the farmers prolong the payback period of drip irrigation often making it unprofitable. The crop price the farmer faces is significantly affected by the bargaining power and access to marketing. In districts located far from big cities and with low accessibility by transport means and facing limited or none=existent storage capacities, the farmers sell their products to wholesalers for the very low price. The more attractive price margin is then collected by the wholesalers. In this case, drip irrigation can be unprofitable. In addition, drip irrigation is not suitable for the districts with high soil salinity as the tubes are quickly clogged by the salt and other minerals.

Actions planned or implemented to collect, store, communicate, and use traditional, indigenous, and local knowledge.

Indigenous peoples and local communities deal with the issues of variability, uncertainty and change based on the history of interactions with the environment of many generations. Thus, traditional and indigenous knowledge and coping strategies can provide an important foundation for responding to climate change and disaster risk reduction, complementing established evidence and closing information gaps. Indigenous knowledge systems, traditional and local knowledge systems, and forms of analysis and documentation such as community mapping can play an important role in identifying and monitoring changes in climate, weather and biodiversity, and impending natural disasters, similar to early warning systems.

The Tajik people, especially in rural areas, have a long history of using traditional methods adapted to the variability of climate change. With the acquisition of independence in 1991, the disintegration of command-and-control methods of management in agriculture, education on the basis of former collective farms, independent dekhkan (farm) farms, forgotten traditional methods became in demand. Unfortunately, currently there is no purposeful planning, collection, storage and transmission of traditional methods of responding to climate change variability. The main reason for this situation is the lack of coordination of research centers for the collection and storage of traditional experiences, the low level of transmission of traditional methods from generation to generation. The development of new technologies, to some extent also contributes to the loss of traditional knowledge.

At the present time, the main sources of information on traditional methods of combating climate change are academic publications, archival data, research carried out by various institutions and organizations, international programs, consultants and scientists.

In 2006, with the assistance of the UNDP Regional Center in Bratislava and the Convention's Global Mechanism Program to Combat Desertification (CCD), an information collection entitled “Traditional Knowledge in Land and Water Management” was published.

The traditional methods in the field of land use in Tajikistan are: Biological drainage is a lowering of the level of mineralized groundwater by transpiration of moisture through perennial trees such as Willow (Tal, Bed), California Maple, Judah Sanjid, cleaning open drains by hand, fish farming as a method for the destruction of aquatic vegetation, a method of deep loosening of soils - it is used when the level of groundwater rises, a high content of gypsum in the soil and its high density; the traditional method is the use of pasture fences, water-saving technology for combined planting of cotton and rice, hanging gardens, stone and earthen terraces, inter-row crops, combined crops, hedges, collection and preservation of rain and melt water.

Table 8-3 Traditional methods of adaptation to climate change in Tajikistan

Directions	Methods
Application of traditional knowledge related to unsustainable use of land and water resources	• Biological drainage; • Manual cleaning of open drains; • Cleaning of closed drains without mechanisms; • Fish farming as a method for the destruction of aquatic vegetation; • Drip irrigation method; • Combined crops; • Inter-row crops; • Collection and preservation of rain and melt water;
Methods for improving soil fertility	• Deep ploughing • Effective use of pastures (fencing) • Mulching • Zero tillage, overseeding of grain crops
Traditional technologies of sustainable nature management in mountain conditions	• Hanging gardens; • Stone terraces; • Terracing of slopes for forest plantations

One of the traditional methods of joint community confrontation in Central Asia, especially in Uzbekistan and Tajikistan, against the risks of natural disasters is the Hashar method (joint work, charity). The "Hashar" method is especially effective when carrying out bank protection works, clearing canals, planting forest belts, restoring mountain roads and bridges, protecting forest plantations from fires.

Based on research and conducted focus groups interviews, result of extensive document and project search, we identified a list of suggested interventions for each domain of intervention (problem type) – see Table 8-4. More discussion on the selected interventions is presented in the following chapter. Based on the list created in the table 8-3, we provide more detailed description of problem status quo, where we identify the problem without any interventions conducted.

Table 8-1 Suggested interventions

Main domain of interventions	**Suggested interventions**
Improved water management	Establishment of a reservoir on the Isfara River in Kanibadam district, as well as the creation of small reservoirs in the BFC (cost of about USD100 million)
	Creation of artificial reservoirs in the foothills (cost of about USD 150 million);
	Provide the WUAs with the machinery to clean the canals
	We suggest to improve use of land and water use culture (cost of about USD 0.1 million). This is linked to state and regional agricultural development programs, which include increasing the knowledge of farmers and agrarians as a tool to improve agricultural efficiency;
	Greenhouses can be developed and equipped with modern technology, which partially solves the problem of irrigation water shortage in the area (cost per 1m2 $17.5) in Kanibadam district.

Main domain of interventions	Suggested interventions
	Improve pumps on steep terrain to increase the efficiency of watering
	Creation of a reservoir on the Zarafshan River in the Gorno-Matchinsky district. This contributes, on the one hand, to solving the problems of lack of irrigation water in the region, and on the other hand, mini power generating units can be installed on this reservoir, which will solve the problem of lack of electricity in the region. For the creation of such reservoirs, there are good conditions and not much investment is required.
	Creation of pumping stations near the Zarafshan River, which will solve the problems of lack of irrigation water in the region.
	Improvement of irrigation infrastructure, contributing to the economical use of irrigation water. Construction of concrete trays and pipelines from water sources to agricultural land (or settlements). This, in turn, prevents the problem of not only high-water loss, but also reduces labour costs for the restoration of ditches and the creation of canals by hand.
	To store water in times of shortage, a reservoir should be built to collect water. The reservoir will also create a microclimate, and this may help to reduce population movements to other parts of the country.
	Rehabilitation and reconstruction of irrigation and collector-drainage networks in Shaartuz district.
	Rehabilitation and modernization of pumping stations supplying water from the Kafernigan River to the 50-solagi canal (out of 4 pumps, only one is operational today) in Fayzabad district.
	Cleaning irrigation canals from sediments and siltation, which negatively affect the volume of transported water.
	The construction of additional water retention facilities on the Surkhak River, from which the Kululyu canal in Muminabad district draws its water, which should facilitate greater water collection, thus addressing water shortages during the irrigation season in Muminabad district.
Land use	The creation of terraces on the steep terrain areas will help to avoid water erosion and improve the productivity of the soil
	Organic farming technologies should be introduced in the area (costs depend on the scale of organic farming implementation);
	Increase the efficiency of existing WUAs by wider introduction of billing system
	Projects aimed at land reclamation and melioration
	Building terraces for agricultural land
	On grassland and rainfed areas, carry out deep loosening of the soil to accumulate rainfall into it.
	Creation of terraces and forest belts to eliminate water and wind erosion.
	Slope stabilization for pastures, pasture restoration

Main domain of interventions	**Suggested interventions**
Improved forestry	Restoration of the pre-existing Soviet-era forest belt around agricultural land (cost of about USD 0.5 million); because silk production is being resumed nationwide and a large number of forest belts consist of mulberry trees. It is also related to the government's greening programme and the introduction of green economy principles in Kanibadam district.
	Project on agroforestry improving the quality of forests
Disaster protection	It is necessary to strengthen drainage systems and change mudflow flows, which helps to reduce the risk of not only washing away agricultural land by mudflows, but also settlements. This measure also improves the quality of coastal agricultural land.
	Creation of artificial forests in adyrs, which helps to reduce the threat of mudflows, avalanches, rockfalls and landslides. This measure will also contribute to the improvement of the ecological state and environment in the region.
	There is a need for bank protection works on the Kafernigan River as well as the construction of flood defences.
	Mudflow protection measures are necessary in Shaartuz district
	Afforestation and forest regeneration will help to reduce mudflows and improve the microclimate in the region, provide more space for pastures and agroforestry in Shaartuz
Abandoned/unused land conversion to orchards	The need for the restoration of over five hundred hectares and the effective use of 1000 hectares of orchards and vineyards in both Shaartuz and Fayzabad districts.
Adapted crop species	Species adapted to droughts and high temperatures including species used in afforestation
	An information and advisory centre should be set up to provide timely information to dekhan farms, which would help farmers to find answers to many of their questions: on crop cultivation technology in relation to weather conditions and other matters in Muminabad district.

9. District related recommendations: the shortlist of climate risks and threats, main domains of intervention and suggested district-level adaptation measures.

The section aims to suggest measures for the target districts. Methodologically this implies that we will concentrate primarily on local interventions, leaving a more systemic approach to the government of Tajikistan and other research projects. For example, the all-country warning system against natural hazards, and inter-regional and inter-governmental water distribution agreements would be immensely helpful for the localities. However, they are out of the scope of this study.

Given the relatively general assessment presented in the current study, we are bound to provide the preliminary suggestions and cost estimation only. The more exact estimations are predicated on the choice of the exact location of the adaptation intervention, the rigorous analysis of the local conditions, and technical possibilities. Moreover, the exact pricing will depend on the price level prevalent at the time of project execution. Thus, the recommendations presented in this study should be viewed as tentative only.

The recommendations provided below are based on four sources of information: the analytical framework presented in previous outputs, the expert interviews, the information from focus groups and the existing experience from already conducted projects.

As almost all the regions suffer from similar climate-related emergencies, such as mudflows or landslides, some of the measures will be similar for all of the districts, though the type of the measure may differ. Similarly, in the case of forestry, afforestation and forest regeneration is advisable in all the districts where the forests existed before (except Kanibadam, where the historical forest areas were low to non-existent). The costs of the afforestation are relatively stable across the districts, thus could be presented in a separate section. On the other hand, the benefits of the forest ecosystem are difficult to measure, as many of these benefits are indirect (see the section The indirect effects of adaptation strategies).

Last but not least, the district levels measures could provide certain synergies. From this perspective, it seems advisable to take into account not only the costs and benefits of particular measure but the possible synergetic effects between them, which may reduce the total scales of intervention and the total costs. For example, the landslides may be partly prevented by increased afforestation (in Muminabad and Kuhistoni Mastchoh).

In this section, each district starts with a short description of the specifics of the district. Then, the main domains of intervention are suggested. It was the aim of the authors to limit the number of domains and suggestions to the most important ones depending on the specifics of the districts and the priorities described above.

Table 9-1 Shortlist of main domains of intervention

District	Improved water/land use	improved forestry, disaster protection	Abandoned/unused land conversion to orchards	Adapted crop species
Kanibadam	x			
Gissar	x			
Kuhistoni Mastchoh	x	x		
Shaartuz	x	x	x	x
Fayzabad	x	x	x	
Muminabad	x	x		

9.1. Kanibadam

The agricultural region with a tradition of canal irrigation. The main source of fruits with increasing land use for orchards.

9.1.1. Main risks and threats:

- lack of water for irrigation,
- Frosts.
- heat waves,
- increased pests (but it is not critical).

Suggested interventions:

- Establishment of a reservoir on the Isfara River in Kanibadam district, as well as the creation of small reservoirs in the BFC (cost of about USD100 million);
- Creation of artificial reservoirs in the foothills (cost of about USD 150 million);
- Restoration of the pre-existing Soviet-era forest belt around agricultural land (cost of about USD 0.5 million); because silk production is being resumed nationwide and a large number of forest belts consist of mulberry trees. It is also related to the government's greening programme and the introduction of green economy principles.
- Increased use of land and water use culture (cost of about USD 0.1 million); This is linked to state and regional agricultural development programs, which include increasing the knowledge of farmers and agrarians as a tool to improve agricultural efficiency.
- Organic farming technologies should be introduced in the area (costs depend on the scale of organic farming implementation);

- Greenhouses can be developed and equipped with modern technology, which partially solves the problem of irrigation water shortage in the area (cost per 1m2 $17.5).

9.1.2. Considered options, not recommended

- Drip irrigation systems are not optimal due to the increasing salinity of the soil and low cost-effectivity. The mineralized water clogs the drip irrigation system in the short while. The costs of the system are high, making it unprofitable given the relatively low crop prices faced by the farmers. Might be applicable in greenhouses on a low scale.
- Note. Although the world prices of agricultural commodities are on the rise, the prices of crops in Tajikistan faced by the farmers are often much lower. The reasons are twofold. First, most of the crops in Tajikistan are produced for local consumption. Second, more often than not the farmers do not have access to effective marketing thus leaving extra profit margins to wholesalers.
- Building new wells, though frequently used in the region, cannot be considered sustainable in the long term due to the limited supply of underground water. Many of the wells go deep underground to 120-140m. At this level, the water is not renewable from precipitation, as it would be if the wells were shallower (up to 40-50 m).

9.1.3. The results of qualitative assessment to supporte the findings (semi-structured interviews and focus groups)

What was done, what projects were undertaken? Who was the donor? What were the results in the short and long term?

In the district, there were mainly projects towards providing drinking water by drilling boreholes with financial support from the World Bank. An investment of $80,000 for four boreholes was attracted. This contributed to provision of four settlements with drinking water. However, no projects were implemented specifically in adaptation to climate change.

Which measures do you consider most effective in terms of output/cost?

- Establishment of a reservoir on the Isfara River in Kanibadam district, as well as the creation of small reservoirs in the BFC (cost of about US$100 million).
- Creation of artificial reservoirs in the foothills (cost of about USD 150 million).
- Restoration of the pre-existing Soviet-era Forest belt around agricultural land (cost of about USD 0.5 million).
- Increased use of land and water use culture (cost of about US$ 0.1 million).

- Organic farming technologies should be introduced in the area (costs depend on the scale of organic farming implementation).
- Greenhouses can be developed and equipped with modern technology, which partially solves the problem of irrigation water shortage in the area (cost per 1m^2 $17.5).

Which measures would have the most political support in the area, why?

- Restoration of the Soviet-era forest belt around agricultural land, because silk production is being resumed nationwide and a large number of forest belts consist of mulberry trees. It is also related to the government's greening programme and the introduction of green economy principles.
- Increasing the culture of land and water use. This is linked to state and regional agricultural development programmes, which include increasing the knowledge of farmers and agrarians as a tool to improve agricultural efficiency.
- Organic farming technology should be introduced in the area (costs depend on the scale of organic farming introduction). Linked to a programme of food security and regional export capacity building.
- It is possible to develop greenhouses, equip them with modern technologies, this will partially solve problems of irrigation water shortage in the district (costs per 1m^2 17.5 US dollars). This is related to the programme of food security and increase of export potential of the regions.

9.2. Gissar

The district is the most important agricultural region well connected to the capital Dushanbe and national and international food marketing. The land degradation is considered one of the most important issues.

The steep terrain of agricultural land is one of the main specifics of the Gissar district. It increases soil degradation via water erosion.

9.2.1. Main risks and threats:

- lack and inefficient use of irrigation water.
- soil degradation due to water erosion.
- poor state of irrigation infrastructure clogged with the soil washed from the high terrain
- High ground water level. In the area of 1,400 hectares are in a state of melioration. On the lands of Kalai Hisor and Orien Jamoats, the groundwater level has increased, and part of the arable land has ceased to be used in agriculture.

9.2.2. Main suggested interventions:

- The creation of terraces on the steep terrain areas will help to avoid water erosion and improve the productivity of the soil
- Provide the WUAs with the machinery to clean the canals
- Improve pumps on steep terrain to increase the efficiency of watering
- Increase the efficiency of existing WUAs by wider introduction of billing system
- Projects aimed at land reclamation and melioration
- Project on agroforestry improving the quality of forests

9.2.3. Not recommended

We encountered several options of adaptation already implemented in districts, which, however, do not produce sufficient results in the long run. Therefore, we do not primarily recommend these options for large-scale implementation. On the other hand, the following adaptation options can be useful and sustainable in small scale or under particular conditions.

Drip irrigation systems: Though the district is not affected by the increased salinity of the soil, clogging the drip irrigation systems, the drip irrigation systems are considered expensive with regard to the pricing of agricultural outputs. At most the systems can be used locally in the greenhouses.

Wells: the level of groundwater enables wells to go 40-50 m deep to the ground. At this level, the water is renewable from precipitation, however, the excessive use may damage the structure of the soil. The expected decrease in precipitation makes the extensive use of this source of water even more questionable.

9.2.4. The results of qualitative assessment to supporte the findings (semi-structured interviews and focus groups)

Adaptation measures

- The adaptation measures are significantly affected by the underfinanced and ineffectively regulated sectors of water management, agriculture, and forestry. One of the most important is the fragmentation of the land into a large number of small farms. The fragmentation significantly decreases the ability to agree and successfully implement large-scale adaptation measures. The inefficient farming, in its turn, does not allow to earn the funds for new, more efficient technologies or methods of adaptation. The only source of change the inhabitants see in grants, projects, or participation of the government.
- Despite the obvious benefits of uniting into larger units such as cooperatives or other types of larger organizations, the households are not eager to be united:

"The households in the jamoat are small, but they are in no hurry to unite or create cooperatives since, as we noted, there is not enough information, financial support, and trust. Many small dekhkan (farmer) farms complicates the process of distributing water between them. For the rational distribution of water, as well as to prevent violations of the schedule on the part of farms, duty was organized both during the day and at night." (Interview data)

Water management

The main visible effects of climate change on water management are the lack of water for irrigation in the middle of the irrigation season and the more frequent negative effects such as water- and mudflows. In part, this lack of water is caused by climate change, as described above, while the other part is due to inefficient water use. While inefficient water use is not primarily the effect of climate change, it can aggravate the effects of the latter and eventually lead to the abandonment of some territories and local or international migration. Given the existing and expected population growth, the efficiency of water use seems to be of paramount importance.

The main adaptation measures include the following:

1. more water needs to be collected and retained in winter
    i. water storage capacities such as small lakes and other
    ii. increase in winter watering technologies
2. less water should be lost in the process of transportation (currently, 20% of water is lost, interview data)
    i. maintenance and improvement watering transportation system, including the concrete coating of the channels
3. the efficiency of water use should increase
    i. control over water use (WUA)
    ii. water-saving technologies
    iii. watering according to the real needs of the crop

The first point requires significant investments into the storage capacities for rain and snow water lost in winter. The increased use of wells is questionable as this water resource is also limited, and the groundwater may increase the salinity of the soil.

<u>**Water Users Association**</u>

The second and the third point measures, to a large part, can be governed by Water Users Association (WUA), where it exists. If no such organization exists, it needs to be organized. In places where it exists, an increase in efficiency is needed. The following needs to be considered.

- The employees of WUA are underpaid, and the use of their time is largely inefficient. The salary of the employees is small and amounts to approx. 40 US dollars. The duties of the employees include collecting the payments for water from single households, regulating the water supply, and maintaining the infrastructure (channels). Much of the time the employees spend collecting the money, with various levels of success (the payment collection rate varies from 44,5% to 125% depending on jamoat see table 2). Little time is left for the actual water regulating services. The billing system of payment, adopted in pilot studies, can be suggested (see appendix 1). Currently approx. 50% of payments in the region are done via a billing system.
- The lack of machinery and equipment obstructs the effective maintenance of irrigation infrastructure (tractors and others). The purchasing of this type of machinery needs to be accompanied by the adequate practice of lending to single users when the fees are then used for the necessary maintenance and the purchase of the spare parts (for the pilot projects, see appendix 1).
- The effective distribution and efficient use of water are contingent upon adequate control over the single water users. The current control over water use is done primarily by measuring the amount of water received by WUA and the day and night watch over the irrigation channels and control points within the WUA, so that no

water is taken non-authorized. The improvement over the control of water use is impossible unless efficient mechanisms of water measurements are in place. The installation of these mechanisms requires control over the loss of water in irrigation channels. The latter requires concrete coating of the irrigation channels and frequent cleaning, which is costly. Besides, purchasing and installation of the measurement and control devices require additional funds that are not available in the region.

Maintenance of irrigation and land reclamation infrastructure.

- Irrigation channels that got congested with the soil from the irrigated hills need to be cleaned
- Irrigation channels need to be covered with concrete, maybe, according to the principle of tray networks, to prevent loss of water
- The other option is to lay pipes of large diameter to reduce the water losses.
- The maintenance of pumps is necessary as much of the agricultural land in the district is located along the side of the hill, and often the transfer of water up the hill is necessary
- the infrastructure for land reclamation was created in the times of Soviet Union needs to be repaired. The groundwater may increase the salinity of the soil.

Education and motivation for efficient water use

- Avoid excess watering
- Make the watering schedule correspond to the needs of the crop
- Improve education of farmers in new technologies

Agriculture

The specifics of the Gissar district are the large proportion of the agricultural lands located on the sides of the hills with steep slopes.

- The creation of terraces on the slope areas will partly help to avoid water erosion and improve the productivity of the soil
- Better water management will make it possible to obtain three harvests per year
- More drought and freeze resistant seeds and technologies
- Education of farmers will enable them to increase the agricultural productivity
- Organizing the small farmers into larger units will improve the efficiency of fighting the pests and will allow for better use of water.

Forestry

- The projects aimed at agroforestry may bring more water to the forest areas.
- Reforestation and forest maintenance technologies will increase the forest areas
- Fencing of the young forests will prevent the damage done by animals (overgrazing, damaging the young trees) and people

9.3. Kuhistoni Mastchoh

The district is located high in the mountains and is difficult to reach by transport means. The population is one of the poorest. The district is most suitable for potato production. The yields are the highest across all the studied regions.

9.3.1. Main risks and threats:

- High probability of an emergency situation. Virtually the entire area of the district is in an unsafe zone, and the probability of avalanches, landslides, and rockfalls is high.
- Increasing lack of irrigation water
- Deterioration of pastures

9.3.2. Suggested interventions:

- It is necessary to strengthen drainage systems and change mudflow flows, which helps to reduce the risk of not only washing away agricultural land by mudflows, but also settlements. This measure also improves the quality of coastal agricultural land.
- Creation of artificial forests in adyrs, which helps to reduce the threat of mudflows, avalanches, rockfalls and landslides. This measure will also contribute to the improvement of the ecological state and environment in the region.
- Creation of a reservoir on the Zarafshan River in the Gorno-Matchinsky district. This contributes, on the one hand, to solving the problems of lack of irrigation water in the region, and on the other hand, mini power generating units can be installed on this reservoir, which will solve the problem of lack of electricity in the region. For the creation of such reservoirs, there are good conditions and not much investment is required.
- Creation of pumping stations near the Zarafshan River, which will solve the problems of lack of irrigation water in the region.
- Improvement of irrigation infrastructure, contributing to the economical use of irrigation water. Construction of concrete trays and pipelines from water sources to agricultural land (or settlements). This, in turn, prevents the problem of not only

high-water loss, but also reduces labour costs for the restoration of ditches and the creation of canals by hand.

9.3.3. The results of qualitative assessment to supporte the findings (semi-structured interviews and focus groups)

What adaptation measures to climate change and soil degradation do you recommend in the jamoat, in the district? Could you rate these measures? What measures are most important? Most appropriate? Why?

- Creation of a reservoir on the Zarafshan River in the Gorno-Matchinsky district. This contributes, on the one hand, to solving the problems of lack of irrigation water in the region, and on the other hand, mini power generating units can be installed on this reservoir, which will solve the problem of lack of electricity in the region. For the creation of such reservoirs, there are good conditions and not much investment is required.
- Creation of greenhouses and development of vertical farming. Such a measure is directly related to the socio-economic development of the region. The implementation of this task contributes to an increase in employment and welfare of the population of the region.
- It is necessary to strengthen drainage systems and change mudflow flows, which helps to reduce the risk of not only washing away agricultural land by mudflows, but also settlements. This measure also improves the quality of coastal agricultural land.
- Creation of artificial forests in adyrs, which helps to reduce the threat of mudflows, avalanches, rockfalls and landslides. This measure will also contribute to the improvement of the ecological state and environment in the region.
- Creation of pumping stations near the Zarafshan River, which will solve the problems of lack of irrigation water in the region.
- Improvement of irrigation infrastructure, contributing to the economical use of irrigation water. Construction of concrete trays and pipelines from water sources to agricultural land (or settlements). This, in turn, prevents the problem of not only high-water loss, but also reduces labour costs for the restoration of ditches and the creation of canals by hand.
- Increasing the use of culture of land use and water use. This is possible by training farmers and households in modern farming and irrigation technologies. Accordingly, such a measure makes it possible to intensify the introduction of water-saving technologies and the application of innovative methods of agricultural technology in the agriculture of the region.

- Conducting scientific research in the direction of agriculture, development of new varieties, scientifically based methods for organizing the effective production of agricultural products.
- Creation of shrub zones suitable for the climatic features of the area.

How do you see the future of the jamoat/district in 20 years if no measures are taken to adapt to climate change?

- There is a drought, and this leads to serious environmental consequences, since in many springs, sources of drinking and irrigation water, the volume of water decreases year after year due to a decrease in precipitation in the mountains of the region.
- The volume of gross agricultural output is sharply declining (in the total structure of the gross output of the region, its share is about 90%), and this will lead to a decrease in the standard of living, an increase in the number of unemployment, respectively, there will be an increase in migration of the population to other regions of the country, and in other countries.
- The area will turn into an empty mountain zone, unsuitable for human life.

How do you see the future of the jamoat/district in 20 years if climate change adaptation measures are taken? What will change?

- Improve the ecology and environment of the region, which will directly affect the quality of life of the population.
- Stable economic growth is ensured, and thus the well-being of the population.
- In the context of the creation of a reservoir on the Zarafshan River, a separate industry will develop in the region - fish farming, which is one of the profitable industries.
- Strengthening of drainage systems in many adyrs reduces the risk of washing away by mudflows of a sufficiently large amount of agricultural land in these areas of the district;
- There is a possibility of developing new agricultural lands, the stock of which is quite large in the region.
- The processing industry will develop, transport infrastructure will develop (it is in a very difficult condition), additional jobs will appear, social and economic well-being is achieved in the region.

- In terms of transport accessibility, mountain and agricultural tourism is developing, for which there are very good prerequisites.

What has been done, what projects have been implemented? Who was the donor? What were the results in the short and long term?

In the district, considering the goals of the project "Improving the quality of life and ensuring food security through the sustainable management of natural resources", projects were mainly implemented in the direction of providing drinking water by laying pipelines from springs, creating barns for farm animals with financial support from the Aga Khan Foundation, ACTED and UNDP. However, no projects have been implemented in the direction of adaptation to climate change.

What measures do you consider the most effective in terms of results/costs?

- Creation of a reservoir on the Zarafshan River in the Kuhistoni Mastchoh district. This contributes, on the one hand, to solving the problem of lack of irrigation water in the region, and on the other hand, mini power generating units can be installed on this reservoir, which solve the problem of lack of electricity in the region. For the creation of such reservoirs, there are good conditions and not much investment is required.
- Creation of greenhouses and development of vertical farming. Such a measure is directly related to the socio-economic development of the region. The implementation of this task contributes to an increase in employment and welfare of the population of the region.
- Creation of artificial forests in adyrs, which will help reduce the threat of mudflows, avalanches, rockfalls and landslides. This measure also contributes to the improvement of the ecological state and environment in the region.
- Improvement of irrigation infrastructure, contributing to the economical use of irrigation water. Construction of concrete trays and pipelines from water sources to agricultural land (or settlements). This, in turn, prevents the problem of not only high-water loss, but also reduces labour costs for the restoration of ditches and the creation of canals by hand.
- Comprehensive training of the population of the region in the culture of land use and water use. This is possible by training farmers and households in modern farming and irrigation technologies. Accordingly, this measure makes it possible to intensify the introduction of water-saving technologies and the application of innovative methods of agricultural technology in the agriculture of the region. Attracting research institutes to the region to substantiate the priorities for the development of agriculture, forestry, and water management.

Which measures will have the most political support in the area, why?

- Creation of greenhouses and development of vertical farming. Such a measure is directly related to the socio-economic development of the region. The implementation of this task contributes to an increase in employment and welfare of the population of the region.
- Creation of artificial forests in adyrs, which will help reduce the threat of mudflows, avalanches, rock falls and landslides. This measure also contributes to the improvement of the ecological state and environment in the area.
- Improvement of irrigation infrastructure, contributing to the economical use of irrigation water. Construction of concrete trays and pipelines from water sources to agricultural land (or settlements). This, in turn, prevents the problem of not only high-water loss, but also reduces labour costs for the restoration of ditches and the creation of canals by hand.
- Comprehensive training of the population of the region in the culture of land use and water use. This is possible by training farmers and households in modern farming and irrigation technologies. Accordingly, such a measure makes it possible to intensify the introduction of water-saving technologies and the application of innovative methods of agricultural technology in the agriculture of the region. Attracting research institutes to the region to substantiate the priorities for the development of agriculture, forestry, and water management.

9.4. Shaartuz

There is considerable agrarian production including livestock. Region is subject to droughts and natural disasters. The district is highly dependent on irrigation

9.4.1. Main risks and threats:

- The region is subject to high temperatures and droughts.
- Regions is subject to mudflows during spring rains and the rising of the Kofarnihon River. Including houses and auxiliary facilities in the village and agricultural lands washed away by the Kofarnihon River. The washed away lands are damaging the lands of Dehkan farms and settlements
- Lack and inefficient use of irrigation water

9.4.2. Suggested interventions:

- There is a need for bank protection works on the Kafernigan River as well as the construction of flood defences.
- Mudflow protection measures are necessary
- Afforestation and forest regeneration will help to reduce mudflows and improve the microclimate in the region, provide more space for pastures and agroforestry
- the need for the restoration of over five hundred hectares and the effective use of 1,000 hectares of orchards and vineyards
- Species adapted to droughts and high temperatures including species used in afforestation
- To store water in times of shortage, a reservoir should be built to collect water. The reservoir will also create a microclimate, and this may help to reduce population movements to other parts of the country.
- Rehabilitation and reconstruction of irrigation and collector-drainage networks.

9.4.3. The results of qualitative assessment to supporte the findings (semi-structured interviews and focus groups)

What projects have been or are being implemented in the area, e.g., on drinking water, supporting Associations, improving the environment, roads, forests, etc.

- A forest restoration project by the international organisation JAICA. A total of **400 hectares of** forestry is under forestry. Basically, saxaul planting has been done on **40-50** hectares of 400 hectares of land. There are no projects on health care, drinking water.
- Do you have plantings of orchards and vineyards and how many hectares are they?

- Yes, we have 1,901 hectares of orchards (apples, peaches, apricots, and plums) and 240 hectares of vineyards. There are no intensive orchards now.

What recommendations would you make to remedy the above problems?

- There is a need for bank protection works on the Kafernigan River as well as the construction of flood defences.
- To store water in times of shortage, a reservoir should be built to collect water. The reservoir will also create a microclimate, and this may help to reduce population movements to other parts of the country.
- Rehabilitation and reconstruction of irrigation and collector-drainage networks.
- Watering of rangelands.
- Application of soil- and water-saving technologies for crop irrigation, drip irrigation, etc. to use scarce water resources more economically.
- Application of more drought-tolerant crop varieties to climate change and adaptation.
- Selection of forest flora and development of forest management methods farm.
- Establishment of information and advisory centres for farmers in the first instance.

9.5. Fayzabad

The agricultural lands of Fayzabad are located in steep terrain, which aggravates water soil erosion. Strong winds add significant wind erosion. Lack of irrigation water and insufficient state of drainage technologies increases water salinity.

9.5.1. Main risks and threats:

- Droughts, lack of water for irrigation
- wind soil erosion, development of soil salinity
- strong winds and wind gust, torrential (strong) rains, floods - Ilok river.
- reduction of vegetation cover, lack of fodder for livestock
- mudflows, landslides, hail, heavy snowfalls, frosts and heavy rains.
- Steep terrain of agricultural land increase water-related soil erosion

9.5.2. Suggested interventions:

- Rehabilitation and modernization of pumping stations supplying water from the Kafernigan River to the 50-solagi canal (out of 4 pumps, only one is operational today).
- Cleaning irrigation canals from sediments and siltation, which negatively affect the volume of transported water.
- Building terraces for agricultural land
- Mudflow and Landslide protection
- The need to restore 900 hectares of land and the effective use of 1,000 hectares of orchards and vineyards.

9.5.3. Not recommended

We encountered several options of adaptation already implemented in districts, which, however, do not produce sufficient results in the long run. Therefore, we do not primarily recommend these options for large-scale implementation. On the other hand, the following adaptation options can be useful and sustainable in small scale or under particular conditions.

Construction of new wells to supply both drinking and irrigation water, though wanted by the population of the regions, needs to be taken with caution, as the level of groundwater is expected to decrease.

9.5.4. The results of qualitative assessment to supporte the findings (semi-structured interviews and focus groups)

What adaptation measures to climate change and soil degradation do you recommend in the jamoat, in the district? Could you rank these measures? Which measures are most important? Are the most feasible? Why?

- Rehabilitation and modernization of pumping stations supplying water from the Kafernigan River to the 50-solagi canal (out of 4 pumps, only one is operational today). These pumps are sufficient to fully supply the farms of the jamoat with water for irrigation.
- Cleaning irrigation canals from sediments and siltation, which negatively affect the volume of transported water.
- Construction of new wells to supply both drinking and irrigation water.
- on pasture and rainfed lands, deep loosening of the soil in order to accumulate atmospheric precipitation into it.
- Establishment of an information and advisory centre to provide timely information to dekhkan (private) farms, which will help farmers to get answers to many of their questions: on crop cultivation technology depending on weather conditions and other;
- to improve the culture of farming and retraining of human resources it is necessary to carry out various training activities for dehkan (farmer) farms.

How do you see the future of the jamoat/district in 20 years, if no measures are taken to adapt to climate change?

If no measures are taken to adapt to climate change, then it is possible that the following may happen in the future:

- In case the pumps supplying water from the Kafernigan River to the canal are not rehabilitated (rehabilitation of existing pumps and purchase of new pumps), in this case, due to lack of water, crop yields will decrease, at the same time the living standards of Jamoat residents will fall (for example, due to lack of fodder for cattle, dairy products cost 2-2.5 times more).
- A sharp decrease in the groundwater table due to reduced precipitation, which will negatively affect not only drinking but also agricultural water supply.
- Under disturbance of ecological balance in jamoat due to water shortage, reduction of vegetation cover, the negative impact of wind "Afghans" from Afghanistan will increase (during a year "Afghans" covers from 40 to 60 times).

- Sharp increase of mudflows, landslides, rockfalls, etc.
- Decrease of productivity in crop and livestock production, as well as degradation of ecosystems, which puts on the agenda the risks to food security and income of the most vulnerable categories of the population.

How do you see the future of the jamoat/district in 20 years if climate change adaptation measures are in place? What will change?

- Rising temperatures and extreme weather increasingly affect food security. Accordingly, measures should be taken to reduce the impact on crop yields, livestock, forestry, etc:
- Sufficient volume of water in the canal "50-solagi" for agricultural water supply of the jamoat.
- Reduced migration among the population; Employment will increase.
- Improved management of agricultural and natural resources.
- Ensuring stable operation of the canal and pumps.
- Significant reduction of land degradation processes and increase of its productivity.
- Improving the environmental condition of the district, which will directly affect the quality of life of the population.

What has been done, what projects have been undertaken? Who was the donor? What were the results in the short and long term?

- What measures do you consider the most effective in terms of results/costs?
- Modernization of the canal "50 solagi" to provide water to dekhkan (farm) households in the jamoat; This work gives good results; however, it is very costly.
- On pasture and rainfed lands, application of necessary innovative methods of irrigation; requires large financial investments.
- Training of land users for efficient use of water and land resources. Costly.
- Which measures will have the greatest political support in the district, why?
- Transition to more modern irrigation technologies.
- Development of intensive orchards, which will increase the export potential in dekhkan (farm) farms.
- Investing in new technologies (e.g., mechanization to replace manual labour);
- Ensuring permanent soil cover.

9.6. Muminabad

The district is located in a mountainous area in the southern part of the country. The climate conditions are unfavourable for potato production (too high temperature), dust for floral products (dust), and fruits (heavy rain). The population increases the production of livestock, though the latter suffers from the lack of fodder. Although the district is not supposed to suffer from the lack of irrigation water as the Muminabad reservoir is supposed to fill the water needs, the distribution of water across the district and season is very uneven leading to the lack of irrigation water in certain localities in summer months. A significant proportion of agricultural land is located on steep terrain, which increases water erosion and decreases the efficiency of irrigation.

9.6.1. Main risks and threats:

- Lack of irrigation water during the growing season of crops
- Reduced quality and volume of drinking water, as well as difficulties in distribution among water users due to the difficult terrain;
- Significant reduction in vegetation on rangelands and rainfed land, resulting in a shortage of fodder for the livestock industry.
- Increased land degradation due to drought, water and wind erosion;
- In forestry, disappearance of forest plantations, forest belts in forestry farms; there is a reduction in the number of trees in the rows;
- Landslides and mudflows

9.6.2. Suggested interventions:

- The construction of additional water retention facilities on the Surkhak River, from which the Kululyu canal in Muminabad district draws its water, which should facilitate greater water collection, thus addressing water shortages during the irrigation season.
- On grassland and rainfed areas, carry out deep loosening of the soil to accumulate rainfall into it.
- Creation of terraces and forest belts to eliminate water and wind erosion.
- Mudflow protection
- Slope stabilization for pastures, pasture restoration
- Afforestation, forest regeneration, agro forestry
- An information and advisory centre should be set up to provide timely information to dekhan farms, which would help farmers to find answers to many of their questions: on crop cultivation technology in relation to weather conditions and other matters.

- Sound sirens should be installed to alert the population to the threat of mudslides and other natural disasters.

9.6.3. The results of qualitative assessment to supporte the findings (semi-structured interviews and focus groups)

What adaptation measures to climate change and soil degradation do you recommend in the jamoat, in the district? Could you rank these measures? Which measures are most important? Are the most feasible? Why?

- The construction of additional water retention facilities on the Surkhak River, from which the Kululyu canal in Muminabad district draws its water, which should facilitate greater water collection, thus addressing water shortages during the irrigation season.
- D Rehabilitation of existing and construction of new wells for both drinking and irrigation water supply.

Rehabilitation of irrigation systems and pumping stations "Muminabad" and "Margak - 1", **11** pumping stations in total. This will allow uninterrupted water supply to all water consumers and water users;

- On grassland and rainfed areas, carry out deep loosening of the soil to accumulate rainfall into it.
- Creation of terraces and forest belts to eliminate water and wind erosion.
- An information and advisory centre should be set up to provide timely information to dekhan farms, which would help farmers to find answers to many of their questions: on crop cultivation technology in relation to weather conditions and other matters.
- Sound sirens should be installed to alert the population to the threat of mudslides and other natural disasters.
- To use energy economically and thereby reduce energy bills, use solar energy to run the pumping stations.
- In order to improve farming culture and retrain human resources, various training activities for dekhan (farm) households are needed.

How do you see the future of the jamoat/district in 20 years if no climate change adaptation measures are taken?

If no action is taken to adapt to climate change, then perhaps the following could happen in the future

- There will be an acute problem for the water resources required by the various sectors of the economy.

- Increased land degradation due to drought, water and wind erosion.
- deterioration of the ecological balance of the environment.
- disappearance of forest plantations, forest belts in forestry farms.
- a sharp increase in debris flows, landslides, rockfalls, etc.
- A decrease in the productivity of cultivated land, which will have a negative impact on food security.

How do you see the future of the jamoat/district in 20 years if climate change adaptation measures are in place? What will change?

If climate change adaptation measures are implemented, the following is possible

- Accumulation of water resources in the constructed reservoirs, which will contribute to a drastic reduction of water scarcity in various sectors of the economy.
- Dynamic development in agriculture, drinking water supply, fisheries, energy, etc.
- Reduction of natural disasters, especially debris flows.
- Ensuring the reliability, stability, and safety of hydraulic structures.
- A significant reduction in land degradation and an increase in land productivity.
- Restoration of forest plantations and, in general, sustainable development of forestry.
- Improving the environmental condition of the area, which will have a direct impact on the quality of life of the population.
- Efficient use of the area's hydropower and solar potential.
- Socio-economic growth and development of the area, and thereby improving the well-being of the population.

What has been done, what projects have been undertaken? Who were the donors? What were the results in the short and long term?

The following projects have been implemented in the Muminabad district:

- A project to support dekhkan farms, grazing lands, cleaning of irrigation and drainage systems, and bank protection works. These projects were financed by CARITAS.
- The drinking water project, which was financially supported by the international organisation OXFAM.
- A 4–5-hectare intensive orchard project funded by the UN Food and Agriculture Organisation FAO in Tajikistan.

The listed projects, which were implemented in Muminabad district, contributed to the development of the agricultural sector, and drinking water supply. However, no projects have been implemented specifically in climate change adaptation.

Which measures do you consider most effective in terms of outcome/cost?

- Construction of a reservoir on the Surkhak River to collect 5-10 million m of water^{3}. This work gives good results but is very costly.
- Rehabilitation of irrigation systems and pumping stations. It should be noted here that it is costly to replace pumps that have fallen into disrepair.
- On pasture and rainfed land, the application of the necessary water retention technologies does not require large financial investments.
- Reforestation of forest plantations and terraces necessary in preventing soil erosion. This work does not require a large investment.
- Training of land users for efficient use of water and land resources. There is little cost involved.

Which measures would have the most political support in the area, why?

- Creation of a reservoir, which will contribute to the development of all sectors of the district economy (land irrigation, drinking water supply, fisheries, hydropower) related to government programmes.
- Development of forestry, which will primarily contribute to the ecological balance of the area, i.e. - purification and oxygenation of the air, in connection with the development of related industries.
- Due to diminishing water resources, the introduction of water-saving and soil-protecting irrigation technologies for crops is a priority in the agricultural sector and has political support based on government programmes.
- Diversification of the crop and livestock sectors, which are linked to state and regional agrarian sector development programmes.
- Construction of modern storage facilities to develop the export potential of the area.

10. Summarization of most pressing climate-related problems and suggested adaptation scenarios for focus districts

For each out of six target districts, we identified major problems within the 5 major categories: (i) Lack (damaged/insufficient) of irrigation; (ii) Insufficient access to drinking water; (iii) Land degradation/Soil erosion; (iv) Natural disasters; (v) Reduction in vegetation/ forest plantations/pastures. The problems presented in table 10-1 through table 10-3 are based on the analyses performed in theprevious reports. Namely, the results are based on analysis of relevant statistical district level data, mathematical modelling, focus groups and interviews with local and country level experts. Table 10-1 presents the most pressing climate related issues in the selected districts.

Table 10-1 Summarisation of prioritized climate-related problems in selected districts

Districts	Problems
Kanibadam	**1. Lack (damaged/insufficient) of irrigation capacities/or lack of water for irrigation**
	- Lack of water in irrigation period.
	2. Insufficient access to drinking water
	- Reduced drinking water coming from the Big Fergana Canal (BFC) in the western part of the district (about 60% of the district).
	- Increase in dental disease, kidney disease and other types of illness due to poor quality drinking water.
	3. Land degradation/Soil erosion (including salinity increase)
	- Increased erosion and salinity of agricultural land due to improper (non-normalised) irrigation and changes in the timing of agronomic measures as a result of climate change (untimely ploughing and cultivation of crops (cotton)).
	4. Natural disasters /abnormal weather patterns
	- A gradual increase in temperature during the summer (abnormal heat waves) and winter period, a sudden cold spells in the spring period at the start of the sowing season.
	- Intermittent rainfall, flash floods in spring and summer.
	- Increase in the threat of drought on about 16,000 hectares of agricultural land.
	5. Reduction in vegetation/ forest plantations/pastures
	- Reduced crop yields.
Gissar	**1. Lack (damaged/insufficient) of irrigation capacities/or lack of water for irrigation**
	- Irrigation and land reclamation is one of the most important problems of the region's agriculture.
	- Poor state of irrigation infrastructure clogged with the soil washed from the high terrain (5 water stations do not work and do not supply water to 951 hectares of irrigated lands).
	2. Insufficient access to drinking water
	- Insufficient access to drinking water. According to official data, 65% of the district's population do not have access to drinking water
	3. Land degradation/Soil erosion (including salinity increase)
	- High ground water level. In the area of 1400 hectares are in a state of melioration.
	- Increase of watering in areas where is agricultural land in slopes leads to an increase in water erosion that damages the water channels.
	4. Natural disasters /abnormal weather patterns
	- Temperature shocks and heat waves.
	5. Reduction in vegetation/ forest plantations/pastures
	Hectare yields are reduced by up to 50% (not supported by empirical data, not only the effects of climate change).
Kuhistoni Mastchoh	**1. Lack (damaged/insufficient) of irrigation capacities/or lack of water for irrigation**
	- Increasing lack of irrigation water.
	- Reduction of drinking and irrigation water coming from mountain springs (almost 100% of the district).
	2. Insufficient access to drinking water
	- Supply of drinking fresh water to the population. Although there are high quality water sources in the area, only 83% of the population or 21508 people have access to water.
	3. Land degradation/Soil erosion (including salinity increase)
	- Decreased quality of soil fertility due to lack of crop rotation and dry soil.
	4. Natural disasters /abnormal weather patterns
	- Irregular precipitation, flash floods in spring and summer.
	- Change in the timing of sowing crops (mainly potatoes) and the application of agrotechnical measures.
	- High probability of an emergency situation. Virtually the entire area of the district is in an unsafe zone, and the probability of avalanches, landslides, and rockfalls is high.

Districts	Problems
	5. Reduction in vegetation/ forest plantations/pastures
	- Deterioration of pastures
Shaartuz	**1. Lack (damaged/insufficient) of irrigation capacities/or lack of water for irrigation**
	- Lack of irrigation water due to decrease in rainfall in recent years and decrease the water level in Kafernigan river.
	2. Insufficient access to drinking water
	N/A
	3. Land degradation/Soil erosion (including salinity increase)
	- Soil salinization in pasture lands and abandoned lands and also in irrigated lands.
	4. Natural disasters /abnormal weather patterns
	- The region is subject to high temperatures and droughts.
	- Regions is subject to mudflows during spring rains and the rising of the Kofarnikhon River. Including houses and auxiliary facilities in the village and agricultural lands washed away by the Kofarnikhon River.
	5. Reduction in vegetation/ forest plantations/pastures
	Deforestation and reduction of forest areas.
Fayzabad	**1. Lack (damaged/insufficient) of irrigation capacities/or lack of water for irrigation**
	- Lack of water for irrigation; maintenance of pumping networks, irrigation canals and drainage systems has not been carried out in recent years.
	- Unsatisfactory level of infrastructure (canals and pumping stations).
	2. Insufficient access to drinking water
	- Lack of water from canal of Vahdat city for dekhkan (farm) households (example of jamoat "Buston" – focus group)
	3. Land degradation/Soil erosion (including salinity increase)
	Insufficient maintenance and condition of the drainage system leads to an increase in the level of groundwater and salinity of the soil.
	- Steep terrain of agricultural land increase water-related soil erosion.
	4. Natural disasters /abnormal weather patterns
	- Strong winds and wind dust, torrential (strong) rains, floods (Ilok river).
	- Mudflows, landslides, hail, heavy snowfalls, frosts and heavy rains.
	- The spring freezes endangering fruit trees.
	5. Reduction in vegetation/ forest plantations/pastures
	- Reduction of vegetation (mainly on pastures) leading to a shortage of fodder.
Muminabad	**1. Lack (damaged/insufficient) of irrigation capacities/or lack of water for irrigation**
	- Lack of irrigation water during the growing season of crops.
	2. Insufficient access to drinking water
	- Reduced quality and volume of drinking water, as well as difficulties in distribution among water users due to the difficult terrain.
	3. Land degradation/Soil erosion (including salinity increase)
	- Increased land degradation due to drought, water and wind erosion.
	4. Natural disasters /abnormal weather patterns
	- Landslides and mudflows.
	5. Reduction in vegetation/ forest plantations/pastures
	- Significant reduction in vegetation on rangelands and rainfed land, resulting in a shortage of fodder for the livestock industry.
	- In forestry, disappearance of forest plantations, forest belts in forestry farms; there is a reduction in the number of trees in the rows.

Table 10-2 presents projects according to selected problem category and connect projects what specific topics. 15 identified projects are related to irrigation capacities (missing, insufficient, damaged), 13 projects are related to insufficient access to drinking water, and then 8 projects are related to land degradation, natural disasters and reduction in vegetation/ forest or pastures.

Table 10-2 Problems and selected projects

Problems	Projects	Project sponsor and starting year of realisation	Topic
1. Lack (damaged/insufficient) of irrigation capacities/or lack of water for irrigation	Building "Punukai" Reservoir (Mudflow Reservoir) In Asht District of Sughd Region	Asia Development Bank (ADB); 2016	Improved watershed management
	Ferghana Valley Water Resources Management Project	World Bank (WB); 2013	Improved watershed management
	Community Agriculture & Watershed Management Project	WB; 2013	Improved watershed management
	Development of National water security systems for ensuring food security in Tajikistan	Green Climate Fund (GCF); 2021	Improved water/land use
	Strengthening land-based adaptation practices in Tajikistan	GCF; 2022	Improved water/land use
	Reclaimed Land and Irrigation in Gafurov District	ADB; 2016	Improved water/land use
	Rehabilitation of Hydrotechnical Construction of Great Gissar Canal	ADB; 2016	Improved water/land use
	Construction and Rehabilitation of Irrigation Systems for Development of New and Existing Water Provision of Land in Jirgital District	ADB; 2015	Improved water/land use
	Environmental Land Management and Rural Livelihoods Project	WB/ Global Environment Facility (GEF); 2013	Improved water/land use
	Tajikistan Second Public Employment for Sustainable Agriculture and Water Resources Management Project	WB; 2013	Improved water/land use
	Rural Infrastructure Rehabilitation Project	WB; 2013	Improved water/land use
	Climate- and Disaster-Resilient Irrigation and Drainage Modernization in the Vakhsh River Basin Project	Asian Development Fund (ADF)/Technical Assistance Special Fund (TASF); 2021	Improved water/land use
	Irrigation Rehabilitation Project	ADB/Japan Special Fund (JSF); 2004	Improved water/land use
	Tajikistan: Building Climate Resilience in the Pyanj River Basin	ADB/Strategic Climate Fund (SCF); 2015	Improved water/land use

Problems	Projects	Project sponsor and starting year of realisation	Topic
	Drip irrigation helps farmers in Tajikistan to grow crops, adapt to climate change	UNDP with the support of the Russian Fed.; 2020	Abandoned/unused land conversion to orchards
2. Insufficient access to drinking water	Community Agriculture & Watershed Management Project	WB; 2013	Improved watershed management
	Ferghana Valley Water Resources Management Project	WB; 2013	Improved watershed management
	Development of National water security systems for ensuring food security in Tajikistan	GCF; 2021	Improved water/land use
	Strengthening land-based adaptation practices in Tajikistan	GCF; 2022	Improved water/land use
	Rehabilitation of Hydrotechnical Construction of Great Gissar Canal	ADB; 2016	Improved water/land use
	Environmental Land Management and Rural Livelihoods Project	WB/GEF; 2013	Improved water/land use
	Tajikistan Second Public Employment for Sustainable Agriculture and Water Resources Management Project	WB; 2013	Improved water/land use
	Rural Infrastructure Rehabilitation Project	WB; 2013	Improved water/land use
	Irrigation Rehabilitation Project	ADB/JSF; 2004	Improved water/land use
	Tajikistan: Building Climate Resilience in the Pyanj River Basin	ADB/SCF; 2015	Improved water/land use
	From service delivery to sustainable water management in Tajikistan	Oxfam/Tajikistan WASH Programme; 2013	Improved water/land use
	Integrated Health and Habitat Improvement (IHHI) Rasht Valley	UNDP/GEF; 2007	Others
	Khatlon Livelihoods Support Project	International Fund for Agricultural Development (IFAD); 2008	Others
3. Land degradation/Soil erosion (including salinity increase)	Reclaimed Land and Irrigation in Gafurov District	ADB; 2016	Improved water/land use
	Construction and Rehabilitation of Irrigation Systems for Development of New and Existing Water Provision of Land in Jirgital District	ADB; 2015	Improved water/land use
	Facilitating Climate Resilience in Tajikistan	UNDP with the support of the Russian Fed.; 2020	Improved water/land use

Problems	Projects	Project sponsor and starting year of realisation	Topic
	RESILAND CA+ Program: Tajikistan Resilient Landscape Restoration Project	WB; 2022	Improved water/land use
	CACILM: Demonstrating Local Responses to Combating Land Degradation and Improving Sustainable Land Management in SW Tajikistan-under CACILM Partnership Framework	UNDP/GEF; 2007	Improved water/land use
	Environmental Land Management and Rural Livelihoods Project	WB/GEF; 2013	Improved water/land use
	Climate- and Disaster-Resilient Irrigation and Drainage Modernization in the Vakhsh River Basin Project	ADF)/TASF; 2021	Improved water/land use
	Project for Agro-Technical Measures to Combat Secondary Salinization of Soils	ADB; 2015	Others
4. Natural disasters /abnormal weather patterns	Integrated Watershed and Sustainable Land Management to Build the Resilience of Local Communities in Tajikistan	UNDP with the support of the Russian Fed.; 2019	Improved watershed management
	Building "Punukai" Reservoir (Mudflow Reservoir) In Asht District of Sughd Region	ADB; 2016	Improved watershed management
	Study And Development of Agricultural Climate Adaptation Technologies	ADB; 2016	Adapted crop species
	Mudslides and floods: Emergency appeal n° MDRTJ005, GLIDE n° MS-2009-000083-TJK, FL-2009-000095-TJK, MS-2009-000099-TJK	International federation of Red Cross and Red Crescent Society of Tajikistan; 2009	Others
	Emergency assistance to mudflow affected population of Khuroson district	UNDP/UNDAF; 2020	Others
	Facilitating Climate Resilience in Tajikistan (FCRT)	UNDP with the support of the Russian Fed.; 2020	Others
	Project to Reconstruct Existing Warehouses and Construct Modern Storage Facilities for Crops and Livestock	ADB; 2016	Others
	Strengthening Critical Infrastructure against Natural Hazards	WB/UNDP; 2017	Others
5. Reduction in vegetation/ forest plantations/pastures	Livestock and Pasture Development Project	IFAD; 2011	New pasture/livestock systems

Problems	Projects	Project sponsor and starting year of realisation	Topic
	Livestock and Pasture Development Project II (Pasture systems)	IFAD; 2015	New pasture/livestock systems
	Project to Develop High Yield Crops in the Context of Climate Change	ADB; 2016	Adapted crop species
	Study And Development of Agricultural Climate Adaptation Technologies	ADB; 2016	Adapted crop species
	Facilitating Climate Resilience in Tajikistan	UNDP with the support of the Russian Fed.; 2020	Improved water/land use
	RESILAND CA+ Program: Tajikistan Resilient Landscape Restoration Project	WB; 2022	Improved water/land use
	Project for Improving the Efficiency of Land Use through Agricultural Diversification	ADB; 2016	Improved water/land use
	Climate Adaptation and Mitigation Program for Aral Sea Basin (CAMP4ASB)	WB; 2021	Improved water/land use

Table 10-3 identifies problems connect them with the project and also present the region off the project implementation. Six colours indicate locations, no colour (white) indicates project to be implemented on the whole territory of Tajikistan. Brown, blue, yellow, green and red suggest more specific locations. More details are presented in legend to Table 10-3. 25 projects are Tajikistan wide; 12 projects are focused on the territory of Kafernigan river basin (incl. Gissar and Shaartuz districts).

Table 10-3 Problems, projects and districts

Problems	Projects	Region
1. Lack (damaged/insufficient) of irrigation capacities/or lack of water for irrigation	Building "Punukai" Reservoir (Mudflow Reservoir) In Asht District of Sughd Region	Sughd
	Ferghana Valley Water Resources Management Project	Gissar
	Community Agriculture & Watershed Management Project	Tajikistan generally
	Development of National water security systems for ensuring food security in Tajikistan	Tajikistan generally
	Strengthening land-based adaptation practices in Tajikistan	Tajikistan generally
	Reclaimed Land and Irrigation in Gafurov District	Sughd
	Rehabilitation of Hydrotechnical Construction of Great Gissar Canal	Gissar

Problems	Projects	Region
	Construction and Rehabilitation of Irrigation Systems for Development of New and Existing Water Provision of Land in Jirgital District	Gissar
	Environmental Land Management and Rural Livelihoods Project	Tajikistan generally
	Tajikistan Second Public Employment for Sustainable Agriculture and Water Resources Management Project	Gissar
	Rural Infrastructure Rehabilitation Project	Tajikistan generally
	Climate- and Disaster-Resilient Irrigation and Drainage Modernization in the Vakhsh River Basin Project	Yovon /Khatlon/ lower Vakhsh river
	Irrigation Rehabilitation Project	Tajikistan generally
	Tajikistan: Building Climate Resilience in the Pyanj River Basin	Muminabad
	Drip irrigation helps farmers in Tajikistan to grow crops, adapt to climate change	Ayni
2. Insufficient access to drinking water	Community Agriculture & Watershed Management Project	Tajikistan generally
	Ferghana Valley Water Resources Management Project	Gissar
	Development of National water security systems for ensuring food security in Tajikistan	Tajikistan generally
	Strengthening land-based adaptation practices in Tajikistan	Tajikistan generally
	Rehabilitation of Hydrotechnical Construction of Great Gissar Canal	Gissar
	Environmental Land Management and Rural Livelihoods Project	Tajikistan generally
	Tajikistan Second Public Employment for Sustainable Agriculture and Water Resources Management Project	Gissar
	Rural Infrastructure Rehabilitation Project	Tajikistan generally
	Irrigation Rehabilitation Project	Tajikistan generally
	Tajikistan: Building Climate Resilience in the Pyanj River Basin	Muminabad
	From service delivery to sustainable water management in Tajikistan	Tajikistan generally
	Integrated Health and Habitat Improvement (IHHI) Rasht Valley	Vakhsh river basin
	Khatlon Livelihoods Support Project	Vakhsh/Kofernigon river basin (Shaartuz)
	Reclaimed Land and Irrigation in Gafurov District	Sughd

Problems	Projects	Region
3. Land degradation/Soil erosion (including salinity increase)	Construction and Rehabilitation of Irrigation Systems for Development of New and Existing Water Provision of Land in Jirgital District	Gissar
	Facilitating Climate Resilience in Tajikistan	Zarafshan valley - Kuhistoni Mastchoh
	RESILAND CA+ Program: Tajikistan Resilient Landscape Restoration Project	Tajikistan generally
	CACILM: Demonstrating Local Responses to Combating Land Degradation and Improving Sustainable Land Management in SW Tajikistan-under CACILM Partnership Framework	Shaartuz
	Environmental Land Management and Rural Livelihoods Project	Tajikistan generally
	Climate- and Disaster-Resilient Irrigation and Drainage Modernization in the Vakhsh River Basin Project	Yovon /Khatlon/ lower Vakhsh river
	Project for Agro-Technical Measures to Combat Secondary Salinization of Soils	Tajikistan generally
4. Natural disasters /abnormal weather patterns	Integrated Watershed and Sustainable Land Management to Build the Resilience of Local Communities in Tajikistan	Zarafshan valley
	Building "Punukai" Reservoir (Mudflow Reservoir) In Asht District of Sughd Region	Sughd
	Study And Development of Agricultural Climate Adaptation Technologies	Tajikistan generally
	Mudslides and floods: Emergency appeal n° MDRTJ005, GLIDE n° MS-2009-000083-TJK, FL-2009-000095-TJK, MS-2009-000099-TJK	Tajikistan generally
	Emergency assistance to mudflow affected population of Khuroson district	Vakhsh river basin
	Facilitating Climate Resilience in Tajikistan (FCRT)	Tajikistan generally
	Project to Reconstruct Existing Warehouses and Construct Modern Storage Facilities for Crops and Livestock	Tajikistan generally
	Strengthening Critical Infrastructure against Natural Hazards	Tajikistan generally
5. Reduction in vegetation/ forest plantations/pastures	Livestock and Pasture Development Project	Khatlon (Kafernigan/Pyandj)
	Livestock and Pasture Development Project II (Pasture systems)	Khatlon (Kafernigan/Pyandj)
	Project to Develop High Yield Crops in the Context of Climate Change	Khatlon and Sughd
	Study And Development of Agricultural Climate Adaptation Technologies	Tajikistan generally

Problems	Projects	Region
	Facilitating Climate Resilience in Tajikistan	Zarafshan valley - Kuhistoni Mastchoh
	RESILAND CA+ Program: Tajikistan Resilient Landscape Restoration Project	Tajikistan generally
	Project for Improving the Efficiency of Land Use through Agricultural Diversification	Tajikistan generally
	Climate Adaptation and Mitigation Program for Aral Sea Basin (CAMP4ASB)	Tajikistan generally

Legend to table 10-3

Key	Location:
no colour	Tajikistan generally
Brown	Syrdarya river basin (incl. Kanibadam)
Blue	Kafernigan river basin (incl. Gissar and Shaartuz)
Yellow	Zarafshan river basin (incl. Kuhistoni Mastchoh)
Green	Vakhsh river basin (incl. partially Fayzabad)
Red	Pyandj river basin (incl. Muminabad)

10.1. **Problem A**: Lack (damaged/insufficient) of irrigation capacities/or lack of water for irrigation

<u>A.1 STATUS QUO</u>

Agricultural land in Tajikistan covers about 4.6M hectares (ha), with a potential irrigable land of 1.57 million hectares. However, currently only 753,083 ha of irrigated land and 201,370 ha of rain fed arable land is cultivated due to technical and economic constraints (Shenhav et al., 2019)

Wheat, cotton, fruit and vegetables are the main irrigated crops. Livestock production relies mainly on forage production and local grazing resources rather than the 3.3 million ha of permanent pasture, which further increases the pressure on scarce arable land. Crop and livestock productivity are low, not only in comparison to more advanced agricultural economies but also to other countries in Central Asia.

As a result of inefficient use of irrigation water, all Central Asian countries score high in global rankings that compare the water use per person and per unit of Gross Domestic Product. Helping Central Asia countries improve irrigation efficiency would thus provide an important contribution to reducing public expenditures and increasing incomes (Burt, 2017).

Due to the differences in altitude, 44% of cultivated lands rely on irrigation pumps to supply them with water – the highest percentage in Central Asia. Irrigation pumps require a steady energy supply to ensure proper functioning (Burt, 2017).

According to World Bank estimates, in some cases only 35% of pumped water may reach cultivated lands, due to leakages and inefficient agricultural water use (Burt, 2017). The main reasons for this inefficient use are obsolete on-farm infrastructures in land reclamation, irrigation and drainage systems, worn out technical facilities and poor financial support of Water User Associations (Shenhav et al., 2019).

Improvements in irrigation services, improvements in agricultural training are essential to rise farm production, specifically in arid and semi-arid locations (Darko et al., 2016).

As Dukhovny et al. defined, efficient irrigation system needs to introduce institutional management system over delivery, water demand and control (inspection). Without adequate institutional reforms, investments into infrastructure would be ineffective. Economic mechanisms and financial instruments are needed to provide financial sustainability at the lower institutional levels, where final products are created by water uses (Dukhovny et al., 2013).

As defined above, water availability is crucial for the agriculture production, country economic development and country food security. However, it can be stated, that all the 6 assessed region are endangered by different aspects of water stress over the next 10 to 20 years.

Own results defined that waster is a problematic issue in all regions. Complex risk of water stress represents a medium risk, except in the areas of Muminabad, Kuhistoni and Kanibadam where the risk is extremely high. Seasonal variability has a high degree of risk. This means that dry months can be even drier and wet months wetter, there is a risk of drought and extreme rains. Selected areas are equally affected by high levels of risk, except in the Muminabad area, which is extremely vulnerable. The highest risk in water supply is in the areas of Gissar, Fayzabad and Shaartuz, the lowest risk is in Kuhistoni Mastchoh. The fact that the Kuhistoni area is alpine, where snowfall and melting are expected, may play a role here.

Water supply is also related to glaciers and effects of climate change on glaciers. Glacial zones are projected to decrease by 15% -20% compared to the current level, while according to forecasts based on the current rate of glacier retreat, most of the small glaciers in Tajikistan will completely disappear in 30-40 years. The reduction of the number of glacial zones will have a significant impact on the freshwater reserves in the Zarafshan, Kafernigan, Karatag and Obikhingou rivers, which will further exacerbate tensions over the rights to use water resources, both inside and outside the state borders.

Observed increases in river flows are unlikely to continue until the middle of the century (the Pyanj River basin). If there are missing adequate preventive measures, climate change can increase the average temperature of the basin from 0.7°C to 1.40°C - 3.0°C by the middle of the 21st century and reduce the volume of glaciers by 50% - 70%; The risk of floods, mudflows and avalanches is expected to increase. They already occur regularly during the spring snowmelt months. Tajikistan also faces significant risks from glacier lake outburst floods (GLOFs), which occur when moraine dams holding back accumulated meltwater in high altitude areas. These events can also happen as a result of, or cause, landslides and dangerous mudflows. Drought, floods or extreme weather conditions, through the intensification of the problem of poverty (destruction of crops and deprivation of income), contribute to an even greater activation of migration processes - the population is forced to move in search of work (Chapman et al., 2021)

Water consumption in Tajikistan is increased by the high need for water to irrigate crops. Estimates of this consumption are a 21-year average around the target year for the two-time horizons 2030 and 2040. All three scenarios for the time horizon 2030 show a match - the highest risk - the highest water consumption - for the Kanibadam area, a lowland agricultural area. For the time horizon of 2040, with an optimistic, common, and pessimistic scenario, the Kuhistoni area was added to the Kanibadam area.

About half of the irrigated area supplied by Agency for Land Reclamation and Irrigation (ALRI) is supplied by pumped water. In 2017, according to ALRI, the area under pumping irrigation received 2.15 billion m3 of water, However, to deliver this quantity, ALRI had to pump about 5.07 billion m3. Current situation of piping is not in good conditions. About half of the 600km pressure pipes need replacement. ALRI estimated that the water supply cost under pumped system is of 0.77 USD/m3. Gravity irrigation is less demanding in infrastructure, costs and maintenance. About 47% of the ALRI total service area is fed by gravity and received 2.3 billion m3 of water. According to an estimate, the real cost of water supply by gravity was about 0.27USD/m3 in 2017. About 3% of the ALRI total service area is fed by groundwater wells with submerged pumps. In 2017, water from wells was delivered in amount of about 122 million m3. Cost of water from groundwater wells was estimated to be in 2016 about 0.42 USD/m3. In later years, this figure was likely to be at least two times higher because the electricity costs increased significantly. According to the recent study, the costs of irrigation inefficiency are about or USD 44.11 per irrigated hectare per year or USD 11.16 million on average per year (OECD, 2020).

In the following section, issues related to water and irrigations are specified.

Fayzabad

The available data suggest, that the main reason for the reduction of water in the canal and, consequently, the lack of water for farm households is, a decrease in the annual amount of precipitation during the autumn-winter period. Snow cover has been reduced. In the past it was possible to observe water in the canal covered in ice, freezing, this phenomenon has not been seen in the last, about 10 years. The lack of water is, especially, observed during the re-seeding period, i.e., in June-July.

The arable land of the Fayzabad district of 3,566 hectares is irrigated with the help of an irrigation network (canals and ditches, reinforced concrete flumes and pumping stations). of which 1,055 ha are irrigated with pumping networks. Water was provided through 1 and 2 lifts using a 29 km long canal for the lands of the Fayzabad region from the Kafirnigan River. Out of total sown agricultural land (8,666 ha in 2016) it makes 41% of land under irrigation.

Gissar

The available data suggest, it has been investigated, that snow and the glacier cover has been decreasing over time, which led to the lack of water in summer and water emergencies in winter. The acute shortage of water is perceived at the end of July. An increase in average temperatures moves the start of the irrigation and agricultural season to earlier dates. While 20 years ago, people planted crops in March, currently, the irrigation and agricultural season starts in February. Some farms started to collect three harvests per year instead of two. This leads to more water requirements and more evaporation.

The irrigated area of agricultural land in the entire Gissar district was 11,645 hectares, of which 951 hectares are irrigated with the help of 18 pumping stations and 10,934 hectares by gravity from the Gissar Canal and the Khanaka River. Out of total sown agricultural land (18,887 ha in 2016) it makes 62% of land under irrigation.

Muminabad

The available data suggest that the impact of climate change on the agro-industrial sector in our area can be assessed as a significant problem. As a result of decreasing precipitation, water resources are decreasing. For example, the flow rate in the Kululu canal (design capacity 2.8 m3/sec) in the spring period of the year, is only 2 m3/sec, and in June the water flow is minimal (0.15-0.20 m3/sec). This leads to a shortage of irrigation water in dekhkan (farm) households. Also, an increase in atmospheric air temperature has led to a reduction in snow cover (maximum temperature in summer is 40-42 °C).

On the balance of these institutions are 145 facilities and a pumping station. In comparison with other districts of the Khatlon region, one of the characteristic features of the district is the location of the district in the lowland of the mountain range. For this reason, the level of groundwater is very high and becomes the cause of the deterioration of the ameliorative state of agricultural land and the ecological situation. In the Muminabad district, the total area of irrigated agricultural land is 2,676 hectares. The total length of the drainage and collector networks of the district is 56.3 km, of which 29 km (51.5 percent) are on the balance of the water supply enterprise, 27.3 km (48.5 percent) on the balance of rural jamoats. More than 490 hectares of sown lands are irrigated with the help of canals and 10 pumping stations on the territory of the district.

Out of total sown agricultural land (14,207 ha in 2016) it makes 19% of land under irrigation.

Kuhistoni Mastchoh

In Kuhistoni Mastchoh, there is gradual increase in temperature in summer and winter combined with reduced precipitation. In the last 10 years, there has been almost no snowfall in the Zarafshan valley. Precipitation is irregular leading to flash floods in spring and summer. Almost 100% of the region drinking and irrigation water is supplied from mountain springs. In winter the region has only little precipitation and dry air, in spring there is an increase in rainfall above (the norm), resulting in mudflows, avalanches, rockfalls and landslides.

The irrigated area of agricultural land in Kuhistoni Mastchoh totalled 3,536 hectares; irrigation is carried out by gravity from the stream of the Zeravshan River. In the region, almost all sown land is under irrigation.

Shaartuz

In Shaartuz, there has been a decrease in rainfall in recent years. Consequently, the water level in the canals is going down. Water is available until May 15 when the grain harvest. For the second harvest (re-sown in June and July) there is a particular shortage of water for irrigation during this period.

On the territory of Shaartuz region 14216 hectares are irrigated lands. In the district, the "State Enterprise of Water Management of the Lower Kafirnigan River" operates, which is engaged in the provision of irrigation water. The enterprise is responsible for the maintenance, cleaning, and restoration of 133 km of on-farm and inter-farm canals, 77.5 km of on-farm and inter-farm drainage channels, and collectors. On the territory of the district, 2,706 hectares of irrigated land are irrigated with the help of pumping stations. There are 5 pumping stations in the district, in which there are 13 units of pumps.

Out of total sown agricultural land (12,839 ha in 2016) it makes 21% of land under irrigation.

Kanibadam

The available data suggest, that increased drilling of boreholes and use of groundwater (technical) not only for irrigation but also for drinking purposes. Currently there is Increase in the threat of drought on about 16,000 hectares of agricultural land. In the region there is observed a change in the period of warm winds, contributing to the melting of glaciers in the Isfara River. Reduced drinking water coming from the Big Fergana Canal (BFC) in the western part of the district (about 60% of the district).

The irrigated area of agricultural land in the city of Kanibadam totalled 23,764 hectares, of which 6,500 hectares are irrigated with the help of pumping stations of water taken from the Syr Darya River and 17,264 hectares by gravity from the Great Fergana Canal and the Isfara Say River. Irrigation of lands and improvement of their ameliorative condition is a key area that determines the development of the agricultural industry and affects the volume of agricultural production.

A.2 ADAPTATION SCENARIOS/MAIN INTERVENTIONS

- Establishment of a reservoir on the Isfara River in Kanibadam district, as well as the creation of small reservoirs in the BFC (cost of about USD100 million)
- Creation of artificial reservoirs in the foothills (cost of about USD 150 million)[2];
- Provide the WUAs with the machinery to clean the canals[3]. Sediments and siltation, which negatively affect the volume of transported water.
- Increased use of land and water use culture (cost of about USD 0.1 million). This is linked to state and regional agricultural development programs, which include increasing the knowledge of farmers and agrarians as a tool to improve agricultural efficiency.
- Greenhouses can be developed and equipped with modern technology, which partially solves the problem of irrigation water shortage in the area in Kanibadam district[4]
- Improve pumps on steep terrain to increase the efficiency of watering

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[2] Small reservoirs could be one alternative to the pumping cascades. There were constructed several reservoirs in Soghd and Khatlon which simplified water delivery. Small reservoirs construction can solve problems, helps reduce damage by floods and mudflows during spring and winter. There is plan by ALRI for potential 26 locations. Those reservoirs could simplify water delivery, by changing pumped system into gravity irrigation. However, the small reservoirs are not able to replace all pumping stations delivering a massive 2.15 billion m3 of water annually. One 3.5-4 million m3 reservoir requires costs of 10.9 million USD. ALRI estimates construction of small reservoirs could provide 130 million m3 of water, which would save about 1 million USD on its annual electricity bills (about 1% of total electricity costs) (OECD, 2020)

[3] Tajikistan is facing lack of agricultural equipment. As observed in the figure below (latest FAOstat data from 2008 - (FAOstat, 2022)), Tajikistan was facing reduction in number of tractors over the years. As resulted from panel discussions, in selected regions there is not enough capital to maintain vehicles or renew old soviet machines by more recent tractors. Machines are later missing for drainage maintenance. The irrigation and drainage infrastructure is seriously degraded The lack of agricultural equipment in general means that the irrigation canals and drainage ditches cannot be cleaned, and irrigated land goes out of production. During the Soviet times, Ministry of Land Reclamation and Water Resources operated about 10,000 pieces of equipment; now it has fewer than 800 (Asian Development Bank, 2013). Thus, the Ministry is incapable of cleaning drainage canal which has led to serious problems of high-water tables. Farmers have neither the equipment nor resources to do this on their own.

[4] For Tajikistan, the UNDP (2019) report estimated, that costs of greenhouse construction ranges from USD 100 /m^2 for plastic southern wall up to USD 150/m^2 if southern wall covered by glass. The investment costs could be coupled in less than 3 years if well managed. According to Tajik Start-ups (2021) the costs of greenhouse construction ranges USD 15 – 20 / m^2

- Introduction of drip irrigation[5]
- Creation of a reservoir on the Zarafshan River in the Kuhistoni Mastchoh district. This contributes, on the one hand, to solving the problems of lack of irrigation water in the region, and on the other hand, mini power generating units can be installed on this reservoir, which will solve the problem of lack of electricity in the region. For the creation of such reservoirs, there are good conditions and not much investment is required.
- Creation of pumping stations near the Zarafshan River, which will solve the problems of lack of irrigation water in the region.
- Improvement of irrigation infrastructure, contributing to the economical use of irrigation water. Construction of concrete trays and pipelines from water sources to agricultural land (or settlements). This, in turn, prevents the problem of not only high-water loss, but also reduces labour costs for the restoration of ditches and the creation of canals by hand.
- To store water in times of shortage, a reservoir should be built to collect water. The reservoir will also create a microclimate, and this may help to reduce population movements to other parts of the country.
- Rehabilitation and reconstruction of irrigation and collector-drainage networks in Shaartuz district.
- Rehabilitation and modernization of pumping stations supplying water from the Kafernigan River to the 50-solagi canal (out of 4 pumps, only one is operational today) in Fayzabad district.
- The construction of additional water retention facilities on the Surkhak River, from which the Kululyu canal in Muminabad district draws its water, which should facilitate greater water collection, thus addressing water shortages during the irrigation season in Muminabad district

[5] Introduction of drip irrigation in pump-fed areas could be another option to increase irrigation efficiency and reduce costs. On average, about 4.4 thousand USD/ha would be required to introduce drip irrigation, where feasible. For example, ALRI estimates that introduction of drip irrigation on the fourth and upper levels in areas fed by pumping cascades would save about 128 million m3 of water and over 0.9 million USD in electricity costs annually. Recent ALRI studies also suggest that drip irrigation and a shift to higher value crops could significantly improve water productivity, particularly in the case of sweet cherries, melons and potatoes (OECD, 2020). Increase in crop yields of 40% is anticipated among all crops. Payback period ranges between 4-5 years in the case of wheat and cotton, to 1 – 2 years in the case of orchards (UNDP, 2019).

10.2. **Problem B**: Insufficient access to drinking water

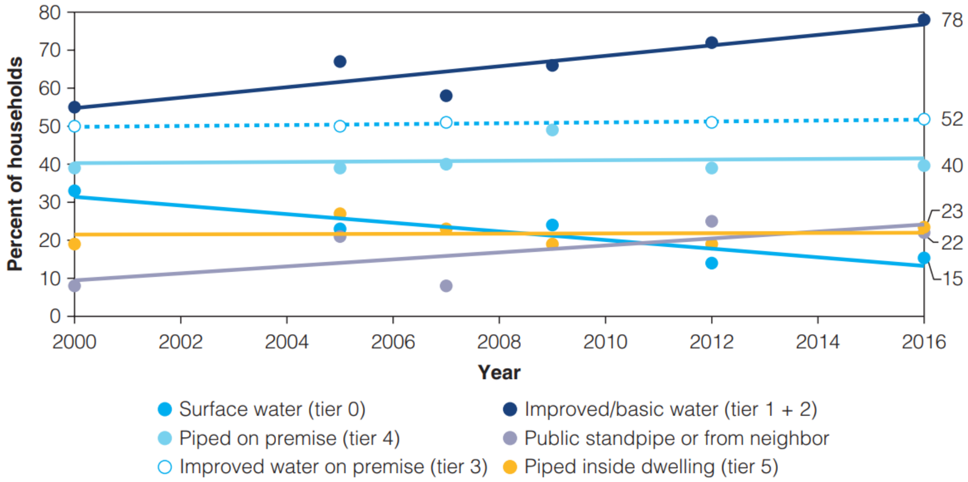
B.1 STATUS QUO

According to a 2018 UN study, Tajikistan ranks 156th among 177 countries in the world in terms of its population's access to drinking water. Despite considerable effort and investment, lack of access to clean drinking water continues to be a major issue in Tajikistan, particularly in rural areas. Only 51.4% of the country's population have access to clean water and many residents rely on rivers and open ditches for drinking water.

Tajikistan has abundant resources of fresh water. Its lakes hold reserve of 20 km3 of water, while glaciers hold 845 km3 freshwater additionally. Nevertheless, the mentioned facts, outside the capital of Dushanbe the quality and availability of water supply remain poor. Poor is also sanitation, and hygiene (WASH – Water Supply, Sanitation, Hygiene) remain poor. The current water, sanitation infrastructure was built before the 1980s, recently it has not been updated. WASH infrastructure is either in poor condition or absent. Mainly in rural areas and small towns. In 2011, the State Unitary Enterprise Khojagii Manziliyu Kommunali (national monopoly of water distribution) estimated the physical investments needs for water supply and sanitation alone to be near $2 billion (World Bank, 2017).

Between 2000 and 2016, improved/basic water access increased from 55 to 78 percent of the rural population from 2000 to 2016 (see Figure 10-1). This improvement has been caused by replacing surface sources with water from public standpipes. In the rural areas, the private piped connections are very rare and reach only limited segments of the rural population. As a contrast, see the urban population. Over 80 percent of the urban population has water pipes connected in their dwellings. Water availability remains a challenge. Even when households have water access, availability and continuity of water supplies is not stable. 25% of households in Tajikistan have problem with sufficient access wate quantities needed. Water availability is interrupted for a long, as there often occurs breakdowns in water supply infrastructure. Interruptions are more often in rural areas, they could last week or more. More significant water problems are increased during winter, mainly because of frozen water, frozen pipes, or electricity outages. Another issue is water consumption metering. Only 15 percent of water connections on the national level, in rural areas this is only 5%. This situation result into the fact, that households waste water, do not use it efficiently and do not pay enough for the amount of water they consume (World Bank, 2017).

Figure 10-1 Trends in multi-tier levels for household access to main water source, 2000 – 2016 (% of households)



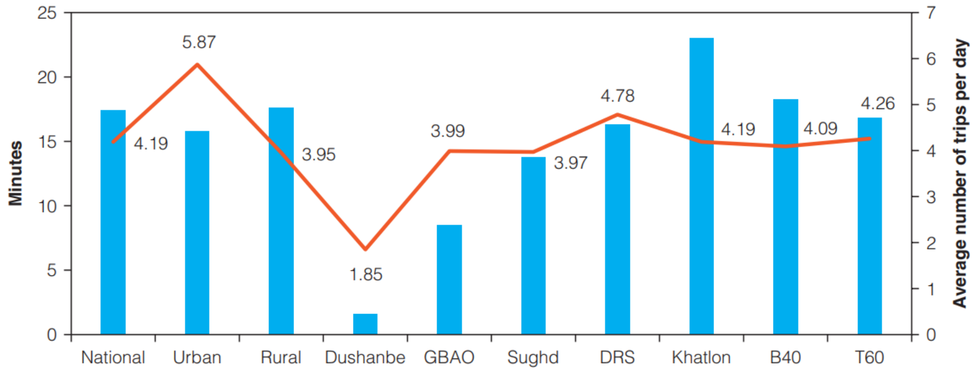
Source: World Bank (2017)

Due to insufficient infrastructure, drinking water contains high levels of bacteria with low palatability. However as observed, Tajikistan water does not include high rates of E. coli, so it could be stated that faecal contamination is not a major concern. Because in rural areas prevails more opened and unprotected sources, coliform bacteria are more commonly detected in rural households (58 percent) than in the urban locations (49 percent). Low E. coli rates are explained by the fact, that less than 1 percent of the population practices defecation in open area. Population access to safely managed water sources varies. Only 31 percent of rural households has access to safety managed water source, while in urban households this makes almost 60% (World Bank, 2017).

Poor WASH conditions are often connected with the risk factors for stunting and childhood mortality, diarrhoea. This results into increased health costs for the population, mainly health costs related to children. Children in poorer households carry majority of the cumulative share of exposure risk and overall disease risk (55%). The 40 percent of children with the highest risk are in urban settings and 75 percent of the overall risk in rural areas. This leads to conclusions that higher risks are often found in the poorest and most vulnerable communities.

Among different costs related to health problems of children, households in Tajikistan incur a range of monetary and nonmonetary costs related to supply of water. Piped households spend about 5% of their annual expenditures on cold water. Poorer households and households from rural areas mentioned to spend even more than 5. Non-piped households also include higher per unit costs. Non-piped customers also have to cover costs, among water, related to repairs, water treatment, and water transportation. If the household is not piped, members must spend an average of 17.4 minutes to reach their water source, collect water, and come back home. Results of the survey (Figure 10-2) present, that households' members have to go for water 4.19 times per day. Most commonly (80 percent of these trips) members have to carry on foot heavy buckets of water from long distances. The WASH survey presented, that 21 percent of the Household surveyed reported back pain and 12 percent of respondents reported having musculoskeletal problems.

Figure 10-2 Average time to reach the main water source (blue bars) and average number of trips per household (red line), by location and wealth (2016)



Source: World Bank (2017)

Initially households were accustomed to spending TJS 70–500 per month on water services. These costs included fuel to deliver water, and/or electricity for private well pumps to pump water. After the piped connection returned to operation (after reconstruction), most community residents reported a decrease in household costs. The financial obligations have dropped to TJS 10–120 per household per month, depending on family size, scheme type, and month of the year. Measures positively affected the well-being of Tajik households, while reduced the financial burdens associated with securing drinking water supplies. Costs related to travelling to water distribution point also needs to be considered. Women and school-age children were primarily responsible for these tasks. Health risks associated with water transportations included miscarriages, bleeding, fractures, stretched muscles and joints, back pain, and kidney inflammation. Positively, improved access to water improved frequency and consistency of household hygiene practices, such as frequency of washing, bathing, laundry. If gastrointestinal disorders (diarrhoea) appear among the family members 1st use traditional medicine (drinking pomegranate skin water, yellow flower tea, or boiled rice water). If not helping, households need to buy treatment, while cutting expenditures on clothing and food.

Table 10-4 Typology of monetary expenses of households to obtain water (qualitative field research)

Indicator	Centralized water supply	Artesian well/ private well	Water brought by private cars[a]	Water delivered by water trucks
Average monthly expenditure (TJS)	20–30	20–30	10–50	30–120
Average annual expenditure (TJS)	240–360	240–360	120–600	600–1440

Source: World Bank (2017)

Table 10-5 Monetary, time and health costs households spend for each water source

Water source	Monetary costs	Time costs	Health costs
Centralized water supply	Low/Medium	Medium/High	Medium/High
Open sources (rivers, canals, aryks, etc.)	Low	High	High
Water delivered by trucks	High	Low	Low
Water brought by private cars from other places	Medium/High	Medium/High	Low
Artesian well/private well	Low/Medium	Low	Low
Bottled water	High	Low	Low

Source: World Bank WB (2017) team analysis of qualitative data collected through focus group discussions.

Additionally, the costs related to medical problems could involve the following:

- cost of doctor visit USD 13.9 for those visiting due to an acute condition (Fischer et al., 2020).
- mean expenditures on drugs procured following consultation corresponded to 77.6 % of total expenditures related to the visit (Donadel et al., 2016).

B.2 ADAPTATION SCENARIOS/MAIN INTERVENTIONS

- Establishment of a reservoir on the Isfara River in Kanibadam district, as well as the creation of small reservoirs in the BFC (cost of about USD 100 million) (Big Ferghana Canal)
- Creation of artificial reservoirs in the foothills (cost of about USD 150 million).
- Provide the WUAs with the machinery to clean the canals.
- Improve pumps on steep terrain to increase the efficiency of watering.
- Creation of a reservoir on the Zarafshan River in the Kuhistoni Mastchoh district. This contributes, on the one hand, to solving the problems of lack of irrigation water in the region, and on the other hand, mini power generating units can be installed on

this reservoir, which will solve the problem of lack of electricity in the region. For the creation of such reservoirs, there are good conditions and not much investment is required.

- Creation of pumping stations near the Zarafshan River, which will solve the problems of lack of irrigation water in the region.
- To store water in times of shortage, a reservoir should be built to collect water. The reservoir will also create a microclimate, and this may help to reduce population movements to other parts of the country.
- Rehabilitation and modernization of pumping stations supplying water from the Kafernigan River to the 50-solagi canal (out of 4 pumps, only one is operational today) in Fayzabad district.

10.3. **Problem C**: Land degradation/Soil erosion (including salinity increase)

C.1 STATUS QUO

Based on the historical context and irrigation, land degradation has become a serious issue in the region. This is intensified by increase in livestock numbers on rangelands, and agricultural land conversion in steep areas. All together threatens the living and economic conditions of rural populations (Quillérou et al., 2016). Although estimates vary and can be imprecise, land degradation is estimated to be quite extensive in Central Asia, ranging from 4% to 10% of cropped land, 27% to 68% of pastureland and 1% to 8% of forested land. In total, this represents 40% of 66% of the areas degraded in each country (World Bank, 2020)

The land degradation mostly causes problems as follows: (i) widespread losses of fertile topsoil and nutrients necessary for growth, (ii) losses of biodiversity and habitats, (iii) declining productivity of crops and pastures, (iv) increasing weed infestation in rangelands, and (v) increasing salinisation and deforestation (Quillérou et al., 2016).

Given the country's mountainous geography, only 5% of the land is arable. The most economically impacting land degradation occurs in agricultural areas. Agriculture also accounts for 90% of water consumption. High water tables, erosion and salination are diminishing soil productivity and erosion affects 60% of the irrigated land. This is a major problem in a country were only 5% of the land area is arable and agriculture accounts for about quarter of GDP (World Bank, 2021).

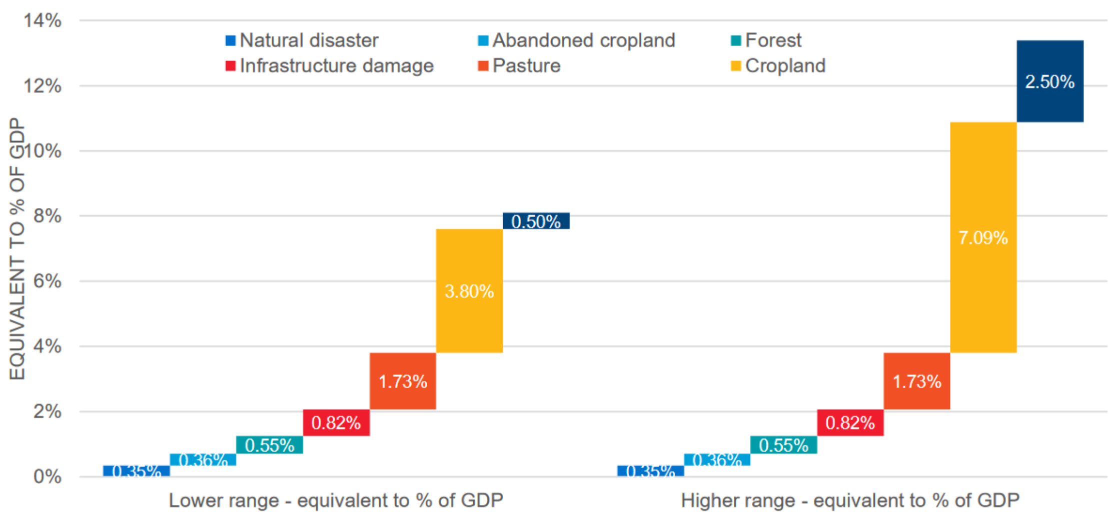
Being one of the most land-deprived countries in Central Asia, land degradation in the country aggravates the scarcity of land and is therefore one of the main problems the rural population faces. Nearly 10,000 hectares (ha) of irrigable land is not used due to soil salinization and other reasons (Akhmadov, 2010)

Total land area used for agriculture production increased by approximately 30 % between 1992 and 2004 and stagnated around 900,000 hectares afterwards. In particular, while in 1992 about 700,000 hectares was used for agricultural production, in 2020 more than 900,000 hectares was cultivated (Food and Agricultural Organization, 2022).

FAO recorded a massive growth of fertilizers, water and labour force consumption. Agricultural production is becoming to be more and more intensive. While in 1992 the average crops yield per hectare reached about 3 tonnes, in 2020 it was nearly 9 tonnes per hectare. The intensity of agricultural production increased, and its performance is more dependent on water consumption and investments. The growth of production is even boosted through more convenient climate conditions in several regions in Tajikistan. According to local data – the number of local harvests increased in several regions. On the other hand, the demand for inputs also increased. The key weakness of future agricultural performance development in Tajikistan is limited water access as water availability in many regions in Tajikistan is limited and upcoming climate changes could make water availability even more limited.

In all of the analysed districts we observe clear trend of decrease of agricultural land. The steepest decline is evident in Muminabad (minus 27%) followed by Fayzabad and Gissar (-14% and -13% respectively). The smallest decline in agricultural land is shown in Shaartuz where the sown area decreased by only 2% between 2005 and 2016. Most of the land in the selected regions is used for grain and legume cultivation, where does share a ranged from 17.5% in Kuhistoni Mastchoh to 73% in Muminabad. Forage crops play also important role in region cultivation as they cover 34.1% of cultivated land in Fayzabad and about 20% in Gissar and Kanibadam. Cotton is seen as a third important commodity, even though it is being produced only in Gissar Kanibadam and Shaartuz. Sown agriculture land usage in six selected regions goes in the opposite direction to general trend of the whole Tajikistan.

Figure 10-3 Costs of environmental degradation by category



Source: (World Bank, 2020)

The study of World Bank (2020) tried to estimate the costs of land degradation the minimum total economic cost of land degradation in Tajikistan in 2019 to be between USD 539 million and USD 950 million, equivalent to 8.1% and 13.4% of GDP, respectively. These estimates are rather conservative, and the real costs are believed to be much higher. The major costs are related to yield loss in crop lands (equivalent to 7.5% of GDP). The study calls for action as it investigated, that left unchecked, the scope of land degradation is expected to rise, especially with climate change, and extreme weather events, which will see the cost of inaction rise even further

C.2 ADAPTATION SCENARIOS/MAIN INTERVENTIONS

- The creation of terraces on the steep terrain areas will help to avoid water erosion and improve the productivity of the soil
- Organic farming technologies should be introduced in the area (costs depend on the scale of organic farming implementation);
- Increase the efficiency of existing WUAs by wider introduction of billing system
- Projects aimed at land reclamation and melioration
- Building terraces for agricultural land
- On grassland and rainfed areas, carry out deep loosening of the soil to accumulate rainfall into it.
- Creation of terraces and forest belts to eliminate water and wind erosion.
- Slope stabilization for pastures, pasture restoration

10.4. **Problem D**: Natural disasters /abnormal weather patterns

D.1 STATUS QUO

Tajikistan must deal with many emergency situations, which are related to the climatic and geographical constraints. Also, climatic change contributes to the unpredictability of the frequency and the strength of natural phenomena. These factors cause the occurrence of hazard events such as avalanches, mudslides, landslides, glacier movement, floods, etc. (OSCE, 2021). Improved functioning of national agencies related to water/disasters predictions would eliminate number of damages[6].

The impact of natural disasters is both short-term, and long-term on infrastructure, economic performance, and social well-being. The World Bank (World Bank, 2021) estimates the total costs and economic losses from natural disasters higher than 1.8 billion USD and direct negative impact on approximately 7 million inhabitants within the years 1992 - 2016.

[6] There have been proposed measures evaluated by World Bank (2016). Modernization program for Tajik Hydromet should bring benefits within 12 – 22 million USD with estimated costs amounts 6,1 million (World Bank, 2016).

Another study focused on benchmark assessment for selected Central Asia countries shows the negative effect of hydrometeorological hazards on Tajikistan GDP with -1.6 % annually for period 2002 – 2007 (World Bank, 2016).

Between the natural disasters with high risk becomes avalanches. The avalanche prone areas occupy about 75% of the territory and about 30,000 to 40,000 avalanche spots was observed by Ashurov et al. (1999). According to Saidov and Ischuk (2018) it is very complicated to predict the occurrence of avalanches. Generally said the risk raises with the altitude, slope, and the year season. They are typically present at the end of winter and brings the losses on infrastructure and also lives. The direct impact of avalanches was recorded in residential areas as Jirgatal, Hoyit, Gharm, Shughnon, which were destroyed. Damaged infrastructure as bridges and halted transportation for a long period are also recorded (e.g., the road to the southern portal of the Istiklol tunnel, Anzob, Shahriston and Haburobod).

These authors also indicated high risk of mudflows, when approx. 85 % of Tajikistan is threatened by mudflows and 32 % of this area is indicated as high-risk zone. Landslides are very common, and they have both seismic and non-seismic cause. Between the main drivers for mudflow creation have been identified climatic conditions as heavy rainfall, rapid snow melt, glacial lake outburst, geology and geomorphological features as topography leading to slope failure (source of soils and rocks), lack of vegetative ground cover, earthquakes, and anthropogenic as deforestation, overgrazing, the consequences of mining operations and so forth (Saidov & Ischuk, 2018).

About 95 % of mudslides are caused by heavy rainfall or continuous rain (Perov, 2012). In Tajikistan, valley parts and foothills mudflows typically occur in the spring. In the mountainous and highland regions, mudflows usually emerge in summer, when the snowmelt begins. Mudflows is serious hazard in Tajikistan. In 2015 in Tajikistan a simultaneous sharp rise in temperature and precipitation during the spring triggered a series of massive mudflows with catastrophic effects in the country.

Also, landslides are related with the geological conditions of Tajikistan. Together with changing climate reaching new extremes and seismic activity they are the next very common risk in the country. There is also a need to mention the anthropogenic influence as deforestation, formation of irrigation landslides on the slopes of hills crossed with irrigation cannels, as well as in river sides, terrace slopes, etc. They are common in Gissar, Yavan, and Obikiik valleys. Such landslides reduce the area of irrigated lands, destroy water management constructions, villages, and roads, and cause many deaths. Landslide hazards are also significant in Tajikistan. The most active landslide zones are between 700 metres and 2,000 metres above mean sea level (Saidov & Ischuk, 2018).

The selected regions face to the different risk of natural disasters due to their variability. Gissar is characterized by average summer temperature in extremes increased by 40 - 50^{0}C. This leads to temperature shocks (with negative effects on both the health of humans and animals) and to quicker melting of ice in mountain areas. In case the extremely high temperatures in the mountain areas stay for 14 days and over, the newly melted ice and snow is partly absorbed by the soil and creates the potential for mudflows.

On the other hand, in Kuhistoni Mastchoh there is little precipitation and dry air in winter, in spring there is an increase in rainfall above the norm, as a result, mudflows, avalanches, rockfalls and landslides are observed.

Intermittent rainfall, flash floods in spring and summer are typical for Kanibadam. A change in the period of warm winds, contributing to the melting of glaciers in the Isfara River spring. Also increase in the threat of drought on about 16,000 hectares of agricultural land and climate change leads not only to abnormal heat waves, but also leads to a cold spell at certain times. Prolonged cold spells prolonged cold spells physiological and pathological strain on people's health, especially the health of the elderly and those suffering from respiratory and cardiovascular diseases

D.2 ADAPTATION SCENARIOS/MAIN INTERVENTIONS

- It is necessary to strengthen drainage systems and change the way of mudflows, which helps to reduce the risk of not only washing away agricultural land by mudflows, but also settlements. This measure also improves the quality of coastal agricultural land.
- Rehabilitation and plantation of forests will decrease an impact of climate change and will also reduce a risk of mudflows where it is possible. I the areas where the slope is too steep, or where is not possible to plant the forests the other measures should be considered as barriers or artificial corridors for mudflows where the risk is too high and could bring a damage on agricultural production, livelihoods, or even lives (Dazé, 2016). All the afforestation and forest regeneration efforts are contingent upon first establishing control and sustainable use of pastures. Both stat-financed efforts and change in private incentives need to be applied foe a successful results (for more see the section of afforestation and the examples of good practice).
- The artificial forests should be created in adyrs (low, barren hills), which helps to reduce the threat of mudflows, avalanches, rockfalls and landslides. This measure will also contribute to the improvement of the ecological state and environment in the region. Also, the afforestation and forest regeneration will help to reduce mudflows and improve the microclimate in the region, provide more space for pastures and agroforestry in Shaartuz.
- Mudflow protection measures are necessary in Shaartuz district. The Shaartuz district has been identified as very vulnerable and the mudflow protection is needed to be designed according to the local conditions.
- There is a need for bank protection works particularly on the Kafernigan River as well as the construction of flood defences.

10.5. **Problem E**: Reduction in vegetation/forest plantations/pastures

E.1 STATUS QUO

The area covered by forests in Tajikistan has been reduced over the last century. In 1920, up to 30% of Tajikistan was covered by forests (interview data), while in 2016, it amounted to approx. to 3% for Tajikistan in total and for only 0,8% for some districts. The dramatic decrease of forests in 1990th was caused by the disconnection of Tajikistan from the USSR energy resource, deindustrialization of the country, and substantial damage to infrastructure caused by the civil war. Being deprived of the traditional source of energy, the village population of Tajikistan had to resort to firewood for cooking and heating. Much of the trees close to the people's dwellings were cut and burnt. The energy crisis was partly alleviated in 2010-2020, and many new trees were planted. However, the damage to the forest ecosystems has not been recovered yet.

The negative anthropogenic effects on the forestry sector in Tajikistan over the last 30 years were aggravated by population increase. Over the last 30 years, the population of Tajikistan increased almost twofold from approx. 5,200,000 in 1990 to approx. 9,500,000 in 2020 (World Bank, 2022). Over the same time, the rural population increased from to 72% in 2020 (World Bank, 2022) The local ecosystems, including agriculture and forestry, had to accommodate much more people, which given the energy crises, increased the pressure for local energy resources even more.

While agriculture and livestock dominate the Tajik economy, only about 30% of the total land area is classified as agricultural and 7% as arable. Of this agricultural land, 81% is pasture. Much of these pastures are located in high-altitude areas. Often forests are also used as pastures. Over the last ten years of available district-level data (2005-2016), the number of cattle in heads in target districts has increased 1,5 times (Gissar, Kanibadam, Kuistoni Mastchoh, Muminabad) to two times (Fayzabad, Shaartuz). The amounts of sheep and goats in heads increased even more. Most of the livestock is fed on pastures, which leads to overgrazing. Overgrazing may substantially worsen the negative consequences of climate change, namely the soil degradation, especially erosion and consequently reduce availability of water. Also, it can lead to other negative weather-related emergencies such as floods and mudflows. The damaged forests and pastures cannot efficiently serve as parts of water catchment areas. The reasonable management of pastures and livestock is indispensable for sustainable agriculture and water use.

The forest system in Tajikistan was substantially damaged over the last century. Much of this damage was of anthropogenic nature - cutting the woods to create more space for agriculture and pastures, to get the firewood to feed and warm a much bigger population, to accommodate much larger livestock. The negative effects of climate change are then aggravated by already thinned forest cover and damaged forest ecosystems. Based on interviews with experts can be noted that, if nothing is done, the most probable outcome for the period of next 10-20 years will be:

- increased devastation of forests by livestock and human activities will eventually lead to the elimination of forests in the areas accessible to humans
- the existing forests will get older, which will limit their role in local ecosystems in locations far from humans
- the droughts will damage the forests, especially in the lower altitudes
- the mudflows and waterflows will damage the forests in higher altitudes
- the pests will continue to damage the forests, especially in the southern parts of the country

As a result, the most negative scenario accounts for the elimination of forests in lower altitudes. The remaining forests are in higher altitudes and in areas not accessible to humans.

The predicted effects of climate change on the population if nothing is done, the most negative scenario. The effects of this scenario can be devastating for the population, agriculture, water systems in many ways:

- The population will be more affected by droughts as areas originally covered by forests will lose their power to transfer the rainfall water underground. This will affect both the access to drinking water and the water for irrigation. Agriculture, especially in the areas where it relies on underground water, will lose this source of water. In addition, lack of underground water may increase the salinity of the soil, which may eventually make the soil unsuitable for agricultural production.
- The population will be more affected by sudden water- and mudflows in the regions vulnerable to this, as the area, originally covered by forests, will lose the capacity to slow the water down.
- The population will have to face the increase in temperature, as the territory originally covered by forests will lose its capacity to accumulate parts of sun energy. This may negatively affect the health status.
- The population will have to face decreased air humidity, which may negatively affect the health status.
- The pastures, originally covered by low-density forests, will lose the stability of their ecosystems and most likely will not be suitable for grazing.
- The population will lose the fruits, nuts, and other forest products it used to pick in forests.
- The areas originally covered by forests will be more prone to water and wind erosion and the creation of canyons, which eventually make these areas unproductive.
- The wind erosion may cause dust storms, which will negatively affect the health status of both humans and animals and decrease the outputs of agricultural production.

- In some regions, conflicts of wild predatory animals and local farmers are more probable.
- All the factors above may make most affected parts unsuitable for living and create a push factor for national or international migration. Given the existing habits of the local male population to get employment in foreign countries (mainly Russia), this may lead to cross-country migration of the whole families.
- The country will lose a part of its capacity to accumulate CO_2 in forests, which will have a negative effect on local and global warming.

Fortunately, this extremely negative scenario is fought against. The Government of Tajikistan and international donors exert notable efforts to prevent the total devastation of the forest sector in Tajikistan. Yet, much more needs to be done.

E2) ADAPTATION SCENARIOS/MAIN INTERVENTIONS

- Species adapted to droughts and high temperatures including species used in afforestation
- An information and advisory centre should be set up to provide timely information to dekhan farms, which would help farmers to find answers to many of their questions: on crop cultivation technology in relation to weather conditions and other matters in all districts.
- the need for the restoration of over five hundred hectares and the effective use of 1,000 hectares of orchards and vineyards in both Shaartuz and Fayzabad districts.

  For pastures, the following recommendations are summarized below

Table 10-6 Recommendations for pastures

	Introduce an institutionally viable pasture management system to limit the number of animals authorized to graze in fall-spring, winter and all-year pastures
	Make pasture management the responsibility of users through a pasture users association
	Clearly define the rules of pasture use that will establish access to pastures on a sustainable basis
	Increase the availability of livestock feed through sustainable and economically acceptable agricultural practices (reinforce cotton-Lucerne crop rotation, raise forage crop yields, increase the domestic supply of wheat)
	Raise forage and mixed feed availability by making land and business permits easily available for mixed feed storage and production plants and for forage and mixed feed sales point operated by farmer cooperatives in rural areas
	Eliminate trade barriers for imported wheat flour from Russia and Kazakhstan, thus making more domestically grown soft wheat available for feed use

Source: Adapted from Sedik (2009).

11. The examples of good practice

Examples of good practices: Forestry. The Gissar example

Based on interview data, In the Gissar district, there are approximately 13,000 hectares of forests in total, 11,000 of which are transferred to private hands for maintenance, while the land ownership remains in the hands of the government. The government kept the remaining 2,000 hectares only. Several models of government-private cooperation have been proven successful and long-term sustainable.

- The private side gets some area covered by forest for private administration and maintenance. The private side is responsible for maintaining the forests, having the right to utilize the forests as pastures, and keeping 60-70% of fruits and nuts produced by the forests. In this case, the forests need to be fenced to prevent other villagers and animals from entering the forest, thus preventing overgrazing and other damage. The private side is then able to provide the pasture space for other fellow villagers for a price. The population is helped in education, seedlings, technical assistance, agro-technics, training, and management plan. The funds for this assistance come from leskhoz, the state program or from the international donors (together or in parallel)
- The private side gets some small area within the forest to plant fruit trees or watermelons. This motivates the private side to bring water to the area in order to water whatever it plants. This increases the overall amount of water in the area, and the trees nearby benefit from the water flowing from the planting space to the outer terrain.
- The forests space in the hands of the government gets fenced, and the right to pasture cattle is then sold to other villagers.

Example of good practice: Education and local participation

Education of locals about climate change is considered one of the most important factors for success. In this respect, the experience of the project "*Ecosystem-based adaptation to climate change in high mountainous regions of Central Asia*" is of paramount importance. The participants from local villages were educated about the possible scenarios of climate change and were asked to analyse adverse impacts on their livelihoods and propose measures to help adapt to these changes. The measures were then tested, implemented, and monitored. The project was conducted in pilot regions in Kazakhstan, Kyrgyzstan, Tajikistan.

The government-private partnership can only be possible in the areas close to the people's dwellings and in the areas not affected by immense climate-related disasters such as water- and mud flows as private persons usually do not have funds to invest in substantial climate-related protection (such as mudflow diversion or drainages). Forests far from villages need to be maintained by the state forestry organs (leskhozs).

Based on the project outcomes, the following was defined as most urgent:

- The biggest problem was reported to be the lack of water. Thus, all the irrigation systems need to be rebuilt, renewed or built anew. Irrigation systems in high mountainous areas the irrigation systems can be built on springs, while on plains, machine-tractor irrigation accompanied by spring irrigation is more applicable.
- The other problem is the protection of forests from overgrazing. Fences are needed.
- Capacity building of organizations involved in forest maintenance is the other way to go. The following needs to be done:
    a. To strengthen the material and technical base (tractors and other techniques)
    b. Providing training and seminars for the population and advanced training of forestry workers.
    c. Bringing new young employees to the forestry sector, increasing their level of education, connecting to practice, diminishing brain drain, increasing salaries and/or other benefits. Many of the current workers of Leskhozs are specialists educated in the Former Soviet Union. These people get old and soon will not be able to work. The young generation is not attracted to the sector of forestry due to low wages and low connection of existing study programs in forestry in Agrarian universities to practice. More contact with the actual forests needs to be included in the study programs. Currently, 20-25 people graduate from forest faculty, and 2-3 only will likely work in Forest Agency (leskhoz). The rest, who works in Forest Agency (leskhoz) do not have higher education. The remuneration policy can be inspired by that of Soviet times. In Soviet times people working in forestry got one hectare of forest for use. In addition, the state provided free firewood, uniform clothing, animal transport (horses). Currently, maintaining horses is expensive and rarely done.

Examples of good practice. Water resources

17 machines and mechanisms (excavators, loaders, concrete mixers, trucks) were allocated to the Agency of melioration and irrigation by UNDP in Tajikistan with the financial support of the Government of Japan. These investments give good results. For example, from July 2021 till March 2022, the mechanisms helped to perform the work of 142,380 m, of the volume of 205,790 m3. These works have been implemented in 11 districts and cities (Rudaki, Gissar, Vahdat, Fayzabad, Tursunzada, and Lakhsh in the districts of republican subordination and Danghara, Kulyab, Farkhor, Bokhtar and Levakant in Khatlon region). As a result, 200 thousand of people of these districts, that previously have been affected by natural disasters

are now in the security zone. In addition, 1,400 hectares of land were put into an agricultural turnover in Farkhor district and about 5600 people were provided with work on these lands.

For sustainable maintenance of allocated machinery under the Agency for Land Reclamation and Irrigation under the Government of the Republic of Tajikistan (ALRI) the State Institution "*Mechanized Construction and Repair of Hydraulic Structures*" was established. For this organization, the Ministry of Finance will support the budget for salaries, ALRI will support the budget for maintenance and operation of machinery.

This is a unique case of UNDP support to enhance ALRI's capacity for disaster risk reduction and climate change adaptation.

ALRI hopes that under the second phase of the UNDP Disaster Risk Reduction and Response project, the same vehicles and machinery will be allocated to Sogd, where a similar structure will also be established under ALRI.

ALRI is trying to offer this positive experience to other development partners. It is too early to say, but there is already some progress on this issue.

<u>Practices that do not work</u>

Water-saving technologies are of little use - they do not pay off due to the low price of farm products. For example, drip irrigation is very expensive, payback is problematic. The system is also dependent on the quality of irrigation water (no sediment, no mineralization), otherwise, it will be clogged down. On the other hand, drip irrigation is profitable for greenhouses.

<u>Project success or failure - the role of the domestic population.</u>

Case study: the purchasing of the mechanization (excavators, tractors) - the three contrasting experiences

The short- and long-term benefits of adaptation projects are substantially dependent on the ability of the population to exert the benefits and maintain the infrastructure. The difference can be illustrated in the following case study of three contrasting experiences with one type of development assistance.

The interviewees, participants of the focus groups, and the experts in all the districts listed the purchase of mechanization, such as tractors or excavators to be one of the most wanted types of assistance. However, the equipment naturally needs maintenance and fuel. We were presented with three contrasting stories:

- The equipment was bought, worked for a year, got broken, and there was no money for repair and for purchasing of necessary spare parts. The outcome was the tractor staying unused after one year of usage.
- The equipment was purchased; however, no lease mechanism was created. As a result, the business owner of the tractor did not allow anybody to use it because he

was afraid that the tractor will get broken and there is no money for spare parts. As a result, after one year of experience, a completely new tractor stayed unused.

- The purchase of a tractor was combined with the system of lease and the agreement that the tractor can be moved to different localities. The lease fees were sufficient to maintain the equipment and the use of the tractor was long-term and sustainable.

The example above illustrates the role of locals in achieving the benefits of internationally supported projects.

In some cases, the efficient utilization of project potential can be substantially increased if the follow-up projects are adopted and enacted. The next example presents a relevant case study.

Case study: Water Users Association, Gissar

Water Use Association was originally founded in Gissar with the help of international donors. The donors helped to build houses, where the organization could operate, provided the relevant know-how and legal support, and left. Currently, the WUAs suffer from significant inefficiency for the following reasons:

- The employees of WUA are underpaid, and the use of their time is largely inefficient. The salary of the employees is small and amounts to approx. 40 US dollars. The duties of the employees include collecting the payments for water from single households, regulating the water supply, and maintaining the infrastructure (channels). Much of the time the employees spend collecting the money, with various levels of success (the payment collection rate varies from 44,5% to 125% depending on jamoat). Little time is left for the actual water regulating services. The billing system of payment, adopted in pilot studies, can be suggested. Currently approx. 50% of payments in the region are done via a billing system. The projects aimed at billing systems are advisable
- The lack of machinery and equipment obstructs the effective maintenance of irrigation infrastructure (tractors and others). The purchasing of this type of machinery needs to be accompanied by the adequate practice of lending to single users when the fees are then used for the necessary maintenance and the purchase of the spare parts (see example above)
- The effective distribution and efficient use of water are contingent upon adequate control over the single water users. The current control over water use is done primarily by measuring the amount of water received by WUA and the day and night watch over the irrigation channels and control points within the WUA, so that no water is taken non-authorized. The improvement over the control of water use is impossible unless efficient mechanisms of water measurements are in place. The installation of these mechanisms requires control over the loss of water in irrigation channels. The latter requires concrete coating of the irrigation channels and frequent cleaning, which is costly. Besides, purchasing and installation of the measurement and control devices require additional funds that are not available in the region. Additional projects are necessary.

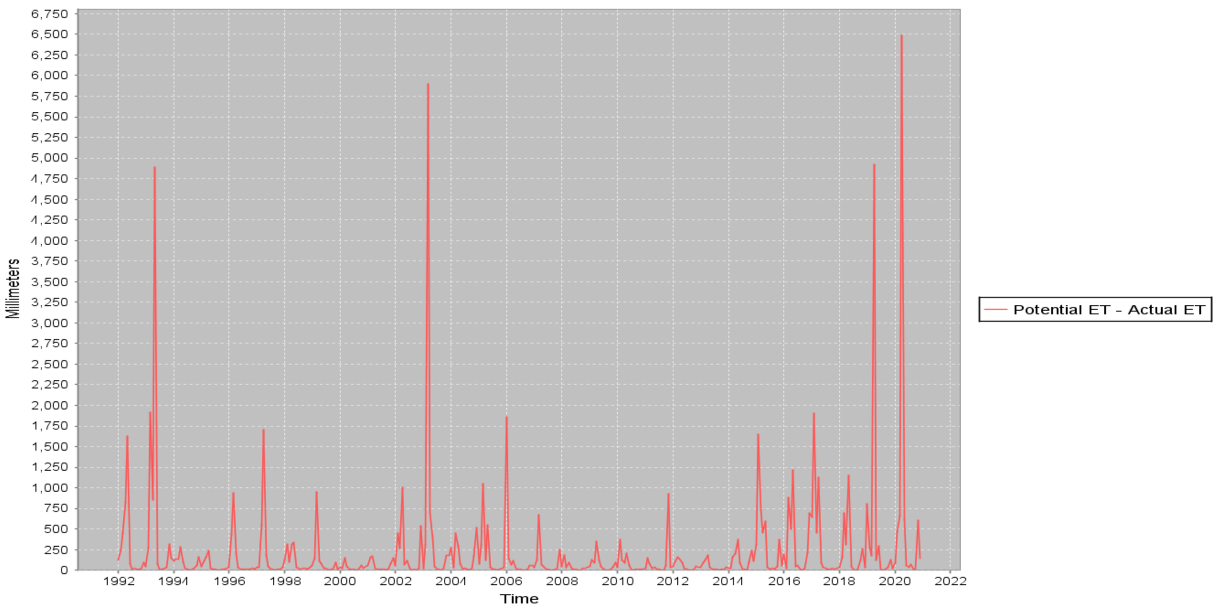
12. Cost-effectiveness of selected climate change adaptation measures in Tajikistan

12.1. The cost effectiveness of measures

The aim of this chapter is to identify cost effectiveness of measures to adapt for climate change in the analysed regions of Tajikistan. To understand the scale of adaptation measures adoption it is important to look at the possible benefits of these measures related to water. Specifically, the issue of water scarcity and its impact upon agricultural production must be evaluated. Water scarcity can be measured using many methods (Goyal and Harmsen ,2014). One of them is Thornthwait's water balance (Thornthwait, 1948; Mather, 2019). Thornthwait's water equilibrium uses a numerical procedure to analyse the distribution of water between the various components of a hydrological system. The inputs to the model are monthly temperature and precipitation. Outputs include monthly potential and current evapotranspiration, soil moisture storage, snow storage, surplus and runoff (McCabe and Markstrom, 2007).

The calculation of water deficit based on the water balance model (see methodological section) for the years 1992 to 2020 can be seen in the Figure 12-1 using the introduced Thornthwaite model.

Figure 12-1 Historical water deficit for Tajikistan between 1992 and 2020.



The output of the model was then used as an explanatory variable to explain changes in the production index for the major crops grown in the individual districts. These crops are seen in the Table 12-1.

Table 12-1 Major crops

Name	crop 1	crop 2	crop 3	crop 4	crop 5
Kanibadam, Tajikistan	vegetable	cotton	cereals	melons	potatoes
Muminabad, Tajikistan	cereals	potatoes	vegetables	fruits	
Fayzabad, Tajikistan	cereals	potatoes	vegetables		
Kuhistoni Mastchoh, Tajikistan	potatoes	Fruits	cereals	vegetable	
Shaartuz, Tajikistan	vegetable	cereals	potatoes	fruits	
Gissar, Tajikistan	cereals	cotton	vegetables	melons	potatoes

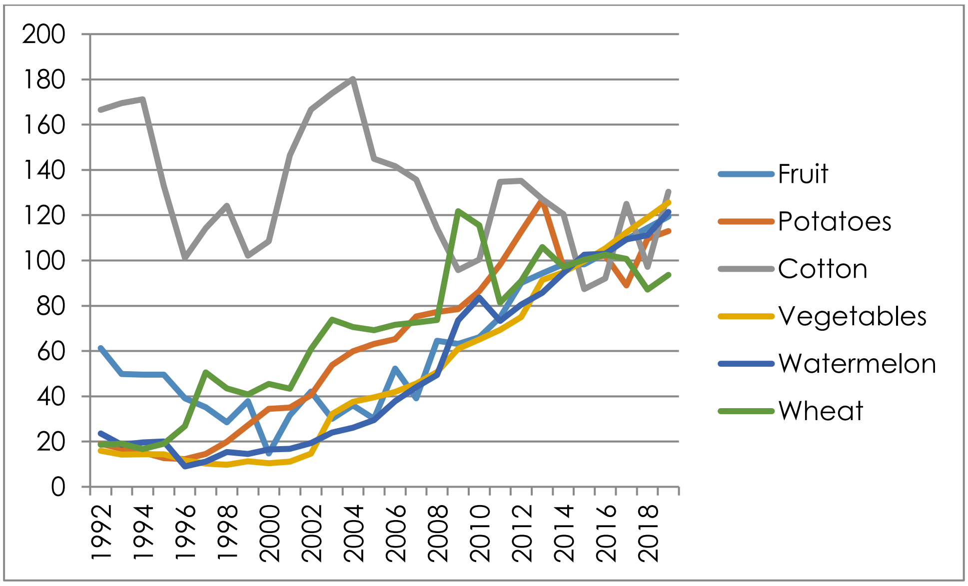
Source: Tajik passports (2022)

For the crops as the source of data food production index has been utilized for individual crops on the aggregate Tajikistan level. These crop production indices are visualized in the Figure 12-2 for the years 1992-2019.

As can be seen from the Figure 12-2, all crops but cotton are strongly trending beginning the early 2000s. Therefore, it has been decided to remove the trend that cannot be explained to the best knowledge of the researchers by the analysed climatic variables.

Consequently, de-trended variables were analysed using ordinary least squares estimation to find out how water deficit influences crop production in Tajikistan. In other words, to what extent can fluctuations in the production of individual crops can be explained by water deficit modelled using Thornwaite model.

Figure 12-2 Crop production index for six analysed crops



Source: FAOSTAT (2022)

Surprisingly, out of the analysed crops, the only significantly influenced crop has been identified the vegetables. The estimated coefficient does not have the expected direction as can be seen from the regression results presented in Table 12-2. For vegetables, trend function had coefficient determination of 0.87 with coefficient of 3.7.

Table 12-2 Regression results for vegetables

R Square	0.165187	
	Coefficient	**P-value**
Intercept	-9.76	0.013
Wdef	0.03	0.031

This result can be interpreted that for vegetable production, abundant water that leads to water deficit can mean lower production due to, for example, unfavourable distribution of precipitation. Furthermore, low R Square coefficient implies that other variables omitted from the model exercise influence over the vegetable production in Tajikistan. These can be related to technological and economic changes in the agricultural sector of Tajikistan. If we accept the idea that water deficit as experienced in the last almost three decades leads to a slight increase in the vegetable production, i.e., if water deficit goes up by 1mm vegetable production index goes up by 0.03 then any changes that lead to massive decrease of water deficit (abundant water, possibly floods) may negatively influence production of vegetable that is a key crop for all analysed regions of Tajikistan. Any adaptation measures and investments must be cost effective and hence any changes in water deficit due to global climate change must be offset thereby. Using the coefficient from the Table 12-2, it is possible to estimate maximum cost for any adaptation measures that should prevent decrease in vegetable production.

General measures taken from World Bank (2008) to adapt to climate change in the region of Central Asia are summarized in the Table 12-3. The table describes individual measures and how they affect risks that are introduced as individual columns which are signified by crosses on the appropriate rows.

Table 12-3 Technological adaptation measures and investments to offset climate change related risks

Aggregation of technological measures and investments	Technological adaptation measures and investments	Drought	Need for soil moisture conservation (rain-fed)	Need for water use efficiency (irrigated)	Land degradation soil infertility, erosion	Heat stress	Pest disease control	Excess rain flooding, storms	Milder winters, longer growing season	Emissions mitigation, carbon sequestration
Soil management	Conservation tillage	x	x	x	x					x
	Nutrient management and use of organic matter	x	x		x					x
Water management	Watershed management	x	x		x			x		
	Water harvesting techniques, storage reduction of run-off	x	x	x	x	x	x		x	x
	Drainage systems	x			x			x	x	
	Use of marine water	x		x						
	Dams for water storage, flood control	x	x		x	x		x		
Irrigation management	Supplemental irrigation	x		x		x				
	Irrigation at critical stages of crop growth	x		x		x				
	Sprinkler irrigation	x		x						
	Rehabilitation and modernization of irrigation infrastructure, canals	x		x		x		x		
	Develop new irrigation facilities	x				x			x	
	Drip irrigation	x		x						
	Furrow and flat-bed irrigation	x		x						
Crop management	Crop diversification	x	x	x	x		x		x	
	Use water-efficient crops, varieties	x		x	x				x	
	Heat- and drought-resistant crops/varieties/hybrids	x	x	x		x			x	
	Switch to crops, varieties appropriate to temp, precipitation	x		x	x	x	x	x	x	
	Crop rotation (sequencing)	x	x				x			
	Switch from field to tree crops (agro-forestry)	x	x	x	x	x	x	x		x
	Timing of operations (planting, inputs, irrigation, harvest)	x	x	x		x	x	x	x	

Aggregation of technological measures and investments	Technological adaptation measures and investments	Drought	Need for soil moisture conservation (rain-fed)	Need for water use efficiency (irrigated)	Land degradation soil infertility, erosion	Heat stress	Pest disease control	Excess rain flooding, storms	Milder winters, longer growing season	Emissions mitigation, carbon sequestration
	Response farming (using seasonal forecasts)	x		x	x	x	x		x	
Field management	Strip cropping, contour bunding and farming	x	x		x			x		
	Vegetative barriers, snow fences, windbreaks	x	x	x	x	x	x			x
Animal Husbandry management	Rangeland rehabilitation and management	x	x		x	x	x	x	x	
	Pasture management (rotational grazing, etc) and improvement	x	x		x	x	x	x	x	
	Supplemental feed	x			x					
	Fodder banks	x			x					
	Watering points	x			x	x			x	
	Livestock management (including animal breed choice)				x	x	x	x		
Non-water disaster management	Fire management for forest and brush fires				x					

Source: World Bank (2008)

Table 12-3 provides a list of technological adaptation options for agriculture, from small-scale measures (e.g., changed timing of planting and harvesting) to the large-scale systematic efforts (e.g., installation of new drip or sprinkler irrigation facilities) (World bank, 2008). For the technological adaptation measures and investments, their grouping has been done to capture main characteristics of these measures and investments. These categories are soil management, water management, irrigation management, field management, animal husbandry management and non-water disaster management.

The adaptations specifically for crop cultivation include conservation tillage (low to no tillage) that means a ploughing technique that does not disturb the soil, thus conserving moisture, reducing fossil fuel usage from field operations, and reducing CO_2 (World bank,2008). Utilization of organic matter to protect field surfaces also helps to preserve soil moisture that is important in Tajikistan.

Several measures concerning the capture and efficient usage of water will be extremely important in currently rain-fed areas and areas where scaled-up irrigation is environmentally unsustainable or economically infeasible which is the case of some parts of Tajikistan (World bank, 2008). Drainage and watershed management will be particularly important in areas with increasing precipitation that can lead to flood risk that has been identified for parts of Tajikistan. Given the predicted water stress for Tajikistan, better managed and expanded irrigation will be a very important part of adaptation and therefore their cost is analysed in detail in the Table 12-4. More efficient use of irrigation water can be achieved with properly timed applications and drip irrigation, among other methods (World bank, 2008).

While representatives of each category can be somehow related to water-related risks, the focus of this chapter is on measures and investments that are related to water scarcity that fall within categories of irrigation management and water management. Irrigation management costs per hectare are calculated based on the study of Inoncio et al. (2005) and can be seen in the Table 12-4.

Table 12-4 Irrigation costs comparison for seven regions ($ per hectare) based on 314 analysed projects

	New irrigation projects	**Irrigation Projects rehabilitation**
Sub-Saharan Africa*	11,828	8,233
Middle east and North Africa*	6,311	4,582
South Asia*	1,847	1,008
South East Asia*	4,386	1,840
East Asia*	5,105	1,990
Latin America*	4,006	3,432
Estimated Central Asia Projects for 2022	6,333.0825	3,619.45

*prices in 2005 re-calculated to 2000 base year.

Source: Inoncio et al.

Original costs are adjusted to 2022 prices and re-calculated using power purchasing parity based on the regions that are climatically closest to the analysed region of Tajikistan. New construction projects include new construction with land opening new construction from rainfed, and new construction and rehabilitation. Rehabilitation projects include rehabilitation plus new construction and rehabilitation.

Another key adaptation is diversification of crops and of agricultural activities that is more feasible for small farms rather than big farms (World bank, 2008). The greater the number of distinct crops, cultivars, and varieties on a farm, the greater the chance that some of the harvest will survive a severe storm, a drought, an early arrival of spring or another unexpected event (World bank, 2008). Thus, resilience of Tajik agricultural can be increased. This is also true for different combinations of trees, crop, and animals. The efficiency gains from specialization (lower marginal costs of production) may be less important relative to the risk-reduction achieved through diversification as climate change results in much greater uncertainty about climate means and variability, and the timing and intensity of weather events (World bank, 2008).

It is also important to mention other techniques such as crop rotation that can increase amount of soil organic matter of offset erosion. Erosion can be also managed through different field techniques (land use) such as creation of strips, riparian zones, etc. This is extremely important for hilly parts of Tajikistan. Crop rotation can also help to mitigate damages related to pests that may survive possibly milder winters in some regions of Tajikistan. Using proper information and management, which means deployment of precision agriculture can also offset certain costs related to climate change in Tajikistan.

For animal husbandry, the key area is proper grassland management, rotational grass feed etc. as presented in the Table 12-3.

Finally, fire management is extremely important for forestry and possible agro-forestry that is proposed as one tool to adapt to climate change in Tajikistan.

Many of the proposed techniques and investments have overlap beyond the benefits related to climate change adaptation and when applied cost-effectively, can lead to positive internal as well as external benefits.

12.2. Cost benefit analysis (CBA) of selected projects

12.2.1. Methodology CBA

Note: In order to make this section manageable, we concentrated on a limited number of adaptation strategies and projects. The selection pool of strategies relied on results of previour reports. The actual selection of project was primarily influenced by the availability of data.

Limitations: like any analysis, this study is subject to a number of limitations. The largest limitation concerned the availability and reliability of relevant data. In many cases, the requested data were not available or did not exist. Another type of limitation concerns the quality of the available data. Next, we are only able to take into account the direct benefits or costs. More often than not, adaptation strategies bring indirect benefits, which are impossible to estimate in monetary terms.

12.2.2. CBA of selected projects

The cost/benefit analyses were conducted for selected projects implemented and financed by external donors, namely:

- Building Climate Resilience in the Pyanj River Basin
- Rehabilitation of Hydrotechnical Construction of Great Gissar Canal
- Building "Punukai" Reservoir (Mudflow Reservoir) In Asht District of Sughd Region

The results suggest that 2 out of 3 projects reached positive net present value of the investment and under the sensitivity analyses. The least performing was Punukai reservoir project, where the net present values were all negative. Pyanj river project was positive only under discount rate below 6%), while Gissar project reached positive values for discounts 2 – 16%.

Methodology

The costs and benefits of particular projects and strategies were estimated qualitatively and quantitatively when possible. In the quantitative part we computed the model of Net Present Value[7] (NPV) of a particular adaptation project. The parameters of the model were set as follows:

The discount rate[8] was set to 12 %. The common discount rate for Tajikistan is used (for the reference see ADB, 2016). In order to incorporate climatic β[9] into this project, a simulation of discount rate lower than 12 % has been done for individual projects and is presented in each project in the according figure. The project life period was set to 30 years.

[7] Model of net present value (NPV) is the difference between the present value of cash receipts and the present value of cash outflows over a period of time. NPV is used in capital budgeting and investment planning to analyze the profitability of an anticipated investment or project. The Financial Net Present Value of a project is the sum of the discounted net flows of a project. The FNPV is a very concise performance indicator of an investment project: it represents the present amount of the net benefits (i.e. benefits less costs) flow generated by the investment expressed in one single value with the same unit of measurement used in the accounting tables.

[8] A discount rate is the rate of return used to discount future cash flows back to their present value.

[9] The environmental beta is intended to take into account the systemic risk associated with environmental damage, which in turn will affect the current value. A major problem in determining environmental beta is the very long time before there are obvious environmental impacts.

Results

Tajikistan is very vulnerable to natural disasters and has limited financial resources to eliminate them. Alpine low forest areas and steep valleys, the threat of earthquakes, irregular rainfall - all this causes natural disasters such as landslides, mudslides, avalanches and floods. These disasters, together with environmental degradation and climate change, are the trigger for social, economic and environmental losses (Zaripova, 2018).

The climate in all areas is changing and temperatures are expected to rise in the future, the threat of drought and, on the other hand, torrential rain and related floods and mudslides. The following steps, among others, will be needed when planning building climate resilience. Extension of the river basin monitoring network, introduction of new procedures (GIS tools, remote sensing, modelling), introduction of early warning systems against floods and other climatic extremes. It is necessary to plan irrigation and distribution of irrigation water, reconstruction of irrigation systems infrastructure. In disaster protection planning, it is the inspection and repair of flood defences and the construction of new ones, the modernization of existing and the construction of new reservoirs and the restoration of ecosystems that can better retain water in the river basin (forest planting, etc.). Last but not least, public involvement is needed - raising public awareness of the threats and benefits of sustainable and managed water management in the river basin (Ministry of energy and water resources, 2021)

On the other hand, Tajikistan has the potential to be one of the largest producers of hydropower, but due to the country's poverty, only 10% of water capacity is used. Hydropower potential ranks eighth in the world (300 billion kWh per year). Tajikistan could be the main exporter of energy in the region (Zaripova, 2018).

In this report, three projects are analysed in the area of Pyanj, Great Gissar and Sughd region. These projects were selected as they provide numerous benefits that are described in the following text. The projects represent a variance of the benefits o while one project focuses primarily on mudslides, the second project provides benefits related to irrigation and provision of drinking water and the third project is a combination of these benefits. In other words, they address the most important problems related to climate change in Tajikistan (see previous chapter).

Cost/benefit analysis of the project Pyanj

The Pyanj river basin is prone to floods and mudslides, destroying crops and infrastructure. It was therefore necessary to proceed with projects that include flood protection measures, measures to eliminate mudslides and improve water management. These include the revitalization of streams and dams and the construction of new dams, the maintenance and expansion of irrigation facilities for better crop yields and improved water supply to the population. The main aim is to improve employment, social security and the health of the population. For this reason, the construction of reservoirs is planned, which will bring benefits in the form of improved water management, reduction of floods and mud flows, the benefit will be irrigation and supply of drinking water to the population and, last but not least, energy production. Currently, the largest reservoirs in the Pyanj River basin are Lake

Sarez on the Bartang River and YashilKul on the Gunt River. There are two smaller tanks used mainly for irrigation. The planned reservoirs are in Dasthi-Jum (estimated water volume 17.6 km3), Granite Gate (expected volume 1.3 km3) and Rushan (expected water volume 5.5 km3). The development and coordinated management of the Pyanj River Basin aims to increase the economic and social development of the area and ensure the sustainability of important ecosystems.

Tajikistan: Building Climate Resilience in the Pyanj River Basin

Location: Tajikistan / Pyanj River Basin

Year: 2015 – ongoing

Organization: ADB / Strategic Climate Fund

Goal and description:

The project aims to increase resilience to climate vulnerability and change of communities in the Pyanj River Basin. The project's impact will be improved livelihoods of Pyanj River Basin communities vulnerable to climate variability and change. The project's outcome will be reduced adverse effects of climate variability and climate change in 59 villages in 19 jamoats in the Pyanj River Basin.

Finance: US$ 21.55 million

Impact:

- Flood protection was provided to 3,973.5 ha.
- Irrigation canals were extended to 2,081 ha.
- Water supply was provided to 4,500 households in 15 villages.
- 1,934 microcredits were issued to promote climate resilience.

In the Table 12-5 cost benefit analysis is done for this project in Pyanj. Data from the project report were taken as a proxy for potential benefits. Operation costs were taken from Environment Agency (2015) and have been selected as an average of 3 percent. Future decommissioning was set to 10 percent of fixed costs which is based on the literature review. Benefits were estimated based on the methodology presented in the section 3 of this report. One of the most important variables that influences the value of discounted cash flows is the discount rate. It has been set in between 2 and 16 percent. For the detailed presentation, a discount rate was set to 12 percent as it corresponds with the common discount rate for Tajik projects.

Table 12-5 Cost benefit analysis of project “Building Climate Resilience in the Pyanj River Basin”

Years	**Description**	**Valuation**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Time			0	1	2	3	4	5	6	7	8
Irrigation capacity	2,081 ha	2081									
Water supply inhabitants	4,500 households (avg. 6 people/ household)	27000									
Fixed cost (Planning, design, construction)	USD 21,500,000		-21500000								
Operation and maintenance cost	1 - 5% p.a.	0.03		-645000	-645000	-645000	-645000	-645000	-645000	-645000	-645000
Future decommissioning, replacement	10 % at the end of lifetime		0	0	0	0	0	0	0	0	0
Benefits lives (mudslides)	2 lives each year	131407		262814	262814	262814	262814	262814	262814	262814	262814
Benefits property damage (mudslides)	USD 2,353/ household 170 households	400000		400000	400000	400000	400000	400000	400000	400000	400000
Benefits crop yields	Scenario 1 (IR)			19633	25848	7189	2954	5535	23140	12516	23221
Benefits crop yields	Scenario 2 (IR)			31960	38310	29714	35943	31701	67876	24510	40636
Benefits drinking water	USD 47.41 per inhabitant	27000		1280070	1280070	1280070	1280070	1280070	1280070	1280070	1280070
BENEFITS (scenario 1)				3539401	3545616	3526957	3522722	3525303	3542908	3532284	3542989
BENEFITS (scenario 2)				3551728	3558078	3549482	3555711	3551469	3587644	3544278	3560404
COSTS			-21500000	-645000	-645000	-645000	-645000	-645000	-645000	-645000	-645000
CF (scenario 1)			-21500000	2894401	2900616	2881957	2877722	2880303	2897908	2887284	2897989
CF (scenario 2)			-21500000	2906728	2913078	2904482	2910711	2906469	2942644	2899278	2915404
DCF (scenario 1)	discount rate	0.12	-21500000	2584286	2312353	2051320	1828844	1634361	1468170	1306061	1170449
DCF (scenario 2)	discount rate	0.12	-21500000	2595293	2322288	2067353	1849809	1649208	1490835	1311486	1177483
NPV (scenario 1)			-10855797								
NPV (scenario 2)			-10499170								
IRR (scenario 1)	4.26%										
IRR (scenario 2)	4.71%										

Table 12-5 cont.

Years	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
Time	9	10	11	12	13	14	15	16	17	18	19	20
Fixed cost (Planning, design, construction)												
Operation and maintenance cost	-645000	-645000	-645000	-645000	-645000	-645000	-645000	-645000	-645000	-645000	-645000	-645000
Future decommissioning, replacement	0	0	0	0	0	0	0	0	0	0	0	0
Benefits lives (mudslides)	1839698	1839698	1839698	1839698	1839698	1839698	1839698	1839698	1839698	1839698	1839698	1839698
Benefits property damage (mudslides)	400000	400000	400000	400000	400000	400000	400000	400000	400000	400000	400000	400000
Benefits crop yields	46969	52246	87077	97632	82328	103965	105548	93410	61746	94993	122436	128769
Benefits crop yields	67023	83383	142490	149351	156212	170988	191570	180488	179960	210569	226401	233262
Benefits drinking water	1280070	1280070	1280070	1280070	1280070	1280070	1280070	1280070	1280070	1280070	1280070	1280070
BENEFITS (scenario 1)	3566737	3572014	3606845	3617400	3602096	3623733	3625316	3613178	3581514	3614761	3642204	3648537
BENEFITS (scenario 2)	3586791	3603151	3662258	3669119	3675980	3690756	3711338	3700256	3699728	3730337	3746169	3753030
COSTS	-645000	-645000	-645000	-645000	-645000	-645000	-645000	-645000	-645000	-645000	-645000	-645000
CF (scenario 1)	2921737	2927014	2961845	2972400	2957096	2978733	2980316	2968178	2936514	2969761	2997204	3003537
CF (scenario 2)	2941791	2958151	3017258	3024119	3030980	3045756	3066338	3055256	3054728	3085337	3101169	3108030
DCF (scenario 1)	1053608	942420	851460	762941	677690	609508	544493	484174	427687	386187	347996	311367
DCF (scenario 2)	1060839	952446	867390	776216	694622	623222	560209	498378	444904	401216	360067	322199

Table 12-5 cont.

Years	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**
Time	21	22	23	24	25	26	27	28
Fixed cost (Planning, design, construction)								
Operation and maintenance cost	-645000	-645000	-645000	-645000	-645000	-645000	-645000	-645000
Future decommissioning, replacement	0	0	0	0	0	0	0	-2150000
Benefits lives (mudslides)	1839698	1839698	1839698	1839698	1839698	1839698	1839698	1839698
Benefits property damage (mudslides)	400000	400000	400000	400000	400000	400000	400000	400000
Benefits crop yields	169405	139324	174155	182071	190515	185237	176793	182599
Benefits crop yields	286036	294480	336699	338282	365725	382085	399500	410583
Benefits drinking water	1280070	1280070	1280070	1280070	1280070	1280070	1280070	1280070
BENEFITS (scenario 1)	3689173	3659092	3693923	3701839	3710283	3705005	3696561	3702367
BENEFITS (scenario 2)	3805804	3814248	3856467	3858050	3885493	3901853	3919268	3930351
COSTS	-645000	-645000	-645000	-645000	-645000	-645000	-645000	-2795000
CF (scenario 1)	3044173	3014092	3048923	3056839	3065283	3060005	3051561	907367
CF (scenario 2)	3160804	3169248	3211467	3213050	3240493	3256853	3274268	1135351
DCF (scenario 1)	281767	249092	224974	201391	180310	160714	143099	37991
DCF (scenario 2)	292563	261915	236968	211683	190617	171053	153542	47536

Two scenarios were simulated with respect to crop benefits. Scenario 1 represents difference in yields between neutral and status quo options and Scenario 2 represents difference between optimistic and status quo options (see section 3 Methodology).

For the simulated variable levels, results are presented below the table. While both of the scenarios yield negative returns, internal rate of return is 4.26% for Scenario 1 and 4.71% for Scenario 2.

Also, a simulation has been conducted for various operating and maintenance costs as presented in the Figure 12-3 that shows how it affects the internal rate of return.

Figure 12-3 Internal Rate of Return (IRR)

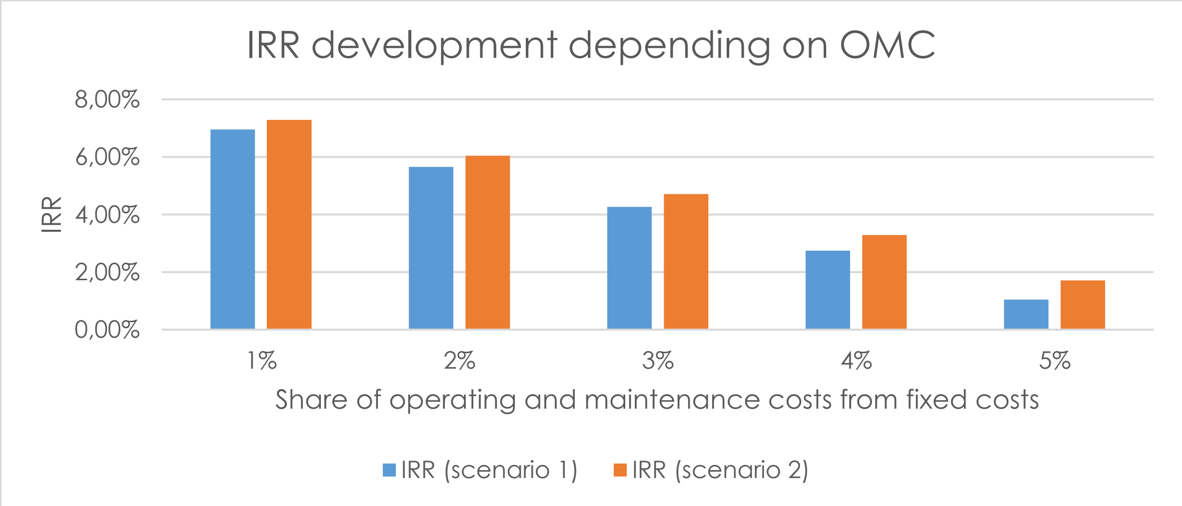


Figure 12-4 Net Present Value (NPV) for different discounting rates

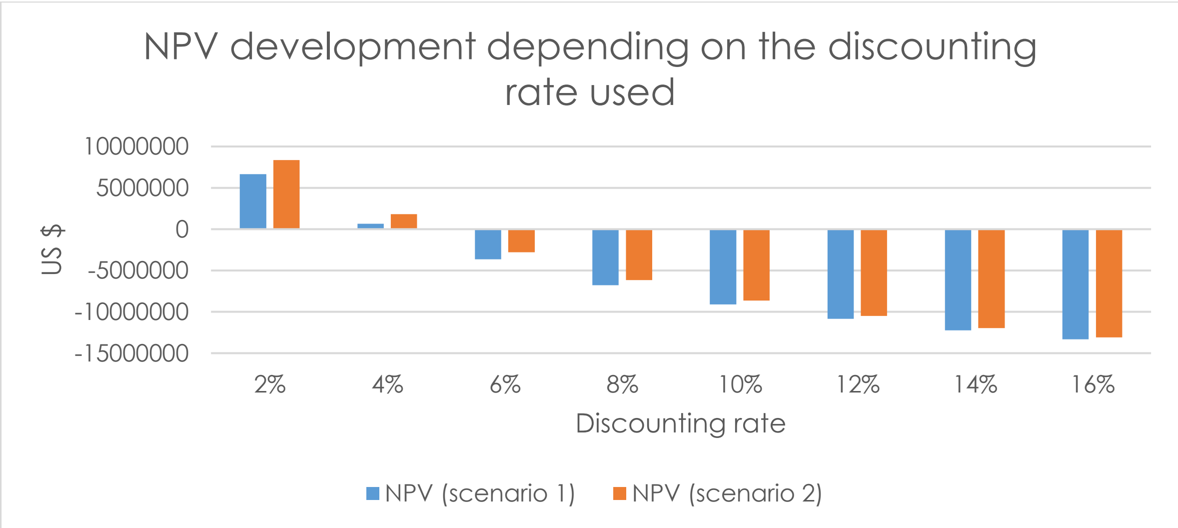
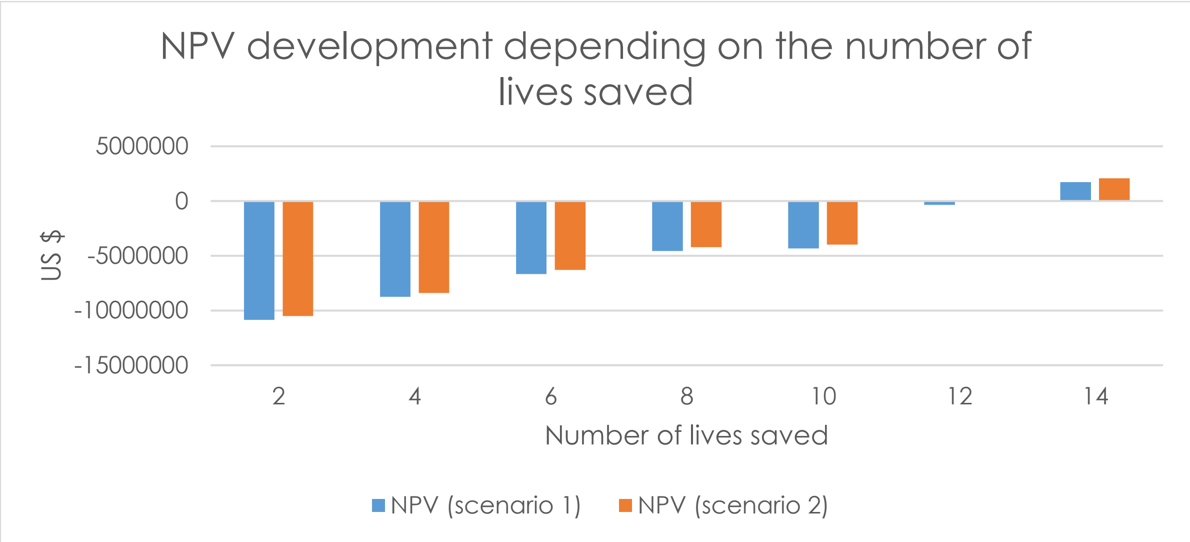


Figure 12-4 shows influence of various discount rates on net present value. This is very important as negative beta in the CAPM can reduce the discount rate from usually used 12% up to 2%. This shows that incorporating climatic beta may lead to higher net present value.

Finally, as there is relative uncertainty as to how many lives can be saved when mudslides are prevented, several options are presented ranging from 2 to 14 lives saved a year.

Figure 12-5 Nett Present Value (NPV) in relation to the number of lives saved



Project Gissar

An important future item for the province of Gissar is the cultivation of irrigated crops, especially cotton, fruit, vegetables and wine. Cotton is a key component of the Tajik agricultural sector. Cotton is the main source of income for 75% of poor and extremely poor households. Tajikistan is the world's fourth largest exporter of cotton (Zaripova, 2018). The project supports the revitalization of irrigation facilities and their expansion, and thus the expansion of cultivated crops. On the one hand, there will be an increase in job opportunities, but also a reduction in poverty and migration of people from this area. The construction of reservoirs is planned, one of which should be on the Khanaka River (Khanakin) with a reservoir of 40 million m3. The reservoir should help retain water needed for irrigation and electricity generation. Another benefit of the reservoir should be the protection of property against floods and mudslides. Not only the areas of crop production, but also the infrastructure and property and the lives of citizens are threatened by floods and mudflow. There is a risk of landslides in the foothills of Tajikistan after heavy rains. Factors leading to the formation of mud streams are climatic - precipitation and melting of snow, geological and topographic - slope and type of soil cover, earthquakes, and anthropogenic - deforestation and overgrazing and more. 95% of landslides are torrential rains or persistent rain (OSCE, 2019). The area could prosper by reducing the risk of natural disasters that cause great damage and by developing agriculture, which can be a key area of the region when irrigation water is available.

Rehabilitation of Hydrotechnical Construction of Great Gissar Canal

Location: Rudaki, Gissar, Shahrinav and Tursunzade / Tajikistan

Year: 2016

Organization: Asia Development Bank

Goal and description: Great Gissar Canal provide the districts of Rudaki, Gissar, Shahrinav and Tursunzade with irrigation water by way of a regulating dam on a branch of the Dushanbinka River and a pipe across the Khanaka River. Over the years the GGC has lost operational capacity. Annual floods and mudflows destroy irrigation works, affect water supply, cover irrigated land, and disrupt food supply with socioeconomic consequences.

Finance: US$ 3.1 million

Impact: The project supports 1) land reclamation and irrigation of new agricultural land of 20,000 hectares for cotton, fruit, onions, grain and irrigated pasture for increased food security of the growing population; 2) the renovation and modernization of facilities for water supply and irrigation in 4 districts and 400,000 people; 3) job creation and improved welfare of the population; 4) a decrease in migration from mountain areas; 5) an increase in electricity supply; and 6) a reduction in flood and mudflow risks.

It is intended that the population of the district of Shaartuz, of 13,400, will be the direct beneficiaries of new irrigated agriculture.

Resource: National Climate Change Adaptation Strategy TAJ: Building Capacity for Climate Resilience, Asian Developing Bank – ADB consultants´ Report, Project Number: 45436-001, November 2016. URL: https://www.adb.org/projects/45436-001/main

For Great Gissar project, only benefits related to clean water supply and raised crop yields were considered. For clean water supply, 1.83% of planned benefits were considered as this was an estimate based on averaged expert opinion. All other variables are defined similar to Pyanj project that were discussed above.

Table 12-6 Cost benefit analysis of project “Rehabilitation of Hydrotechnical Construction of Great Gissar Canal”

Years			**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Time			0	1	2	3	4	5	6	7	8
	Description	Valuation									
Irrigation capacity	20,000 hectares	20000									
Water supply inhabitants	400,000 households (assumed 5%)	44000									
Fixed cost (Planning, design, construction)	USD 3,000,000		-3000000								
Operation and maintenance cost	1 - 5% p.a.	0.03		-90000	-90000	-90000	-90000	-90000	-90000	-90000	-90000
Future decommissioning, replacement	10 % at the end of lifetime			0	0	0	0	0	0	0	0
Benefits lives (mudslides)	0 lives each year	0		0	0	0	0	0	0	0	0
Benefits property damage (mudslides)	0 or low damages	0		0	0	0	0	0	0	0	0
Benefits crop yields	Scenario 1 (IR)			188684	248416	69090	28392	53196	222390	120288	223168
Benefits crop yields	Scenario 2 (IR)			307160	368188	285572	345436	304668	652344	235564	390544
Benefits drinking water	USD 47.41 per inhabitant (5% of 400,000)	44000		2086040	2086040	2086040	2086040	2086040	2086040	2086040	2086040
BENEFITS (scenario 1)				2274724	2334456	2155130	2114432	2139236	2308430	2206328	2309208
BENEFITS (scenario 2)				2393200	2454228	2371612	2431476	2390708	2738384	2321604	2476584
COSTS			-3000000	-90000	-90000	-90000	-90000	-90000	-90000	-90000	-90000
CF (scenario 1)			-3000000	2184724	2244456	2065130	2024432	2049236	2218430	2116328	2219208
CF (scenario 2)			-3000000	2303200	2364228	2281612	2341476	2300708	2648384	2231604	2386584
DCF (scenario 1)	discount rate	0.12	-3000000	1950646	1789267	1469919	1286563	1162792	1123926	957319	896301
DCF (scenario 2)	discount rate	0.12	-3000000	2056429	1884748	1624006	1488050	1305484	1341754	1009464	963901
NPV (scenario 1)			16493795								
NPV (scenario 2)			19921246								
IRR (scenario 1)	72.28%										
IRR (scenario 2)	77.76%										

Table 12-6 cont.

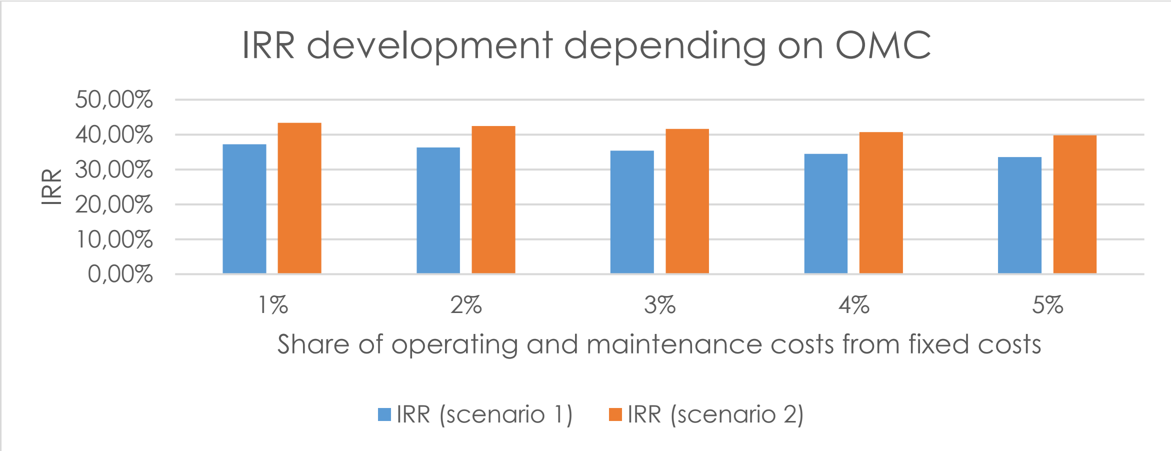
Years	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**
Time	9	10	11	12	13	14	15	16	17	18	19	20
Irrigation capacity												
Water supply inhabitants												
Fixed cost (Planning, design, construction)												
Operation and maintenance cost	-90000	-90000	-90000	-90000	-90000	-90000	-90000	-90000	-90000	-90000	-90000	-90000
Future decommissioning, replacement	0	0	0	0	0	0	0	0	0	0	0	0
Benefits lives (mudslides)	0	0	0	0	0	0	0	0	0	0	0	0
Benefits property damage (mudslides)	0	0	0	0	0	0	0	0	0	0	0	0
Benefits crop yields	451408	502128	836880	938320	791232	999184	1014400	897744	593424	912960	1176704	1237568
Benefits crop yields	644144	801376	1369440	1435376	1501312	1643328	1841136	1734624	1729552	2023728	2175888	2241824
Benefits drinking water	2086040	2086040	2086040	2086040	2086040	2086040	2086040	2086040	2086040	2086040	2086040	2086040
BENEFITS (scenario 1)	2537448	2588168	2922920	3024360	2877272	3085224	3100440	2983784	2679464	2999000	3262744	3323608
BENEFITS (scenario 2)	2730184	2887416	3455480	3521416	3587352	3729368	3927176	3820664	3815592	4109768	4261928	4327864
COSTS	-90000	-90000	-90000	-90000	-90000	-90000	-90000	-90000	-90000	-90000	-90000	-90000
CF (scenario 1)	2447448	2498168	2832920	2934360	2787272	2995224	3010440	2893784	2589464	2909000	3172744	3233608
CF (scenario 2)	2640184	2797416	3365480	3431416	3497352	3639368	3837176	3730664	3725592	4019768	4171928	4237864
DCF (scenario 1)	882574	804343	814397	753177	638771	612882	549996	472039	377141	378285	368377	335218
DCF (scenario 2)	952077	900693	967495	880759	801503	744687	701038	608552	542611	522729	484389	439326

Table 12-6 cont.

Years	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**
Time	21	22	23	24	25	26	27	28
Irrigation capacity								
Water supply inhabitants								
Fixed cost (Planning, design, construction)								
Operation and maintenance cost	-90000	-90000	-90000	-90000	-90000	-90000	-90000	-90000
Future decommissioning, replacement	0	0	0	0	0	0	0	-300000
Benefits lives (mudslides)	0	0	0	0	0	0	0	0
Benefits property damage (mudslides)	0	0	0	0	0	0	0	0
Benefits crop yields	1628112	1339008	1673760	1749840	1830992	1780272	1699120	1754912
Benefits crop yields	2749024	2830176	3235936	3251152	3514896	3672128	3839504	3946016
Benefits drinking water	2086040	2086040	2086040	2086040	2086040	2086040	2086040	2086040
BENEFITS (scenario 1)	3714152	3425048	3759800	3835880	3917032	3866312	3785160	3840952
BENEFITS (scenario 2)	4835064	4916216	5321976	5337192	5600936	5758168	5925544	6032056
COSTS	-90000	-90000	-90000	-90000	-90000	-90000	-90000	-390000
CF (scenario 1)	3624152	3335048	3669800	3745880	3827032	3776312	3695160	3450952
CF (scenario 2)	4745064	4826216	5231976	5247192	5510936	5668168	5835544	5642056
DCF (scenario 1)	335450	275617	270787	246786	225119	198335	173279	144489
DCF (scenario 2)	439201	398851	386057	345696	324171	297697	273650	236229

Results show based on the scenarios difference a relatively high net present value and internal rate of return. This may be due to relatively large population supplied with clean water and large chunk of agricultural land irrigated. This project assessment, however, does not incorporate natural hazards mitigation which, if included, would increase the IRR even more.

Figure 12-6 Internal Rate of return (IRR)



Note: OMC stands for Operating and Maintenance Costs, IRR stands for Internal Rate of Return

Internal rate of return based on various operation and maintenance costs is presented in the Figure 12-6. It shows that higher Operating and Maintenance Costs (OMC) leads to lower IRR albeit still high.

Figure 12-7 Nett Present Values (NPV) for different discounting rates

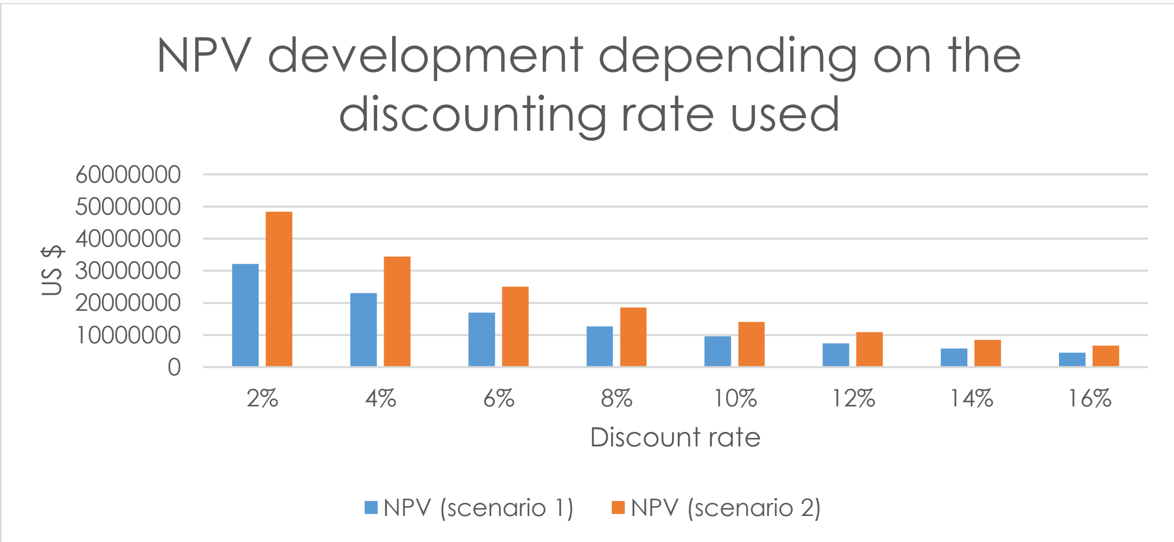
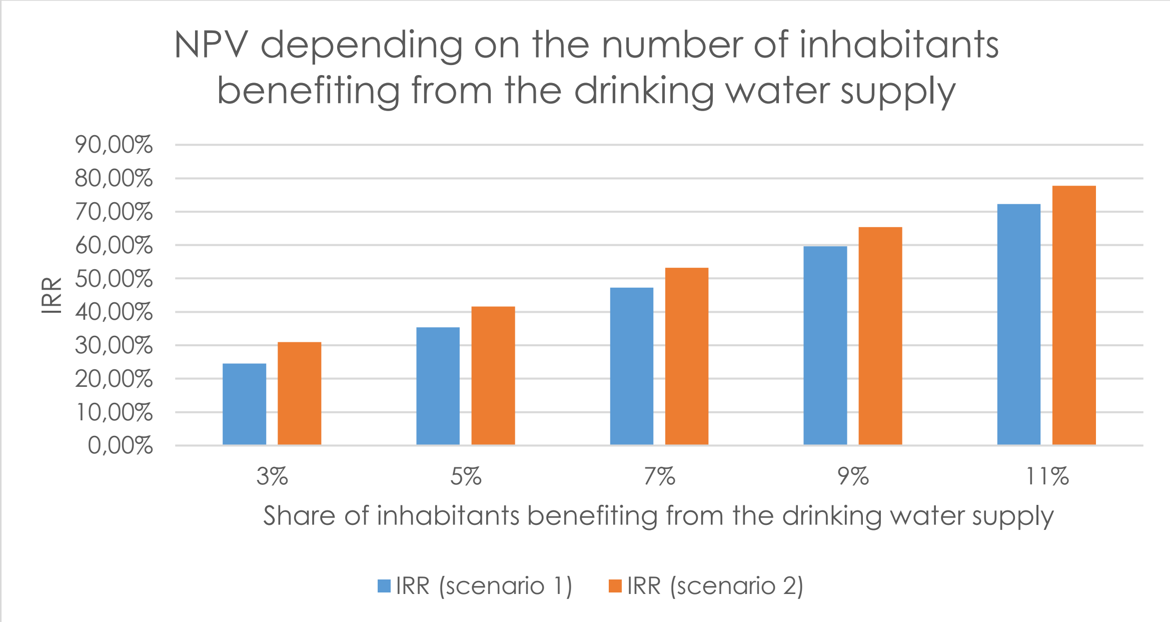


Figure 12-7 shows difference in net present value (NPV) based on selected discount rate. Incorporation of climatic beta into the NPV calculation may lead to lower discount rate and therefore higher outcomes for net present value of this project.

As the estimate of 1.83% having access to drinking water may seem to be relatively low scenarios ranging from 3 to 11 percent are presented (Figure 12-8).

Figure 12-8 Nett Present Value (NPV) in relation to the number of inhabitants having access to drinking water



Note: IRR stands for Internal Rate of Return

Project Sughd Region

In the Syr Darja river basin in the Sughd Region, the greatest risk is the frequent occurrence of floods from melting snow. The level of risk increases after heavy rains during periods of high temperatures - especially the month of April. Along with the floods, there is also a risk of mudflats. The area near the high mountains is prone not only to episodes of drought, but also to significant damage from spring frosts. A number of vines and fruit trees are grown in this region. The effects of drought will limit the expansion and revitalization of irrigation networks, and damage caused by frost can reduce fogging with irrigation water. These measures can allow the expansion of orchards and vineyards as well as the cultivation of other crops, thus creating jobs and reducing population migration from these areas. The threat of floods and mudslides can be eliminated by small water reservoirs, which act as a trap for water or mud. This would reduce damage to orchards and vineyards, fields and agricultural and industrial infrastructure. The local population is also endangered by mudslides and floods, especially from melting snow or long-lasting rains, so small reservoirs can also protect human lives and property. The project aims to increase the availability of water on the one hand and improve the living standards of the area's inhabitants. Although Tajikistan is rich in freshwater resources, access to it is mainly in rural areas - still only for about 50% of the population. It affects the health and vitality of the population. Another priority of the project is to reduce the risk of water management-related disasters and to strengthen the revitalization of irrigation and drainage facilities. There are approximately 700,000 hectares of agricultural land in the Sughd region, of which 200,000 hectares are connected to irrigation systems, but only about half are cultivated due to the dilapidation of this infrastructure. Agriculture in the region is essential for economic growth and social stability of the population (World Bank, 2005). The volume of the reservoirs should be anywhere between 1 to 3 million m3 as this is the volume of mudslides in a similar area of Tajikistan (World Bank, 2014).

Building "Punukai" Reservoir (Mudflow Reservoir) In Asht District of Sughd Region

Location: Asht District of Sughd Region / Tajikistan

Year: 2016

Organization: Asia Development Bank

Goal and description: In the last 5 years, 3 to 5 large mudflows have destroyed the centre of the town with 10 lives lost, schools, hospitals, roads and bridges and houses destroyed near slopes. In 2011, floods and mudslides displaced 800 people and 150 households. Kitchen gardens, an important source of household food, were flooded, 500 meters of water pipeline was damaged, and 35 families had to be resettled. In 2015 heavy snow destroyed 95% of fruit trees and the harvests of wheat and barley were reduced by 35 to 40%.

Finance: US$ 13.55 million

Impact: Reduce destruction from mudflows and floods of irrigation systems; Build small reservoirs to help minimize mudflow and flood damage; Reduce vulnerability to drought through climate adaptation; Improve water use efficiency on agricultural land in mountain areas and river and lake embankments. Benefits are connected to:

- Prevent premature cost and damage to the facilities.
- Reduce or prevent damage to embankments, houses and public infrastructure from increasing mudflows and flooding.
- Irrigation water will reduce the impact of drought on crops and household income.
- Mist irrigation will prevent frost damage to fruit trees and grapes.
- Decrease flow of environmental migration from mountains

In the Table 11-7 results of NPV and IRR are presented for the Sughd region. As these planned projects are intended primarily to save lives and property damages, these are the benefits presented. No benefits are included for crop yields due to irrigation and no benefits for drinking water supply are included. Instead benefits related prevention of crop damage were calculated as 10% of estimated yields. Property damage was derived from past incidences of property damages. Lives lost were set to 2 per annum.

Table 12-7 Cost benefit analysis of project "Mudflow Reservoir in Asht District of Sughd Region"

Years			**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Time			0	1	2	3	4	5	6	7	8
	Description	Valuation									
Irrigation capacity	just mudflow protection	0									
Water supply inhabitants	no water supply	0									
Fixed cost (Planning, design, construction)	USD 13,400,000		-13400000								
Operation and maintenance cost	1 - 5% p.a.	0.03		-402000	-402000	-402000	-402000	-402000	-402000	-402000	-402000
Future decommissioning, replacement	10 % at the end of lifetime			0	0	0	0	0	0	0	0
Benefits lives (mudslides)	2 lives each year	131407		262814	262814	262814	262814	262814	262814	262814	262814
Benefits property damage (mudslides)	USD 2,353/household 150 households	352950		352950	352950	352950	352950	352950	352950	352950	352950
Benefits of undamaged crops	2,748 ha of cereals (2016), average yield 4.15 t/ha, losses 10%	1140.42		250208	252945	262639	269823	275754	281798	285789	289211
Benefits drinking water	no supply of drinking water	0		0	0	0	0	0	0	0	0
BENEFITS				865972	868709	878403	885587	891518	897562	901553	904975
COSTS			-13400000	-402000	-402000	-402000	-402000	-402000	-402000	-402000	-402000
CF			-13400000	463972	466709	476403	483587	489518	495562	499553	502975
DCF	discount rate	0.12	-13400000	414261	372058	339094	307329	277765	251067	225973	203143
NPV			**-9491946**								
IRR	**0.27%**										

Table 12-7 cont.

Years	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**
Time	9	10	11	12	13	14	15	16	17	18
Fixed cost (Planning, design, construction)										
Operation and maintenance cost	-402000	-402000	-402000	-402000	-402000	-402000	-402000	-402000	-402000	-402000
Future decommissioning, replacement	0	0	0	0	0	0	0	0	0	0
Benefits lives (mudslides)	262814	262814	262814	262814	262814	262814	262814	262814	262814	262814
Benefits property damage (mudslides)	352950	352950	352950	352950	352950	352950	352950	352950	352950	352950
Benefits of undamaged crops	289211	289211	289211	289211	289211	289211	289211	289211	289211	289211
Benefits drinking water	0	0	0	0	0	0	0	0	0	0
BENEFITS	904975	904975	904975	904975	904975	904975	904975	904975	904975	904975
COSTS	-402000	-402000	-402000	-402000	-402000	-402000	-402000	-402000	-402000	-402000
CF	502975	502975	502975	502975	502975	502975	502975	502975	502975	502975
DCF	181378	161944	144593	129101	115269	102919	91892	82046	73255	65407

Table 12-7 cont.

Years	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Time	19	20	21	22	23	24	25	26	27	28
Fixed cost (Planning, design, construction)										
Operation and maintenance cost	-402000	-402000	-402000	-402000	-402000	-402000	-402000	-402000	-402000	-402000
Future decommissioning, replacement	0	0	0	0	0	0	0	0	0	-1340000
Benefits lives (mudslides)	262814	262814	262814	262814	262814	262814	262814	262814	262814	262814
Benefits property damage (mudslides)	352950	352950	352950	352950	352950	352950	352950	352950	352950	352950
Benefits of undamaged crops	289211	289211	289211	289211	289211	289211	289211	289211	289211	289211
Benefits drinking water	0	0	0	0	0	0	0	0	0	0
BENEFITS	904975	904975	904975	904975	904975	904975	904975	904975	904975	904975
COSTS	-402000	-402000	-402000	-402000	-402000	-402000	-402000	-402000	-402000	-402000
CF	502975	502975	502975	502975	502975	502975	502975	502975	502975	502975
DCF	58399	52142	46555	41567	37113	33137	29587	26417	23586	21059

The results show almost zero internal rate of return with negative net present value. This is due to high discount rate set to 12% and also no benefits accruing to drinking water supply.

Nature of these mud reservoirs may mean relatively lower operation and maintenance costs. This is evident from the figure 12-9.

Figure 12-9 IRR

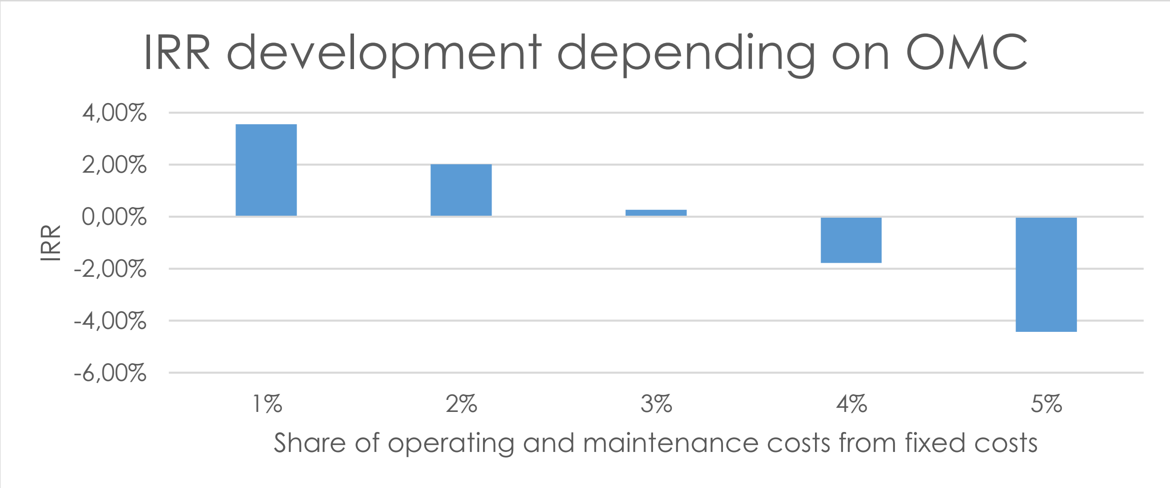
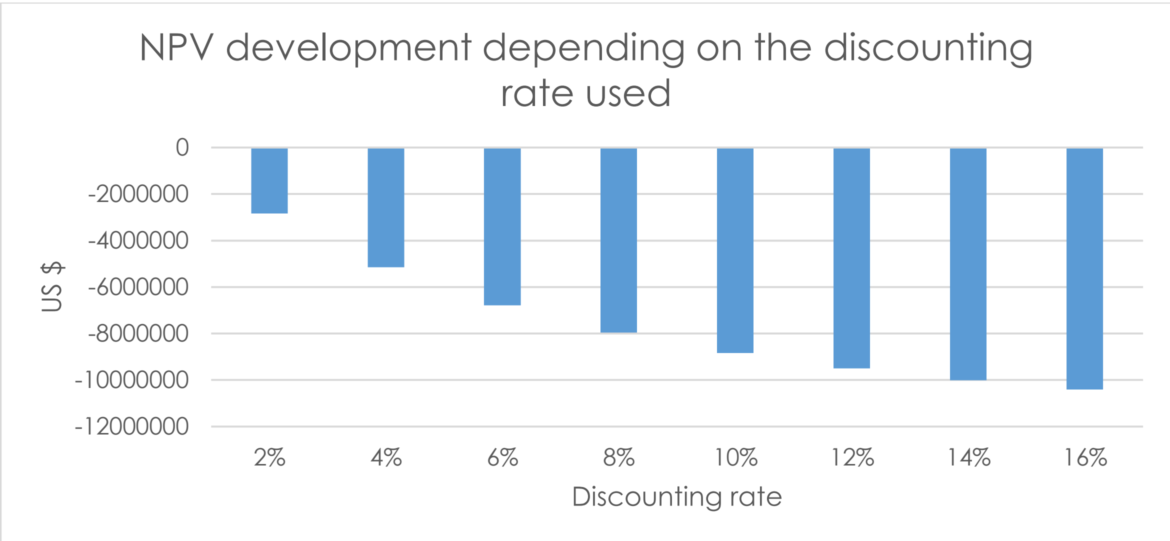


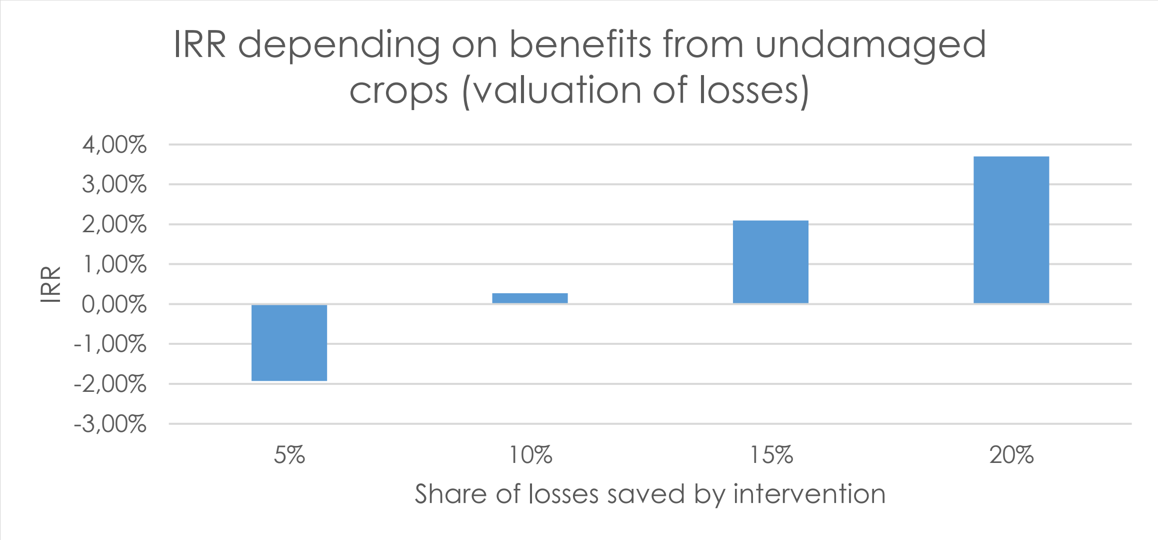
Figure 12-10 NPV for different discounting rates



Presentation of results related to changes in NPV based on varying is presented in the Figure 12-10 and shows how incorporation of climatic beta may positively influence NPV.

Finally, Figure 12-11 shows how different share of crops affects internal rate of return (IRR) for this project.

Figure 12-11 NPV in relation to share of crops prevented from damage



12.2.2.1. Estimation of benefits for selected strategies

The hectare wheat yields under the status quo will drop by 20% - from 3.148 tonnes/ha in 2021 to 2.516 tonnes/ha in 2050. In case of optimal irrigation, the yields will show 4% increase by 2050 – from 3.148 tonnes/ha in 2021 to 3.294 tonnes/ha in 2050. In monetary terms, that difference between optimal adaptation scenario and status quo in wheat yields 2050 amounts to 162 USD per ha, which is above the average monthly salary in the country nowadays. The costs of adaptation are dependent on the district, water availability, type of irrigation and the current condition of irrigation system.

Benefits of floods and mudflow prevention may be as high as 4,712,912 $ US per year. The costs are dependent on the locality.

Benefit of improved access to drinking water per one inhabitant is estimated as 47.41 US$/person.

Only the benefits that can be quantified in a reasonable way with respect to data availability and quality are considered. In our case we calculate benefits in the following areas: a) Improved irrigation; b) Water supply to households; c) Reduced flood and mudslides damages; d) Reduced lives losses related to floods and mudslides. Other benefits shall be considered qualitatively when evaluating the overall impact of the particular project.

A) Improved irrigation. The benefits for wheat yields

Evaluated projects provide irrigation to nearby agricultural land and thus contribute to maintaining of yields that would be present with no climate change. The benefits of improved irrigation are calculated based on the yield prediction using CARD model. In particular, we calculate the benefits as yield benefits due to the improved irrigation. We assume that status quo for irrigated land is represented by the pessimistic scenario of the wheat yield development. Scenario 1 is the difference between median (neutral) scenario and the pessimistic scenario of wheat yield development. Scenario 1 represents the situation with the minimum effect of the implementation of adaptation strategy. Scenario 2 is the difference between optimistic and pessimistic scenario of wheat yield development. Scenario 2 represents the situation of maximum (optimal) effect of the implementation of adaptation strategy on the wheat yield. Table 12-8 presents the wheat yield in status qua and the benefits in wheat yield under Scenario 1 and 2. To monetize the effect of improved irrigation we then use the prices of wheat calculated in OECD/FAO Agricultural outlook up to 2030 (OECD/FAO, 2021). The price for this ending year was used also for years 2031 – 2050.

Table 12-8 Wheat yields under different irrigation scenarios (results of CARD model, Tajikistan). Scenario 1 represents the minimum effect of the adaptation strategy. Scenario 2 represents the optimal effect of adaptation strategy (tonnes/ha, USD)

Year	Wheat yields, and change in wheat yields (t/ha), irrigated land			FAO predicted wheat price	Wheat yields, and change un wheat yields (USD), irrigated land,	
	Status Quo	Scenario 1	Scenario 2	USD/t	Scenario 1	Scenario 2
2021	3.148	-0.012	-0.016	234.4	-2.8128	-3.7504
2022	3.129	0.006	0.011	215.4	1.4064	2.5784
2023	3.101	0.043	0.07	219.4	10.0792	16.408
2024	3.081	0.056	0.083	221.8	13.1264	19.4552
2025	3.106	0.015	0.062	230.3	3.516	14.5328
2026	3.112	0.006	0.073	236.6	1.4064	17.1112
2027	3.098	0.011	0.063	241.8	2.5784	14.7672
2028	3.063	0.045	0.132	247.1	10.548	30.9408
2029	3.085	0.024	0.047	250.6	5.6256	11.0168
2030	3.062	0.044	0.077	253.6	10.3136	18.0488
2031	3.004	0.089	0.127	253.6	20.8616	29.7688
2032	2.988	0.099	0.158	253.6	23.2056	37.0352
2033	2.909	0.165	0.27	253.6	38.676	63.288
2034	2.889	0.185	0.283	253.6	43.364	66.3352
2035	2.885	0.156	0.296	253.6	36.5664	69.3824
2036	2.861	0.197	0.324	253.6	46.1768	75.9456
2037	2.835	0.2	0.363	253.6	46.88	85.0872
2038	2.865	0.177	0.342	253.6	41.4888	80.1648
2039	2.863	0.117	0.341	253.6	27.4248	79.9304
2040	2.806	0.18	0.399	253.6	42.192	93.5256
2041	2.773	0.232	0.429	253.6	54.3808	100.5576
2042	2.772	0.244	0.442	253.6	57.1936	103.6048
2043	2.675	0.321	0.542	253.6	75.2424	127.0448
2044	2.679	0.264	0.558	253.6	61.8816	130.7952
2045	2.623	0.33	0.638	253.6	77.352	149.5472
2046	2.597	0.345	0.641	253.6	80.868	150.2504
2047	2.566	0.361	0.693	253.6	84.6184	162.4392
2048	2.550	0.351	0.724	253.6	82.2744	169.7056
2049	2.54	0.335	0.757	253.6	78.524	177.4408
2050	2.516	0.346	0.778	253.6	81.1024	182.3632

Note: We assume that status quo for irrigated land is represented by the pessimistic scenario of the wheat yield development. Scenario 1 is the difference between median (neutral) scenario and the pessimistic scenario of wheat yield development. Scenario 1 represents the situation with the minimum effect of the implementation of adaptation strategy. Scenario 2 is the difference between optimistic and pessimistic scenario of wheat yield development. Scenario 2 represents the situation of maximum (optimal) effect of the implementation of adaptation strategy on the wheat yield. FAO stands for Food and Agriculture Organisation

Source: CARD model and own calculations

From the table above follows, that in status quo the hectare wheat yields will drop by 20% - from 3.148 tonnes/ha in 2021 to 2.516 tonnes/ha in 2050 (Scenario 1). In case of optimal irrigation, the yields will show 4% increase by 2050 – from 3.148 tonnes/ha in 2021 to 3.294 tonnes/ha in 2050. In monetary terms, that difference between optimal adaptation scenario and status quo in wheat yields 2050 amounts to 162 USD per ha, which is above the average monthly salary in the country nowadays.

The costs of adaptation are dependent on the district, water availability, type of irrigation and the current condition of irrigation system.

B) Reduced flood and mudslides damages

Global climate change has significant impacts upon incidence of disasters in Tajikistan. One of the economically most striking disasters caused by climate change are mudslides. This is apparent from the Table 12-9.

Table 12-9 Material damage related to individual disasters in Tajikistan in 2020 ($ US)

Disaster	Material Damage
Earthquakes	70,056
Avalanches	0
Rockfalls	20,800
Landslides	2,688
Strong winds	2,985,936
Mudflows	1,623,144
Floods	10,288
Other types	0
Total	4,712,912

Source: own calculation, adapted from review of Committee of Emergency Situations, Tajikistan, https://www.osce.org/files/f/documents/4/5/503953.pdf Accessed 14.5.2022

According to the report of OSCE 2021, in order to mitigate the impact of mudflows, there is a need on a national scale to implement additional engineering and technical measures directly in vulnerable settlements and areas (disaster-prone areas), which measures will enable to better prepare and protect the population, economic facilities, and territory before the activation period of dangerous natural phenomena and onset of disasters (CES Tajikistan/OSCE, 2021).

Damages inflicted by mudflows are usually related to damaged housing and infrastructure. For example, in May 2019, in Khuroson district of Tajikistan, 260 residential houses were damaged. In 2021, around 400 houses were damaged due to mud slides (OCHA, 2021). 10 years earlier, in 2011, 150 households had to move due to damages inflicted to their houses.

From the above follows, that the benefits of full adaptation in relation to reduced flood and mudslide damage may be as high as 4,712,912 $ US per year. However, it is unlikely that it will be ever possible to reduce the whole damage. The costs are highly dependent on the region.

C) Water supply to households

Benefit of water supply are provided in the Table 12-10 below. These benefits can be categorized into three major groups: health, health economic and time value.

Table 12-10 Benefits of improved water supply in Tajikistan

Averted cases of diarrhoeal disease
Malnutrition-related diseases
Health-related quality of life impacts
Decrease of costs related to diseases such as health care, productivity, mortality
Travel and waiting time averted for collecting water

Adapted from: WHO (2012)

Benefits expressed in a quantitative way are introduced in the Table 12-11 below. While these data represent entire Caucasus and Central Asia region, it is assumed that they are valid also for Tajikistan alone as no other study has been found that would monetize value for water supply in the analysed regions.

Table 12-11 Economic benefits mil. US $

Caucasus and Central Asia (CAA)	Water
Total annual economic value	100
Annual value of health care gains	10
Annual value of mortality reductions	0
Annual value of health-related productivity	0
Total time value	100
Total	210
Population to be reached, per intervention (thousands)	4429
Benefit per 1 inhabitant (US$/person)	47.41

Benefit for one inhabitant is used in the cost/benefit analysis and is multiplied by the number of expected people that will newly have access to clean water. It has to be noted that the improved access to water assumes that cost of pipes will be included in the cost of the project which may not be always a realistic assumption

D) Reduced lives losses related to floods and mudslides

In recent history of Tajikistan, many regions have been affected by various natural disasters caused to some extent by global climate change. Examples of these disasters are floods and mudflows. Recently, the torrential rains of 7 – 12 May 2021 triggered floods, landslides and mudflows in many of the country's districts with the most affected being Kulob city and districts of Vakhsh, Jomi, Vose, Shamsiddini Shohin, Yovon, Dusti, Muminabad, Qushoniyon, Dangara and Khuroson (OCHA, 2021). Last May incident has been also related to loss of lives with 3 people killed in Kulob city.

In the Asht district, in the last 5 years, 3 to 5 large mudflows have destroyed the centre of the town with 10 lives lost. In 2020, 3 lives were lost due to mudslides (CES Tajikistan/OSCE, 2021). While it is generally hard to estimate value of life, for the purposes of cost/benefit analysis a common concept in use is the value of statistical life (VSL). Any measure that prevents these losses does have hence monetary benefits that can be represented by VSL

Value of statistical life (VSL)

For Tajikistan, the VSL should be extrapolated from the studies dealing with low-income countries. For cost benefit analysis there are two possible approaches. First, results of studies conducted in the country of concern can be used if they are available. Second, if these studies are not available or are not of sufficient quality, as is the case of Tajikistan, it is necessary to extrapolate from values from higher income countries and adjust them for differences in income.

Usually, it is common to use data from the US regulatory analyses or data from OECD member countries. The values from these studies may differ significantly in terms of the absolute amount and/or the relationship to income. For the US, VSL estimates range between $9 million and $10 million (expressed in 2015 US dollars). For the OECD group, the VSL estimate is around $3 million (2005 U.S. dollars; Robinson et al., 2018).

These estimates are compared to gross national income (GNI) per capita and result in a VSL to GNI per capita ratio of 155 to 172 for the US estimates and a ratio of 98 for the OECD estimate. (Robinson et al., 2018)

The substantial difference in these ratios is attributable at least in part to the use of divergent approaches to developing these estimates, not solely differences in the incomes and preferences of these populations. (Robinson et al., 2018)

To extrapolate values across countries, it is necessary to select an estimate of the degree of change in the VSL associated with the change in income. This is also known as the VSL income elasticity. Usually for high-income populations VSL is less than proportional to income, which implies an income elasticity between zero and one. (Robinson et al., 2018)

An income elasticity that is greater than one implies that the ratio of VSL to GNI per capita is smaller among lower than in higher income populations. Given that lower-income individuals spend larger share of their incomes to more necessary or urgent expenses, it is reasonable. (Robinson et al., 2018)

VSL is likely to differ across countries for many reasons other than variation in income. For example, differences in life expectancy, health, economic and social support, religion, and culture across individuals as well as across countries are likely to affect these values. Effects of these factors are not well understood. Using the study of Robinson et al. (2018), income elasticity of 1.5 is selected for Tajikistan. Extrapolated from U.S. VSL with elasticity = 1.5, the Tajikistan's VSL is calculated to be $131,407 based on the inputs from Table 12-12.

Table 12-12 Value of statistical life

GNI per capita	GNI per capita *160	GNI per capita *100	Extrapolated from U.S. VSL with elasticity = 1.5
$3,360	$537,600	$336,000	$131,407

Calculation of costs

Many factors influence the costs of building water reservoir/dam. For example, it is necessary to assess lithology of water bed whereas differences may arise when it is sedimentary, regolith or hard rock. (Petheran, McMahon, 2019). For the analysed projects, mostly Tajikistan's bed are Quaternary deposits (Zaripova, 2018).

Also, dam type will have significant influence over the cost, so that a difference will arise when it is rock embankment, concrete gravity, earth embankment or concrete arch (Petheran, McMahon, 2019). Also, other variables play an important role for flood production such as discharge volume.

The costs may be decomposed into the fixed cost and variable costs. Other decomposition of costs is presented in the Table 12-13. For the peculiarities of Tajikistan, the largest proportion of costs will fall under construction cost.

Table 12-13 Cost decomposition

Costs
• Acquisition of land where relevant • Engineering design and supervision • Construction costs • Conservation and habitat creation where relevant • Operating costs • Possible payments to landowners where relevant

Source: adapted from Keating et al. (2015)

Fixed costs, in other words, costs that do not change with the volume of captured water are introduced in the cost benefit analysis for individual projects. Variable costs are estimated to be in-between (1-5%) of fixed costs per annum based on the expert opinions and literature review.

Many factors will exercise influence over both fixed and variable costs. These factors are summarized in the Table 12-14 that were identified in the study of Keating et al. (2015) but are relevant also for Tajik conditions.

Table 12-14 Factors relevant to Tajikistan conditions

Factor	Impact on cost estimation
Access to site	Easy access (during construction and subsequent maintenance and operation works) will reduce costs.
Presence of services and other onsite constraints	Implications for the type of construction plant and protection may be needed for buried services.
Presence of contaminated land	Remediation will increase costs.
Height of dam/embankment	Head of water retained affects the width of the wall or embankment needed.
Size of storage area	The larger the storage, generally the greater the costs, although this will depend on the type of storage and type and size of impounding dam or embankments required.
Geology	Impermeable foundations or cut-off required of sufficient bearing capacity to support impounding structure.
Material type and availability onsite	Presence of suitable earth/clay will reduce import costs.
Source of imported material and disposal of waste material	Costs of importing and disposal of material can be significant.
Suitability of site	Taking advantage of a narrower part of a valley for the impounding structure for the reservoir will reduce dam lengths and reduce costs.
River nature	A wide floodplain will maximise storage and reduce impounding structure heights.
Balancing cut and fill	Minimising earthmoving will reduce costs.
Impact of works on environment	Need for the inclusion of environmental impact studies and environmental mitigation/enhancement.
Weather during construction	Adverse conditions will affect efficiencies.

Source: adapted from Keating et al. (2015)

The study of Keating et al. also shows a wide range of costs per m^3 of the dam capacity. The median is 19.4, but the values vary from 1.7 to almost 650 US $ (see Table 12-15).

Table 12-15 Example for costs per m³ of the dam capacity taken from the study of Keating et al. (2015)

Site	Volume (m^3)	Cost (US$)	Cost (US$/$m^3$)	source of data
Melton Mowbray flood alleviation scheme	3500000	10443290	3.0	UCD
Bodmin Town storage pond	20000	617245,2	30.9	UCD
Harbertonford flood defence scheme	15000	671799,7	44.8	UCD
Afon Adda flood alleviation scheme	3300	202631	61.4	UCD
Afon Adda flood alleviation scheme	312	202631	649.5	UCD
Harnham flood defence scheme	1875	324209,6	172.9	private developer
Blackburn Brook flood attenuation reservoir	32000	2727725	85.2	private developer
Weedon flood storage reservoir	810000	1932788	2.4	Environment Agency
Bruton flood storage reservoir - improvement	500000	4676100	9.4	Environment Agency
Long Eau	18300	116902,5	6.4	Morris et al (2004)
Harbertonford	35000	3896750	111.3	Morris et al (2004)
Leigh Barrier	5580000	9352200	1.7	Morris et al (2004)
Unnamed	15000	109109	7.3	Morris et al (2004)
Unnamed	100000	341355,3	3.4	Morris et al (2004)
Cobbins Brook	758000	9352200	12.3	Morris et al (2004)
Kersal	650000	17145700	26.4	Bichard and Kazmierczak (2009)
Min	***312***	***109109***	***1.7***	
Max	***5580000***	***17145700***	***649.5***	
Median	***33500***	***1302293,9***	***19.4***	

A similar study has been conducted for Australia (Petheran, McMathon, 2019) whose results are presented in the Table 12-16 below.

Table 12-16 Summary of costs for Australian projects

	Number of projects	Min	75%	Mean	25%	Max
Final cost (2016) US$/$m^3$	98	0,035	0,287	0,717	1,49	12,86

Source: Petheran and McMathon, 2019

Furthermore, a comparative study has been conducted for six water reservoirs across the world. Results of this study are presented in the Table 12-17.

Table 12-5 Costs of six water reservoirs across the world

Region	Name of dam	Capacity	Price	Source
Africa - Bafing river (Senegal river basin)	Manantali Dam	11,270 bcm (billion m^3)	1,343 bil. US$	https://www.fao.org/3/bc815e/bc815e.pdf
	Diama Dam	0.250 bcm (billion m^3)	65,85 mil. US$	https://www.fao.org/3/bc815e/bc815e.pdf
Portugal - Guadiana River	Alqueva	4150 mil. m^3	1,7 bil. US$	https://www.fao.org/aquastat/en/databases/dams
Jordan Zarqua river	King Talal Dam	86 mil. m^3	62 mil. US$	https://www.fao.org/aquastat/en/databases/dams
Jordan	Al Karama	55 mil. m^3	80 mil.US$	
Turkey - Büyük River	Dilimli Baraji	62.88 mil. m^3	41.7 mil. US$	https://web.archive.org/web/20120503003549/http://www2.dsi.gov.tr/baraj/detayeng.cfm?BarajID=222

It is important to mention that some of the costs also include costs for hydroelectricity generation, water supply, irrigation canals and substantial landscaping.

For the three analysed projects, the costs are taken based on the volume of the reservoirs and also project money allocated for the area. Finally, researchers have included in the costs also costs related to piping (drinking water supply) and irrigation canals.

12.2.2.2. Assessment of the projects through the shadow value of agricultural production

In the shadow value[10] analyses, presented in previous reports the results show that even if we take only one general benefit of the project (in this case, only the agricultural perspective/impact) at least one-third of the project displays a positive net present value (under 12% discount rate). However, even the projects with the negative present value might have positive economic effects when taking into consideration further non-monetarized effects.

The previous chapter provided CBA for the three selected projects. Other projects are not analysed in detail due to the data and time limitations of the project. However, the general assessment of the project through their shadow value of agricultural production were carried out. In particular, shadow values of the agricultural production represent the gains of implementation of adaptation and/or mitigation strategies. In this respect, status quo for rainfed and irrigated land characterise the pessimistic scenario of the wheat yield development that can be associated with the situation when there is not implemented any adaptation and/or mitigation strategy with respect to the climate change. Scenario 1 is the difference between median (neutral) scenario and the pessimistic scenario of wheat yield development that can be associated with the minimum effect of the implementation of adaptation and/or mitigation strategy on the wheat yield. Scenario 2 is calculated as the difference between optimistic and pessimistic scenario of wheat yield development and represents the situation of maximum (optimal) effect of the implementation of adaptation and/or mitigation strategy on the wheat yield. Then, since wheat belongs to the most important commodity in Tajikistan it is used for the calculation of the shadow values of agricultural production that represent the monetary effects of the implementation of the adaptation and/mitigation strategy that allows to carry out the comparison of the effects of different adaptation and mitigation strategies despite the fact that they differ in their natures and scopes.

Table 12-18 present the net present values of the projects using the discount rate 12 %. We may observe that even we take only one general benefit of the project (in this case only the agricultural perspective/impact) at least one third of the project displays positive net present values. However, even the projects with negative present value might have positive economic effects when taking into consideration further non-monetarized effects.

[10] A shadow value is an estimated price for something that is not normally priced or sold in the market. Shadow pricing can provide businesses with a better understanding of the costs and benefits associated with a project.

Table 12-18 Net present value of the projects based on shadow value of agricultural production

	Rainfed		**Irrigated**	
	Scenario 1	Scenario 2	Scenario 1	Scenario 2
Project (title)	NPV50	NPV50	NPV50	NPV50
6.5 Project for Agro-Technical Measures to Combat Secondary Salinization of Soils	14893185	16699700	8780248	21308958
2.2 Livestock and Pasture Development Project II (Pastrure systems)	46852770	53609922	23987728	70850550
4.10 CACILM: Demonstrating Local Responses to Combating Land Degradation and Improving Sustainable Land Management in SW Tajikistan-under CACILM Partnership Framework, Phase 1	642530	893871	-207965	1535159
2.1 Livestock and Pasture Development Project	2139657	3844065	-3627766	8192799
4.4 Rehabilitation of Hydrotechnical Construction of Great Gissar Canal	203163	517339	-859957	1318949
4.13 Rural Infrastructure Rehabilitation Project	-2529443	-487295	-9439719	4723170
4.12 Tajikistan Second Public Employment for Sustainable Agriculture and Water Resources Management Project	-6823586	-3106878	-19400289	6376169
4.11 Environmental Land Management and Rural Livelihoods	-13804230	-13109350	-16155585	-11336389
4.7 RESILAND CA+ Program: Tajikistan Resilient Landscape Restoration Project	-34099563	-33062781	-37607858	-30417468
1.4 Community Agriculture & Watershed Management Project	-11282329	-11042864	-12092639	-10431877
4.5 Construction and Rehabilitation of Irrigation Systems for Development of New and Existing Water Provision of Land in Jirgital District	-4798051	-4724628	-5046502	-4537292
4.3 Reclaimed Land and Irrigation in Gafurov District	-20395819	-20243239	-20912123	-19853937
4.15 Irrigation Rehabilitation Project	-27366496	-27212078	-27889019	-26818086
1.1 Integrated Watershed and Sustainable Land Management to Build the Resilience of Local Communities in Tajikistan	-4767	-4745	-4842	-4688
1.3 Ferghana Valley Water Resources Management Project	-26104730	-26003408	-26447586	-25744889
4.16 Tajikistan: Building Climate Resilience in the Pyanj River Basin	-21310521	-21287743	-21387597	-21229626

13. Assessment of the projects

General information on each project is enclosed in Table 13-1. Table one presents the project's name, finance (express in US dollars), and the measure of quantitative impacts. Unfortunately, identified projects involved a wide range of activities and indicators, as they dealt with diversified problems, actions, and output indicators.

As for the indicators identified in the final report, mid-term reports, or applications, we observed the following indicator categories:

- amount of affected people or households,
- number of creative jobs,
- length of irrigated canals (reconstruction / construction),
- length of water system supplying fresh and clean water,
- number of items delivered to local communities,
- number of created associations, pasture unions,
- size of the affected/improved lant,
- and some others.

The highest number of projects is related to improved land or water used. This category involves 17 projects. The other measures are the second-largest category with eight projects. Categories 1, 2, 3 and 5 include less than five projects each.

Category 1 targeted improved watershed management. Within this category, preventive measures to strengthen the resilience of local communities were implemented. Delaware proposed an implementation it new practices which should lead to the mitigation of natural hazards (floods, mad slides). The total value identified what's over 54 million USD:

Category 2 focused on new approaches toward posturing practices. Two consecutive projects of almost 40 million USD aim to target problems related to overgrazing. Over the last decade, the total number of animal heads increased, contributing to higher stress off Tajik pastures.

Category 3 is relatively small in the total allocation of financial resources (less than 5 million USD). The most critical measures targeted yield improvement by implementing higher yield varieties, improving production patterns, or providing new technologies (tractors, tools, etc.).

As stated above, Category 4 is related to improved water or land use. It involves 17 projects exceeding 445 million USD. Although those are under the same category still, they are diverse. To a certain extent, projects consider improved water management (including drinking water), and they try to introduce climate resilience and adaptation strategies. Projects also focused on reconstructing irrigation channels, environmental management, and agriculture diversification of different regions.

Category 5 includes only one project aiming at land conversion. For the fifth category, we don't have any financial data. The one project did not publish any trustworthy information about total budget sources.

Category 6 involves eight projects with a total value of 88 million USD. In most cases, these other measures are also related to cultural hazards – preventing mudslides and reducing salinization.

To proceed further with the assessment, hectares have been used as a primary unit for impact assessment (Table 13-2).

Table 13-1 Project summarization

Project (title)	Finance (USD)	Measured/quantified impact (hectares; t/ha; reduction of losses, etc.)
Integrated Watershed and Sustainable Land Management to Build the Resilience of Local Communities in Tajikistan	5,000	1.41ha vulnerable areas and planting them with 462 species
Building "Punukai" Reservoir (Mudflow Reservoir) In Asht District of Sughd Region	13,550,000	no data; just 800 people + 185 households
Ferghana Valley Water Resources Management Project	27,170,000	6,450 ha
Community Agriculture & Watershed Management Project	13,800,000	43,000 households and 15,244 ha
Livestock and Pasture Development Project	15,780,000	22,400 households; about 108,500 ha of pasture are expected to be improved
Livestock and Pasture Development Project II (Pasture systems)	24,190,000	38,000 rural households; 132,000 ha of pastures to be managed in more climate-resilient manner
Project to Develop High Yield Crops in the Context of Climate Change	1,530,000	no data: 225 rural households, an increase of yields from 10 to 20%
Study And Development of Agricultural Climate Adaptation Technologies	3,150,000	no data
Development of National water security systems for ensuring food security in Tajikistan	70,000,000	no data
Strengthening land-based adaptation practices in Tajikistan	20,000,000	no data
Reclaimed Land and Irrigation in Gafurov District	22,000,000	24000 people affected: 9,713 ha
Rehabilitation of Hydrotechnical Construction of Great Gissar Canal	3,100,000	13400 people and 20,000 ha
Construction and Rehabilitation of Irrigation Systems for Development of New and Existing Water Provision of Land in Jirgital District	5,570,000	14,000 people and 4,674 ha
Facilitating Climate Resilience in Tajikistan	67,600,000	800 farmers, 14,000 seedlings
RESILAND CA+ Program: Tajikistan Resilient Landscape Restoration Project	45,000,000	66,000 ha
Project for Improving the Efficiency of Land Use through Agricultural Diversification	10,000,000	5,000 farm households or over 30,000 people
Climate Adaptation and Mitigation Program for Aral Sea Basin (CAMP4ASB)	19,000,000	15,000 people and supporting the creation of 4,300 new jobs. Over 6,500
CACILM: Demonstrating Local Responses to Combating Land Degradation and Improving Sustainable Land Management in SW Tajikistan-under CACILM Partnership Framework, Phase 1	2,000,000	16,000 ha
Environmental Land Management and Rural Livelihoods	21,110,000	44,235 ha; 16 Water Use associations, US$ 11.32 million toward enhanced rural production and land resource management - investments
Tajikistan Second Public Employment for Sustainable Agriculture and Water Resources Management Project	45,900,000	236,600 ha (irrigation and drainage services), person-days worked - 1,146,000
Rural Infrastructure Rehabilitation Project	24,000,000	n/a
Climate- and Disaster-Resilient Irrigation and Drainage Modernization in the Vakhsh River Basin Project	31,000,000	6,700 farmers
Irrigation Rehabilitation Project	28,990,000	9830 ha
Tajikistan: Building Climate Resilience in the Pyanj River Basin	21,550,000	Flood protection was provided to 3,973.5 ha; Irrigation canals were extended to 2,081 ha, water supply was provided to

Project (title)	**Finance (USD)**	**Measured/quantified impact (hectares; t/ha; reduction of losses, etc.)**
		4,500 households in 15 villages, and 1,934 microcredits were issued to promote climate resilience.
From service delivery to sustainable water management in Tajikistan	9,950,000	To date, it has provided 200,000 people with safe drinking water in rural areas
Drip irrigation helps farmers in Tajikistan to grow crops, adapt to climate change	-	n/a
Mudslides and floods: Emergency appeal n° MDRTJ005, GLIDE n° MS-2009-000083-TJK, FL-2009-000095-TJK, MS-2009-000099-TJK	806,936	726 affected families aided after mudslides (food, shelter, information, tools)
Emergency assistance to mudflow affected population of Khuroson district	51,000	Non-food emergency supplies are sufficient to cover the needs of 100 families
Facilitating Climate Resilience in Tajikistan (FCRT)	950,130	no more data is available
Project to Reconstruct Existing Warehouses and Construct Modern Storage Facilities for Crops and Livestock	10,150,000	no data: reconstructed storehouses should cut stored losses by 25% (the amount saved annually - 148,000 tons of wheat - is based on the three-year average Tajik production from 2012 to 2014)
Project for Agro-Technical Measures to Combat Secondary Salinization of Soils	4,100,000	115,000 ha
Integrated Health and Habitat Improvement (IHHI) Rasht Valley, Tajikistan	10,382,104	14 Watershed Management Plans, developed and 111 Disaster risk reduction driven Natural Resource Management projects to be implemented, 4 emergency communications systems and 7 safe havens/emergency shelters established, 21 water supply systems (120,000 people in 140 villages)
Strengthening Critical Infrastructure Against Natural Hazards	50,000,000	Crisis management centres (100), 441,100 people with reduced disaster risks through more resilient flood protection
Khatlon Livelihoods Support Project	12,300,000	98 agricultural/ construction machinery subprojects; demonstration plots (2 hectares of demonstration plots on intensive orchards, 10 hectares were planted with 15 types of crops), construction of 4 water supply lines (10 000 people), rehabilitation of 8 000 m of roads, rehabilitation of 27.5 km of power lines.
Total	634,685,170	

Source: compilated data, 2022

Table 13-2 Project assessment – production approach – costs per hectare

Project (title)	Finance (USD)	ha	USD / ha
Integrated Watershed and Sustainable Land Management to Build the Resilience of Local Communities in Tajikistan	5,000	1.41	3,546.10
Building "Punukai" Reservoir (Mudflow Reservoir) In Asht District of Sughd Region	13,550,000	n/a	n/a
Ferghana Valley Water Resources Management Project	27,170,000	6,450	4,212.40
Community Agriculture & Watershed Management Project	13,800,000	15,244	905.27
Livestock and Pasture Development Project	15,780,000	108,500	145.44
Livestock and Pasture Development Project II (Pasture systems)	24,190,000	132,000	183.3
Project to Develop High Yield Crops in the Context of Climate Change	1,530,000	n/a	n/a
Study and Development of Agricultural Climate Adaptation Technologies	3,150,000	n/a	n/a
Development of National water security systems for ensuring food security in Tajikistan	70,000,000	n/a	n/a
Strengthening land-based adaptation practices in Tajikistan	20,000,000	n/a	n/a
Reclaimed Land and Irrigation in Gafurov District	22,000,000	9,713	2,265.01
Rehabilitation of Hydrotechnical Construction of Great Gissar Canal	3,100,000	20,000	155
Construction and Rehabilitation of Irrigation Systems for Development of New and Existing Water Provision of Land in Jirgital District	5,570,000	4,674	1,191.70
Facilitating Climate Resilience in Tajikistan	67,600,000	n/a	n/a
RESILAND CA+ Program: Tajikistan Resilient Landscape Restoration Project	45,000,000	66,000	681.82
Project for Improving the Efficiency of Land Use through Agricultural Diversification	10,000,000	n/a	n/a
Climate Adaptation and Mitigation Program for Aral Sea Basin (CAMP4ASB)	19,000,000	n/a	n/a
CACILM: Demonstrating Local Responses to Combating Land Degradation and Improving Sustainable Land Management in SW Tajikistan-under CACILM Partnership Framework, Phase 1	2,000,000	16,000	125
Environmental Land Management and Rural Livelihoods	21,110,000	44,235	477.22
Tajikistan Second Public Employment for Sustainable Agriculture and Water Resources Management Project	45,900,000	236,600	194
Rural Infrastructure Rehabilitation Project	24,000,000	n/a	n/a
Climate- and Disaster-Resilient Irrigation and Drainage Modernization in the Vakhsh River Basin Project	31,000,000	n/a	n/a
Irrigation Rehabilitation Project	28,990,000	9,830	2,949.14
Tajikistan: Building Climate Resilience in the Pyanj River Basin	21,550,000	6,054.5	3,559.3
From service delivery to sustainable water management in Tajikistan	9,950,000	n/a	n/a
Drip irrigation helps farmers in Tajikistan to grow crops, adapt to climate change	-	n/a	n/a
Mudslides and floods: Emergency appeal n° MDRTJ005, GLIDE n° MS-2009-000083-TJK, FL-2009-000095-TJK, MS-2009-000099-TJK	806,936	n/a	n/a
Emergency assistance to mudflow affected population of Khuroson district	51,000	n/a	n/a
Facilitating Climate Resilience in Tajikistan (FCRT)	950,130	n/a	n/a
Project to Reconstruct Existing Warehouses and Construct Modern Storage Facilities for Crops and Livestock	10,150,000	n/a	n/a
Project for Agro-Technical Measures to Combat Secondary Salinization of Soils	4,100,000	6,050	677.7
Integrated Health and Habitat Improvement (IHHI) Rasht Valley, Tajikistan	10,382,000	n/a	n/a
Strengthening Critical Infrastructure against Natural Hazards	50,000,000	n/a	n/a
Khatlon Livelihoods Support Project	12,300,000	n/a	n/a

Source: own calculations based on compilated data, 2022

Table 13-2 summarises identified costs of the project and the total impact on the area (expressed in affected hectares). In our approach, affected hectares cover land, which is protected from flooding, land which was irrigated by new construction works, where do irrigation system was improved, area of improved pasture management practices, agricultural land where new production practices were introduced, area with improved disaster management or area under land conversion practises.

Needed data we're always reached from the paying agency proposals (for ongoing projects), the monitoring reports (for ongoing projects), or the concluding information delivered after project termination.

Unfortunately, many projects did not provide any information on the area affected. 15 projects out of 34 indicated area impacts; others use different qualitative or quantitative indicators. The total value of those 15 projects exceeds 280 million USD and thus represents 44% of all identified spending. The identified measures affected 681,352 ha with an average per hectare cost of 411.3 USD. Table 13-3 presents the project ranked according to costs expressed per hectare of the affected land.

Table 13-3 Ranking of the projects according to the costs per hectare – production approach

Project (title)	**Finance (USD)**	**ha**	**USD / ha**
CACILM: Demonstrating Local Responses to Combating Land Degradation and Improving Sustainable Land Management in SW Tajikistan-under CACILM Partnership Framework, Phase 1	2,000,000	16,000	125
Livestock and Pasture Development Project	15,780,000	108,500	145.44
Rehabilitation of Hydrotechnical Construction of Great Gissar Canal	3,100,000	20,000	155
Livestock and Pasture Development Project II (Pasture systems)	24,190,000	132,000	183.3
Tajikistan Second Public Employment for Sustainable Agriculture and Water Resources Management Project	45,900,000	236,600	194
Environmental Land Management and Rural Livelihoods	21,110,000	44,235	477.22
Project for Agro-Technical Measures to Combat Secondary Salinization of Soils	4,100,000	6,050	677.7
RESILAND CA+ Program: Tajikistan Resilient Landscape Restoration Project	45,000,000	66,000	681.82
Community Agriculture & Watershed Management Project	13,800,000	15,244	905.27
Construction and Rehabilitation of Irrigation Systems for Development of New and Existing Water Provision of Land in Jirgital District	5,570,000	4,674	1,191.70
Reclaimed Land and Irrigation in Gafurov District	22,000,000	9,713	2,265.01
Irrigation Rehabilitation Project	28,990,000	9,830	2,949.14
Integrated Watershed and Sustainable Land Management to Build the Resilience of Local Communities in Tajikistan	5,000	1.41	3,546.10
Tajikistan: Building Climate Resilience in the Pyanj River Basin	21,550,000	6,054.5	3.559.3
Ferghana Valley Water Resources Management Project	27,170,000	6,450	4,212.40
Total	280,265,000	681,352	411.3

Source: own calculations based on compilated data, 2022

Results indicated in Table 13-3 show that the costs per affected land differ a lot. The values range from 125 USD per hectare up to 4,212 USD per hectare. The lowest costs were identified within the CACILM project focused on land degradation. The project costs of a total of 2 million USD brought and environmental benefits on an area of about 16,000 hectares, combating land degradation through improving land management practices.

The second-lowest costs per climate change mitigating measures were related to the Livestock and Pasture Development Project and its second phase (Livestock and Pasture Development Project II), where the price per affected land ranges between 155 and 183 USD/ha.

However, all three projects mentioned above are somewhat extensive. No specific (physical) investment activities are planned. Activities are strategic as they prepare to impact pastoral and land management practices, establish policy discussion, or start policy changes and/or establish communities of people with the same interest (i.e., pastoral communities).

The costliest activities combine both strategic activities with construction projects. Ferghana Valley Water Resources Management Project (4,212 USD / ha) implements water user associations, rehabilitation of irrigation structures, pumping stations, tube wells, adjustments of embankments and implementation of demonstration fields with new cultivation and cropping activities. Those complex projects certainly require more physical labour and material, and thus the price must be higher.

Table 13-4 Changes in wheat yield under different scenarios

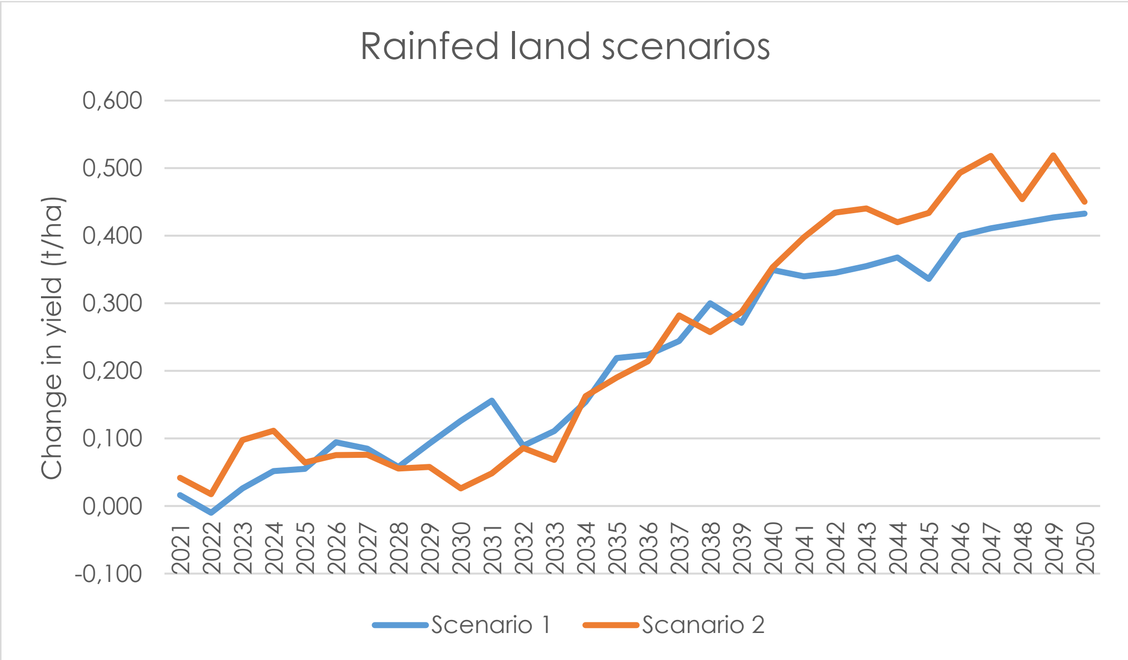
Year	Rainfed land			Full Irrigation		
	Status Quo	Scenario 1	Scenario 2	Status Quo	Scenario 1	Scenario 2
2021	3.154	0.016	0.042	3.148	-0.012	-0.016
2022	3.163	-0.010	0.018	3.129	0.006	0.011
2023	3.128	0.026	0.098	3.101	0.043	0.070
2024	3.116	0.052	0.112	3.081	0.056	0.083
2025	3.108	0.055	0.065	3.106	0.015	0.062
2026	3.095	0.094	0.076	3.112	0.006	0.073
2027	3.078	0.085	0.076	3.098	0.011	0.063
2028	3.083	0.058	0.055	3.063	0.045	0.132
2029	3.076	0.093	0.058	3.085	0.024	0.047
2030	3.092	0.126	0.026	3.062	0.044	0.077
2031	3.063	0.156	0.048	3.004	0.089	0.127
2032	3.061	0.089	0.086	2.988	0.099	0.158
2033	3.067	0.111	0.068	2.909	0.165	0.270
2034	3.057	0.154	0.163	2.889	0.185	0.283
2035	3.013	0.219	0.190	2.885	0.156	0.296
2036	2.998	0.224	0.214	2.861	0.197	0.324
2037	2.982	0.244	0.282	2.835	0.200	0.363
2038	3.002	0.300	0.257	2.865	0.177	0.342
2039	2.981	0.271	0.287	2.863	0.117	0.341
2040	2.928	0.349	0.353	2.806	0.180	0.399
2041	2.900	0.340	0.398	2.773	0.232	0.429
2042	2.910	0.345	0.434	2.772	0.244	0.442
2043	2.891	0.355	0.440	2.675	0.321	0.542
2044	2.878	0.368	0.420	2.679	0.264	0.558
2045	2.895	0.336	0.434	2.623	0.330	0.638
2046	2.859	0.400	0.493	2.597	0.345	0.641
2047	2.845	0.411	0.518	2.566	0.361	0.693
2048	2.838	0.419	0.454	2.550	0.351	0.724
2049	2.825	0.427	0.519	2.540	0.335	0.757
2050	2.805	0.433	0.450	2.516	0.346	0.778

Source: CARD, own calculations, 2022

Table 13-4 uses the results of yield prediction based on CARD approach. These results serve for the calculation of shadow values of the agricultural production representing the gains of implementation of adaptation and/or mitigation strategies. In particular, status quo for rainfed and irrigated land represents the pessimistic scenario of the wheat yield development that can be associated with the situation when there is not implemented any adaptation and/or mitigation strategy with respect to the climate change. Scenario 1 is the difference between median (neutral) scenario and the pessimistic scenario of wheat yield development that can be associated with the minimum effect of the implementation of adaptation and/or mitigation strategy on the wheat yield. Scenario 2 is calculated as the difference between optimistic and pessimistic scenario of wheat yield development and represents the situation of maximum (optimal) effect of the implementation of adaptation and/or mitigation strategy on the wheat yield. Then, since wheat belongs to the most important commodity in Tajikistan, we use it for the calculation of the shadow values of agricultural production that represent the monetary effects of the implementation of the adaptation and/mitigation strategy that allows us to carry out the comparison of the effects of different adaptation and mitigation strategies even though they differ in their natures and scopes.

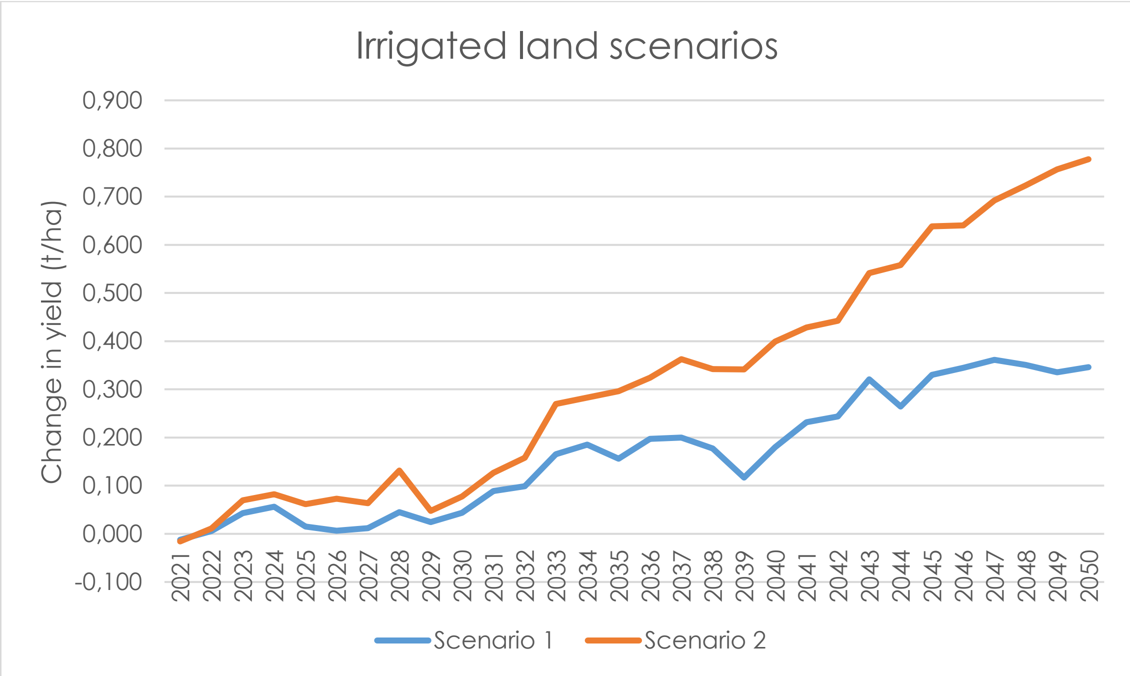
Figures 13-1 and 13-2 displays the gains in wheat yield under Scenario 1 and 2 for rainfed and irrigated land. The positive trends suggest the increasing gains in wheat production under adaptation and/or mitigation strategies. That is, since the negative climate change effects are more and more pronounced in the period 2021 and 2050, the adaptation and/or mitigation strategies have considerably increased effect on the wheat yield.

Figure 13-1 Changes in wheat yield – Rainfed land – Scenario 1 and 2



Source: own calculations, 2022

Figure 13-2 Changes in wheat yield – Irrigated land – Scenario 1 and 2



Source: own calculations, 2022

Tables 13-5, 13-6, 13-7 and 13-8 present detail information about shadow values of wheat production under Scenario 1 and 2 for rainfed and irrigated land. In particular, the tables provide for these scenarios and types of land the cumulative shadow values of wheat production for periods 2021 – 2030, 2031-2040 and 2041-2050 because of the implementation of adaptation and/or mitigation measures. Moreover, the tables show net values that represent the difference between cumulative shadow values of production (without implementation of discounting) for periods 2021 – 2030 (PV30), 2021 – 2040 (PV40) and 2021 – 2050 (PV50) and project investment costs. The results suggest that most projects have positive net values.

Table 13-5 Shadow value of wheat production under Scenario 1 – Rainfed

Project (title)	2021- 2030	2031- 2040	2041- 2050	NV30	NV40	NV50
Project for Agro-Technical Measures to Combat Secondary Salinization of Soils	711913	2535615	4591401	-3388087	-852472	3738929
Livestock and Pasture Development Project II (Pasture systems)	15532654	55322501	100176022	-8657346	46665155	146841177
CACILM: Demonstrating Local Responses to Combating Land Degradation and Improving Sustainable Land Management in SW Tajikistan-under CACILM Partnership Framework, Phase 1	1882746	6705758	12142548	-117254	6588504	18731052
Livestock and Pasture Development Project	12767371	45473419	82341655	-3012629	42460790	124802445
Rehabilitation of Hydrotechnical Construction of Great Gissar Canal	2353432	8382197	15178185	-746568	7635630	22813815
Tajikistan Second Public Employment for Sustainable Agriculture and Water Resources Management Project	27841106	99161392	179557931	-18058894	81102498	260660429
Environmental Land Management and Rural Livelihoods	5205204	18539324	33570351	-15904796	2634529	36204880
RESILAND CA+ Program: Tajikistan Resilient Landscape Restoration Project	7766327	27661251	50088011	-37233673	-9572422	40515589
Community Agriculture & Watershed Management Project	1793786	6388911	11568813	-12006214	-5617303	5951510
Construction and Rehabilitation of Irrigation Systems for Development of New and Existing Water Provision of Land in Jirgital District	549997	1958919	3547142	-5020003	-3061083	486059
Reclaimed Land and Irrigation in Gafurov District	1142944	4070814	7371286	-20857056	-16786242	-9414956
Irrigation Rehabilitation Project	1156712	4119850	7460078	-27833288	-23713438	-16253360
Integrated Watershed and Sustainable Land Management to Build the Resilience of Local Communities in Tajikistan	166	591	1070	-4834	-4243	-3173
Ferghana Valley Water Resources Management Project	758982	2703259	4894965	-26411018	-23707759	-18812795
Tajikistan: Building Climate Resilience in the Pyanj River Basin	712443	2537501	4594816	-20837557	-18300057	-13705240

Source: own calculations, 2022

Table 13-6 Shadow value of wheat production under Scenario 2 – Rainfed

Project (title)	2021- 2030	2031- 2040	2041- 2050	NV30	NV40	NV50
Project for Agro-Technical Measures to Combat Secondary	747060	2334190	5462861	-3352940	-1018749	4444112

Salinization of Soils						
Livestock and Pasture Development Project II (Pasture systems)	16299499	50927792	119189695	-7890501	43037291	162226986
CACILM: Demonstrating Local Responses to Combating Land Degradation and Improving Sustainable Land Management in SW Tajikistan-under CACILM Partnership Framework, Phase 1	1975697	6173066	14447236	-24303	6148763	20595998
Livestock and Pasture Development Project	13397694	41861102	97970317	-2382306	39478796	137449113
Rehabilitation of Hydrotechnical Construction of Great Gissar Canal	2469621	7716332	18059045	-630379	7085953	25144998
Tajikistan Second Public Employment for Sustainable Agriculture and Water Resources Management Project	29215617	91284209	213638498	-16684383	74599826	288238325
Environmental Land Management and Rural Livelihoods	5462184	17066598	39942092	-15647816	1418782	41360874
RESILAND CA+ Program: Tajikistan Resilient Landscape Restoration Project	8149749	25463896	59594847	-36850251	-11386354	48208493
Community Agriculture & Watershed Management Project	1882345	5881388	13764604	-11917655	-6036266	7728337
Construction and Rehabilitation of Irrigation Systems for Development of New and Existing Water Provision of Land in Jirgital District	577150	1803307	4220399	-4992850	-3189543	1030856
Reclaimed Land and Irrigation in Gafurov District	1199371	3747437	8770375	-20800629	-17053192	-8282817
Irrigation Rehabilitation Project	1213819	3792577	8876020	-27776181	-23983604	15107584
Integrated Watershed and Sustainable Land Management to Build the Resilience of Local Communities in Tajikistan	174	544	1273	-4826	-4282	-3009
Ferghana Valley Water Resources Management Project	796453	2488517	5824042	-26373547	-23885030	18060988
Tajikistan: Building Climate Resilience in the Pyanj River Basin	747616	2335927	5466924	-20802384	-18466457	-12999533

Source: own calculations, 2022

Table 13-7 Shadow value of wheat production under Scenario 1 – Irrigated

Project (title)	2021- 2030	2031- 2040	2041- 2050	NV30	NV40	NV50
Project for Agro-Technical Measures to Combat Secondary Salinization of Soils	285815	1874974	3747544	-3814185	-1939212	1808332
Livestock and Pasture Development Project II (Pasture systems)	6235957	40908518	81764595	17954043	22954475	104719070
CACILM: Demonstrating Local Responses to Combating Land Degradation and Improving Sustainable Land Management in SW Tajikistan-under CACILM Partnership Framework, Phase 1	755874	4958608	9910860	-1244126	3714482	13625342
Livestock and Pasture Development Project	5125767	33625562	67208019	10654233	22971330	90179349
Rehabilitation of Hydrotechnical Construction of Great Gissar Canal	944842	6198260	12388575	-2155158	4043102	16431677
Tajikistan Second Public Employment for Sustainable Agriculture and Water Resources Management Project	11177480	73325420	146556842	-34722520	38602900	185159742
Environmental Land Management and Rural Livelihoods	2089754	13709002	27400431	-19020246	-5311244	22089187
RESILAND CA+ Program: Tajikistan Resilient Landscape Restoration Project	3117978	20454259	40882297	-41882022	-21427762	19454535
Community Agriculture & Watershed Management Project	720159	4724314	9442572	-13079841	-8355527	1087044
Construction and Rehabilitation of Irrigation Systems for Development of New and Existing Water Provision of Land in Jirgital District	220810	1448533	2895210	-5349190	-3900657	-1005447
Reclaimed Land and Irrigation in Gafurov District	458862	3010185	6016511	-21541138	-18530952	-12514441
Irrigation Rehabilitation Project	464390	3046445	6088985	-28525610	-25479165	-19390181
Integrated Watershed and Sustainable Land Management to Build the Resilience of Local Communities in Tajikistan	67	437	873	-4933	-4496	-3623
Ferghana Valley Water Resources Management Project	304712	1998939	3995315	-26865288	-24866350	-20871034
Tajikistan: Building Climate Resilience in the Pyanj River Basin	286027	1876368	3750331	-21263973	-19387604	-15637273

Source: own calculations, 2022

Table 13-8 Shadow value of wheat production under Scenario 2 – Irrigated

Project (title)	2021- 2030	2031- 2040	2041- 2050	NV30	NV40	NV50
Project for Agro-Technical Measures to Combat Secondary Salinization of Soils	721103	3477992	7426101	-3378897	99095	7525196
Livestock and Pasture Development Project II (Pasture systems)	15733161	75883458	162024027	-8456839	67426619	229450647
CACILM: Demonstrating Local Responses to Combating Land Degradation and Improving Sustainable Land Management in SW Tajikistan-under CACILM Partnership Framework, Phase 1	1907050	9197995	19639276	-92950	9105045	28744321
Livestock and Pasture Development Project	12932182	62373903	133178841	-2847818	59526085	192704926
Rehabilitation of Hydrotechnical Construction of Great Gissar Canal	2383812	11497494	24549095	-716188	10781306	35330401
Tajikistan Second Public Employment for Sustainable Agriculture and Water Resources Management Project	28200499	136015350	290415795	-17699501	118315849	408731644
Environmental Land Management and Rural Livelihoods	5272397	25429582	54296461	-15837603	9591978	63888439
RESILAND CA+ Program: Tajikistan Resilient Landscape Restoration Project	7866581	37941729	81012014	-37133419	808310	81820323
Community Agriculture & Watershed Management Project	1816942	8763390	18711320	-11983058	-3219669	15491652
Construction and Rehabilitation of Irrigation Systems for Development of New and Existing Water Provision of Land in Jirgital District	557097	2686964	5737124	-5012903	-2325939	3411185
Reclaimed Land and Irrigation in Gafurov District	1157698	5583758	11922268	-20842302	-15258544	-3336276
Irrigation Rehabilitation Project	1171644	5651018	12065880	-27818356	-22167338	10101458
Integrated Watershed and Sustainable Land Management to Build the Resilience of Local Communities in Tajikistan	168	811	1731	-4832	-4021	-2291
Ferghana Valley Water Resources Management Project	768779	3707942	7917083	-26401221	-22693279	14776196
Tajikistan: Building Climate Resilience in the Pyanj River Basin	721640	3480579	7431625	-20828360	-17347782	9916157

Source: own calculations, 2022

Table 13-9 Shadow value of wheat production - Ranking – Rainfed

Ranking	**Rainfed**			
	Scenario 1		**Scenario 2**	
Project (title)	**NV50**	**Ranking**	**NV50**	**Ranking**
Project for Agro-Technical Measures to Combat Secondary Salinization of Soils	3738929	9	4444112	9
Livestock and Pasture Development Project II (Pasture systems)	146841177	2	162226986	2
CACILM: Demonstrating Local Responses to Combating Land Degradation and Improving Sustainable Land Management in SW Tajikistan-under CACILM Partnership Framework, Phase 1	18731052	7	20595998	7
Livestock and Pasture Development Project	124802445	3	137449113	3
Rehabilitation of Hydrotechnical Construction of Great Gissar Canal	22813815	6	25144998	6
Tajikistan Second Public Employment for Sustainable Agriculture and Water Resources Management Project	260660429	1	288238325	1
Environmental Land Management and Rural Livelihoods	36204880	5	41360874	5
RESILAND CA+ Program: Tajikistan Resilient Landscape Restoration Project	40515589	4	48208493	4
Community Agriculture & Watershed Management Project	5951510	8	7728337	8
Construction and Rehabilitation of Irrigation Systems for Development of New and Existing Water Provision of Land in Jirgital District	486059	10	1030856	10
Reclaimed Land and Irrigation in Gafurov District	-9414956	12	-8282817	12
Irrigation Rehabilitation Project	-16253360	14	-15107584	14
Integrated Watershed and Sustainable Land Management to Build the Resilience of Local Communities in Tajikistan	-3173	11	-3009	11
Ferghana Valley Water Resources Management Project	-18812795	15	-18060988	15
Tajikistan: Building Climate Resilience in the Pyanj River Basin	-13705240	13	-12999533	13

Source: own calculations, 2022

Table 13-9 and 13-10 provide net values for the period 2021 – 2050 and the ranking of the project according to the size of net values. The monetary effects of the implementation of adaptation and/or mitigation strategies are in 10 out of 15 cases for rainfed land and in 9 out of 15 cases for irrigated land positive. However, even the projects with negative present value might have positive economic effects when taking into consideration further non-monetarized effects.

Table 13-10 Shadow value of wheat production - Ranking – Irrigated

Ranking	Irrigated			
	Scenario 1		Scenario 2	
Project (title)	**NV50**	**Ranking**	**NV50**	**Ranking**
Project for Agro-Technical Measures to Combat Secondary Salinization of Soils	1808332	8	7525196	9
Livestock and Pasture Development Project II (Pasture systems)	104719070	2	229450647	2
CACILM: Demonstrating Local Responses to Combating Land Degradation and Improving Sustainable Land Management in SW Tajikistan-under CACILM Partnership Framework, Phase 1	13625342	7	28744321	7
Livestock and Pasture Development Project	90179349	3	192704926	3
Rehabilitation of Hydrotechnical Construction of Great Gissar Canal	16431677	6	35330401	6
Tajikistan Second Public Employment for Sustainable Agriculture and Water Resources Management Project	185159742	1	408731644	1
Environmental Land Management and Rural Livelihoods	22089187	4	63888439	5
RESILAND CA+ Program: Tajikistan Resilient Landscape Restoration Project	19454535	5	81820323	4
Community Agriculture & Watershed Management Project	1087044	9	15491652	8
Construction and Rehabilitation of Irrigation Systems for Development of New and Existing Water Provision of Land in Jirgital District	-1005447	11	3411185	10
Reclaimed Land and Irrigation in Gafurov District	-12514441	12	-3336276	12
Irrigation Rehabilitation Project	-19390181	14	-10101458	14
Integrated Watershed and Sustainable Land Management to Build the Resilience of Local Communities in Tajikistan	-3623	10	-2291	12
Ferghana Valley Water Resources Management Project	-20871034	15	-14776196	15
Tajikistan: Building Climate Resilience in the Pyanj River Basin	-15637273	13	-9916157	16

Source: own calculations, 2022

14. Conclusion

Tajikistan is a primarily agrarian country with 75-100% of the population in target districts working in agriculture. Though the country possesses an extensive potential for industrialization, the limited time scope of this project does not allow the researchers to count on the option of quick and intense industrialization and urbanization. The intense focus on agriculture, rural style of living, geographic location, and overall natural conditions make the country especially vulnerable to climate change.

This is the fourth and the last report of the project "*Assessment of Costs and Benefits of Climate Change Adaptation in Agriculture, Forestry and Water management Sectors in Tajikistan*." The current report is aimed at recommendations to local authorities and a final overall report on adaptation measures.

The project relied on three basic methodologies: trend analysis of existing data on agriculture and climate change, climate related standardized models of agricultural yields (CARD) and water resources (WRI 2019), and qualitative methods based on semi-structured interviews with experts and stakeholders, and focus groups. The selection of the projects was based on stepwise procedure if selection subject to following ranking criteria: (1) Socio-economic and health conditions of the households in the short and long run; (2) Sustainable and efficient agriculture; (3) Preservation of arable land and natural resources, reduction of land degradation; (4) Preservation and sustainable use of water resources; (5) Preservation, maintenance, and enhancement of existing forests; (6) Cost efficiency.

The results suggest that climate change in Tajikistan brings additional pressure to water resources in terms of both water availability in the periods of intense irrigation and the increase water need caused by higher temperature and more intense evaporation. The demand of water is also expected to increase due to intense population growth. The lack of water is not new to Tajikistan, as the area was dependent on artificial irrigation for long time. However, the deterioration of infrastructure, the sub-optimal ways of water distribution, lack of relevant education in population and the possibility of free-riding decrease the efficiency of water use.

The availability of water in irrigation period is highly related to the ability of high-altitude areas to catch and retain the water from melting glaciers, snow, and precipitation in periods when irrigation is not necessary (e. g. autumn, winter). These areas are currently highly damaged by overgrazing, which worsens land degradation and limits water retention capacity. These areas constitute 81% of all agricultural land in the country and present the largest unregulated land and water use. Overgrazing caused by quickly growing livestock dependent on pastures limits the effectiveness of the afforestation and forest regeneration efforts as the animals damage the young trees and other vegetation. It also limits the ability of the forests to provide other eco-system services. The effects of pasture regulation might not be visible on the first sight, but the regeneration of water-catching capacities of higher altitude pastures and forests presents one of the most indispensable strategies for the long run.

The lack of (primarily) irrigation water is reflected in increased land and forest degradation, lower agricultural production, the inability of the country to capitalise on possible positive effects of climate change (e.g. three harvests per year). The adaptation measures include the project aimed at water retention, increase of water availability and water use efficiency. The measures may include relevant infrastructure projects, provision of necessary mechanisation, incentivisation of efficient water use including prevention of free riding, and overall provision of education and expertise.

The effects of climate change on agriculture and forestry include the effects of higher temperatures on crops, increased frequency of extreme weather events such and summer heatwaves and spring frosts, increase in pests due to higher temperature in winter, and overall higher probability of droughts. The suggested measures include introduction of more temperature- and drought-resistant crops, adaptation measures to extreme weather events and intensified pest control. All these measures require intense provision of education and expert opinion.

The climate adaptation in agriculture and water use is largely affected by the significant land fragmentation, deteriorated infrastructure, lack of relevant education and motivation, inadequate systems of incentives. In addition, local adaptation measures in agriculture are substantially hindered by low prices of crops faced by farmers in the districts, where they do not have access to efficient marketing. In this case, the larger price margins collected by wholesalers, which leaves local small farmers little funds for climate adaptation. These problems are similar to other types of development assistance, not primarily related to climate change. Thus, we suggest, that the adaptation measures are coordinated among the donor organisations to achieve the largest possible synergies.

We divide the suggested measures aimed at CC adaptation to four general categories: infrastructural projects, provision of relevant animal and floral material (seeds, seedlings, animal species), local capacity building, and systemic measures. The infrastructural measures and the provision of climate adapted floral and animal materials are generally possible to evaluate vis cost/benefit analysis. The effects of capacity building projects and systemic measures are hard to estimate in monetary terms. However, the outcomes of these two types of projects make the effects of infrastructure and material provision more sustainable in the long run. Thus, even the cost-benefit analysis of infrastructural projects may be viewed as contingent upon the capacity building and systemic projects. Therefore, our main recommendations concern both the locally designed infrastructural projects suggested for particular districts, local capacity building projects and systemic measures. We also provide the examples of good/bad practices and suggestions for particular areas. In this conclusion we are able just to present a general summary of recommended measures.

Key recommendations for policy makers can be summarised as follows.

a) The sustainability of any CC adaptation project is contingent upon local capacity building. This implies both the transfer of existing knowledge from the old generation of people usually educated in the FSU times, and provision of information/incentive to employ more efficient CC adapted measures (including the style of life) on the local level. We suggest to put more effort to these types of measures as they will have immense positive effects on the all the other infrastructure and other efforts and will make the economy of Tajikistan more stable a sustainable. The exact measures and difficulties that might be encountered in this process are described in this study.

b) Under the conditions of limited water capacity, the Reforestation/Afforestation efforts and improved pasture management seem to gain at importance. Both of the measures are indispensably linked to the ability of water catchment areas to catch the glacier and snow water, improve the underground water balance in the areas affected by droughts, partially limit the water-related emergencies, and improve the provision of other eco-services. We suggest a number of measures related to pasture management, afforestation and forest regeneration as the second way to go.

c) Introduction of projects that provide synergies such as any projects aiming at improvement of water catchment areas which may also include building water reservoirs. These provide numerous benefits related to lives lost, property damage prevention due to mud flows mitigation and clean water provision.

d) The infrastructure projects, the projects related to provision of CC adapted floral and animal species are the third types of projects to suggest. These projects are substantially district specific. In this study we name exact local level projects as suggested by the local and country level experts.

e) The systemic measures such as decrease of fragmentation of agricultural land are in the hands of the government and are not a part of this project.

The second aim of this study was to provide cost benefit analysis of available adaptation options. Our findings could be divided into 2 categories: (1) Findings based on classic cost/benefit analysis; (2) Findings based on shadow price of agricultural crops.

Based on the data availability, the cost/benefit analyses were conducted for 3 selected projects implemented and financed by external donors, namely:

- Building Climate Resilience in the Pyanj River Basin
- Rehabilitation of Hydrotechnical Construction of Great Gissar Canal
- Building "Punukai" Reservoir (Mudflow Reservoir) In Asht District of Sughd Region

The results suggest that 2 out of 3 projects reached positive net present value of the investment and under the sensitivity analyses. The least performing was Punukai reservoir project, where the net present values were all negative. Pyanj river project was positive only under discount rate below 6%), while Gissar project reached positive values for discounts 2 – 16%.

In the shadow value analyses, presented in previous reports the results show that even if we take only one general benefit of the project (in this case, only the agricultural perspective/impact) at least one-third of the project displays a positive net present value (under 12% discount rate). However, even the projects with the negative present value might have positive economic effects when taking into consideration further non-monetarized effects.

As water and feed are the key inputs to animal husbandry, any projects aiming at improving water availability and higher yields, will also positively influence animal husbandry in Tajikistan.

The third aim of this study was to provide the recommendation for the relevant adaptation options for the target districts. The results suggest that, apart from the local capacity building and systemin measures discussed above, the water resources can be considered as most prioritized area of intervention for almost all the districts. The second most frequent area related to the control of floods, landslides and mud flows. These emergencies produce considerable danger in all the selected districts. The third most prioritised area of intervention was depended on a particular district. The exact district level measures are described in the section “The shortlist of climate risks and threats of target districts, main domains of intervention and suggested district-level adaptation measures”.

To sum it up, the climate change in Tajikistan presents significant challenges. The importance of adoption of climate change adaptation measures is emphasised by the immense population growth. The population of Tajikistan currently amounts to 9.54 million and is expected to reach 13.85 million by 2040 and 25.33 million by the end of the century (UN, 2022). As most of the population is rural and dependent on agricultural production and water resources, the intensification of agriculture and climate adaptation will be of immense importance.

This study aims at assessing the costs of specific adaptation measures, i.e., costs of implementing UNDP/other donor interventions (such as improved watershed management, new pasture/livestock systems, adapted crop species, improved water/land use, abandoned/unused land conversion to orchards, etc.). The next goal is to rank the cost-effectiveness of specific adaptation strategies.

To identify the most effective measures, there have been conducted a semi structured interview and focus groups for each selected district. The output of these semi-structured interviews and focus group aims to answer the questions about the impact of implemented adaptation and mitigation measures focused on the climate change.

As in the previous section, representatives, and farmers from the six target districts were questioned. The districts are: Fayzabad, Gissar, Kuhistoni Mastchoh, Muminabad, Shaartuz, Kanibadam. Those were deliberately chosen to represent wide variety of Tajikistan districts, which are diverse in their climatic and environmental conditions. All together they contain the whole spectrum of challenges posed by climate change. Based on the interviews it has been identified that's adaptation measures for different districts varies, there should be implemented different strategies to tackle different challenges indifferent time frame. These recommendations are described by chapter 5.3.

We also identified the prominent donors who are active in the territory of Tajikistan, and we collected formation from the national resources (public sources, government documents and reports) and international resources. We proceeded extensive overview of all data available, identified projects related to the issues mentioned above and sorted them into 6 categories: improve watershed management; new pasture/livestock systems; adapted crop species; improved water/land use; abandoned/used land conservation and the orchard; others.

After extensive research of available data (a totally 34 projects), we identified that international financial institutions, national development agencies and some nongovernmental organizations are active contributors to Tajikistan's development. The following institutions are the most active in the territory of Tajikistan: Asian Development Bank (ADB); Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ); European Bank for Reconstruction and Development (EBRD); Food and Agriculture Organization (FAO); Global Environmental Facility (GEF); Green Climate Fund (GCF); International Fund for Agricultural Development (IFAD); Japan International Development Agency; Oxfam; United Nations Industrial Development Organization (UNIDO); United Nations Development Programme (UNDP); USAID; Word Bank (mainly IDA).

Category targeted improved watershed management. Within this category, preventive measures to strengthen the resilience of local communities were implemented. Delaware proposed an implementation it new practices which should lead to the mitigation of natural hazards (floods, mad slides). The total value identified what's over 54 million USD.

Category focused on new approaches toward pasturing practices. Two consecutive projects of almost 40 million USD aim to target problems related to overgrazing. Over the last decade, the total number of animal heads increased, contributing to higher stress off Tajik pastures.

Category focusing on adaptation of new species is relatively small in the total allocation of financial resources (less than 5 million USD). The most critical measures targeted yield improvement by implementing higher yield varieties, improving production patterns, or providing new technologies (tractors, tools, etc.).

Category related to improved water or land use involves 17 projects exceeding 445 million USD. Although those are under the same category still, they are diverse. To a certain extent, projects consider improved water management (including drinking water), and they try to introduce climate resilience and adaptation strategies. Projects also focused on reconstructing irrigation channels, environmental management, and agriculture diversification of different regions.

There is only one project aiming at land conversion.

The last category involves eight projects with a total value of 88 million USD. In most cases, these other measures are also related to cultural hazards – preventing mudslides and reducing salinization.

Individual projects have been assessed and compared according to average costs per affected hectare. The values range from 125 USD up to 4,212 USD per hectare. The lowest costs per hectare are for rather extensive projects. No specific (physical) investment activities are planned, activities are rather strategic. The costliest activities combine both strategic activities with construction projects.

The next step was assessment of the cost effectiveness of measures to adapt for climate change in Tajikistan. To understand the scale of adaptation measures adoption it is important to look at the possible benefits of these measures related to water. Specifically, the issue of water scarcity and its impact upon agricultural production must be evaluated. Water scarcity can be measured using many methods.

The most important output variable of the model is the water deficit that is calculated as the difference between potential evapotranspiration minus the actual evapotranspiration.

The results of yield prediction based on CARD approach serve for the calculation of shadow values of the agricultural production representing the gains of implementation of adaptation and/or mitigation strategies. Scenario 1 is the difference between median (neutral) scenario and the pessimistic scenario of wheat yield development that can be associated with the minimum effect of the implementation of adaptation and/or mitigation intervention on the wheat yield. Furthermore, shadow values of agricultural production that represent the monetary effects of the implementation of the adaptation and/mitigation intervention allow us to carry out the comparison of the effects of different adaptation and mitigation interventions even though they differ in their nature and scope.

Then, since wheat belongs to the most important commodity in Tajikistan and it is also a good measure of food security in general, we use it for the calculation of the shadow values of agricultural production that represent the monetary effects of the implementation of the adaptation and/mitigation strategy that allows us to carry out the comparison of the effects of different adaptation and mitigation strategies even though they differ in their natures. Also, wheat production estimate can be used as an excellent proxy indicator for pastures management. This is especially true in the lower parts of Tajikistan where both pastures and grain production enjoy similar agronomical conditions/requirements such as certain level of temperature and precipitation.

The positive trends suggest the increasing gains in wheat production under adaptation and/or mitigation strategies. That is, since the negative climate change effects are more and more pronounced in the period 2021 and 2050, the adaptation and/or mitigation strategies have considerably increased effect on the wheat yield.

There is proposed detail information about shadow values of wheat production under Scenario 1 and 2 for rainfed and irrigated land. In particular, the tables provide for these scenarios and types of land the cumulative shadow values of wheat production for periods 2021 – 2030, 2031-2040 and 2041-2050 because of the implementation of adaptation and/or mitigation measures. Moreover, the tables show net values that represent the difference between cumulative shadow values of production (without implementation of discounting) for periods 2021 – 2030 (PV30), 2021 – 2040 (PV40) and 2021 – 2050 (PV50) and project investment costs. **The results suggest that most projects have positive net values. Therefore, any investment into adaptation projects that would improve the conditions for agricultural production in Tajikistan such as the projects introduced in this report, is cost-effective and should be done.**

There are provided the net values for the period 2021 – 2050 and the ranking of the project according to the size of net values. The monetary effects of the implementation of adaptation and/or mitigation strategies are in 10 out of 15 cases for rainfed land and in 9 out of 15 cases for irrigated land positive. However, even the projects with negative present value might have positive economic effects when taking into consideration further non-monetarized effects.

The adaptations specifically for crop cultivation include conservation tillage (low to no tillage) that means a ploughing technique that does not disturb the soil, thus conserving moisture, reducing fossil fuel usage from field operations, and reducing CO_2. Utilization of organic matter to protect field surfaces also helps to preserve soil moisture that is important in Tajikistan.

Several measures concerning the capture and efficient usage of water will be extremely important in currently rain-fed areas and areas where scaled-up irrigation is environmentally unsustainable or economically infeasible, which is the case of some parts of Tajikistan. Drainage and watershed management will be particularly important in areas with increasing precipitation that can lead to flood risk that has been identified for parts of Tajikistan. Given the predicted water stress for Tajikistan, better managed and expanded irrigation will be a very important part of adaptation and therefore their cost is analysed in detail. More efficient use of irrigation water can be achieved with properly timed applications and drip irrigation, among other methods.

The greater the number of distinct crops, cultivars, and varieties on a farm, the greater the chance that some of the harvest will survive a severe storm, a drought, an early arrival of spring or another unexpected event

It is also important to mention other techniques such as crop rotation that can increase amount of soil organic matter of offset erosion. Erosion can be also managed through different field techniques (land use) such as creation of strips, riparian zones, etc. This is extremely important for hilly parts of Tajikistan. Crop rotation can also help to mitigate damages related to pests that may survive possibly milder winters in some districts of Tajikistan. Using proper information and management, which means deployment of precision agriculture can also offset certain costs related to climate change in Tajikistan.

For animal husbandry, the key area is proper grassland management, rotational grass feed etc.

Finally, fire management is extremely important for forestry and possible agro-forestry that is proposed as one tool to adapt to climate change in Tajikistan. Many of the proposed techniques and investments have overlap beyond the benefits related to climate change adaptation and when applied cost-effectively, can lead to positive internal as well as external benefits.

Climate change represents a big challenge for developing and least developed countries, such as Tajikistan, and therefore the adaptation strategies need to be applied in the most vulnerable sectors to contribute to the sustainable rural development. The proposed assessment shows the importance and significance of adopted measures for adaptation strategies in Tajikistan.

Lastly, it is important to stress out the need for more intensive capacity building and know-how transfer between generations, as currently, the analysed districts have issues related to the lack of education. Education must be improved in the affected areas of knowledge such as modern agrarian technologies and the aspects of climate change adaptation. It is important to keep the educated people in the communities and prevent any possible brain drain from the rural areas. Limitations

This study aimed to assess the cost-effectiveness of the adaptation measures to climate change. This study, like any research, is subject to a number of limitations. The first and the most obvious limitation is the lack of reliable data. A number of international organizations provided development support for the target districts and Tajikistan as a whole. The researchers were able to rich descriptions of some projects but not all. In several cases, the information about the costs of adaptation was not available.

The next factor concerns the uniqueness of some projects, where, in some cases, repairs are necessary, while in others, brand-new systems need to be built. Often it is hard to estimate the costs.

The most difficult is to estimate the sizes of the effects as many of them might be indirect or incomparable. For example, the direct effects of the watershed management might account for the fewer water-related emergencies damaging the infrastructure. In case the infrastructure is the road between the two villages, the indirect effect might account for the undamaged trade between the two villages. Few people will be able to estimate the effects of this trade if not broken. Similarly, the road might serve to get the person to a doctor in the case of emergency, to bring the food to the village if needed, etc. It is not possible to estimate all of these effects.

The other hard to estimate effects concern the ecosystem services provided by the agro-, forest-, aqua- ecosystems. The disturbance of one ecosystem will eventually affect the others. Oppositely, the adaptation measure aimed at one of the systems will most likely affect the other two. Most of the indirect effects are expected in the ecosystem of forestry. On the other hand, the effects on regulating, cultural, and supporting services should not be overestimated compared to the effects of the provisioning services.

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16. Limitations and suggestions for further research

The current study is affected by the following limitations.

16.1. Data availability

The availability of the data is affected by the following limitations. First, some data are not collected in a sufficient time span. The data on the quality of the soil is not available for the given districts in the sufficient quality and the sufficient time span. This fact disables the analysis of the land degradation. The authors had to rely upon the qualitative information from the given districts and the very imprecise information on the yields of particular crops in the particular districts. The methodology of the computation of the yields was not available to the authors. Thus, it was not possible to differentiate the methodology of the controlled experiments and the simple division of the currently produced agricultural crops in the district by the area used for the production. The latter method inevitably bears the imprecision of varying technologies, fertilizer use, the availability of water, the number of harvests per year.

The forest data are not collected yet either, as the all-country forest inventory is just planned for the year 2022 (interview data). The relevant data are available from single projects and do not have time-related systemic nature. For example, the data available from GIZ are based on two data points of 2000 and 2010, which does not produce a sufficient timeline. The lack of high-quality data makes it impossible to produce all-encompassing plans for the reforestation efforts. Thus, reforestation efforts will have to continue to rely on the pointed efforts in particular districts employing the local specificities.

The hydrometeorological data collected by the country are contingent upon the existence of hydrometeorological stations within the districts. In some districts, the hydro-data seem to be collected but not reported to the central authorities. In other districts, there seems to be no meteorological station. Thus, the climate data had to be interpolated from the adjacent districts. The research team chose to rely upon the data collected via satellite imagery technologies, which enables the team to bring the location of the districts studied in higher accordance with the assignment.

In general, the data availability was seriously impeded by the troublesome access to the data from various agencies and the proclaimed lack of computerization in data provision. Namely, it was reported that some of the data were needed to be manually input into the computer from the printed archive sources.

16.2. Data reliability

While the direct measurement data, such as hydrometeorological data, are relatively reliable as they are subject just to the errors of the measurement devices, the data on agricultural production are less reliable. The total data on agricultural production collected in jamoats are collected via the local community for the purpose of reporting and, eventually, paying taxes (interview data). The latter creates the incentive to underreport the production. Moreover, because of lacking marketing, especially in the districts dislocated from the main cities, some of the crops will likely not reach the market, leading to no taxes paid. The reporting of these crops in the district- region- or state-level statistics is also problematic.

The interview data suggest that after the crop data are collected at the district level, the data are aggregated and corrected at the regional level. The methodology of this correction is not known to the authors.

16.3. The selection of indicators

The selection of indicators used in this study reflected the qualitative analysis of selected districts and the existing literature on the topic. However, the selection of indicators was also contingent on data availability, which precluded some of the planned analysis. In the course of the research, some new relevant indicators appeared, which need to be taken into account in further research. Some of such reflect the expected impact of climate. The most used indicators of climate change use indicators such as an average increase in the temperature, precipitation in winter or summer, the frequency of extreme weather events, etc. However, our analysis suggests that the indicators need to be tuned to particular places and conditions. Averages need not be enough. For example, the qualitative assessment reported the effects of 2-week long heatwaves or freezes in particular months or an increase in precipitation in some months and a decrease in others. Greater temperature- and precipitation- variances, etc., also need to be studied. The effects of climate change on these indicators need to be studied as they are relevant to agricultural production and water availability. The effect of particular weather conditions on the phenomena such as dust storms or the reproduction of pests also requires attention.

16.4. The limitation of the methodology

Like any methodology, the adopted methodology revealed some limitations. The empirical methodology relied on three levels of analysis. The first is the district-level qualitative analysis of the perception of climate change by the population of the district. Second, the qualitative analysis of the perception of the effects of climate change by the experts was performed. Third, a quantitative analysis of the climate effects on the quantitative data was done where possible. These three levels of the analysis presented considerable limitations.

First, the farmers and the region's population were often not able to connect the effects they perceived to climate change. In many cases, they are concentrated on the day-to-day situation and are not able to perceive the long-term trends. This effect could be partly eliminated by the interviews with the older farmers, who could remember their way of farming twenty or thirty years ago, which was done in the districts upon availability. However, these people were much affected by their memories on how it was done in the former Soviet Union and over the civil war, which dimmed their memories on the effects of the climate. In addition, the farmers were effectively in a position where they perceived the opportunity to bargain for funds, more investments in infrastructure, which eventually would improve their crops. Thus, they felt incentivized to overstate some of the effects and phenomena and attribute them to climate.

The second stage of the analysis was the impression of the expert community on the local level and all-country level. While in general, this stage of analysis was extremely helpful as it localized the research efforts, some experts were too disconnected from the day-to-day lives in districts, and the solutions presented were more of a theoretical basis. The theoretical bias is understandable as the effects of climate and the solutions are highly affected by a large variety of possible factors, many of which may not be visible on the theoretical level.

The third stage of analysis relied on the quantitative estimates, which generally enable the researcher to test the hypothetical effects to do some data mining, but not to explain the links between the phenomena. In this study, these estimations and linkages were highly blurred by the low quality and the lack of available data. Moreover, given the multi-factorial causes of some phenomena, the relatively short time span, and the large effect of political factors on agriculture, water management, and forestry, it was often impossible to statistically separate the effects.

Last but not least, the limitation of the analysis is also related to the phenomenon studied. The effect of climate on agriculture, forestry and water management in Tajikistan is one of many. More often than not it is difficult to separate the effects.

The agricultural sector of Tajikistan has substantially suffered from the disconnection from the Soviet Union, the disarrays of the civil war, population increase, deterioration of infrastructure, fragmentation of arable land, and troublesome relations to the neighbouring countries leading to the lack of irrigation water in some districts. The inability of the small farmers to invest in new technologies, the lack of adequate education, the brain drain made the situation even worse. The eventual effects of climate change are just aggravating the situation, bringing new challenges the country needs to face. Or from the other point of view, the underfinanced agriculture lacking the Soviet-Style financed and maintained investment and monitoring networks, facing substantial population increase, have a low capacity to adapt to climate change. Thus, the investments in better performing and more sustainable agriculture can go in line with climate change adaptation.

For example, suppose the increase in water- and mudflows are viewed to be a direct effect of climate change. In that case, the protection from these disasters requires similar measures as the measures one could generally consider for water- and mudflows, such as alternative routes for the mud flows. These new urbanization plans exclude the endangered areas from living spaces, firming the banks of the rivers and creating warning systems. Climate change just makes disasters more frequent, but the system of disaster control should have been there anyway.

Similarly, the measures necessary for efficient and sustainable agriculture facing increased demands from the ever-growing population are very similar to the measures necessary to combat climate change, including efficient and water-saving technologies, better seed funds, more coordination of efforts among the small farmers, more protection against extreme weather events, etc. Climate change makes the already troublesome situation worse and introduces some new challenges. On the other hand, it also provides some benefits, such as three crops per year. However, in order to utilize them, one needs to increase the availability of water or eth efficiency of the use of water resources.

16.5. The suggestions for further research on the effects of climate change in Tajikistan

Further research may go in three directions. First and foremost, it is necessary to increase the data availability. More efforts need to be made in collecting, storing, and presenting the data. Second, more efforts need to be made in researching the impacts of climate change on indicators relevant to the three studied sectors in Tajikistan. The overall issue of climate change is not resolved by climatologists and several views exist about the prediction of the climate in the future. Similarly, there are conflicting ideas on the effect of climate change on glaciers. Some studies suggest that the glaciers will melt away, while others predict that, due to the increase in the depth of the glaciers, they will be able to collect even more water than before. Third, more research needs to be done on the practical applicability of the suggested measures in the particular districts and districts for the local communities. The cultural and political aspects need to be taken into account.

17. Appendices

17.1. Appendix 1. Report on costs of implemented UNDP and other projects

This section provides overview of costs of implemented UNDP and other projects in the into 6 following categories: improved watershed management; new pasture/livestock systems; adapted crop species; improved water/land use; abandoned/used land conservation and the orchard; others.

17.1.1. Improved watershed management

17.1.1.1. Integrated Watershed and Sustainable Land Management to Build the Resilience of Local Communities in Tajikistan

Location: Zarafshan valley

Year: 2019

Organization:

United Nations Development Programme (UNDP) in Tajikistan initiated the "Building Climate Resilience in Agriculture and Water Sectors of Rural Tajikistan" project, financed by the Government of the Russian Federation in 2019

Goal and description:

One of the project objectives is to reduce the risks of flash floods and debris flow from micro-watersheds to settlements by restoring the micro-watershed ecosystems and finding sustainable solutions to the use of natural resources. Thus, a specific integrated community-led approach to micro-watershed rehabilitation was designed that uses low-cost methods to make replication by other communities facing similar challenges feasible.

The components of the community-led approach are:

1) Restoration of vegetative cover through the reduction in grazing pressure achieved with fencing and changing herding practices.

2) "Gray" solutions to slow the runoff of water that included physical low-cost control measures such as gabion check dams, bunds, and contour trenches; and lastly

3) "Green" methods to reduce risks in the longer achieved with biological control measures, "living barriers," such as tree and shrub planting

Flash floods and debris flows were addressed gradually from the top of watersheds down to settlements at risk by building “green” and “grey” infrastructures at several heights in each micro-watershed. This method effectively allows to slow down flows along the slopes and stop emerging upper and mid-gully development.

Finance: N/A

Impact:

The villagers have contributed to the implementation of the project by performing manual works worth over 5,000 USD. This "community mobilization" approach was intended to build long-term capacity, communities' commitment and prove replicability.

The results that have been achieved so far:

Construction of over 30 flow check barriers and contour trenches complemented by multiple "living barriers" in gullies.

Fencing 1.41ha vulnerable areas and planting them with 462 species of diverse trees and shrubs.

In addition, the project supported the rehabilitation of two previously constructed concrete dams and the cleaning of accumulated debris.

The initiative benefits over 5000 people in four villages of Penjikent and Ayni districts by using the capacity of the local community so that the costs remain low. Full results will only be reaped over multiple years as communities, according to the rehabilitation plans, step by step increase the number of physical structures and plants. In the next few years, maintenance of the achieved progress and further implementation will significantly reduce debris flows and flash flood.

This sustainable micro-watershed initiative demonstrates that with low-cost collaborative actions that target the roots of the problem local communities can be powerful actors in addressing the impacts of climate change.

Resource:

Replication-Receiver. "Drip Irrigation Helps Farmers in Tajikistan to Grow Crops, Adapt to Climate Change: UNDP in Tajikistan." UNDP. UNDP, March 15, 2022. URL: https://www.tj.undp.org/content/tajikistan/en/home/presscenter/stories/2022/03/drip-irrigation-helps-farmers-in-tajikistan-to-grow-crops--adapt.html.

17.1.1.2. Building "Punukai" Reservoir (Mudflow Reservoir) In Asht District of Sughd Region

Location: Asht District of Sughd Region / Tajikistan

Year: 2016

Organization: Asia Development Bank

Goal and description: In the last 5 years, 3 to 5 large mudflows have destroyed the centre of the town with 10 lives lost, schools, hospitals, roads and bridges and houses destroyed near slopes. In 2011, floods and mudslides displaced 800 people and 150 households. Kitchen gardens, an important source of household food, were flooded, 500 meters of water pipeline was damaged, and 35 families had to be resettled. In 2015 heavy snow destroyed 95% of fruit trees and the harvests of wheat and barley were reduced by 35 to 40%.

Finance: US$ 13.55 million

Impact: Reduce destruction from mudflows and floods of irrigation systems; Build small reservoirs to help minimize mudflow and flood damage; Reduce vulnerability to drought through climate adaptation; Improve water use efficiency on agricultural land in mountain areas and river and lake embankments. Benefits are connected to:

Prevent premature cost and damage to the facilities.

Reduce or prevent damage to embankments, houses and public infrastructure from increasing mudflows and flooding.

Irrigation water will reduce the impact of drought on crops and household income.

Mist irrigation will prevent frost damage to fruit trees and grapes.

Decrease flow of environmental migration from mountains

Protect household gardens for food security of poor population

Prevent danger to life and the loss of basic household goods.

Resource:

National Climate Change Adaptation Strategy TAJ: Building Capacity for Climate Resilience, Asian Developing Bank – ADB consultants´ Report, Project Number: 45436-001, November 2016. URL: https://www.adb.org/projects/45436-001/main

17.1.1.3. Ferghana Valley Water Resources Management Project

Location: Tajikistan / Gissar

Year: 2013 - 2020

Organization: World Bank

Goal and description: The objectives of the Ferghana Valley Water Resources Management Project are: to improve the capacity for increased productivity of irrigated agriculture in the Ferghana valley by improving land and water management, and to improve safety and regulation of the Kayrakum dam and reservoir, thereby contributing to enhanced water management security and efficiency at the basin level. The original closing date was May 31, 2011, which was extended to May 31, 2013, when the additional financing was approved. It is to extend the closing date by an additional year to May 31, 2014. The extension is necessary to complete all works and strengthen the Water User Associations (WUAs). Construction works can only be implemented during a few months per year. As a result of this, some of the works have been delayed. It would be challenging to recover these delays as only a few months of effective construction time remain before the closing date, by which time it is unlikely that all works will be completed. This will be the second closing date extension for the project for a cumulative extension of three years.

Finance: US$ 27.17 million

Impact:

- Area returned to effective irrigation under the project. (6,450 ha)
- Operational water user associations created and/or strengthened (125)
- Early warning system established/improved and tested (100)
- BCF Irrigation structures rehabilitated (160)
- Length of main and secondary drains rehabilitated (120 Km)
- I&D pumping station systems rehabilitated (9)
- I&D tube-wells rehabilitated and renovated (118 ha)
- Lengths (km) of reservoir side embankments rehabilitated (10.2)
- Early warning system operational (6)
- Demonstrations held (No) and new cultivation or cropping technologies adopted (40)

Resource:

World Bank. (2018). Ferghana Valley Water Resources Management Project. World Bank. https://projects.worldbank.org/en/projects-operations/project-detail/P084035

17.1.1.4. Community Agriculture & Watershed Management Project

Location: Tajikistan

Year: 2013 - 2020

Organization: World Bank

Goal and description: The objective of the Project is to build productive assets of rural communities in selected mountain watersheds in ways that sustainably increase productivity and curtail degradation of fragile lands and ecosystems.

To entail protection of globally significant mountain ecosystems by mainstreaming sustainable land use and biodiversity conservation considerations within agricultural and associated rural investment decisions.

Component I: Rural Production Investment

(i) Farm Productivity Improvement through socially mobilizing individuals and groups of farming households with further support to investment in productivity enhancing and income generating activities.

(ii) Land Resource Management through support to local population to adopt more sustainable use of fragile lands and to provide land use certificates.

(iii) Rural Infrastructure through productive investments to rehabilitate rural infrastructure, including drinking water, small irrigation, access track rehabilitation, and small power generation

Component II: Institutional Support and Capacity Building, (i) Research and demonstration by providing help to scientific institutions; (ii) Community Mobilization and Subprojects Preparation.

Finance: US$ 13.8 million (IDA / Global Environmental Facility)

Impact:

- No. households participating in some part of the rural production component (32,000)
- Number of improved public facilities, disaggregated by type of investment (village drinking water, roads, electricity) - 577 total including facilities held by private beneficiary groups. 170 drinking water facilities, 131 small irrigation and drainage rehab, 227 access road rehab, 32 micro energy generation and transition, and 17 others.

- Cumulative number of rural people who have received technical training from TAAS, FOs, or other project partners (8,000)

Resource:

World Bank. (2015). Tajikistan—Community Agriculture & Watershed Management Project. World Bank. https://documents.worldbank.org/en/publication/documents-reports/documentdetail/188881475113279627/Tajikistan-Community-Agriculture-Watershed-Management-Project

17.1.2. New pasture/livestock systems

17.1.2.1. Livestock and Pasture Development Project

Location: Tajikistan / Khatlon region

Year: 2011 - 2018

Organization: IFAD

Goal and description: The development goal of the Project was to contribute to the reduction of poverty in the Khatlon Oblast. Its development objective was to increase the nutritional status and incomes of around 22,400 poor households living in the five districts of Baljuvon, Khovaling, Muminabad, Shurobad and Temurmalik, by enhancing livestock productivity in a sustainable manner. The project consisted of three principal complementary components and the required support for project management and implementation as follows: (i) Institutional Development; (ii) Livestock and Pasture Development; (iii) Income Generation for Women; and (iv) Project Management.

Finance: US$ 15.78 million

Impact: Overall project achievement at completion is rated satisfactory. The project succeeded in: (i) piloting the PUU model and showcasing best practices in pasture management, contributing to the revision of the Pasture Law; (ii) reducing overgrazing and restoring heavily degraded pastures with 60% of District pasture land under protection; (iii) enhancing village communities' empowerment through their participation in decision-making processes while strengthening their role in controlling the village natural resources (pasture lands); and (iv) increasing village communities' resilience to climate change.

On the quantitative aspect, the project achieved: (i) an EIRR estimated at 23.9%; (ii) increase in agriculture productivity by 10-20%; (iii) increase in women's income by 20% leading to diet improvements within the household; and (iv) increase of average targeted HHs income by 41% for around 60 to 70% of beneficiaries. It is estimated rural poverty in the project area has been reduced, at a scale largely in line with appraisal expectations.

Resource:

IFAD. (2020). Livestock and Pasture Development Project. IFAD. https://www.ifad.org/en/web/operations/-/project/1100001575

17.1.2.2. Livestock and Pasture Development Project II (Pasture systems)

Location: Tajikistan / Khatlon region

Year: 2015 - 2021

Organization: IFAD

Goal and description: The Livestock and Pasture Development Project II builds on LPDP Phase I. The second of the project will reach out to an additional 38,000 rural households in at least five communities in five districts of the Khatlon region. 132,000 ha of pastures to be managed in more climate-resilient manner. The project's development goal is to contribute to the reduction of poverty in the Khatlon region and to increase the nutritional status and incomes of some 38,000 poor households by enhancing livestock productivity and resilience to climate change. In particular, the project will focus on:

- developing institutions,
- enhancing productivity and improving animal health,
- developing pasture management.

The project will reduce the vulnerability of pasture communities to the increased threat posed by changing climate and address urgent environmental and poverty issues through a grant provided by IFAD's Adaptation for Smallholder Agriculture Programme (ASAP).

Finance: US$ 24.19 million

Impact: Pasture Users Unions established. Advancement of Policy and Legal Framework and Strengthening National Institution. Promotion of fodder production and conservation. Sheep breeding. Cattle breeding. Improved animal health. Community Resilience Pasture Management and Investments. Investment plans (Each plan includes an average of 3 sub-projects. 405 have been approved so far: 58% are mechanization projects; 17% demonstration plots; 16% livestock improvement; and 9% infrastructure), Income Diversification

Resource:

IFAD. (2022). Livestock and Pasture Development Project II (LPDP). IFAD. https://www.ifad.org/en/web/operations/-/project/2000000977

17.1.3. Adapted crop species

17.1.3.1. Project to Develop High Yield Crops in the Context of Climate Change

Location: Tajikistan

Year: 2016

Organization: Asia Development Bank

Goal and description: This project will define strategic directions and ways to ensure high-yielding and export-oriented agriculture in consideration of climate change. It will include agriculture, biodiversity, and forestry. Its results will contribute to increasing the living standards of the rural population, satisfy agricultural demands at a reduced cost through import substitution and ensure food safety at the national level. Intensive cultivation of high-value crops, especially marketed outside the country, is expected to cover project costs, increase sales and revenues. The project should also lead to improvements in economic efficiency of farming enterprises. The primary purpose is poverty reduction.

Finance: US$ 1.53 million

Impacts:

- The intended primary purpose is to improve conditions for poverty reduction.
- Beneficiaries are projected to be 225 climate vulnerable rural households.
- Improving rural livelihoods to reduce poverty will build household income, assets, and reserves to reduce vulnerability and increase resilience in high climate risk areas.
- Research and pilots to grow high value crops will produce more resilience, flexibility, and income.
- Develop seed bank for different crops, focus on wild native plants.
- Plant trees adapted to climate change.

Resource: National Climate Change Adaptation Strategy TAJ: Building Capacity for Climate Resilience, Asian Developing Bank – ADB consultants´ Report, Project Number: 45436-001, November 2016. URL: https://www.adb.org/projects/45436-001/main

17.1.3.2. Study And Development of Agricultural Climate Adaptation Technologies

Location: Tajikistan

Year: 2016

Organization: Asia Development Bank

Goal and description: The project is to develop agricultural technologies and conduct scientific research with a focus on drought-resistant seeds and crops with particular attention to 1) the selection of varieties of cereals and legumes such as safflower, flax, grains, rice and fruits; 2) the climatic factors that influence harvests and affect the productivity of crops and 3) increasing the productivity of the agricultural and livestock sectors by using innovative methods acceptable to farming enterprises and local households.

Finance: US$ 3.15 million

Impacts:

Reduce future household vulnerability, food insecurity, crop, and income losses from the following research activities:

- Develop and test agricultural technologies adapted to climate change.
- Methods to increase household and farm food production and income.
- Methods to stabilize crop yields despite climate change.
- Methods to reduce post-harvest losses.
- New seeds and better yield from identification, testing and selection of drought tolerant seeds.
- Identification of adaptive temperature zones.
- Test and cultivate special demonstration plots.
- Develop master training program and regional information centres.
- Provide information to farmer associations.
- Publish information.
- Reduce soil erosion and land degradation through improved land, energy, and water management.
- Support full participation of vulnerable groups in decision-making process and activities.
- Increase resilience to climate impacts by providing households with greater flexibility and assets.

Resource: National Climate Change Adaptation Strategy TAJ: Building Capacity for Climate Resilience, Asian Developing Bank – ADB consultants´ Report, Project Number: 45436-001, November 2016. URL: https://www.adb.org/projects/45436-001/main

17.1.4. Improved water/land use

17.1.4.1. Development of National water security systems for ensuring food security in Tajikistan

Location: Tajikistan

Year: 2021 (6y)

Organization: Green Climate Fund

Goal and description: Climate scenarios show that severe droughts and desertification tendencies, are acute in Tajikistan.

The presented changes in climatic conditions need to be addressed by many ways, one being the renaturation of the irrigation system in:

- a rational (drip irrigation systems),
- an efficient (how it serves best), and
- in an environmentally friendly (where it is justifiable) manner. Furthermore, irrigation is needed, to keep productivity of the land and food security of vulnerable communities as well as to halt the tendencies of land degradation (salinization, wind erosion, carbon emission etc.).

Finance: US$ 70 million

Impact:

Project will have main benefits: Health, Food and Water Safety - improvement of irrigation schemes and water supplies are the adaptation measures contributing to the achievement of these goals; Prevention of desertification and land degradation through increase in the irrigated areas; Decrease in carbon dioxide ($CO2$) emissions – through Land degradation control and preservation and improvement of soil productivity.

Resource:

National Climate Change Adaptation Strategy TAJ: Building Capacity for Climate Resilience, Asian Developing Bank – ADB consultants´ Report, Project Number: 45436-001, November 2016. URL: https://www.adb.org/projects/45436-001/main

17.1.4.2. Strengthening land-based adaptation practices in Tajikistan

Location: Tajikistan

Year: 2022 (5y)

Organization: Green Climate Fund

Goal and description: Due to the changes in climate conditions, Tajikistan with a mountainous landscape, fragile ecosystems and a vulnerable, agriculturally based economy, is heavily affected.

Finance: US$ 20 million

Impact:

Project will have main benefits: Health, Food and Water Safety - improvement of irrigation schemes and water supplies are the adaptation measures contributing to the achievement of these goals; Prevention of desertification and land degradation through increase in the irrigated areas; Decrease in carbon dioxide (CO2) emissions – through Land degradation control and preservation and improvement of soil productivity.

Resource:

National Climate Change Adaptation Strategy TAJ: Building Capacity for Climate Resilience, Asian Developing Bank – ADB consultants´ Report, Project Number: 45436-001, November 2016. URL: https://www.adb.org/projects/45436-001/main

17.1.4.3. Reclaimed Land and Irrigation in Gafurov District

Location: Tajikistan

Year: 2016

Organization: Asia Development Bank

Goal and description: To reclaim 24,000 hectares in Mirzotavat-Samgar mountain block in Gafurov District in Sughd Province and construct a water intake, pump stations, a pressure pipeline, and construction of inter-farm and on-farm irrigation systems. An important aspect of the project is to reclaim agricultural land that was abandoned for cultivation due to impacts such as floods and mudflows that have damaged land and facilities. This loss of land has had an impact on food security and livelihoods.

The project will incorporate new methods and techniques to protect land and facilities from climate-related damage. This is particularly important as the damage from flooding and mudflows are expected to increase in Bobojon Gafurov. Additional activities may include more efficient water use through drip irrigation. If the activities are successful, it may reduce migration from mountain areas.

Finance: US$ 22 million

Impact:

- Reduction in scale and timing of damage and necessary repair costs to embankments and irrigation systems and canals that protect 24,000 acres of mixed cropland from increased damage from floods and mudslides.
- Avoided income losses from crops damaged or lost from increased flood and mudslides.
- Avoided cost of replanting flooded areas including time and income lost to re-establish trees crops.
- Avoided cost of repairing water intake and pump station on Sir Darya river.
- Avoided impact on livelihoods due to lost incremental income for up to 24,000 people.
- Avoided loss of incremental income for industries and employment associated with crops with added value.
- Fewer farmers displaced from land that has become unusable.

Resource: National Climate Change Adaptation Strategy TAJ: Building Capacity for Climate Resilience, Asian Developing Bank – ADB consultants´ Report, Project Number: 45436-001, November 2016. URL: https://www.adb.org/projects/45436-001/main

17.1.4.4. Rehabilitation of Hydrotechnical Construction of Great Gissar Canal

Location: Rudaki, Gissar, Shahrinav and Tursunzade / Tajikistan

Year: 2016

Organization: Asia Development Bank

Goal and description: Great Gissar Canal provide the districts of Rudaki, Gissar, Shahrinav and Tursunzade with irrigation water by way of a regulating dam on a branch of the Dushanbinka River and a pipe across the Khanaka River. Over the years the GGC has lost operational capacity. Annual floods and mudflows destroy irrigation works, affect water supply, cover irrigated land, and disrupt food supply with socioeconomic consequences.

Finance: US$ 3.1 million

Impact: The project supports 1) land reclamation and irrigation of new agricultural land of 20,000 hectares for cotton, fruit, onions, grain and irrigated pasture for increased food security of the growing population; 2) the renovation and modernization of facilities for water supply and irrigation in 4 districts and 400,000 people; 3) job creation and improved welfare of the population; 4) a decrease in migration from mountain areas; 5) an increase in electricity supply; and 6) a reduction in flood and mudflow risks.

It is intended that the population of the district of Shaartuz, of 13,400, will be the direct beneficiaries of new irrigated agriculture.

Resource: National Climate Change Adaptation Strategy TAJ: Building Capacity for Climate Resilience, Asian Developing Bank – ADB consultants´ Report, Project Number: 45436-001, November 2016. URL: https://www.adb.org/projects/45436-001/main

17.1.4.5. Construction and Rehabilitation of Irrigation Systems for Development of New and Existing Water Provision of Land in Jirgital District

Location: Rudaki, Gissar, Shahrinav and Tursunzade / Tajikistan

Year: 2015

Organization: Asia Development Bank

Goal and description: Tajikistan is particularly vulnerable to flooding and mudflows that destroy or damage irrigation facilities and damage crops in mountain areas. One result is that agricultural lands are abandoned. Environmental migration occurs, especially from the mountains, as people seek other means of livelihood. In order to maintain the security of the food supply, provide rural livelihoods and improve conditions for this vulnerable rural population, this project is intended to reclaim cropland and restore damaged irrigation activities in the mountain block of Lakhsh in Jirgital district.

Finance: US$ 5.57 million

Impact: Total improved area of 4,674 ha. Sixty percent of the project cost has been al located to climate adaptation. This is particularly important because of this area has particularly high vulnerability to flooding, risk of landslides, avalanches, and mudflows. Rise in temperature could lead to rapidly melting glaciers in normally calm periods causing an increase in mudslides. Savings through avoided costs of $2.5 million to rebuild non-adapted new irrigation structures subject to on-going mudslides and flooding, based on the expected frequency of these events. Avoided income losses from crops damaged or lost from increased flood and mudslides. Avoided impact on livelihoods due to lost incremental income for 800 households and up to 14,000 people

Resource: National Climate Change Adaptation Strategy TAJ: Building Capacity for Climate Resilience, Asian Developing Bank – ADB consultants´ Report, Project Number: 45436-001, November 2016. URL: https://www.adb.org/projects/45436-001/main

17.1.4.6. Facilitating Climate Resilience in Tajikistan

Location: Tajikistan and Zeravshan Valley

Year: 2020 - 2021

Organization: UNDP Tajikistan and Government of the Russian Federation

Goal and description: UNDP in Tajikistan hold a steering committee meeting to review the activity of two projects, aimed at building climate resilience in Tajikistan, which are funded by the Government of the Russian Federation, namely: "Facilitating Climate Resilience in Tajikistan" and "Building Climate Resilience in Agriculture and Water sectors in Rural Tajikistan".

Within the framework of the first project, which is aimed at raising additional funding to the republic for implementation of climate-related initiatives, UNDP developed several project proposals that mobilized donor funds in the amount of US $ 67.6 million.

The agenda of the meeting included review of the projects progress in 2020 and annual work plans for 2021. In addition, the ways of adapting of agriculture and water management initiatives to the conditions of the COVID-19 pandemic was discussed.

Finance: US $ 67.6 million

Impact:

It is expected that these investments will have a direct positive impact on the livelihoods of more than 132,000 people, and about half a million residents will be indirect beneficiaries.

The second project enabled more than 800 farmers in the Zeravshan Valley to receive specialized trainings, aimed at expanding the use of climate-adapted agricultural technologies, as well as finding additional sources of income for rural residents. In addition, 14,000 seedlings of fruit trees were provided by UNDP to local farmers for planting on abandoned land.

The agenda of the meeting included review of the projects progress in 2020 and annual work plans for 2021. In addition, the ways of adapting of agriculture and water management initiatives to the conditions of the COVID-19 pandemic was discussed.

Resource:

UNDP. "Russia Supports Building Climate Resilience in Tajikistan: UNDP in Tajikistan.", December 26, 2020. https://www.tj.undp.org/content/tajikistan/en/home/presscenter/pressreleases/2020/12/russia-supports-building-climate-resilience-in-tajikistan.html.

17.1.4.7. RESILAND CA+ Program: Tajikistan Resilient Landscape Restoration Project

Location: Tajikistan

Year: 2022

Organization: World Bank's Board of Executive Directors approved today $45 million in grant financing from the International Development Association (IDA) for the RESILAND CA+ Program: Tajikistan Resilient Landscape Restoration Project

Goal and description:

The World Bank's Board of Executive Directors approved today $45 million in grant financing from the International Development Association (IDA) for the RESILAND CA+ Program: Tajikistan Resilient Landscape Restoration Project. The goal of the project is to support sustainable land management in Tajikistan and promote collaboration with Central Asian countries on transboundary landscape restoration. This is the first project under the World Bank's Central Asia Resilient Landscape Restoration (RESILAND CA+) Program.

Ozan Sevimli, World Bank Country Manager for Tajikistan. "The project will introduce modern approaches and climate smart practices in forest, pasture and cropping lands management to help restore natural resources and improve people's livelihoods.

In Tajikistan, the project will invest in forest and pasture management and restoration, climate-smart agriculture practices, knowledge exchange and capacity building, and sustainable management of protected areas. It will also help align policies and implementation frameworks for forests, pastures, and protected areas with international norms and obligations.

Finance:

$45 million investment will support landscape restoration, sustainable use of natural resources, and climate change mitigation practices.

Impact:

These activities are designed to enhance rural livelihoods through land-based restoration and conservation activities, while investing in climate change mitigation and adaptation. On the regional level, the project will contribute towards improved connectivity and integrity of natural resources across borders (including biodiversity), increased resilience of key regional infrastructure such as roads, and livelihoods protection of corridor communities.

The project will support Tajikistan's global climate commitments, including under the 2018 Bonn Challenge to restore 66,000 ha of degraded forest land by 2030, and the 2018 Astana Resolution on reinforced cooperation on landscape restoration in Central Asia.

Resource:

World Bank Group. "Tajikistan to Protect Its Natural Resources and Increase Climate Resilience, with World Bank Support." World Bank. World Bank Group, February 25, 2022. https://www.worldbank.org/en/news/press-release/2022/02/25/tajikistan-to-protect-its-natural-resources-and-increase-climate-resilience-with-world-bank-support.

17.1.4.8. Project for Improving the Efficiency of Land Use through Agricultural Diversification

Location: Tajikistan

Year: 2016

Organization: Asia Development Bank

Goal and description: At present, farmers cultivate one type of crop for five months. Now, with adaptation to climate change it should be possible to cultivate crops for shorter rotation periods of two months. This project enables farmers to produce agricultural products at different times of the year. As a result, greater revenue can be received. The number of tended beneficiaries is 5000 farm households or over 30,000 people. Depending on the forecasted seasonal climate and temperature, farmers will be informed and will be advised of what kind of crop to plant. This approach also will encourage crop and livestock pasture rotation that will improve soil and pasture conditions.

Finance: US$ 10.0 million

Impacts:

- Shorter cultivation times and more crops harvested per season in some places.
- Multi-cropping will make better use of resources.

- Crop rotation will provide soil support.
- Livestock will be rotated to allow pasture to recover.
- A market will be developed for growing and selling special crops.
- Increase farmer flexibility.
- Prevent farmers from losing income.
- Reduce vulnerability of farmers to climate change.
- Livestock as an important household asset will be protected from flooding.

Resource:

National Climate Change Adaptation Strategy TAJ: Building Capacity for Climate Resilience, Asian Developing Bank – ADB consultants´ Report, Project Number: 45436-001, November 2016. URL: https://www.adb.org/projects/45436-001/main

17.1.4.9. Climate Adaptation and Mitigation Program for Aral Sea Basin (CAMP4ASB)

Location: Aral Sea Basin / Tajikistan

Year: 2021

Organization: World Bank

Goal and description: To this end, the project will fund a range of activities, such as crop diversification, better water resource management, rehabilitation of degraded lands, and expansion of renewable energy sources, among others. To ensure sustainability and ownership of these sub-projects, the beneficiaries will be required to make at least a 10 percent contribution. The project expects to reach 205,000 individuals, with women making up at least 40 per cent.

Finance: US$ 19 million

Impact: Launched in August 2016, the CAMP4ASB program has worked to equip and ultimately enable countries in Central Asia to address climate challenges through better access to improved climate change knowledge services, investments, and capacity-building of key stakeholders. The project has supported climate-smart agriculture investments benefitting more than 15,000 people and supporting the creation of 4,300 new jobs. Over 6,500 farmers and other project beneficiaries have participated in capacity-building and awareness-raising activities and events. Among project beneficiaries are the specialists of state institutions and academia working in the areas of hydrological modelling, early warning, updating curricula at universities, etc.

Resource:

World Bank. (2021). Additional Financing Support by the Green Climate Fund to Help Strengthen Climate Resilience in Central Asia. World Bank. https://www.worldbank.org/en/news/press-release/2021/06/24/additional-financing-support-by-the-green-climate-fund-to-help-strengthen-climate-resilience-in-central-asia

17.1.4.10. CACILM: Demonstrating Local Responses to Combating Land Degradation and Improving Sustainable Land Management in SW Tajikistan-under CACILM Partnership Framework, Phase 1

Location: Tajikistan / Rasht Valley

Year: 2007 - 2013

Organization: UNDP / Global Environment Facility

Goal and description: Rasht Valley is the most neglected and fragile region in Tajikistan - the poorest country of the former Soviet Union republics. The region marked by a sluggish transition and fragility patterns – remnants of the Civil War in the country. This project will improve quality of living conditions of Rasht Valley's population by increasing access to better quality drinking water, sanitation, and healthcare services, as well as strengthening resilience of communities to the impact of natural hazards. Less than 45% of the local communities have access to safe drinking water; hygiene and sanitation conditions are below standards in most of the places. With only 2% of GDP spent on healthcare the central government is not capable to provide good quality healthcare services in country's remote areas; in many places primary health care. People benefit from basic public services in a peaceful and equitable society allowing them to improve their quality of life. facilities are in poor condition or inexistent.

Finance: US$ 2 million

Impact: N/A

Resource:

Global Environment Facility. (2013). CACILM: Demonstrating Local Responses to Combating Land Degradation and Improving Sustainable Land Management in SW Tajikistan-under CACILM Partnership Framework, Phase 1. Global Environment Facility. https://www.thegef.org/projects-operations/projects/3237

17.1.4.11. Environmental Land Management and Rural Livelihoods

Location: Tajikistan

Year: 2013 - 2018

Organization: World Bank / GEF

Goal and description: Maintain or improve flows of agro-ecosystem services to sustain livelihoods of local communities. Farmers in Tajikistan's uplands will be supported to adopt sustainable agriculture and land management practices. Capacities will be built to reduce desertification, soil erosion and deforestation in the important Tien Shan and Pamir Mountain ecosystems. Field-based activities will improve community-based agriculture, integrated soil fertility, water and pest management, field and horticultural crop production, rangeland management, livestock production efficiency, as well as management of impacts of climate change. Project outcomes include an increase in area in uplands under improved and effective agricultural, land and water management practices and improved household assets of beneficiaries. Results will include increased vegetative cover and productivity in agro-ecosystems, and diversified financial resources for sustainable land management

Finance: US$ 21.11 million

Impact:

- Number of pasture management plans under implementation by Pasture User Groups (8)
- Number of on-farm water management plans under implementation by Water User Associations in lowland areas (16)
- Hectares in which local communities have adopted management practices in land use and land use change, resulting in restoration and enhancement of carbon stocks. (39,125)
- Number of client days of training provided in organizational and technical topics (42,000)
- Instructional good practice short videos produced (50)
- Created 2,349 CIGs and 8 PUUs, and supported 16 existing WUAs who implemented sub-projects Invested US$11.32 million toward enhanced rural production and land resource management, related to agricultural crops, horticulture and gardening, livestock breeding, poultry development, beekeeping, irrigation system rehabilitation, drinking water rehabilitation and bridge and road rehabilitation, but also knowledge, training, and capacity building

- Purchased productive assets including: 5,162 beehives; 674 cattle of improved breed; 5,258 sheep of improved breed; 29 horses; 16,695 poultry (chicken, turkey, goose, duck, ostrich, royal bird, partridge, peacock, pheasant); 35 rabbits; 260,225 fish; 247,494 fruit trees; 159,517 non- fruit trees; 263,977 meters of fencing; 48 wool processing tools; 10 incubators; 2 generators;806,442 kg of good quality seeds; 150 yoghurt processing equipment; 9 solar panels; 13 sewing machines; 73 tons of briquets; 74 small agricultural machinery; 127,842 meters of pipes; 93 irrigation pumps; 131 water gates; and other irrigation related equipment
- Constructed or rehabilitated 11 veterinary clinics; 27 livestock watering points; 8 veterinary pharmacies; 25 kashars (resting places for herders and animals) in pasture lands; 2 butcher shops; 237 greenhouses; 21 bridges; 196,300 meters of pasture roads; 172,268 meters of internal village roads; 8 wells; 257 aqueducts; 177 water distribution valves; 113 water distribution hydrants; 5 irrigation dams
- Covered 44,235 hectares with effective agricultural, land and water management practices suited to local agro-ecological conditions and climate change resilience: planted trees, bushes, grasses on 736 hectares of slope land; afforested 12 hectares of land; established or improved 15,459 hectares of pastures; decreased stoniness/salinization/waterlogging and improved soil structure/fertility on 28,028 hectares of land. Decreased grazing pressure through 11,559 reduced heads of livestock; protected 12,485 meters of rivers banks and canals; implemented 440 sub - projects contributing to water/energy/resource savings; substituted biological pesticides (for chemicals) on 110 hectares of land. 8 pasture management plans developed and under implementation by PUUs (a total of 158 activities implemented, e.g.), 8 GIS based community pasture maps completed (indicating boundaries, paddocks, infrastructure, and ecological sites) and submitted to IG; detailed annual budgets prepared annually for all PUUs).
- 16 on-farm water management plans developed and under implementation by WUAs in lowland areas (a total of 134 activities implemented, e.g., all or most WUA fields prepared to provide suitable run-off and reduced erosion; actions taken to address salinity issues and waterlogging in all 16 WUAs).
- Expected total overall carbon balance of -976,460 tons of CO2-equivalent over a 20-year period. 44 findings of climate change and environmental appraisals integrated into CAPs (average of 80% score for integration based on scorecard developed under the project to assess plans).

Resource:

World Bank. (2018a). Environmental Land Management and Rural Livelihoods Project. World Bank. https://projects.worldbank.org/en/projects-operations/project-detail/P122694

17.1.4.12. Tajikistan Second Public Employment for Sustainable Agriculture and Water Resources Management Project

Location: Tajikistan / Gissar

Year: 2013 - 2020

Organization: World Bank

Goal and description: The objectives of the Additional Financing for the Second Public Employment for Sustainable Agriculture and Water Management Project for Tajikistan are to: (i) provide employment to food insecure people through the rehabilitation of irrigation and drainage infrastructure, (ii) increase crop production in response to improved irrigation and infrastructure, and (iii) support the development of improved policies and institutions for water resource management, as a means to improve food availability and food access for low-income people in poor rural areas supported by the project. The additional funds would be used to scale-up the public works component of the project in support of government measures to create employment for low-income and food insecure population, including migrant workers returning to Tajikistan. These activities would create an estimated 10,000 person days of temporary work through rehabilitation of 2,800 km of irrigation canals to improve irrigation on 70,000 hectares of irrigated land in six districts in Khatlon and the Districts of Republican Subordination (DRS). A parallel restructuring of the project will be implemented to: (a) reflect the additional activities, (b) improve the alignment of project development objectives and project activities, and (c) reformulate the project's relationship with its main government partners in response to a recent Government reorganization. Project design and implementation was originally based on a partnership with the Ministry of Amelioration and Water Resource Management (MAWR), which has now been replaced by a new Ministry of Energy and Water Resources (MEWR). The main operating arm of the former MAWRM has also been set up as an independent agency, the Agency for Land Reclamation and Irrigation (ALRI), which will be the project's implementing agency. A slightly different institutional agenda will also be added.

Finance: US$ 45.9 million

Impact:

- Number of person days worked by participants of public works program (1,146,000)
- Operational water user associations created and/or strengthened (125)
- Number of registered WUA Members (45,000)
- Beneficiaries of Flood Protection Works (62,400)
- Increase in wheat and vegetable yield on rehabilitated irrigated land (10.00)
- The Water Information System established (YES)
- Area provided with irrigation and drainage services (236,600 ha)
- Length of flood channel and flood protection embankments rehabilitated (6.2)
- Length of canals cleaned (7,065)
- Length of drains cleaned (1,180)
- Key hydraulic sections, structures, installations, and equipment rehabilitated or provided (4,030)

Resource:

World Bank. (2022). Tajikistan Second Public Employment for Sustainable Agriculture and Water Resources Management Project. World Bank.

https://projects.worldbank.org/en/projects-operations/projects-list

17.1.4.13. Rural Infrastructure Rehabilitation Project

Location: Tajikistan

Year: 2013 - 2020

Organization: World Bank

Goal and description: The Rural Infrastructure Rehabilitation Project aims to increase water supply and efficiency in the main and secondary irrigation canals supplying the farms being privatized under the Farm Privatization Support Project (FPSP) and adjoining farms, develop institutional capability in land and water resources management, and improve the quality of drinking water in selected villages. There are four project components: 1) Rehabilitation of main irrigation and drainage works; 2) Provision of community-based village water supply; and 3) Institutional capacity building. This means:

Rehabilitation of main irrigation and drainage works (Cost at Appraisal: US$16.04 million - 66 percent of total; Actual US$15.73 million - 98 percent of appraisal). Rehabilitation of critical irrigation and drainage infrastructure in urgent need of repair over the project area (130,000 ha). This covered the same geographical regions as the FPSP and amounted to about one-sixth of Tajikistan's total irrigated area. This included: Repair of head works, and downstream protection works; Desilting of canals and structural repairs and replacement of damaged canal linings; Replacement or rehabilitation of water control structures; Rehabilitation of drainage works; Rehabilitation of pump stations; Repair of electric motors and submersible pumps for tube wells; Re-establishment of water measurement devices; and Selective improvement of access roads to main and secondary canals and pump stations

Provision of community-based village water supply in selected villages (Cost at Appraisal: US$1.5 million – 6 percent of total; Actual US$1.5 million, 100 percent of appraisal). Construction of tube wells with submersible pumps in 17 selected villages, rehabilitation of a main pump unit and construction of a new pump station in specified locations, and laying of main water pipes in four selected villages

Institutional capacity building for improved land and water resources management (Cost at Appraisal: US$3.5 million - 15 percent of total; Actual: US$3.7 million - 105 percent of appraisal) Improvement of management and operations of main water supply organizations; Establishment of Water Users' Associations (WUAs) at the field systems level; Strengthening of the Tajik University of Agricultural Sciences (TAU); Establishment of the Tajikistan Land and Water Resources Management Unit (TLWRMI) using the rehabilitated facilities of an existing demonstration farm; and Undertaking a study of irrigation institution restructuring

Finance: US$ 24.0 million

Impact:

The achievement of the project's specific objectives was uneven. The I&D works were carried out and potential improvements in water supply were achieved, although the actual level of water supplied remained stable. But it is not clear that this led to more efficient use of water as there was no reported improvement in agricultural yields and production

Resource:

World Bank. (2010). Rural Infrastructure Rehabilitation Project. World Bank. https://projects.worldbank.org/en/projects-operations/document-detail/P058898?type=projects

17.1.4.14. Climate- and Disaster-Resilient Irrigation and Drainage Modernization in the Vakhsh River Basin Project

Location: Yovon / lower Vakhsh river / Tajikistan

Year: 2021 - 2024

Organization: Asian Development Fund / Technical Assistance Special Fund

Goal and description: The project is the first gender equity themed irrigation and drainage (I&D) investment of the Asian Development Bank (ADB) in Tajikistan. The project will enhance climate resilience, water productivity, and the income of female and male farmers by modernizing selected areas of the Yovon I&D system, located in Khatlon province of the lower Vakhsh river basin. The project will introduce (i) climate- and disaster-resilient modernization of prioritized I&D infrastructure, (ii) streamlined institutions and systems for effective planning and operation and maintenance (O&M) of I&D infrastructure, and (iii) policies and strategies for gender equality to enhance women's participation in land and water management. The I&D systems, which were developed prior to the country's independence in 1991, have deteriorated or are entirely defunct. Deteriorated I&D facilities and poor on-farm water management result in low crop yields, excessive water losses, waterlogging, and soil salinization.

The project will modernize irrigation canals and associated structures, install energy-efficient water pumps, and upgrade drainage structures. By using satellites to measure water productivity and crop production, and a buried pipe system with metering for increased control of irrigation water use, the project has a strong innovation and technological component.

Finance: USD 31 million

Impact: The project will modernize irrigation canals and associated structures, install energy-efficient water pumps, and upgrade drainage structures in the project area. The project will also help mainstream gender policies in water users' associations and in the Agency for Land Reclamation and Irrigation to increase women's involvement in management and access to services. Around 6,700 farmers will benefit from improved water services and climate resilient technologies enabling them to harvest and earn more.

Resource:

Asian Development Bank. (2021, December 1). Climate- and Disaster-Resilient Irrigation and Drainage Modernization in the Vakhsh River Basin Project (Tajikistan). Asian Development Bank. https://www.adb.org/projects/53109-001/main

17.1.4.15. Irrigation Rehabilitation Project

Location: Tajikistan

Year: 2004 - 2011

Organization: ADB / Japan Special Fund

Goal and description: The Project goals are to achieve sustainable improvement in living standards of the rural population in the project area. The objective of the Project is to increase the income of rural communities through (i) rehabilitation of irrigation and drainage infrastructure and support to improve water management; (ii) improvement of selected potable water supply systems; (iii) support for agricultural development; and (iv) project management, monitoring and evaluation. The Project will also support policy reforms with regard to farm profitability, and cost recovery for operation and maintenance.

Finance: US$ 28.99 million

Impact:

- Selected I&D systems rehabilitated, and improved O&M is in place.
- Improved potable drinking water supply systems in the selected project areas are available.
- Farmers have adopted improved agricultural technologies.
- Agricultural policy and market reforms are operational.
- Recruitment of consultants.
- Capacity building.

Resource:

Asian Development Bank. (2004, December 10). Irrigation Rehabilitation Project (Tajikistan). Asian Development Bank. https://www.adb.org/projects/33042-013/main

17.1.4.16. Tajikistan: Building Climate Resilience in the Pyanj River Basin

Location: Tajikistan / Pyanj River Basin

Year: 2015 - ongoing

Organization: ADB / Strategic Climate Fund

Goal and description:

The project aims to increase resilience to climate vulnerability and change of communities in the Pyanj River Basin. The project's impact will be improved livelihoods of Pyanj River Basin communities vulnerable to climate variability and change. The project's outcome will be reduced adverse effects of climate variability and climate change in 59 villages in 19 jamoats in the Pyanj River Basin. The project has four outputs:

Output 1 is flood protection infrastructure climate-proofed in 10 jamoats. It will (i) upgrade and climate-proof flood and mudflow protection infrastructure in 10 locations, including riverbank reinforcement, embankment reconstruction, restoration of stream beds, terracing and planting of trees, and soil stabilization; (ii) establish O&M practices, develop O&M guidelines, and train local units of the responsible agencies; (iii) develop early warning communication systems through the use of modern technologies; (iv) establish disaster risk management committees; and (v) conduct training and disseminate information on the impact of climate change and adaptation measures for local government officials and local institutions such as khashar (mutual self-help groups), mahala (neighbourhood associations), and women's committees.

Output 2 is irrigation systems climate-proofed in eight jamoats. It will (i) rehabilitate and climate-proof irrigation canals and network assets, including reconstruction and desilting of drainage and delivery channels and rehabilitation of pumping stations; (ii) pilot a drip irrigation scheme; (iii) strengthen water users' associations; and (iv) provide advice and disseminate information on water resources management and climate-resilient agricultural practices to farmers, local government officials, women' groups, and other stakeholders.

Output 3 is water supply infrastructure climate-proofed in seven jamoats. It will (i) rehabilitate and climate-proof seven rural drinking water supply systems, including rehabilitation, upgrade, and construction of boreholes, provision of new and rehabilitated pumping equipment, and construction of new service reservoirs and water tanks; (ii) establish O&M practices for drinking water supply systems, develop O&M guidelines, and train local units of the responsible agencies; (iii) establish drinking water consumer groups to influence responsible agencies and ensure performance of the water supply facilities; and (iv) raise awareness of health and other risks associated with climate change.

Output 4 is micro credits and micro deposits made available to promote climate resilience in the Pyanj River Basin. It will (i) expand capacity of participating financial institutions (PFIs) in the Pyanj River Basin to accept micro and small deposits and provide micro loans in support of climate-resilient economic activities; (ii) provide credit lines for agricultural improvements (climate-resilient agriculture credit line) and economic diversification (income diversification credit line), particularly targeting women; (iii) strengthen financial literacy of the local population; and (iv) assess the feasibility of collateral insurance linked to credit and, if appropriate, pilot a credit insurance scheme.

Finance: US$ 21.55 million

Impact:

- Flood protection was provided to 3,973.5 ha.
- Irrigation canals were extended to 2,081 ha.
- Water supply was provided to 4,500 households in 15 villages.
- 1,934 microcredits were issued to promote climate resilience.

Resource:

Asian Development Bank. (2013, July 25). Building Climate Resilience in the Pyanj River Basin (Tajikistan). Asian Development Bank. https://www.adb.org/projects/45354-002/main

17.1.4.17. From service delivery to sustainable water management in Tajikistan

Location: Tajikistan

Year: Start Date December 2013, End Date March 2023

Organization: Oxfam, Tajikistan WASH Programme

Donors: European Union Directorate-General for International Cooperation and Development (DG DEVCO), FinWater, Swiss Agency for Development and Cooperation (SDC), World Bank

Goal and description:

- Governance of drinking (and multiple use) water and sanitation improved at national and local levels.
- Increased demand and supply of sanitation for households and improved hygiene behaviour.
- Ensuring social accountability in water supply.
- Water supply and sanitation (WS&S) is financed with innovative solutions.

Problem analysis Tajikistan is often described as the poorest country in Central Asia, with GDP per capita consistently lower than any of its regional neighbours. Its water and sanitation infrastructure are severely dilapidated, suffering from decades of underinvestment and the failure to address widespread damage suffered during the country's civil war (1991–1996). While great strides have been made in recent years, the pace of change remains slow, and around one-third of the rural population is still without access to improved water sources, compared with less than 10 percent in Tajikistan's cities, and less than 20 percent in rural areas of neighbouring Uzbekistan.

Efforts to ensure everyone has access to adequate water and sanitation take place at the national level and are managed through a water governance structure that is expensive, unwieldy, and characterized by contradictory legislation and blurred responsibilities between the public and private sectors. Reform of the sector and roll-out of improved infrastructure have been slow, requiring both revenue collection from service users for financial sustainability, and strong accountability mechanisms to ensure that the rights of the most vulnerable are adequately protected.

The current iteration of Oxfam's WASH programme in Tajikistan began in 2009. It has a strategic vision that runs until 2023 and the budget for the period FY2018–23 is £7.45m (USD 9.95 million). The programme is based on a theory of change which has four pillars: improved governance of water and sanitation at national and local levels; building demand for and supply of sanitation at a household level, alongside improved hygiene practices; social accountability in water provision; and securing financing for water and sanitation through innovative funding models. Oxfam is an influential player in national-level dialogue on water governance, and has built a coalition for coordination, advocacy and influencing, The Network of Stakeholder Organizations on Sustainable Water Supply and Sanitation (TajWSS). At district level, Oxfam promotes governance through Water User Associations, which are part of local government structures and are responsible for water supply and management in rural areas. They are accountable to Water Trust Funds, which are made up of local WASH actors from the government and private sector and select villages in need of water and sanitation infrastructure.

It seeks to stimulate household investment in sanitation to strengthen the market for sanitation products, create jobs, reduce costs, and promote sanitation norms. Oxfam is boosting water supply by building the capacity of those actors responsible for the supply and maintenance of water systems and is supporting sustainable cost-recovery through community-led tariff arrangements. Oxfam has also directly supported the construction of WASH infrastructure, through the co-financing of projects identified by Water Trust Funds. The programme includes the Tajikistan Water Sector Improving Social Accountability Project (TWISA) project funded by the World Bank, which focuses on increasing the engagement of people Oxfam works with in monitoring the performance of the water supply and sanitation subsector. This could be through, for example, the development of gender-sensitive service quality indicators or using Community Advisory Boards to monitor service delivery. The 'hardware' component is now transitioning to work on identifying models that promote greater financial sustainability, including the use of Revolving Funds, the piloting of Development Impact Bonds and supporting access to finance for infrastructure development.

Finance: Budget: £7.45m (FY 2018–23)

Impact:

Amplifying grassroots voices in the reform process Oxfam's policy work has ensured that the rights of rural communities have consistently been on the agenda during the reform process. This has been achieved by convening high-level stakeholders in the TajWSS network, and effectively linking our work in communities with policy dialogue.

- Partnered with UNDP on the development of a new, equitable, fully cost-recoverable, and locally owned methodology for tariff collection.
- Facilitated the establishment of Water Safety Plans by the government of Tajikistan, which are critical in mitigating water-borne disease.
- Amplified rural voices so that they are included in national legislation, including the 20105 laws 'On drinking water and drinking water supply', and the setting of national targets under the UN Health Protocol in 2013.

Infrastructure sustainability through decentralized tariff collection Oxfam, in partnership with UNDP, has developed and piloted a new methodology for water tariff collection for cost recovery. The methodology – which relies on local assets, decentralized management, and a strong accountability mechanism – has been highly successful, achieving collection rates of up to 85 percent. Specific challenges Tajikistan is one of the most remittance-dependent states in the world,7 with the money sent home from migrant workers in Russia critical to household budgets and national economic development. The ongoing financial crisis in Russia has had a dramatic impact on remittance flows, which have fallen by nearly $1.5bn between 2013 and 2015. The resulting economic impact has been severe, with government budgets cut and infrastructure projects cancelled, and households struggling to keep up with payments for water and sanitation services. This has presented challenges for the programme's efforts to achieve sector reform through a tariff mechanism, and to secure government support for the delivery of water projects. Additionally, the increase in economic instability has made the country a less appealing environment for investors, reducing incentives and opportunities for international financing of water and sanitation projects. While macroeconomic issues continue to frustrate the programme at one level, Oxfam has worked to mitigate the impact on vulnerable rural populations. Oxfam's model promotes local ownership of service provision and maintenance, which encompasses tariff collection. This approach ensures that decisions on fee waivers or in-kind payments (e.g., crops) for poor households are made locally.

Lessons learned Achievements and challenges Tariff mechanisms are an effective way to strengthen the sustainability of WASH programming, but risk increasing vulnerability during economic shocks. Programmes should ensure mechanisms are participatory and community owned to mitigate this dynamic. Convene local actors and work closely with duty-bearers to maximize the impact of advocacy. Consumers' awareness of their rights and responsibilities will ensure the long-term sustainability of water and sanitation, helping to meet the needs of user groups, in particular women

Resource:

Goodrich, Ian. Oxfam, From service delivery to sustainable water management in Tajikistan. Case Study, Published by Oxfam GB for Oxfam International under ISBN 978-0-85598-977-4 in July 2017. Oxfam GB, Oxfam House, John Smith Drive, Cowley, Oxford, OX4 2JY, UK. DOI: 10.21201/2017.9774. URL: https://oxfamilibrary.openrepository.com/bitstream/handle/10546/620294/cs-from-service-delivery-tajikistan-100717-en.pdf;jsessionid=A8EA9F30F20EEC1DA47A1C390EA99B14?sequence=4

17.1.5. Abandoned/unused land conversion to orchards

17.1.5.1. Drip irrigation helps farmers in Tajikistan to grow crops, adapt to climate change

Location: Ayni district in Tajikistan

Year: 2020

Organization: United Nations Development Programme (UNDP), with the support of the Government of the Russian Federation

Goal and description:

For the last few years, farmers in remote villages of Ayni district in Tajikistan incurred huge losses as the irrigation canals get damaged due to climate change-induced events like rapid snowmelt and excessive rainfall. For instance, in 2017, there was a 75% decrease in the harvest in Urmetan village, as the irrigation canal was damaged. The same situation occurred in the larger Zeravshan valley of Tajikistan, where poor communities faced aggravating erosion of arable land because of poor irrigation practices. Climate risks further exacerbate irrigation demand, accelerate land degradation, and increase harvest losses.

In 2020, the United Nations Development Programme (UNDP), with the support of the Government of the Russian Federation, established two drip irrigation systems in two selected orchards in Urmetan and Yori villages. This endeavour complemented earlier tree planting activities on desert slopes within a disaster risk reduction and ecosystem restoration initiative.

Finance:

N/A

Impact:

Drip Irrigation is an efficient system that delivers water directly to the plants' root zone, in the right amount, at the right time, so each plant gets exactly what it needs and when it needs it to grow optimally. It enables farmers to produce higher yields while saving on the water as well as fertilizers and fuel. Farmers are now happy to see the problem of irrigation has a sustainable solution. As a result, they yield better. Not only that, it reduces the risk of mudflows and flooding in villages located downhill. The villagers now want to scale up the practice using their resources.

"There is lack of arable land and together with the project we demonstrated to the villagers that natural resources can bring more if you use them effectively," says Safulloh Dustmuhammedov, one of the farmers, who is very happy to see that his idea of making the desert slopes usable becomes true.

As the project experience shows, the desert slopes turned into orchards can bring multiple positive outcomes: economic, disaster risk reduction, environmental restoration, and esthetical.

This initiative is a part of the "Building Climate Resilience in Agriculture and Water Sectors of Rural Tajikistan" project. The project aims to integrate the best-tested technologies and practices for climate adaptation and build the capacity of the local population. Drip irrigation technology is a valuable contribution to the goal.

Thus, UNDP continues to work with the government for a comprehensive approach to disaster risk reduction and climate change adaptation.

Resource:

Replication-Receiver. "Drip Irrigation Helps Farmers in Tajikistan to Grow Crops, Adapt to Climate Change: UNDP in Tajikistan." UNDP. UNDP, March 15, 2022. https://www.tj.undp.org/content/tajikistan/en/home/presscenter/stories/2022/03/drip-irrigation-helps-farmers-in-tajikistan-to-grow-crops--adapt.html.

17.1.6. Others

17.1.6.1. Mudslides and floods: Emergency appeal n° MDRTJ005, GLIDE n° MS-2009-000083-TJK, FL-2009-000095-TJK, MS-2009-000099-TJK

Location: Tajikistan

The pre-positioned stocks of non-food items in Dushanbe city, Kurgan tube region, Rasht valley, Shahrinau and Tursun-Zade Red Crescent branches made it possible to promptly distribute hygiene kits, blankets, tents, tarpaulins, kitchen sets, and other relief items to the most affected families based on the results of assessments in the abovementioned branches.

Year: 2009

Organization: International federation of Red Cross and Red Crescent Society of Tajikistan

Goal and description:

Objective: 726 families who lost their houses to mudslides and floods, including 344 families (2,410 beneficiaries) in the latest floods are provided with basic non-food items.

Objective: 494 families, including the 344 families (2,410 beneficiaries), who lost their houses to mudslides and floods have temporary shelter and tools to support the reconstruction.

Objective: 344 families (2,410 beneficiaries) residing in temporary shelter have improved access to water, and hygiene promotion information materials have been distributed among 6,333 households.

During the response operation, the Red Crescent of Tajikistan deployed 32 national disaster response team (NDRT) members and 56 local disaster committee (LDC) members on the spot to conduct detailed assessment, to identify the needs and to register the number of families and individuals in need of assistance. The Red Crescent staff and volunteers also helped to clean mud away from the houses and set up tents for the families whose houses were destroyed. The pre-positioned stocks of non-food items in Dushanbe city, Kurgan tube region, Rasht valley, Shahrinau and Tursun-Zade Red Crescent branches made it possible to promptly distribute hygiene kits, blankets, tents, tarpaulins, kitchen sets, and other relief items to the most affected families based on the results of assessments in the abovementioned branches. 2 With funds raised through the appeal the distribution of planned non-food items to all 726 affected households under the first objective was completed in all target districts (see

Table 1). The distributed items were received by the heads of households following the registration of beneficiaries and cross checking, and according to distribution procedures and standards. The replenishment of disaster preparedness stocks in Dushanbe, Rasht, Kurgan tube and Kulyab for 300 families has started. Construction tool sets for 150 households in Khuroson district and for 33 households in Panj district have been distributed. Some 155 displaced families have been also provided with tents in Khuroson and Panj districts. In early June 2009, some 6,000 hygiene promotion materials were reprinted and distributed to the affected population and the surrounding villages in Dushanbe, Shahrinau, Tursun-Zade, and Khuroson districts. The joint needs assessment in Khuroson and Panj districts in October 2009 revealed some additional and urgent needs of the affected families. As winter has arrived, these people need stoves, wood, and coal. Therefore, the Red Crescent Society of Tajikistan and the International Federation's representation in Tajikistan decided to use the Belgium Red Cross pledge for the distribution of heating facilities and the partial replenishment of the Red Crescent disaster management centre stock in Dushanbe, sufficient for 44 families. The response capacity of both the national and the Central Asian regional disaster response teams has been enhanced during this response operation, as they joined the involved Red Crescent branches and other actors in rapid and detailed needs assessments in the area. The deployment of the regional disaster response team (RDRT) has proven the effectiveness of one of the International Federation's responses tools and was also a step towards the implementation of the regional contingency plan developed in 2007. The International Federation on behalf of the Tajikistan Red Crescent Society takes this opportunity to thank those who contributed to the appeal.

Finance: Appeal target (current): CHF 892,624 (USD 806,936 or EUR 589,938)

Impact:

Expected results

- 344 households (2,410 people) in Khuroson, Panj districts, Kulyab, Jilikul, Jirgital, Kumsangir districts and I. Somony and Sino districts (Dushanbe city) are provided with bedding, kitchen sets and hygiene kits. • 150 households (750 people) in Kurgan tube are provided with basic non-food items to help them cope with the consequences of the mudslide. • 232 households (1,160 people) are provided with basic non-food items.
- 344 families are provided with a construction tool kit (hammer, saw, nail driver, hand plane, spirit level, crowbar, sledgehammer, metal bucket, 10 mm rope 10 m long, string line, pliers, tin snips, axes, pickaxes). • 150 displaced families, out of these 344, are provided with tents in Khuroson and Panj districts. • 150 households are provided with construction tools to help them cope with the consequences of the mudslide and preserve their human dignity. Out of them 35 most affected households are provided with family tents.

- Population in Khuroson, Panj districts, Kulyab, Jilikul, Jirgital, Kumsangir districts and I. Somony and Sino districts (Dushanbe city) received water purification tablets for one month and water storage facilities. • Hygiene promotion has been carried out among the target beneficiaries (1,333 households in addition to the 5,000 households previously identified as target population).

Resource:

International federation of Red Cross and Red Crescent Society of Tajikistan. Emergency appeal n° MDRTJ005, GLIDE n° MS-2009-000083-TJK, FL-2009-000095-TJK, MS-2009-000099-TJK, Operations update n° 3 14 December 2009. URL: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjam6juxI73AhXOjqQKHZQtDu4QFnoECAUQAQ&url=https%3A%2F%2Fgo-api.ifrc.org%2Fpublicfile%2Fdownload%3Fpath%3D%2Fdocs%2Fappeals%2F09%2F%26name%3DMDRTJ005eu3.pdf&usg=AOvVaw3pszUcByCScz19pTgbxL-x

17.1.6.2. Emergency assistance to mudflow affected population of Khuroson district

Location: Khuroson district

Year: 01 July 2020–30 June 2021

Organization: UNDP Tajikistan, UNDAF

Goal and description:

Heavy rains on 14-16 May 2020 caused a mudflow in Khuroson, Asadullo and Pakhtaoobod villages of Ayni Jamoat, Khuroson district, Khatlon Region. The preliminary assessment conducted by district level emergency commission highlights that the mudflow damaged 338 houses, 14 houses have been fully and 1 partially damaged. The mudflow also damaged the critical infrastructure, including roads, bridges, electricity lines, and caused flooding the kitchen gardens and household yards. Damages to livelihoods is not assessed yet.

The objective of this Initiation Plan is to enhance immediate response capacities in follow up to the Government appeal to support mudflow affected community of Khuroson district.

Finance: US$ 51,000

Impact:

Output 1: Provision of the emergency assistance to population of Khuroson district of Khatlon region affected by mudflows. Indicators: 1.1.1 # of Non-Food items ready to be dispatched in case of a disaster. 1.1.2 # of affected population supported with NFIs.

Targets: 1.1.1 Non-food emergency supplies sufficient to cover the needs of 100 families are ready to be dispatched. 1.1.2 At least 600 affected people supported with NFIs.

Purpose and expected output: Heavy rains on 14-16 May, 2020 caused a mudflow in Khuroson, Asadullo and Pakhtaoobod villages of Ayni Jamoat, Khuroson district, Khatlon Region. The preliminary assessment conducted by district level emergency commission highlights that the mudflow damaged 338 houses, 14 houses have been fully and 1 partially damaged. The mudflow also damaged the critical infrastructure, including roads, bridges, electricity lines, and caused flooding the kitchen gardens and household yards. Damages to livelihoods is not assessed yet. Reportedly, out of those destroyed houses, 11 have been dismantled by the owners before the assessment was conducted by the relevant services. The Local Disaster Management Commission has invited additional experts from relevant agencies/services, for detailed assessment of the damaged buildings. Khuroson district authorities have announced that land plots in safe locations will be allocated and decision on eligible households will be taken based on the results of the assessment. Currently, residents of destroyed houses are placed in the tent-camp erected nearby the local mosque. Residents of the tent-camp consume drinking water and use sanitation facilities of the mosque. While the tent-camp area is illuminated by projectors, individual tents are not supplied with electricity or cooking facilities due to safety concerns. Meals for the residents are prepared and served at the mosque. A first-aid point is established in the tent-camp by local healthcare services, while safety and security of the tent-camp is ensured by local police guarding the area around the clock. The recruits of the Committee of Emergency Situations and Civil Defence (CoES) cleaned debris from the streets of the village to enable movement within the villages, while inhabitants continued cleaning of the houses. Electricity supply in the affected villages has been restored, however supply of clean drinking water has not been arranged so far. Government-led damage and needs assessment continue in all the affected villages and being compiled by the Committee of Emergency Situations. As of 25 May, total number of residential houses with structural damages caused by mudflows and floods stands at 338 houses, out of which 14 are destroyed, 1 was partially damaged. Number of destroyed and heavily damaged houses may increase, once mudflow liquidation operation in Khuroson district is completed. Predominantly, mudflows and floods damaged the kitchen gardens and auxiliary premises of the residential houses, damaging and destroying assets and stocks of population (livestock, food, water supply systems, latrines, non-food items and etc), leading to humanitarian needs of population. The relief operation was fully carried out by the Government, through local authorities of the district. The Committee of Emergency Situations called to scale-up the delivery of assistance and requested in country humanitarian partners for support. The CoES assessment team reported on observing that the affected population lack basic non-food items. The housing utilities of the affected population were left under the debris and mud. In addition, they lacked basic hygiene utilities such as soaps, toothbrushes, and pastes. Their conditions were further deepened by the lack of adequate cooking utensils. Although, the priority needs such as the shelter and the food were met for a temporarily basis, lack of adequate living conditions, safe hygiene facilities would prove to be at big cost. On 19 May 2020 CoES submitted a request letter to UNDP RR, requesting to release non-food items from UN Emergency Reserve for Tajikistan (UNERT). 3 Pursuant to this request, on 19 May 2020, the decision was taken by UNDP RR to release of the following items: 667 of mattresses, 667 of pillows, 667 of blankets, 667 of bed sheets, 6084 of different kitchen utensils, 100 of bayonet shovels, 100 of shovels, 100 of rubber boots, 100 of working gloves and 100 of soaps. To demonstrate the ownership the CoES has agreed to undertake transportation of the non-food items (NFI) to the mudflow affected population. Following the release condition of NFI from UNERT, UNDP developed a brief concept noted for funding which was approved by Swiss Cooperation Office for the amount of 51,000 USD. Thus, the purpose of this Initiation Plan is to ensure replenishment of the released items that were released to the affected communities of Khuroson district in response to the Government appeal. UNDP, as implementing partner would be responsible for development of the detailed specifications for the items to be procured, initiate solicitation process, award a contract, monitor its implementation. Once the goods are delivered, unloading and placing in appropriate shelves. After the accomplish of the project, development of the financial and narrative reports, Press Releases, ensuring the role and giving a credit to SDC as funding agency, will be undertaken.

Resource:

UNDP, Christophoros Politis. Emergency assistance to mudflow affected population of Khuroson district; INITIATION PLAN, 2020. UNDP, Tajikistan.

17.1.6.3. Facilitating Climate Resilience in Tajikistan (FCRT)

Location: Tajikistan

Year: January 2018 – December 2021

Organization: UNDP, funded by the Government of the Russian Federation

Goal and description:

The project is funded by the Government of the Russian Federation with the total amount of $950,130 with the duration of January 2018 – December 2021. The project is implementing in partnership with the Committee of Environment Protection under the Government of Tajikistan, to facilitate access to climate finance to contribute to building climate resilient communities across Tajikistan and address specific threats to lives, physical and social infrastructure in disaster prone mountainous regions of Tajikistan.

Finance: US$ 950,130

Impact:

- building climate resilient communities across Tajikistan and address specific threats to lives, physical and social infrastructure in disaster prone mountainous regions of Tajikistan.

Resource:

"Facilitating Climate Resilience in Tajikistan (FCRT): UNDP in Tajikistan." UNDP. Accessed April 22, 2022. https://www.tj.undp.org/content/tajikistan/en/home/projects/risk-reduction-and-resilience-projects/ongoing-projects/facilitating_climate_resilience.html.

17.1.6.4. Project to Reconstruct Existing Warehouses and Construct Modern Storage Facilities for Crops and Livestock

Location: Tajikistan

Year: 2016

Organization: Asia Development Bank

Goal and description: To construct five large storage facilities and to re- construct old storage facilities to preserve harvested crops, seeds, and cold storage products. Seven million US dollars are needed for the construction of new climate resilient storage facilities and for new equipment to implement the project in 10 regions of Tajikistan, depending on the region and on the impact of climate change. $1.7 million dollars will be used for reconstruction of old storage facilities and to provide new equipment. At present a great deal of spoilage occurs because of poor storage conditions for agricultural goods. Under present climate conditions, losses are 25 to 45% due to poor or inadequate storage. Losses in border areas are 50% because there are no storehouses. Seasonal harvests in March, and spring potatoes are harder to store.

Finance: US$ 10.15 million

Impacts:

- Under historic climate conditions, reconstructed storehouses should cut stored losses by 25% (down to 10 to 15% losses of total in storage).

- Climate extremes will raise the losses using conventional storage. New equipment will adapt storage facilities to climate extremes, and reduce both current losses, and the greater losses that would occur under climate change.
- Farmers will be able to store agricultural products and keep them fresh at any time of the year.
- The availability of food will be less dependent on short-term changes in climate.

Also, it is expected that Food security will be greater in urban areas, less food will be wasted, and prices will stabilize; Farm revenues may increase as small farmers will be able to market their products away from their immediate surroundings; It will help satisfy demand of the population with less waste of harvested crops. It will provide storage for emergency needs. It will preserve government foreign exchange by reducing import costs.

Resource: National Climate Change Adaptation Strategy TAJ: Building Capacity for Climate Resilience, Asian Developing Bank – ADB consultants´ Report, Project Number: 45436-001, November 2016. URL: https://www.adb.org/projects/45436-001/main

17.1.6.5. Project for Agro-Technical Measures to Combat Secondary Salinization of Soils

Location: Tajikistan

Year: 2015

Organization: Asia Development Bank

Goal and description: At present, saline soils constitute about 30% of the soils or 115 thousand hectares in the total area of irrigated land of the Republic of Tajikistan. It is estimated that 70-100 thousand tons of raw cotton and almost 70 thousand tons of grain, vegetables, and non-irrigated crops are lost annually because of the salinity. Drainage is clogged with salts. Crops produced on saline soils are of inferior quality. The problem is most acute in the south.

People also become ill from the salinity with respiratory and skin problems. This occurs in regions with no central water supply system with only 20 percent of the population having access to drinking water.

The project dealt with restoring the saline soils. It investigates the issues related to combating secondary salinization to invest in agro-technical measures through which farmers can receive economic benefits. The project uses a complex set of preventive measures, and specific measures for desalinization to grow winter crops, making full use of rainfall, and hydraulic drainage. The project then irrigates and harvests grain in the autumn to rid soil of salts.

The available technologies for cropping are accessible to farmers and will be adjusted to the specific soil conditions of the irrigated zones. Effective agro-technical methods will be applied for the purpose of changing the geochemical profiles of all parts of the landscape. Management of the restored land and revitalized fertility of the saline soil will be less expensive if the restoration activities are implemented during the process of cropping. In this way benefits will come earlier. The project is to develop agricultural technologies and conduct scientific research with a focus on drought-resistant seeds and crops with particular attention to 1) the selection of varieties of cereals and legumes such as safflower, flax, grains, rice and fruits; 2) the climatic factors that influence harvests and affect the productivity of crops and 3) increasing the productivity of the agricultural and livestock sectors by using innovative methods acceptable to farming enterprises and local households.

Finance: US$ 4.1 million

Impacts:

Project will counteract the impact of hotter temperatures on soils, to prevent more aridity and salinity due to higher temperatures.

This should improve the quality and number of crops.

Provide more usable land, nutrient-rich soils from multi-cropping and additional crop rotation

Resource: National Climate Change Adaptation Strategy TAJ: Building Capacity for Climate Resilience, Asian Developing Bank – ADB consultants´ Report, Project Number: 45436-001, November 2016. URL: https://www.adb.org/projects/45436-001/main

17.1.6.6. Integrated Health and Habitat Improvement (IHHI) Rasht Valley, Tajikistan

Location: Rasht Valley, Tajikistan

Year: 2007 - 2013

Organization: United Nations Development Programme / Global Environment Facility

Goal and description: The improvement of the sustainability of arid climate irrigation land management in Tajikistan to safeguard the livelihoods and economic well-being of rural populations and the functional integrity of national ecosystems.

Objective was as follow: to demonstrate the potential to implement replicable Sustainable Land Management initiatives at the local level in Tajikistan and to build the capacity of local structures to do this.

Finance: CHF 10,140,000 (USD 10,382,104)

Impact:

21 water supply systems established; 210 of private EcoSan or flush toilets constructed by the households as a result of project advocacy; 109 of youth- and women-focused income generating activities supported 24 doctors and 120 nurses trained on family medicine specialty Clinical Excellence Centre (CEC) established, 3 new Primary Health Centres (PHC) constructed and 10 PHC rehabilitated to ensure the quality of health service provision by the trained staff, 14 Watershed Management Plans (WMPs) developed and 111 DRR-driven NRM projects be implemented, 4 emergency communications systems and 7 safe havens/emergency shelters established

Results from previous phases:

Over 62,000 people (or 12% of the Valley's population) got access to safe drinking water services and 2% of population improved their sanitation conditions by constructing project promoted EcoSan latrines.

Access to family medicine services expanded to reach 50% of the population of Rasht alley; the under-five child mortality rate fell from 25.6 to 23.1 per 1,000 live births.

47% of population improved their livelihoods applying modern Natural Resource Management (NRM) techniques; 30% of communities are better protected from the impact of natural hazards (17% increase from 13% pre-project).

61% of youth and 35% of women in the targeted communities participated in design and implementation of local development planning.

Resource:

EDA. (2022). Integrated Health and Habitat Improvement (IHHI) Rasht Valley, Tajikistan. https://www.eda.admin.ch/countries/tajikistan/en/home/international-cooperation/projects.html/content/dezaprojects/SDC/en/2013/7F08788/phase2?oldPagePath=/content/countries/tajikistan/en/home/internationale-zusammenarbeit/projekte.html

17.1.6.7. Strengthening Critical Infrastructure against Natural Hazards

Location: Tajikistan

Year: 2017 - 2023

Organization: World Bank / UNDP

Goal and description:

The objectives of the Strengthening Critical Infrastructure Against Natural Hazards Project for Tajikistan are to strengthen the recipient's disaster risk management capacities, enhance the resilience of its critical infrastructure against natural hazards, and improve its capacity to respond to disasters. There are four components to the project, the first component being strengthening disaster risk management capacity. This component is intended to strengthen the GoT's capacity for DRM through selected activities that focus on disaster risk identification, disaster preparedness, and financial protection against disasters. It will be implemented in coordination with UNDP, which has been continuously strengthening the capacities of the CoESCD at the national and regional levels, while building regional mechanisms for disaster risk management and mainstreaming disaster risk reduction into state policy at the national and subnational levels. The second component is the making critical infrastructure resilient against natural hazards. This component will finance capital works and contingency planning (for example, equipment for emergency situations) for the transportation network in GBAO, which suffered the most significant damage in July 2015, as well as the flood protection infrastructure that has repeatedly been damaged in the Khatlon Oblast. The third component is the contingent emergency response component. The objective of this component is to enhance Tajikistan's capacity to respond to disasters. An emergency eligible for financing is an event that has caused, or is likely imminently to cause, a major adverse economic and/or social impact to the Borrower, associated with a disaster. Finally, the fourth component is the project management.

Finance: US$ 50 million

Expected impacts:

Bridges reconstructed based on designs considering multi-hazard disaster and climate change risks (15); Crisis management centres and systems become operational (100); Number of people with reduced disaster risks through more resilient flood protection and riverbank erosion prevention infrastructure (556,900); Strengthened capacity to coordinate and respond to emergencies; Seismic hazard maps are updated and understanding of seismic hazard is improved.

Resource:

World Bank. (2022). Strengthening Critical Infrastructure against Natural Hazards. World Bank. https://projects.worldbank.org/en/projects-operations/projects-summary. URL: https://projects.worldbank.org/en/projects-operations/project-detail/P158298

17.1.6.8. Khatlon Livelihoods Support Project

Location: Tajikistan

Year: 2008- 2015

Organization: IFAD

Goal and description: The project purpose is to increase small farm (including household plots) profitability across the project area. The project has two principal inter-related components as well as the required support for project management and implementation as follows: (i) Institutional Support; (ii) Enhancement of Agricultural Productivity and Profitability; and (iii) Project Management. The Institutional Support component has two sub-components: (i) Development of Community Organisations; and (ii) Capacity Building of Project Partners. The second component also has two sub-components: (i) On-farm Technology Validation and Demonstration; and (ii) Community Development Fund. The provision for Project Management is presented as two sub-components: (i) Project Management; and (ii) Monitoring and Evaluation

Finance: US$ 12.3 million

Impact:

The project is successfully completing its activities, and since it resumed its operations 1.5 years ago it has managed to undertake all the planned activities, including the following key ones: (i) delivery of 98 agricultural/ construction machinery subprojects (from both the first and second rounds of priority subprojects). The total income received by VOs in two districts from the machinery rental services during 2014 - September 2015 amounts to about TJS 800 000 while the savings equals to approximately TJS 2 million; (ii) construction of 4 water supply lines resulted in provision of pure drinking water to 10 000 villagers; (iii) rehabilitation of 8 000 m of roads (3 subprojects plus use of supplied machinery) leading to a better access to market and services to 2 800 rural residents; and (iv) rehabilitation of 27.5 km of power lines resulted in regular provision of electricity to 5 000 rural inhabitants. In addition, the following subprojects are under completion: (i) provision of agrochemical laboratory equipment to the Tajik Agrarian University (amounting to about USD 160 000); (ii) technical support and provision of laboratory equipment for development of artificial insemination in Tajikistan (ca. USD 460 000); (iii) procurement and management of purebred cattle (12 heads from the outside and 40 heads within the country, at amount ca. USD 273 000). With the purpose to improve cattle breeding capacity in the project area, in cooperation with the MOA, 40 heads of purebred bulls have been distributed among the population in the Khatlon region. According to the reports from the MOA as of 1 September 2015, about 560 cows have been inseminated. Delivery of additional 12 purebred bulls will be completed by November 2015.

<u>Resource:</u>

IFAD. (2018). Khatlon Livelihood Support Project. IFAD. https://www.ifad.org/en/web/operations/-/project/1100001408

17.2. Appendix 2: Project efficiency analyses

In appendix, we present project efficiency analyses (costs and benefit analyses) as presented in World Bank *Implementation completion and results reports* published after project finalization. This part is intended to be an addition to our own results.

17.2.1. Emergency Food Security And Seed Imports Project[11]

Efficiency

Substantial: During project appraisal the Bank team conducted an economic analysis, which determined the expected benefits but did not include an estimation of the project 's Economic Rate of Return. The analysis was revised at the project restructuring in 2009 to include the changes and addition that were made to the project. The ICR conducted a cost benefit analysis for a period of ten years (2009 to 2018) and identified three main quantifiable benefit streams of the project (ICR p. 35):

- Increasing the production of crops by providing beneficiary households with input packages and improving the agricultural-input supply market;
- Increasing the production of livestock by beneficiary households with inputs to improve their livestock health and husbandry;
- Improving food security, nutrition and diversification of beneficiary households through the development of CPGs.

To estimate the benefit of the three streams, the ICR used seven cost -benefit models. The ICR does not provide the specifics on these models and how values were derived but the calculations seem plausible based on the forecast rates of return. Local costs were converted through a Standard Conversion Factor of 0.85 into their approximate Economic value. An Economic Rate of Return 15.2% and a Net Present Value of US$ 1.3 million were estimated. A discount rate of 10% was applied. While the Economic Rate of Return and the Net present Value for an Emergency Project are reasonable, the ICR does not provide the data and details of the analysis and does not define what cost -benefit models were used to derive these results.

Use of project funds

Delays in implementation did not allow 17% of beneficiary households to plant their seeds in the season they were intended for. Also delays in the distribution of fertilizers left farmers without fertilizers during the spring season. These delays suggest minor inefficiencies in the use of the Bank 's financial resources (see section 9b).

[11] The text as presented in the World Bank document "Implementation Completion Report Review" under number ICRR14604

Cost savings

Due to conservative costing during project design and lower prices offered during a competitive international tendering process, the number of targeted households under component A could be increased to 70,000. In June 2009, additional cost savings allowed the provision of input packages (3 kg of hybrid maize seed and fertilizer) for another 10,000 households. Given the reasonable Economic Rate of Return and Net Present Value for an Emergency Project, and cost savings that allowed an increase in households benefiting from this project, efficiency is rated substantial.

17.2.2. Farm Privatization Support Project[12]

Several studies of the agricultural sector in former CIS countries have demonstrated that the Value Added per hectare of privatized farms is considerably greater than that of large collectively held, or state, farms. This fact and the evidence that has been accumulated in regards of small farm productivity was the basic economic reasoning behind the design of this project. Since small farmers produce more per unit of land than do larger farmers, land privatization and reform have the potential to enhance land efficiency. In the case of Tajikistan, privatization to farm workers would also equalize the size distribution of land holdings and reach the great majority of the rural population thus it would also have a significant element of equity, and as a result poverty alleviation. This was confirmed by the PSIA designated "Welfare Implication of Cotton Farmland Privatization" that was published in June 2004. The main benefits to the project were to occur through an increased value added of agricultural activities by broadly enabling access to land to the farm workers of the former state and collective farming entities. For this to take place, the project investments addressed the key short comings that prevented the emergence, and affected the viability of the new small private family farms. Detailed calculations of ERR and IRR were not made for the entire project at appraisal, but were estimated at 26% and 21% respectively for investments in irrigation.

[12] The text as presented in the World Bank document “Implementation Completion Report” under number no. 36487

Table 17-1 Project Costs:

Farm Restructuring Services	US$ 4.8 million	This component focused on building the necessary institutions and capacity to allow for proper land allocation, mapping and registration, and supporting farmers with adequate farm information. Although the component will greatly contribute to the development of the country's agriculture and set the foundations, along with current activities lead by different donors, for the emergence of effective land use transactions, its economic benefit, is difficult to capture in figures and has not been calculated.
Drought mitigation	US$ 3.58 million	This activity had not been part of the originally designed project and was only introduced after the devastating effects of the 2000 drought that resulted in the failure of one third of crops. Under this component new higher yielding seeds, that were more resilient, as well as winter varieties where introduced. The widespread distribution of these seeds has helped with dramatically improving national wheat production. Economic benefits of this component were not quantified.
Project Management	US$ 7.4 million	Very significant resources went into the management of the project, more than twice than what had been budgeted at project design. This was mostly due to the very limited administrative and technical capacity especially related to Financial, Procurement and Contract management, requiring almost permanent International Technical Assistance. The increased cost was also due to drought mitigation intervention which required a lot of logistical and coordination support to the PMU and government. While the costs of project management are admittedly high, the flip side is that there have never been any significant issues raised in the yearly financial audits, nor on the procurement audit conducted in 2004, and distributions of goods and cash to farm families (a high-risk activity) took place without problems. No economic rate of return was calculated for this component.
Privatization Grants and RSCAs	US$ 4.71 million	The grant was provided to help new private farmers to purchase the basic inputs for the first year of farming. In retrospect, this grant significantly helped private farmers of the pilot farms to remain outside of the clutches of the cotton traders. The private farms under the project area have relatively little or no debt. The RSCAs, have closed their first year of lending with a net profit of US$ 55,000 and a 95% recovery rate. The economic benefit of the grant and the lending of RSCAs were not quantified.
Rehabilitation and Drainage Works	US$ 8.5 million	This component involved the rehabilitation of all three levels of irrigation infrastructure serving private farmers on about 15,000 ha. The rehabilitation of main intakes structures in Karatag, and Dushanbinska serve around 20,000 ha total, and the rehabilitation of pumping stations in Zafarabad, serves about 25,000 ha, of which the majority is well beyond the project area. If the component cost is subdivided over the project are, exclusively, this corresponds to an investment of some US$ 566.00 ha, if it is subdivided over the total area that the system can now again effectively irrigate, the amount invested comes to US$ 190.00/ha. The more reliable delivery of water largely responsible for the slightly increased yields but mostly for the increased cropping intensity with the possibility of an early crop and land preparation for a second crop in fall within irrigated areas. The IRR of this component has been calculated at 21%.

The gross margins per hectare at the time of project preparation were very low; without improvements to enhance productivity, crop production would not improve. The project economic analysis therefore produced crop budgets based on the production realities on farms “without” the project as compared to “with” the project where yields would be increased as a result of increased, and improved inputs, including water supply and labour replacing agro chemicals (fertilizers, weeding & pest control).

Yields:

The yield data collected in the field shows crop yields, in general, have increased throughout the country by approximately 30 percent, with significant variations by crop type, but with only marginally higher yields within the project areas. Calculations made during the design stages of the project expected increases in yields by twofold or more. In retrospect, that estimate was overly ambitious, since these figures assumed large increases in use of inputs (fertilization/tilling practices/pest control). Input use remains very low since the supply market of inputs remains largely tied to cotton production. Farmers and farm workers, however, typically make some inputs they have received for cotton available for their own gardens and fields, by short changing the allocations made for cotton. The gains in yields nationwide for field crops were mostly due to relatively clement weather, with plentiful rains in spring which especially had an impact on rainfed areas (grains), and with the return of peace one can observe improved tending and care of fields and crops, as well as, of course, the rehabilitated irrigation infrastructure financed under this project, and the Rural Infrastructure Rehabilitation Project (RIRP), but also from investments from other bilateral donors, the Asian Development Bank in particular.

Table 17-2 Nationwide yield increases during the project period

		Crop	Wheat		Maize		Rice		Cotton		Potato		Vegetables		Lucerne	
			2004	*1999*	2004	*1999*	2004	*1999*	2004	*1999*	2004	*1999*	2004	*1999*	2004	*1999*
Yield	main prod.	kg/ha	1850	*1120*	3770	*2810*	3600	*2480*	1930	*1264*	17700	*11700*	16200	*7300*	13500	*7500*

Cropping Intensity:

Cropping Intensity has increased nationwide from around 90% in 1999 to around 100% in 2004 which explains the increase in production and improvements in per/ha margins in spite of continued relatively low yields. In project areas, on private family farms, the M&E survey found cropping intensity to be a bit higher than on Dehkan associations. This is mostly attributed to the fact that the small plots of private farmers are somewhat more intensively held, with higher cropping intensity of around 115% compared to around a 100% for non-project areas, and a larger variety of complementary shorter maturing crops such as winter wheat in spring, vegetables until the fall, rotated with pulses or peanuts the following year to save on nitrogen fertilizer. These patterns are particularly visible in areas where water is less dependent on pumping stations and therefore available more evenly throughout the year, and where markets for fresh vegetables are readily available. The provision of the cash grant is considered to have had a significant effect on this since it permitted beneficiary farmers to go out and purchase different seeds for a variety of crops from the market which were not available to them without cash.

Project Effect on gross margins per ha:

Nationwide, the very low average gross margins for the main 7 crops of around US$110/ha at project design, have dramatically improved to US$503/ha per the most recent farm data available for this set of 7 common crops found on farms. The increased cropping intensity on private farms has raised their gross margins by an additional US$ 75/ha to US$578.00/ha assuming that high and low-cost crops are rotated equally. The biggest gains for farmers as indicated above, are not to be attributed to the higher crop yields but much more from gains by replacing inputs with family labour and increased cropping intensity. Greater labour effort has effectively displaced the use of machinery and off farm inputs leading to generation of the greater value added per hectare (or farm labour and net profits). The calculation therefore reflects a corresponding reduction of machinery input from 1999 to 2004. This increase in the gross margin is largely in line with the three to fivefold increase that was proposed in the SAR. However, it should be noted that farmers are more likely to rotate in favour of higher margin crops which would significantly improve that figure and with improvements in the input supply chain, and basic transport and the marketing links for agricultural products improve, that figure again would further grow dramatically.

Economic and Financial Analysis:

Irrigation investments If one conservatively assumes this figure of US$ 75 per ha, and multiplies it per the 18,000 ha that were privatized exclusively under this project we obtain a figure of some US$ 1.35 million that is generated in additional output exclusively within the project area per year from irrigation investments. Attributing this figure as benefit generated mostly from investments in improved irrigation, with benefits accounted for within project areas exclusively, one arrives at an Investment Rate of Return of 21%, largely in line with initial estimates, and a Net Present Value of some US$ 1,883,835.

Table 17-3 Crop Gross Margin in Tajikistan (including 15% higher cropping intensity)

		Crop	Wheat		Maize		Rice		Cotton		Potato		Vegetables		Lucerne	
			2004	1999	2004	1999	2004	1999	2004	1999	2004	1999	2004	1999	2004	1999
Yield	main prod.	kg/ha	1850	1120	3770	2610	3600	2480	1930	1264	17700	11700	16200	7300	13500	7600
	bi-product	kgt/ha	1200	760	3300	2600	3600	2480	2230	1460	0		0		0	0
Inputs																
	seed/ seedings	kg/ha	160	220	50	70	167	170	80	60	2676	3220	10	16	6	9
	fert N	kg/ha	110	110	150	150	350	350	140	140	140	140	500	0	0	0
	fert P	kg/ha	49	49	67	67	0	0	17	17	120	120	0	0	50	50
	fert K	kg/ha	3	3	0	0	0	0	0	0	17	17	0	0	0	0
	manure	kg/ha	750	0	1300	900	0	0	0	0	3067	2400	2200	1600	1000	0
	tractor+impl	h/ha	1	2	1	2	3	4	5	6	2	3	2	2	1	2
	herbicide	kg(l)/ha	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	insecticide	kg(l)/ha	0	0	0	0	1	1	1	1	1	1	1	1	0	0
	fungicide	kg(l)/ha	0	0	0	0	1	1	0	0	0	0	0	0	0	0
	labour	md/ha	40	25	90	60	74	60	180	100	80	60	50	60	65	35
	water	tcm/ha	7	11	3	3	62	62	8	12	8	17	16	30	8	12
Input/ output prices	Crop price	TJS/kg	0.60	0.60	0.30	0.30	0.74	0.74	1.00	1.00	0.26	0.26	0.30	0.30	0.10	0.10
	Crop bi-product	TJS/kg	0.07	0.07	0.10	0.10	0.00	0.00	0.10	0.10	0.00	0.00	0.00	0.00	0.00	0.00
	seed	TJS/kg	0.60	0.45	0.36	0.25	1.43	1.00	0.22	0.12	0.45	0.45	110.00	61.00	17.14	13.00
	fert N	TJS/kg	1.30	1.20	1.30	1.20	1.30	1.20	1.30	1.20	1.30	1.20	1.30	1.20	1.30	1.20
	fert P	TJS/kg	0.80	0.60	0.80	0.60	0.80	0.60	0.80	0.60	0.80	0.60	0.80	0.60	0.80	0.60
	fert K	TJS/kg	0.90	0.70	0.90	0.70	0.90	0.70	0.90	0.70	0.90	0.70	0.90	0.70	0.90	0.70
	manure	TJS/kg	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
	tractor+impl	TJS/h	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00
	herbicide	TJS/kg(l)	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20
	insecticide	TJS/kg(l)	3.00	2.70	3.00	2.70	3.00	2.70	3.00	2.70	3.00	2.70	3.00	2.70	3.00	2.70
	fungicide	TJS/kg(l)	3.00	2.60	3.00	2.60	3.00	2.60	3.00	2.60	3.00	2.60	3.00	2.60	3.00	2.60
	labour	TJS/md	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
	water	TJS/tcm	7.00	0.00	7.00	0.00	7.00	0.00	7.00	0.00	7.00	0.00	7.00	0.00	7.00	0.00
Gross output	main prod.	TJS/ha	1110	672	1131	843	2672	1841	1930	1264	4673	3069	4860	2190	1350	760
	bi-product	TJS/ha	84	53	330	260	0	0	223	146	0	0	0	0	0	0
	subtotal	TJS/ha	1194	725	1461	1103	2672	1841	2153	1410	4673	3069	4860	2190	1350	750
Cropping Intensity		15%	394		394		394		394		394		394		394	
	Subtotal		1588		1855		3066		2547		5066		5254		1744	
Costs	seed	TJS/ha	96	99	18	18	238	170	18	10	1202	1446	1100	916	103	117
	fert N	TJS/ha	143	132	195	180	455	420	182	168	182	168	650	0	0	0
	fert P	TJS/ha	39	39	54	54	0	0	14	14	96	96	0	0	40	40
	fert K	TJS/ha	3	2	0	0	0	0	0	0	15	12	0	0	0	0
	manure	TJS/ha	23	0	39	27	0	0	0	0	92	72	66	45	30	0
	tractor+impl	TJS/ha	45	68	45	90	135	180	225	270	90	135	90	90	45	90
	herbicide	TJS/ha	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	insecticide	TJS/ha	0	0	0	0	3	3	3	3	3	3	3	3	0	0
	fungicide	TJS/ha	0	0	0	0	3	3	0	0	0	0	0	0	0	0
	labour	TJS/ha	200	125	450	250	370	250	900	500	400	300	250	250	325	175
	water	TJS/ha	49	0	21	0	434	0	56	0	56	0	112	0	56	0
	rent	TJS/ha	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	subtotal	TJS/ha	597	465	822	618	1638	1025	1397	964	2136	2232	2271	1303	599	422
Cropping Intensity		15%	157		157		157		157		157		157		157	
	Subtotal		754		979		1795		1554		2293		2428		756	
Gross margin		TJS/ha	833	161	876	319	1,270	540	992	236	2,773	394	2,826	559	988	216
1$=TJ		3.15 $/ha	265	48	278	101	403	171	315	74	880	126	897	177	314	68
Average Crop Margins	109	1999														
	578	2004														

17.2.3. Ferghana Valley Water Resources Management Project[13]

Economic and Financial Analysis

1. Introduction

For the economic and financial analysis, several data sources were used. These include:

- Final report of Monitoring and Evaluation of the results of FVWRMP implementation, Dushanbe, May 2014;
- Results of Interviews with farmers, Sugd Oblast Department of Agency of Land Reclamation and Irrigation and Sugd oblast Department of Agriculture;
- Regions of Tajikistan, 2012. Report of Statistical Agency under President of the Republic of Tajikistan.

The project interventions are concentrated in Kanibadam and Bobojon Gafurov districts, with an irrigated area of about 30,000 ha. About 231,000 people live in these rural areas. The irrigation and drainage infrastructure in these districts has both physical as well as operational problems. The result is an unsatisfactory utilization of water resources and low productivity at farm level.

The actual scope of the planned works was reduced due to (i) higher work and input prices and (ii) omitted details in initial calculations. On 21 March 2010, the Bank and the GoT agreed on an additional financing of the project in the number of US$10Mln. The date of completion was planned for 31 May 2013, but was extended until 31 May 2014.

2. Financial and economic analysis

2.1 Main assumptions

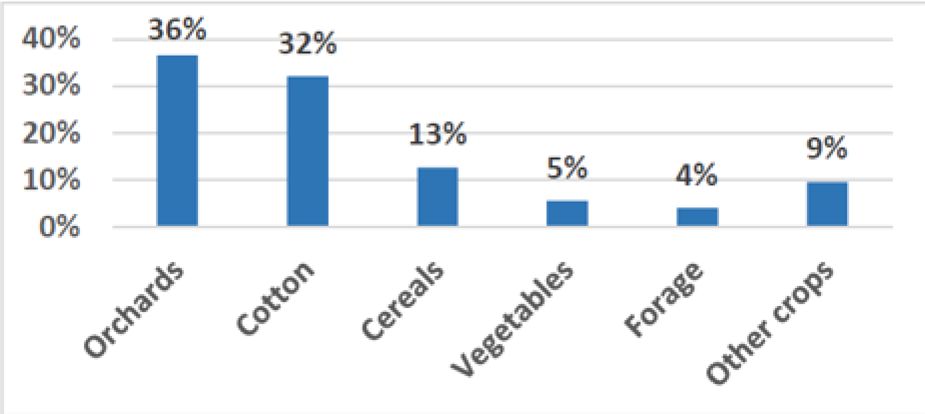
Project area and cropping pattern

The project covers an irrigated area of 29,874 ha (2013), of which 6,685 ha are located in Bobojon Gafurov district and 23,188 ha in Kanibadam district. There is no significant difference between the present cropping patterns in both regions. The composition is presented in Figure 17-1. The dominating crops are orchards and cotton respectively with 36% and 32% of the total area. The cotton area decreased significantly during the last years due to decreasing of price to fibre cotton in the world market. Orchards include different fruit trees such as apricot, peach,

[13] The text as presented in the World Bank document "Implementation Completion Report" under number ICR3160

pomegranate and others. These are followed by cereals, including mainly wheat, oats and sorghum with 12.5%. Fodder crops (alfalfa, maize, including for silage) are grown on 1,194 ha (corresponding to 4%). Others crops cover 9.5% of total irrigated area and include rice, potato, grapes and others crops. Except orchards, future cropping patterns will depend on market demand and profitability of the crops.

Figure 17-1 Cropping pattern (with project interventions)



Project impacts at farm level

The various project components resulted in improving of production conditions at the farm level. This means an improved irrigation water delivery and a reduction of the problems caused by flooding and high groundwater levels from Kayrakkum reservoir. An agricultural extension service and a farm management information system established by the project further improved the water and land management in irrigated farms.

Due to the rehabilitation of the drainage network and drainage pump stations, the groundwater table decreased on a total area of 6,416 hectares, including in Kannibodom district (on the area of 4,755 hectares), and in Bobojon Gafurov district (on an area of 1,661 hectares). An improvement of the drainage collection system allowed control of soil salinity, increased crop yield and thus raised the profitability of irrigated farming in the area close to the Kayrakkum reservoir. Rehabilitation of the Mahram-1 pump station, and concrete lining of the Big Ferghana Canal improved water supply to farms. A better water supply resulted in higher yields for all crops in the project area.

Training on the improvement of agricultural productivity and a more rational water management have been conducted for more than 10,000 persons, out of which 4,400 were women. Results of demonstrations of advanced agriculture and irrigation technologies have been published in the form of brochures, recommendations and booklets, which were distributed to participants of the training.

As compared to the beginning of the project (2006), vegetables, forage and orchards yields increased to 10-20%, although yields of rice and wheat remained stable (Table 16-4). This suggests that farmers still have a potential to increase yield of these crops.

In Table 17-5 the impacts of all project interventions with regard to incremental yields, gross output and costs are summarized for relevant crops. Crop budgets were calculated for 4 major crops: apricot, cotton, wheat, alfalfa and vegetables. The highest incremental gross output was achieved for cotton, apricot and vegetables. However, since the highest share of the irrigated land is cultivated with fruits, it will provide the largest absolute contribution to the project benefits.

Table 17-4 Increase of crops yields in dehkan farms according the survey conducted in 2013 comparatively to 2006

Raw cotton	Cereals	Vegetables	Fruits, including apricot	Forage
23.5	9.6	14	14	11.7

Table 17-5 Project interventions and incremental harvested quantities, gross output and costs

Crops	Yield, ton/ha		Yield incremental		Cost of incremental yield, US$	Additional cost of harvesting and transportation, US$/ton	Total additional cost, US$	Profit, US$/ha
	2006	Average 2010-2013	ton/ha	%				
Cotton	1.94	2.33	0.39	23.51	273[33]	120	46.8	226.2
Wheat	2.55	2.77	0.19	9.57	57[34]	60	11.4	45.6
Vegetables	21.10	24.03	2.93	13.89	293[35]	40	117.2	175.8
Orchards (dried fruits)	4.49	5.11	0.63	13.93	630[36]	100	63	567
Forage (hay)	7.51	8.39	0.88	11.66	88[37]	30	26.4	61.6

Accurately measured data on technical water losses are not available. However, according to expert evaluations of the head of the department of water use of Kanibadam Water Management Department, the value of technical losses from structures before their rehabilitation reached 25% from the water intake volume, and after rehabilitation these losses have been reduced to 20%.

Although the costs of irrigation water delivery for the farmer are not high, reducing losses in the canals and fields will have a positive impact to improving the condition of the irrigated lands, and decreases the pressure on the drainage networks. According to this, annual technical losses of water from water outlets constituted 27 million m3 in 2012 and 33 million m3 in 2013. After rehabilitation they decreased to

5.4 – 6.6 million m3, representing a reduction of losses of 21.6 to 26.4 million m3 annually.

Input and output prices

Input and output prices are expressed in constant 2013 values (US$). Financial prices are based on actual market prices. For the economic analysis, costs and benefits are adjusted to reflect the real value in the economy. The border prices are estimated for all crops, including fodder crops derived from the farm gate prices.

Table 17-6 Expenditures and income of agriculture production for main crops, 2013

Crop	Yield	Unit gross income	Production expenditures	Net income	Land Tax	Profit
	t/ha	US$/ha	US$/ha	US$/ha	US$/ha	US$/ha
Cotton[1]	2	1600	700	900	40	860
Wheat	2	600	250	350	40	310
Potato	20	6000	2500	3500	40	3460
Rice	2.5	1500	600	900	40	860
Fruits	5	5000	1000	4000	40	3960
Lucerne	15	1500	417	1083	40	1146
Melon, watermelon	10	4000	1500	2500	40	2460

[1]Gross income of cotton includes price of cotton stalks used by rural population as fuel.

2.2 Financial and economic results

The cost and benefits streams and the cash flow calculations were completed based on the above-mentioned assumptions. The following benefits were included in the analysis (i) additional production on incremental land as a result of reduced flooding, (ii) higher yield levels as a result of better, more reliable and increased water delivery, and improved groundwater control and earlier spring planting, (iii) production of higher value crops as part of a more diversified cropping pattern, and (iv) reduced pumping costs per m3 as a result of reduced losses. Other benefits that are difficult to quantify and monetize have not been reflected in the EFA and include the (i) benefits to downstream irrigated areas in Uzbekistan and Tajikistan as a result of higher water levels in Kayrakkum reservoir, (ii) reduced damage to lands from overtopping of Kayrakkum reservoir embankments, (iii) reduced damage as a result of reduced risk of Kayrakkum dam failure and better early warning, and (iv) benefits from improved environmental management. Table 17-6 shows the results of the financial and economic analysis.

Table 17-7 Results and financial and economic analyses

Performance indicator	ERR/FRR	NPV
Economic analysis	24.3%	US$ 28.43 million
Financial analysis	19.4%	US$ 17.96 million

The economic viability of the project has been tested by estimating the economic rate of return (ERR) and the financial rate of return (FRR). The estimated ERR of the project is 24.3%, which is well in excess of the opportunity cost of capital (OCC), taken at the discount rate of 10%. The net present value (NPV) at 10% discount rate and a project period of 20 years is estimated at US$ 28.43 million.

The result is an NPV of US$ 17.96 million and an FRR of 19.4%. These performance indicators reflect the project benefits on farm level.

3. Sensitivity analysis

Sensitivity analysis has been carried out for various risks that the project may face in order to evaluate the effect on the project ERR and NPV. Table 16-8 gives a summary of the results.

Table 17-8 Results of sensitivity analyses

Scenario/Performance indicator	ERR	NPV
Cost increase + 40%	18.7%	US$ 21.05 million
Decrease in product prices cotton + apricot - 5% cotton + apricot - 10%	 22.8% 21.2%	 US$ 24.29 million US$ 20.16 million

The ERR is sensitive to variations in project costs or benefits. Increasing of the total cost of project results in a decrease of the ERR of 5.6% to 18.7%. The ERR was tested against changes in the assumptions regarding cotton and apricot prices. If the crop prices are 5% less than assumed, the ERR would be 22.8% and if crop prices are 10% less than assumed, the ERR would be 21.2%. Overall, the sensitivity analysis suggests that the project results are very robust.

17.2.4. Community Agriculture and Watershed Management Project[14]

Economic and Financial Analysis

An incremental cost analysis (ICA) was conducted at appraisal as per GEF requirements. This Annex reviews the ICA against Project implementation results.

Incremental Cost Analysis

a) ICA at Appraisal

The ICA compared the baseline scenario with the GEF-Alternative scenario. The baseline included: (a) on-going and planned activities undertaken by the Government, in order to improve livelihoods of rural communities while reversing degradation of fragile lands and ecosystems (US$2.0 million); (b) the associated contribution by beneficiaries in proportion to their level of external support (US$1.6 million); and (c) activities and resources being financed by IFIs and other donors (US$10.8 million). The full baseline scenario was estimated to be US$14.4 million.

Baseline Benefits:

The baseline scenario included the following benefits:

- Provide rural infrastructure investments;
- Provide support for farm productivity improvements;
- Provide support for land resource management covering 21,000 ha. The scale of gully and landslide prevention would be smaller;
- Support for scientific research, including support for nurseries, field trials, and line agency capacity building. However, there would not be sufficient funding to restore Tajikistan's capacity to preserve specimens of indigenous crop varieties;
- Facilitation and planning support necessary to mobilize communities and ensure the feasibility of rural production investments. Feasibility and eligibility guidelines include communications, group process, organizational and administrative arrangements, contribution requirements, budget limits, and institutional capacity, social, financial, commercial, technical, and environmental considerations. However, training and dissemination efforts would be limited.

[14] The text as presented in the World Bank document "Implementation Completion Report" under number ICR2093

Table 17-9 Incremental cost matrix as of project Appraisal and Completion (USD million)

Component	At Appraisal				At Completion			
	Baseline Cost	Incremental Cost		Total	Baseline Cost	Incremental Cost		Total
		GEF grant	Other			GEF grant	Other	
Rural Production Investments	7.20	3.80	0.90	11.90	6.45	3.34	0.9	10.69
Institutional Support and Capacity Building	3.70	0.60	0.00	4.30	3.92	0.98	0.00	4.9
Project Management and Coordination	3.50	0.10	0.00	3.60	3.55	0.17	0.00	3.72
Total	**14.40**	**4.50**	**0.90**	**19.80**	**13.92**	**4.49**	**0.90**	**19.31**

Source: PAD, Annex 15.

* Including physical and price contingencies.

The GEF-Alternative scenario, at an incremental cost of US$19.8 million of which the GEF would finance US$4.5 million, would support in initiatives in each of the three components:

1. Rural Production Investments (US$11.9 million; GEF financing - US$3.8 million). This component comprised support for subprojects in farm productivity improvement, land resource management, and rural infrastructure. Financing from GEF, blended with the IDA financing, would accelerate and expand the land resource management subcomponent. It would address biodiversity conservation and soil protection through vegetative cover restoration to 78,000 ha, which was 57,000 ha above the level that would have been supported by the government on purely national grounds. It would promote biological conservation and moisture retention techniques which made the best use of in-situ water and recharge profiles, increase vegetative cover and generally improved soil structure and water holding capacity. In addition, because of the requirement that beneficiaries contribute at least 20% of the subproject investment costs, GEF financing would leverage an additional US$0.9 million in beneficiary contributions for land resource management subprojects, which would not have been forthcoming in the absence of the additional GEF financing.

2. Institutional Support and Capacity Building (US$4.3 million; GEF financing - US$0.6 million): This component would strengthen scientific institutions, and included the restoration of Tajikistan's capacity to preserve specimens of indigenous crop varieties, in collaboration with the Consultative Group for International Agricultural Research's Central Asia and Caucasus unit in Tashkent. It would strengthen the capacity for seed and seedling production. It would include training for communities, community-based organizations, and interest groups and the Jamoat and Watershed Development Committees. It included initial confidence building mobilization grants for each participating village. It would also include information and experience sharing on a wide variety of institutional, technical, environmental, financial, and management topics, including monitoring and evaluation. Blended GEF financing would enable additional funding for extra support required to increase the extent of land resource management investments, information sharing and awareness-raising on land degradation and biodiversity conservation topics, as well as specimen preservation of indigenous crop varieties.

3. Project Management: (US$3.6 million; GEF financing - US$0.1 million). The Project management component would support Project coordination and administration staff, procurement, disbursement, financial management, reporting, monitoring, and evaluation activities, at the national level and for each of the four Project watershed areas. The component would also support the secretariat services to be provided to the national Steering Committee, and support the Watershed Development Committees to enable them to appraise Jamoat proposals for financing from rural communities in a manner consistent with good practice. Blended GEF financing would support increased management of land resource management investments, enabled more extensive evaluation of mountain ecosystem degradation trends, as well as exchange of experience both within the country and with other countries, thus further strengthening replication impact.

b) ICA at Completion

Project results were exceeded in all cases with an incremental cost of US$5.39 million including the GEF Grant of US$4.5 million. Thus, from a cost-efficiency standpoint the Project can be rated as highly satisfactory.

17.2.5. Tajikistan Second Public Employment for Sustainable Agriculture and Water Resources Management Project[15]

Efficiency analysis

Project Context

1. The original project design was based on the rehabilitation of an estimated 190,000 ha of high-potential arable land in 12 selected districts of Khatlon and the DRS region, an associated public works program that employed low-income local people to manually clean on-farm irrigation canals, and policy reform and capacity building for WUAs and the public institutions responsible for water management. Expected project benefits included a yield increase of 10 percent for major crops in the rehabilitated areas, temporary employment of 22,000 low-income people, and an improved capacity to manage water delivery for irrigation. Crop production in other high potential districts in the project area provided the without project (WOP) reference for estimating incremental project benefits. The original project launched in February 2013, with a planned completion date of February 2018.

2. The AF in 2015 allowed the project to accommodate the addition of six new districts to the project area from 2015–2020, increasing the target rehabilitated area to 260,000 ha. The AF also helped the GoT to expand public employment opportunities at a time when Tajik migrant workers to Russia were returning to Tajikistan following a severe contraction of the Russian economy, increasing the target for temporary employment to 32,000 people. The second restructuring in 2015 responded to the request of the GoT to finance additional flood emergency works. One project district (Bokhtar) was dropped in order to release funding, which reduced the target rehabilitated area to 236,600 ha and the target for temporary employment to 29,950.

3. The original assumptions for economic analysis were retained. However, the revised project added almost all the high potential districts, leaving only one WOP district (Bokhtar) as a reference point for economic analysis,38 which limited the scope for incremental analysis. The project completion date was extended to February 2020 to allow time to implement the additional investment and the project closed as scheduled.

Project Performance Analysis

4. Table 17-10 summarizes the main results of the economic analyses for the original project, the AF, and project completion. Assumptions for the project completion analysis were based on trends in crop production in the 11 original project districts,

[15] The text as presented in the World Bank document "Implementation Completion Report" under number ICR00005176

as project outcomes in these districts had more time to embed and extrapolated to the full project area.

Table 17-10 Economic Analyses Assumptions and Results

	Original Project[a]	AF[a]	Project Completion[b]
Area rehabilitated (ha)	190,000	236,600[d]	251,433
Net increase in crop yields[c] (%)	10	10	> 10
ENPV (economic prices) (US$, millions)	30.2	27.2	21.9
EIRR (economic prices) (%)	26.1	27.0	41.5
Benefit-cost ratio	5.82	7.14	2.83
Incremental benefits/ha (US$)	158	110	87
Investment life (years)	12	12	12
Discount rate (%)	12	12	12

Note: a. Projected; b. Actual; c. Wheat, all cereals, all vegetables, and fodder. d. Target at second restructuring in 2015.

5. The lower ENPV anYd higher EIRR estimated for project completion reflect the impact of actual patterns of investment and returns, which differed from the original assumptions. Actual investment expenditures were lower than anticipated in the first two years, with lower consequent negative increments. Furthermore, the original projections assumed full impact in the final years, while some reduction was observed in practice because of the failure to adequately maintain the canals in some districts.

6. Although the differing pattern of investments and returns reduced the project ENPV, the benefit-cost ratio and the incremental return per ha relative to projected returns, the investment outcome was still highly positive, with an ENPV of US$21.98 million and an EIRR of 41.5 percent. Sensitivity analysis (table 17-11) also shows that the project outcome is robust. A 20 percent reduction in yields reduces the ENPV to US$11.31 million, a 20 percent reduction of output prices reduces the ENPV to US$8.2 million, and a 20 percent increase in input prices reduces the ENPV to US$19.1 million. The corresponding EIRRs and switching values further confirm the robust nature of project outcomes.

Table 17-11 Sensitivity Analyses

	Change ± (%)	ENPV (US$, millions)	EIRR (%)	Switching Value (%)
Base case		21.981	41.5	100
Crop yield declines	−20	11.306	24.1	42.4
Crop producer prices decline	−20	8.189	18.9	31.9
Crop input prices increase	+20	19.071	37.2	−150.7

7. The satisfactory, positive economic return to investment was due to the combined impact of: (i) increased crop yields; (ii) a change in crop composition to more higher returning crops; and (iii) the restoration of more unused land to crop production in response to irrigation rehabilitation than originally envisaged.

8. **Crop yields.** The analysis of trends in crop yields was based on district-level data from TAJSTAT 2010-2018 as the project survey data were unsuitable for use.

Economic analysis was based on conservative estimates of trends in crop yields in the 11 original project districts for 2010–2018. Equivalent trends in the non-project districts were based on national statistics (from the Food and Agriculture Organization Corporate Statistical Database [FAOSTAT]) due to the lack of comparable WOP districts and limited TAJSTAT data available for the one remaining WOP district. Table 17-12 shows observed trends in crop yields for the main crop groups for the 11 original project districts. As the interannual variability of crop yields and production is high, the base year was calculated as the average for 2010–2012 and the final year as the average for 2017–2018. Paired t-tests were used to calculate the statistical significance of the yield changes.

Table 17-12 Crop Yield Indicators

	Base (2010–2012)	Final (2017–2018)	Change (%)
	Crop Yield (tons/ha)		
Food crops			
All cereals	3.01	3.77	25.2**
Of which: wheat (10 districts[a])	2.82	3.45	22.3 **
All vegetables	27.30	31.43	15.1**
Fodder crops (10 districts[a])	17.51	21.42	22.3^{ns}
Cotton	2.07	1.81	−12.6**

Source: TAJSTAT district-level data on crop production for 2010–2018; authors calculations.
Note: **significant at 5 percent, ns = not statistically significant; a. One district was omitted due to data limitations.

9. **Crop composition.** Economic analysis for the original project and AF assumed no change in crop composition. In fact, producers in the project districts have reduced the area planted to wheat and cotton since 2013 due to low returns and have used this land for higher returning crops. As wheat and cotton account for approximately 70 percent of arable land use, even a small shift in the area planted releases a relatively large area for reallocation to other crops. Improved access to irrigation facilitated the use of this land for vegetable production and the income from temporary employment provided beneficiaries with the means to purchase seeds. The area of alfalfa production also increased although this change reflects the ability to use otherwise marginal land more productively for livestock production rather than the direct return to alfalfa production. Table 17-13 shows that although the percentage reduction of the cotton and wheat area was moderate, the areas released facilitated a significant percentage increase in the areas planted to other cereals and alfalfa. A more modest increase occurred in the overall area planted to vegetables due to a decline in the area planted to potato production,39 but this was offset by the high gross margins for vegetable crops.

Table 17-13 Changes in Crop Composition – Original Project Districts

	2010–2012 (ha)	2017–2018 (ha)	Difference (ha)	% Change	Gross Margin/ha[a] (TJS)
Other cereals	20,260	25,155	4,895	24.2	12,304[b]
Wheat	58,503	54,257	−4,246	−7.3	5,997
All vegetables	11,598	12,205	607	5.2	14,766[c]
Alfalfa	7,415	10,322	2,907	39.2	4,012
Cotton	69,824	65,864	−3,960	−5.7	2,452

Source: TAJSTAT district-level data on crop production for 2010–2018; authors calculations.
Note: a. financial prices; b. average for maize and rice; c. average for potatoes, tomatoes, cucumbers, onions, and cabbage.

10. **Restoration of unused arable land.** The original project design assumed that irrigation rehabilitation would facilitate the return to production of approximately 2,000 ha of unused arable land. The national irrigation authority (ALRI) estimated that 12,395 ha were returned to full production across all 17 project districts for 2013–2019. Further estimates based on satellite data indicate that this area was even higher

Non-quantified Benefits

11. In addition to increased crop production, the project generated the following further benefits:

• **Temporary employment for low-income people.** The public works program to manually clean on-farm irrigation canals created employment for 30,005 people slightly below the AF target of 32,000 people but well above the final target of 29,950. Beneficiaries received an average net income of US$197 after the deduction of social security contributions. The project also paid their income and pension taxes. The total cost of implementing the public works program (including project payment of social security and other taxes) was US$9.978 million, of which US$5.9 million was received by beneficiaries with a benefit-cost ratio of 1.45. A detailed breakdown of these costs and benefits is presented in annex 5.

• **Increased integration with the formal economy (access to tax numbers, bank accounts, and social security).** The project assisted participants in the public works program to obtain tax numbers, open bank accounts, and register for social security. This support was particularly appreciated by the high proportion of rural women without these links to the formal economy.

• **Improved capacity for flood risk mitigation.** The project financed emergency repairs for canals and riverbanks in GBAO, Kulob, and Hamadoni, which benefit 62,400 citizens and improved the capacity for flood risk mitigation.

• **Improved irrigation management.** The project strengthened 130 WUAs across the 17 project districts. At project completion, 80 percent of WUA members reported an improvement in water delivery and 65 percent reported an improvement in the maintenance of infrastructure and collection of irrigation water fees.

Project Implementation

12. Project implementation was broadly efficient, with no delays in implementation, full disbursement, and no cost overruns. The project was extended for two years to accommodate the addition of six new districts and not because of any delays in implementation. Disbursement was below target during the first two years (2013–2014) but then recovered and remained on schedule for the remainder of the project. Actual project implementation costs amounted to 5.1 percent of total expenditure, which is acceptable for this type of project. The planned and actual expenditures by component are provided in table 17-14.

Table 17-14 Planned and Actual Project Expenditure by Component

	Budget (US$)[a]	Budget (US$)[b]	Actual (US$)[c]	Variance (US$)	Variance (%)
Component 1. Public Works and Rehabilitation of Irrigation and Drainage Infrastructure	45,540,000	44,843,935	44,354,635	(489,300)	−1.1
Component 2. Assistance in Water Resources Management, including Technical Assistance for Policy and Institutional Reform	9,570,000	9,023,675	9,135,796	112,121	1.2
Component 3. Project Management	2,790,000	2,962,696	2,898,349	(64,347)	−2.2
Total	**57,900,000**	**56,830,306**	**56,388,780**	**(441,526)**	**−0.8**

Sources: a. AF Project Paper (dated June 2015); b. Borrower's ICR PAMP II. 2020. Impact Assessment; c. PAMP II PMU, Final disbursements, as of August 2020.

Note: The approved budget as stated in the AF project paper differs from the actual budget as reported in the Borrower's ICR due to exchange rate(s) (losses) throughout project implementation. Further information is provided in annex 3. Project cost by component.

13. **Rating.** Project efficiency is rated as High in that the project achieved its targets, generated an acceptable return to investment, and was completed on time with no cost overruns and full disbursement. These outcomes were consistent with sector expectations. The economic analysis generated a benefit-cost ratio of 2.83 and sensitivity analysis showed that this return was robust to adverse changes in yields, crop output prices, and crop input prices. The costs of project implementation were acceptable as a proportion (5.1 percent) of total expenditure.

17.2.6. Zarafshon irrigation rehabilitation and management improvement project[16]

Efficiency analysis

1. The ex post economic analysis was performed at the project level, where the investment costs of all components were considered. Results of the ex post economic analysis, compared to the results of the project appraisal, are summarized in table 16-15.

Table 17-15 Results of the Ex-Post Economic Analyses

Scenario	EIRR[c] (base case) (%)	Sensitivity Analysis				
		Decreased Area Benefiting from Improved Cropping (%)	Decreased Crop Yields (%)	Decreased Crop Output Prices (%)	Increased Crop Input Prices (%)	Increased Project Cost (%)
		by 20% versus base case				
At PAD stage[a]	22.00	15.79	13.92	11.44	17.76	16.85
Ex post[b]	49.65	37.61	32.26	26.58	37.88	n.a.

Note: a. Only increase in crop yields is considered as a monetized benefit resulting from the Project.
b. Not only increase in crop yields but also change in crop patterns and crops rotation are taken into consideration as monetized benefits resulting from the project.
c. Minimum required return is 10 percent (discount rate).

2. The methodology applied at project appraisal is sufficiently clear and transparent and allows for direct comparison with the ex-post results. Therefore, the ex-post analysis only upgrades the economic analysis, concentrating on revising and updating the assumptions and recalculating the main economic results at project end, where the EIRR at the project level is compared with the corresponding values from the ex-ante CBA (at project appraisal).

Methodology for the Ex-Post Economic Analysis

3. The traditional economic evaluation method based on the incremental benefit and cost flows between the 'with project' and 'without project' scenarios were applied to catch the 'pure project' impacts.

4. The ex-post CBA on incremental basis was prepared to calculate the economic rate of return (ERR) and ENPV based on the assumptions described in items 5-8 below:

5. The unit costs and prices,11 exchange rates, conversion factors, and discount rate considered in the ex-post CBA are equal to those used in the PAD analysis (calculated in 2016 constant terms), 12 and the same 15-year project time horizon is applied, to allow for direct comparison with the ex-ante results.

[16] The text as presented in the World Bank document "Implementation Completion Report" under number ICR00005575

Investment Costs

6. The total US$16.3 million (the actual ZIRMIP project costs), split by components, is as shown in table 17-16

Table 17-16 Investment costs by Components

Project Components	Established Budget (US$, millions)	Disbursement of Funds as of June 30, 2021 (US$, millions)	%
I. Rehabilitation of irrigation infrastructure	**11.75**	**10.767**	**92**
Ia. Small irrigation canal rehabilitation program	1.06	1.136	**84**
Ib. Rehabilitation of large-scale irrigation systems	8.75	7.704	**91**
Ic. Emergency flood control and equipment procurement	1.94	1.927	**99**
II. Development and strengthening of irrigation and water management institutions	**3.52**	**3.888**	**110**
IIa. Main Irrigation System Management: Supporting ALRI and MEWR	1.41	1.637	**116**
IIb. Local Irrigation Management - Support for WUAs	1.17	1.367	**117**
IIc. Rehabilitation and equipping of auxiliary facilities	0.94	0.884	**94**
III. Project management	**1.13**	**0.993**	**91**
Total	**16.40**	**15.648**	**95**
Physical and price contingencies/exchange losses	—	0.599	
Grand total	**16.40**	**16.247**	**99**

Table A7.3. Project Costs' Distribution by Year

Project Cost	2018	2019	2020	2021
Total, US$	2,260,000	6,600,000	6,560,000	827,000

Benefits

7. Given the scarcity of arable land in Tajikistan and the geographic specifics of the project area, the monetized benefits of the Project come from the increased intensity of the production. The incremental crops yield, changes in cropping patterns (from low-value crops to higher-value crops, such as vegetables), and crops rotation are a result of better irrigation. However, distinguishing the impact of irrigation on crop yield from other complementary factors is difficult. Further, the available statistical data are insufficient, and although the data compare crop yields in the project districts (that is, Shahriston, Ayni, Devashtich, Kuhistoni Mastchoh, and Panjakent) for 2016–2020, the project area is only a portion of these project districts. Bearing in mind that the Project focuses on improving access to existing irrigation, the data for the ex-post CBA analysis are drawn from the historical data for irrigated land in the sown area in the project districts for 2016–2020. The aggregated district-level data on crop area, production, and yield for 2016–2020 for potatoes, wheat and cereals, vegetables, and other (fodder-alike) crops are used, where the average data from 2019–2020 serve as a basis only for the 'with project' scenario versus the average data from 2016–2018 used only for the 'without project' scenario.

8. The ex post economic analysis applies the same gradual materialization of benefits as envisaged in the PAD analysis, because there is no significant departure in the

project implementation works and schedule. However, there are many external factors that also affect the project results. For instance, once irrigation is assured, there is also considerable potential for further increases in yield in response to increased use of fertilizer and improved seed. Other potential benefits, such as savings in electricity usage, resulting from energy-efficiency interventions in pumping stations and/or water savings from canal rehabilitation works are not accounted for due to lack of reliable data. There are also other uncertainties related to benefits materialization (for example, the limited set of reliable comparable empirical data and the high dependence of the cropping patterns, yield, and prices on external factors such as climate and market fluctuations and so on). Therefore, different scenarios (conservative and optimistic) are developed to better understand the range of potential impacts.

9. Bearing in mind that the Project, as a whole, results in an opportunity to increase the productivity of agricultural crops (due to improved irrigation services) and bring about reduction in water losses, the subsidies are expected to decrease, due to the increased net benefits for the users.

10. Based on these data, the Project is expected to generate significant incremental benefits in terms of increased agricultural production and income in response to improved access to irrigation. Incremental benefits were calculated on the assumptions described above for an area of 29,716 ha of improved irrigation. This generates an ENPV of US$24.18 million or US$814 per ha and a benefit-cost ratio of 3.02 at a discount rate of 10 percent over 15 years. The associated EIRR is 49.65 percent.

Table 17-17 Economic Feasibility of the Project

Economic Feasibility	
ENPV net incremental benefits (US$)	24,177,465
ENPV net incremental benefits per ha of total irrigation area (US$)	814
EIRR (%)	49.65
Benefit-cost ratio	3.02

11. Farmers benefit from higher annual gross margins from crop production by US$178 per ha of improved irrigated land.

Table 17-18 Financial Benefits of the Project (USD)

Financial Benefits - Gross and Net Margin	Without Project	With Project	Incremental Costs
Per Farm			
Revenue from production	17,362	21,372	4,010
Variable costs	9,455	11,682	2,227
Gross margin	7,907	9,690	1,783
Per ha			
Revenue from production	1,736	2,137	401
Variable costs	946	1,168	223
Gross margin	791	969	178

12. The sensitivity analysis shows that project benefits are robust against adverse changes to costs and benefits. The most sensitive variable is the price output, as a 34 percent change in it would switch the result (the remaining variables are less sensitive as higher changes in them are needed to switch the result). Moreover, the range of potential impacts varies from an internal rate of return (IRR) of 10.42 percent (in a case of a 15 percent cumulative negative change in all main variables) to an IRR of 90.83 percent (a 10 percent cumulative positive change in all variables), clearly exceeding the minimal required return (10 percent) in all those scenarios.

Table 17-19 Results of Sensitivity Analyses

Variable	Change (–/+)	IRR	Switching Value
Base Case	**49.65%**		
Percentage of area benefiting from improved cropping decreases from 100% to 80%	–20%	37.61%	66%
Crop yield increase projections decline	–20%	32.26%	45%
Crop output prices decline with and without project	–20%	26.58%	34%
Crop input prices increase with and without project	+20%	37.88%	67%
Scenario	**Cumulative change**		**IRR**
Base case scenario	n.a.		49.65%
Conservative scenario	15% negative change		10.42%
Optimistic scenario	10% positive change		90.83%

13. **In sum, the Project demonstrates significant economic viability at closure**, and the risk for switching the result is low. Results from the ex post economic analysis for each of the scenarios are presented in table 17-19.

Table 17-20 Economic Analyses at the project Level – Conservative Scenario

Year		Project Costs (TJS)	Percentage of Full Benefits	With Project Annual Incremental Benefits (TJS)	Net Incremental Benefits (TJS)
2018	1	2,079,200	0	0	−2,079,200
2019	2	6,072,000	40	806,653	−5,265,347
2020	3	6,035,200	80	1,613,306	−4,421,894
2021	4	760,840	100	2,016,632	1,255,792
2022	5	0	100	2,016,632	2,016,632
2023	6	0	100	2,016,632	2,016,632
2024	7	0	100	2,016,632	2,016,632
2025	8	0	100	2,016,632	2,016,632
2026	9	0	100	2,016,632	2,016,632
2027	10	0	100	2,016,632	2,016,632
2028	11	0	100	2,016,632	2,016,632
2028	12	0	100	2,016,632	2,016,632
2029	13	0	100	2,016,632	2,016,632
2030	14	0	100	2,016,632	2,016,632
2031	15	0	100	2,016,632	2,016,632
Residual value					0
ENPV and 10% discount rate		11,962,363	—	12,202,354	239,991

Year		Project Costs (TJS)	Percentage of Full Benefits	With Project Annual Incremental Benefits (TJS)	Net Incremental Benefits (TJS)
					9.50
EIRR (%)					10.42
Benefit-cost ratio					1.02

Table 17-21 Economic Analyses at the project Level – Base Case Scenario

Year		Project Costs (TJS)	Percentage of Full Benefits	With Project Annual Incremental Benefits (TJS)	Net Incremental Benefits (TJS)
2018	1	2,079,200	0	0	–2,079,200
2019	2	6,072,000	40	2,389,071	–3,682,929
2020	3	6,035,200	80	4,778,143	–1,257,057
2021	4	760,840	100	5,972,678	5,211,838
2022	5	0	100	5,972,678	5,972,678
2023	6	0	100	5,972,678	5,972,678
2024	7	0	100	5,972,678	5,972,678
2025	8	0	100	5,972,678	5,972,678
2026	9	0	100	5,972,678	5,972,678
2027	10	0	100	5,972,678	5,972,678
2028	11	0	100	5,972,678	5,972,678
2028	12	0	100	5,972,678	5,972,678
2029	13	0	100	5,972,678	5,972,678
2030	14	0	100	5,972,678	5,972,678
2031	15	0	100	5,972,678	5,972,678
Residual value					0
ENPV and 10% discount rate		11,962,363	—	36,139,827	24,177,465
					813.60
EIRR (%)					49.65
Benefit-cost ratio					3.02

Table 17-22 Economic Analyses at the project Level – Optimistic Scenario

Year		Project Costs (TJS)	Percentage of Full Benefits	With Project Annual Incremental Benefits (TJS)	Net Incremental Benefits (TJS)
2018	1	2,079,200	0	0	–2,079,200
2019	2	6,072,000	40	3,842,970	–2,229,030
2020	3	6,035,200	80	7,685,941	1,650,741
2021	4	760,840	100	9,607,426	8,846,586
2022	5	0	100	9,607,426	9,607,426
2023	6	0	100	9,607,426	9,607,426

17.2.7. NPV and Climate beta

All projects have some common variables. One of them is a discount rate. It has been set in between 2 and 16 percent. For the detailed presentation, a discount rate was set to 12 percent as it corresponds with the common discount rate for Tajik projects. Generally, any environmental projects should include so called social discount rate as one of the main problems in implementing the changes and innovations needed to achieve better environmental and agricultural standards and the implementation of measures to adapt to global climate change is that any effects are only visible in the long future. It is difficult to identify and quantify clear negatives or positives to investment in Tajikistan's long-term agricultural measures, as it is not clear at this stage how successful the transformation of the economy and agriculture to carbon neutrality will be and how far climate change will affect the functioning of Tajikistan's agricultural sector and its aggregate economies. The basis for determining the social discount rate is the mapping of already created scientific works, a summary of their procedures and assumptions. Model of net present value (NPV) is the difference between the present value of cash receipts and the present value of cash outflows over a period of time. NPV is used in capital budgeting and investment planning to analyse the profitability of an anticipated investment or project. The NPV is the result of calculations used to find today's value of the future payment flow.

$$NPV = \sum_{t=1}^{n} \frac{R_t}{(1+i)^t}$$

Rt = Net cash flows and outflows during one period t, where R = B - C, where B is a benefit and C is cost. i = discount rate is the rate at which future cash flows are discounted to their present value.

NPV seeks to determine the present value of the future cash flows of an investment above the initial cost of the investment. The discount rate element of formula r in the NPV concept discounts future cash flows to the present value and is the percentage rate used to calculate the net present value of investment projects. The discount rate principle is based on the principle that the future value is lower than the present value and that this difference is based on the cost of capital that must be incurred over time.

One of the common procedures for set discount rates is to use the CAPM (Capital Asset Pricing Model) model. This model is based on the relationship between systematic risks and expected return on investment. The formula for calculating the CAPM model is given below:

$$i_\alpha = r_f + \beta_\alpha (r_m - r_f)$$

where iα is the discount rate for investment α. rf is a risk-free interest rate, for example, long-term government bonds of countries with excellent ratings. βα is the beta of a given investment and reflects the riskiness of a specific investment compared to a given market, thus reflecting systemic risks. It is commonly calculated for a specific industry and using regression analysis. Rm is the return on a given market or for a given investment. In this respect (rm-rf) represents the market mark-up for a given market or investment. Beta (0.55) was identified for agriculture and 0.64 for food (Damodaran, 2022).

Furthermore, it is important to mention so called climatic (environmental) beta concept. The environmental beta is intended to take into account the systemic risk associated with environmental damage, which in turn will affect the current value. A major problem in determining environmental beta is the very long time before there are obvious environmental impacts.

At first glance, the view of the situation seems intuitive. If any plan increases the risk to society in the future, then the climate beta should be positive. If the plan reduces the risk to society, then the climate beta should be negative, which will lead to an increase in net present value. This principle is based on the well-known consumption CAPM since 1978 by Lucas. Lucas' equation is below:

$$r = rf + \beta\pi$$

where rf is the risk-free interest rate, π is the systemic risk premium and β is the consumption CAPM beta for the specific investment. It is defined by the elasticity of the net benefit of a given investment in relation to aggregate consumption. In this respect, an investment project that does not correlate with aggregate consumption should be discounted at the rf rate. At the same time, an investment project with a positive β raises collective risk, and in this connection its net benefit is discounted at a higher rate.

Gollier (2019) views environmental beta as a natural capital that creates environmental services that should last for centuries. This long duration creates a problem with a clearly defined value of the environmental asset. In a growing economy, the rarity of irreplaceable and reproducible natural capital. The rarity of such capital grows over time, and so does its value for future generations. This effect may be higher than discounting itself. From this logic, the present value should also be higher, especially for irreplaceable assets

Climate β should be used in investment projects to reflect the societal price of the carbon footprint, or the present societal cost of damage from rising carbon emissions. Further, Dietz et al. (2020) compares several previous studies where, for example, Howarth (2003) argues that there is a net benefit from climate change projects. Furthermore, Howard et al. (2017) is of the opinion that the climate beta should be negative, although he did not support his claim more deeply.

In order to incorporate climatic β into this project, a simulation of discount rate lower than 12 % has been done for individual projects and is presented in each project in the according figure.

17.3. Appendix 3: Key completed, and ongoing development projects related to climate adaptation in agricultural sector in Tajikistan

Programmatic approach	**Integrated interventions for sustainable land management in upland areas (including pasture management, forestry and possibly also energy security in upland areas that addresses need of fuel supply and resulting deforestation)**
Relevant donor initiative or national programs that use such approach	• World Bank: Environmental Land Management and Rural Livelihoods Project; 2013-2018; 16.88 M US$ from GEF; • United Nations University (UNU); Sustainable Land Management in Pamiro-Alai; 2009 - 2011; CHF 250.000 • GEF, UNDP; Demonstrating Local Responses to Combating Land Degradation and Improving Sustainable Land Management in SW Tajikistan; 2007 - 2011; US$ 2.053.000 • International Fund for Agricultural Development (IFAD); Livestock and Pasture Development Project; 2011-2015; 15.8 M US$ • BMZ-funded ongoing projects implemented by GIZ: Adaptation to climate change through sustainable forest management (since 2013); and Sustainable and climate sensitive land use for economic development in Central Asia (since 2001 it its predecessor projects are counted) • BMUB-funded ongoing projects implemented by GIZ: Ecosystem-based adaptation to climate change in high mountainous regions of Central Asia (since 2015)
Basic features of these programming initiatives	• The listed projects provide: (i) Knowledge Management and Institutional support (including technical assistance for rural area population – e.g., trainings and seminars); (ii) Sustainable enhancing of livestock productivity (increase of nutrition status, pasture, water supply and forestry security); (iii) Investments in rural production and land resource management (provision with small grants). The projects outputs are implemented through local and international consultants in each sector and sub-contractors represented by local farmers unions or consulting company.
Any relevant climate-related notes	• The projects support climate resilience activities in selected vulnerable sites to enable rural population to increase their productive assets in ways that improve natural resource and land management, irrigation, and water supply as well as provision of technical assistance.

Programmatic approach	**Integrated interventions for watershed (or river basin) management**
Relevant donor initiative or national programs that use such approach	• European Commission; Promoting Integrated Water Resources Management and Fostering Transboundary Dialogue in Central Asia; 2009 – 2012; 3.4 M EUR • Swiss Cooperation Office (SCO), Canal Automation Project in Fergana Valley, 2004-2009, 1.8 M US$ • ADB, Building Climate Resilience in the Pyanj River Basin Project (Component 2: Irrigation), 2013-2019, 14.6 M US$ • SDC - Integrated watershed management imitative in Tajikistan (implemented since 2011 with assistance of Caritas) • BMUB-funded ongoing projects implemented by GIZ: Ecosystem-based adaptation to climate change in high mountainous regions of Central Asia (since 2015)
Basic features of these programming	• The projects on river basin management are aimed to support following climate change adaptation activities: (i) Water management (efficient

Programmatic approach	Integrated interventions for watershed (or river basin) management
initiatives	irrigation through remote water regulation and control, water allocation and distribution, irrigation canals rehabilitation; (ii) Technical assistance for rural are population; (iii) Reduce adverse effects of climate variability and climate change
Any relevant climate-related notes	• The listed projects support activities related to increasing resilience to climate vulnerability and change of communities in river basin

Programmatic approach	Interventions for improved efficiency of irrigation systems (changes, maintenance, energy supply, etc.)
Relevant donor initiative or national programs that use such approach	• Islamic Development Bank (IDB), IBRD, WB; Danghara valley irrigation, 2008 - 2013, 15.8 M US$ • IBRD/IDA, Public Employment for sustainable agriculture and water management, 2010-2011, 10 M US$ • IBRD/IDA, Tajikistan second public employment for sustainable agriculture and water resources management project, 2012-2020, 45.9 US$ • IDA/Word Bank, Ferghana Valley Water Resource Management Project, 2006-2013, 14.7 M US$
Basic features of these programming initiatives	• The irrigation projects are directed to support following activities: (i) Water management (efficient irrigation through remote water regulation and control, water allocation and distribution, irrigation canals rehabilitation; (ii) Support the development of improved policies and institutions for water resource management; (iii) Support of development and further funding of reservoirs rehabilitation
Any relevant climate-related notes	• The projects increase climate resilience of rural population by rehabilitating the farm level irrigation and drainage network which leads to temporary employment and food insecure

Source: Dusik, J. and B. Sheraliev. 2016. Strategic framework for developing and prioritizing climate change adaptation initiatives in the agricultural sector in Tajikistan. Ministry of Agriculture of Tajikistan, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and Ministry of Environment of Czech Republic. December 2016

17.4. Appendix 4: Greenhouse gas-mitigation through sustainable forestry in Tajikistan (NAMA)

Location: Tajikistan

Year: 2022 - 2027

Organization: Ministry of Economic Development and Trade (MEDT) / NAMA Support Project

Goal and description: The NAMA Support Project has several aims. These include forest renewal, conservation and sustainable management, contributing to climate change mitigation. Its other objectives are to maintain biodiversity, improve the livelihoods of local people and leverage public and private finance.

Finance: EUR 200,000

Impact: Only appraisal processed

Resource:

World Bank. (2022). Tajikistan to Protect its Natural Resources and Increase Climate Resilience, with World Bank Support. World Bank. https://www.worldbank.org/en/news/press-release/2022/02/25/tajikistan-to-protect-its-natural-resources-and-increase-climate-resilience-with-world-bank- or

URL: https://www.nama-facility.org/projects/tajikistan-forestry-nama-support-project/